The Evidence for Evolution

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1 DARWIN'S MOCKINGBIRD

The mockingbird hopped out of the bright sunlight and into the shade, then onto the rim of a tortoise-shell cup. It lowered its beak into the water, and began very calmly to drink. The cup, as it happened, was resting in the hand of a young naturalist named Charles Darwin, but the bird didn't seem to care. It continued drinking even as Darwin raised the cup for a better look.

Darwin's eyes must have widened with astonishment, but not as much as they might have. These events took place on the Galapagos Islands in 1835. At that time, Darwin was still a creationist and had no way of anticipating the revolution this bird would cause in his own thinking, let alone that of the entire world.

The bird on the cup looked much like the other mockingbirds on the island. Yet these mockingbirds did not look quite like those on a nearby island, which Darwin had just visited. And *those* mockingbirds differed from the ones on the next island over. Each island seemed to have its own distinctive mockingbirds. Darwin found this astonishing. The environments offered by these islands were indistinguishable, and the islands were in most cases within sight of each other. Why, Darwin wondered, had the creator made a different mockingbird on each island?

Furthermore, why was the bird on his cup a *mockingbird*? Mockingbirds are found only in the Americas, and Darwin's bird was similar to the ones he had seen in Chile. Yet Darwin was 600 miles from the American mainland. He wondered why the creator had chosen to populate these remote islands with birds that looked so American.

This question was broader than mockingbirds, for the same pattern held for finches and other types of bird. Nor was it just about birds. Each island had its own distinctive tortoises, insects, lizards, and even plants. With only a few exceptions, these were most closely allied to species found in South America.

During his stay in the Galapagos, Darwin was able to explain these questions away. He seems to have assumed that the different populations of mockingbird were mere varieties of a single species. This sort of geographic variation is found in many widespread species and would not have challenged Darwin's creationist views. Furthermore, the Galapagos species of mockingbird might have been created in South America and then immigrated to the Galapagos. For all Darwin knew, that species still lived somewhere in South America. Yet within eighteen months, this hypothesis came crashing down [106, p. 351]. The difficulties arose after Darwin returned to England, where there were experts on birds, reptiles, insects, plants, and all the other forms of life that Darwin had collected. These experts were eager to examine collections from the far-off Galapagos. In case after case, they assured him that entire species of plant and animal were confined to individual Galapagos islands. Yet the species on different islands were similar to each other and also (to a lesser degree) to South American species. As Darwin [30, p. 398] put it in 1845,

> one is astonished at the amount of creative force, if such an expression may be used, displayed on these small, barren, and rocky islands; and still more so, at its diverse yet analogous action on points so near each other. I have said that the Galapagos Archipelago might be called a satellite attached to America, but it should rather be called a group of satellites, physically similar, organically distinct, yet intimately related to each other, and all related in a marked, though much lesser degree, to the great American continent.

Darwin's solution to this puzzle was subtle. It involved thinking not about the plants and animals that lived on the Galapagos, but about those that did not. There were bats and birds but no native land mammals, reptiles but no amphibians, herbaceous plants but no trees. In each case, the forms that were present were those that seemed best able to survive a long journey across several hundred miles of ocean. Bats and birds can fly, but land mammals cannot. Reptiles and their eggs are resistant to salt water, and might have arrived alive on logs after weeks at sea. Amphibians die in salt water and could not survive such a journey. Herbaceous plants have small seeds, which can be carried by wind and in mud on the feet of birds. Trees have larger seeds that cannot travel in this fashion. The Galapagos, it seemed, were populated solely by travelers. This suggested that those plants and animals were not *created* on the Galapagos, but traveled there.

It seemed plausible that these travelers might have come from South America, since that is the closest continent. This accounted nicely for the observation that Galapagos plants and animals were similar to those of South Amer-

ica. But it also raised immediate problems: if they *were* immigrants from South America, why was it impossible to find any Galapagos species on the South American continent? And why were there different species on different islands?

The only explanation, it seemed, was that the immigrants had *changed* after their arrival in the Galapagos. And not only that, the immigrants to each island must have changed once again. This hypothesis would account for all the facts, but it flew in the face of conventional wisdom. For at that time, each species was held to be separately created and unchanging. Darwin's hypothesis was so radical that he did not dare publish it for many years.

During those years, Darwin was hard at work. If you are a good skeptic, you may have noticed some of the same problems that bothered him. Is it really true that the seeds can travel on the feet of birds? How long can the seed of a tree survive in salt water? If Darwin's explanation holds for the Galapagos, then we should find the same pattern in other island chains. Do we? Darwin found ways to answer all these questions, and many more. In some cases, his approach was direct and experimental. If we had visited his home during these years, we would have found rows and rows of jars in which seeds soaked in sea water. One wall was hung with ducks feet, on each of which (if we looked close) we would have found seeds embedded in dried mud. To answer other questions, he collated information gleaned from the literature and from an extensive correspondence with other scientists. Only after 20 years did he dare to publish of this research. The resulting book—*On the Origin of Species*—is one of the most famous in all of science [27]. In it, Darwin argued not only that evolution happens, but also that the mechanism of evolution is a process that he called "natural selection."

Darwin's contemporaries found the first of these arguments more persuasive than the second. During Darwin's lifetime, most working scientists came around to the view that evolution is a fact, but they argued about the importance of natural selection. One hundred and fifty years later, it has turned out that Darwin was essentially right on both counts, but his theory of natural selection left out a lot of details. Those details are still a subject of active research. There is no research however about whether evolution happens. That issue was settled over a century ago. The reality of evolution is no longer an interesting scientific question.

This has led to a bias in the way we scientists teach courses and write textbooks. We tend to emphasize what we find interesting and to gloss over the rest. For this reason, students learn a lot about the mechanisms of evolution but only a little about the evidence that evolution really happens. (Perhaps this contributes to the fact that most Americans view evolution with skepticism and suspicion.) This book will reverse the traditional emphasis. It will focus on the

evidence *that* evolution happens, while saying as little as possible about *how* it happens.

The general structure of the argument is much as it was in 1859. Like Darwin, we must ask: Do species change? Do they split into new species? Does evolution make big changes? Can evolution account for adaptation? These questions form the outline of the book. In every case however, the answers will involve evidence that Darwin did not have. The case for evolution is stronger today than it has ever been.