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EVOLUTION

The Remarkable History of a Scientific Theory

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CHAPTER 3

ON THE ORIGINS OF DARWINISM

After repeated delays due to heavy gales in the Channel, the diminutive British Navy vessel H.M.S. *Beagle* set sail from Plymouth, England, on December 27, 1831, for a projected two-year expedition to chart the southern coast of South America and, perhaps, the islands of the South Pacific. For Charles Darwin, the expedition's young naturalist, it proved an inauspicious start for what became a five-year voyage that would shape his professional career and thrust him into the center of the storm over the origin of species.

The seas ran high for the first week, and harsh punishments inflicted on the crew for predeparture holiday drunkenness made those initial days almost hellish to the well-bred naturalist. "Waked in the morning with an eight knot per hour wind, & soon became sick & remained so during the whole day—my thoughts most unpleasantly occupied with the flogging of several men for offenses brought on by the indulgence granted them on Christmas day," Darwin wrote in his diary about his first full day at sea. For the second day, he added, "The misery is excessive & far exceeds what a person would suppose who had never been at sea more than a few days." The ship's aristocratic captain, Robert FitzRoy, feared that Darwin would abandon the adventure at first landfall. The thought crossed Darwin's mind, as well. "I often said before starting, that I had no doubt I should frequently repent of the whole undertaking, little did I think with what fervour I should do so," Darwin wrote on day three. "I can scarcely conceive any more miserable state, than when such dark & gloomy thoughts are haunting the mind as have to day pursued me."[1]

The choice of Darwin for the expedition and his willingness to go reflected the scientific culture of nineteenth-century Britain. Government-sponsored voyages of scientific discovery had become commonplace by this time. Captains James Cook and George Vancouver had circumnavigated the globe in tall ships with teams of scientists charting the coasts, making scientific observations and collecting natural-history specimens for Britain during the late eighteenth century. France and other European powers had countered with similar expeditions of their own. Even the new United States government was preparing to launch such an endeavor later in the 1830s. Formal graduate programs did not yet exist; in their absence, many of the nineteenth century's finest naturalists cut their teeth aboard scientific expeditions—before settling into permanent positions at universities, natural-history museums, and other institutions.

The voyage of the *Beagle* was not planned as a grand expedition for science, though it later became one. Indeed, it did not even merit an official naturalist. A ninety-foot-long brig awkwardly fitted with three masts, the *Beagle* was better suited to poke along a coast than to sail the high seas. In 1830, it returned prematurely from a mission to chart the coasts in and around the southern tip of South America after its melancholic captain, lonely in command and lost in the desolate labyrinth of Tierra del Fuego, killed himself. The British admiral in charge of the South American station sent FitzRoy, not yet twenty-five but a direct descendant of King Charles II, to assume command of the brig and, ultimately, return it to Britain. Two years later, with FitzRoy still in command, the *Beagle* headed back to finish its mission, with authority to continue on around the world. The young commander suffered a similar temperament as his predecessor, however, and feared a similar fate. FitzRoy's uncle, Lord Castlereagh, had slit his own throat, and FitzRoy would do the same in 1865. For the

Beagle's voyage, he wanted someone on board he could talk with as an equal—and thus he secured permission to take along a gentleman naturalist.

Although he was no one's first choice for the position, Darwin filled its peculiar requirements. Born in 1809 into an affluent family of English capitalists living in rural Shropshire, Darwin was five years younger than FitzRoy and had just graduated from Cambridge. He had developed an abiding interest in natural history at Cambridge, where he regularly collected plants with the young botany professor John Stevens Henslow and once accompanied Adam Sedgwick on a geology field trip. Graduation left Darwin with only vague plans for his future, and the prospect of a round-the-world scientific expedition, even one on the *Beagle*, interested him greatly. Darwin's father initially resisted—seeing the voyage as simply another expensive dalliance for his capricious son—but soon relented (as he usually did) and underwrote the entire cost for his son and (ultimately) his son's manservant, Syms Covington.

"Gloria in excelsis is the most moderate beginning I can think of," Darwin wrote to Henslow, who had recommended Darwin for the position. "What changes I have had: till one to day I was building castles in the air about hunting Foxes in Shropshire, now Lamas in South America. There is indeed a tide in the affairs of men."[2] Visions of the South Pacific especially excited him. "It is such capital fun ordering things," Darwin wrote four days later to a college chum, "to day I ordered a Rifle & 2 pair of pistols; for we shall have plenty of fighting with those d—— Cannibals: It would be something to shoot the King of the Cannibals Islands."[3] Delays and the first week's seasickness dimmed his early enthusiasm, but by the time the *Beagle* reached its first planned landfall, the Canary Islands southwest of Spain, Darwin had recovered his characteristic exuberance. "We saw the sun rise behind the

Charles Darwin, from a portrait made in 1840, shortly after his return from the voyage of the *Beagle*.

rugged outline of the Grand Canary island, and suddenly illumine the Peak of Teneriffe," he wrote. "This was the first of many delightful days never to be forgotten."[4]

A cholera quarantine kept the expedition from disembarking on the Canary Islands, so the *Beagle* sailed farther south to the tropical Cape Verde Islands instead. The expedition's layover in that volcanic archipelago transformed Darwin's thinking about geology. He had begun the voyage as a conventional British catastrophist still under Sedgwick's sway. Indeed, Sedgwick had supplied Darwin with a reading list for the voyage—a list that conspicuously omitted Lyell's controversial *Principles of Geology*. FitzRoy gave a copy of the book to

Darwin, however, and the young naturalist was reading it when the expedition landed on St. Jago, the largest island in the Cape Verde group. What Darwin saw there made him an instant and lifelong convert to Lyellian uniformitarianism.

"On entering the harbour, a perfectly horizontal white band in the face of the sea cliff, may be seen running for some miles along the coast, and at the height of about forty-five feet above the water," Darwin wrote in his *Journal*. Upon close examination, he found that the formation consisted of a light layer of rock derived from cooked corals and seashells between dark layers of volcanic rock. The sea life that created the white band must have lived on a shallow shoal of volcanic rock and been covered by a flow of molten lava while still submerged, Darwin surmised. Then the entire formation rose to its present height gradually enough to maintain its shape. All this must have happened long ago, because the island's volcanic craters were weathered almost beyond recognition; but not *too* long ago, because the shells in the white band were of the same types as on the beach below. Within his first few days on St. Jago, the twenty-two-year-old naturalist had interpreted to his own satisfaction the geologic history of the Cape Verde Islands using Lyellian activism rather than Cuvierian catastrophism. Current geologic forces operating over time could have produced these islands, Darwin concluded, whereas catastrophic past events would have disrupted the strata.[5]

Deciphering island geology was a heady and empowering experience for Darwin. Upon disembarking on St. Jago, he was so "overwhelmed" by the island's unfamiliar volcanic terrain and tropical plants that he wrote in his diary, "It has been for me a glorious day, like giving to a blind man eyes."[6] Recalling the episode nearly a half century later, Darwin wrote that the cliffs of St. Jago "showed me clearly the wonderful superiority of Lyell's manner of treating geology, compared

to that of any other author." Suddenly, his vision of the voyage's scientific significance and of himself as a scientist enlarged. "It then first dawned on me that I might perhaps write a book on the geology of the various countries visited, and this made me thrill with delight," Darwin related. "That was a memorable hour for me, and how distinctly I can call to mind the low cliff of lava beneath which I rested, with the sun glaring hot, a few strange desert plants growing near, and with living corals in the tidal pools at my feet."[7] At that moment, the student-traveler became a self-confident scientist.

Subsequent observations reconfirmed Darwin's newfound faith in geologic actualism. From interpreting coral reefs as the product of gradual subsidence to witnessing active volcanos forming the Galápagos Islands, Darwin saw evidence all around him of the profound effect of ongoing natural forces. Catastrophists could account for these observations by invoking prehistoric events beyond the magnitude of current ones, of course, but such explanations no longer satisfied Darwin—particularly after he experienced a major earthquake in Chile. "The motion made me giddy," he noted in his diary for February 20, 1835. "The world, the very emblem of all that is solid, moves beneath our feet like a crust over a fluid."[8] For Darwin, the earthquake proved the mountain-building power of current geologic forces. "Captain Fitz Roy found beds of putrid mussel-shells *still adhering to the rocks,* ten feet above high-water mark," Darwin observed with emphasis in his *Journal* about one site the expedition visited two weeks after the earthquake. "The elevation of this province is particularly interesting, from its having been the theatre of several other violent earthquakes, and from the vast numbers of sea-shells scattered over the land, up to a height of certainly 600, and, I believe, of 1000 feet."[9] About such an earthquake, Darwin wrote to a friend shortly after experiencing the Chilean one, "It is certainly one of the very grandest phenomena to which the globe is subject."[10]

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Although Darwin's conversion to uniformitarian geology lay the foundation for his later acceptance of organic evolution, the second step did not follow automatically from the first. Indeed, Lyell himself long maintained that uniformitarianism (by denying direction in geologic history) affirmatively undermined evolutionism. In *Principles of Geology,* he offered the alternative gradualist view that God (or a "Presiding Mind") continually created species to fit local environments. According to this view, those species would spread out from their "*centre* or *foci* of creation" to occupy suitable territory for so long as environmental conditions permitted, and then become extinct.[11] Darwin spent much of his time during the *Beagle* expedition looking for the Lyellian "centre of creation" for individual species, and interpreting the distribution of various plants and animals accordingly.[12] Yet by lengthening the earth's history indefinitely, eliminating life-destroying catastrophes, and postulating gradual environmental change over time (which presumed gradual organic change, as well), a uniformitarian view of geology points those committed to its principles toward an evolutionary view of biology. Darwin the disciple simply surpassed Lyell the master in accepting the implications of uniformitarianism.

Absorbing Lyell's *Principles of Geology* during the *Beagle* expedition affected Darwin in subtle ways, as well—so much so that he dedicated his book about the voyage to Lyell, "as an acknowledgment that the chief part of whatever scientific merit this *Journal* and the other works of the author may possess, has been derived from studying the well-known and admirable *Principles of Geology.*"[13] For instance, Lyell opened the *Principles* with a self-serving history of geology that uncriti-

cally hailed any insight anticipating uniformitarianism and utterly dismissed the contributions of catastrophists. This account heaped particular scorn on revealed religion and church doctrine for holding back scientific progress. "In short," Lyell concluded near its end, "a sketch of the progress of geology is the history of a constant and violent struggle between new opinion and ancient doctrines, sanctioned by the implicit faith of many generations, and supposed to rest on scriptural authority."[14] This was law-office history written by a barrister, and Darwin swallowed it whole. In its methods and findings, however, the geology of Lyell did not represent a revolutionary advance over that of Sedgwick, Murchison, Agassiz, or Owen (all of whom favored naturalistic explanations for geologic phenomena and helped lay the foundation for the modern understanding of the geologic column), but the *Principles* made it seem so—and Darwin signed on for the revolution. "I always feel as if my books came half out of Lyell's brains," Darwin later wrote, "for I have always thought that the great merit of the *Principles,* was that it altered the whole tone of one's mind & therefore that when seeing a thing never seen by Lyell, one yet saw it partially through his eyes."[15]

Just as the observations that Darwin made on the Cape Verde Islands early in the *Beagle* expedition opened his eyes to uniformitarian geology, what he saw in the Galápagos archipelago late in the voyage inspired his thoughts on organic evolution. Like the Cape Verde group, the Galápagos Islands are isolated and desolate. Seeing them through Lyell's eyes, Darwin recognized both archipelagos as the peaks of volcanic mountains risen relatively recently from the sea. They remained hostile living environments with a limited variety of mostly indigenous species. The Cape Verde Islands stand at fifteen degrees north latitude nearly four hundred miles off

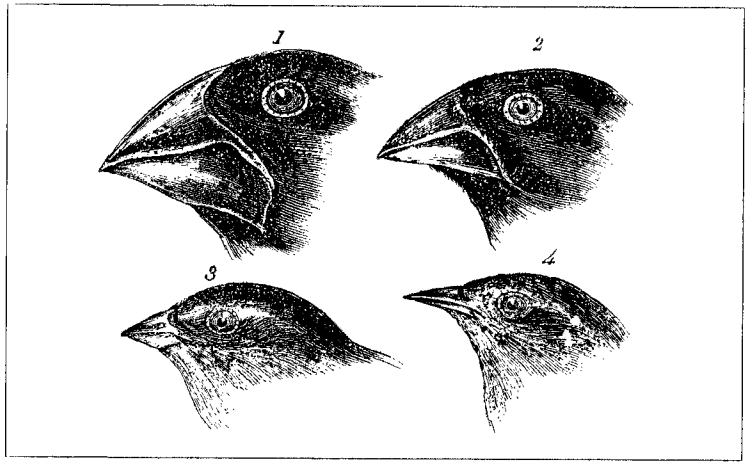
the Atlantic coast of Africa; the Galápagos straddle the equator more than five hundred miles off the Pacific coast of South America. The physical ecology of the two places was similar, yet the former's plant and animal species were like those of Africa and the latter's like those of South America. "The creationist" must consider these "as so many ultimate facts," Darwin wrote in a private 1844 essay that summarized his thinking of the previous eight years. "He can only say that it so pleased the Creator... that the inhabitants of the Galapagos Archipelago should be related to those of Chile... and that all its inhabitants should be totally unlike those of the similarly volcanic and arid Cape de Verde and Canary Islands." This could be, Darwin conceded, "but it is absolutely opposed to every analogy, drawn from [physics] that facts, when connected, should be considered as ultimate and not the direct consequence of more general laws." In short, he charged, the creationist explanation was unscientific.[16]

In 1837, Darwin began outlining his evolutionary explanation for these observations in a series of private notebooks and essays, one of which identified the "species of the Galapagos Archipelago" as a primary source "of all my views."[17] In his first such notebook, for example, he jotted, "My idea of Volcanic islands elevated. Then peculiar plants created.... Yet new creation affected by Halo of neighboring continent."[18] In other words, individual plants and animals from the nearest landmass should colonize a newly formed island, become isolated there from their parent population, and then evolve to fit the island's environment and fill available niches. Spelling this out in an 1842 essay, Darwin noted, "So if Island formed near continent, let it be ever so different that continent would supply inhabitants, and new species (like the old) would be allied with that continent."[19] Addressing the same issue in an 1838 notebook entry, he asked himself rhetorically, "Did Creator make all new [species on oceanic islands,] yet

[with] forms like [on] neighbouring Continent? This fact speaks volumes. My theory explains this but no other will."[20] Only through a process of colonization, isolation, and evolution would the Cape Verde Islands have African-like species and the Galápagos Islands have American-like species, Darwin reasoned. A Creator would have fashioned species to fit their environment, not some neighboring continental template.

While such reasoning reinforced Darwin's thinking about evolution, his initial conversion experience came from the even narrower observation that these relationships between South American and Galápagos species carried over to inter-island differences. Although he did not notice it while collecting specimens in the archipelago from September 16 to October 20, 1835, on closely examining them during the *Beagle*'s ensuing yearlong voyage back to Britain, Darwin recognized a potentially significant relationship among Galápagos mockingbirds. "I have specimens from four of the larger Islands," he recorded in a notebook he kept aboard ship. "The specimens from Chatham and Albemarle Islands appear to be the same, but the other two are different. In each island each kind is *exclusively* found." If these specimens represented distinct species (as opposed to simply marked varieties of the same species), then those species must have evolved in isolation on their separate islands from a common ancestral type (probably blown to the archipelago from South America), Darwin surmised. "Such facts would undermine the stability of species," he concluded.[21]

Soon after the *Beagle* returned to Britain late in 1836, ornithologist John Gould definitively identified three island-specific species of Galápagos mockingbirds from Darwin's specimens. Even more striking, he identified fourteen species of Galápagos finches (differentiated primarily by the size and shape of their beaks) from the array of small land birds in



Charles Darwin's 1845 sketch of Galápagos finch beaks.

Darwin's collection. Darwin could not determine from his records whether the various finch species came from separate islands, but if some of them did (and he believed it likely), then they reinforced his conclusion. A rational Creator would not have made so many different species of finches and mockingbirds for ecologically similar islands in one small archipelago, he argued to himself. Adaption to niches became Darwin's answer for the origin of these species and, ultimately, by extrapolation, of all species everywhere.

By themselves, however, isolation and evolution represented only a partial answer to what Darwin called in his travel *Journal* "that mystery of mysteries—the first appearance of new beings on this earth."[22] They did not explain how the process operated. Doing so became Darwin's obsession for the rest of his life. He knew that other naturalists had proposed theories of organic evolution before, but none of them contained a credible mechanism for evolutionary change. For forty years, mainstream scientists had ridiculed Lamarck's theory that living things evolve by adapting to their changing

environment and passing on those adaptations to their descendants. Similar theories offered by others—including a pre-Lamarckian one by Charles Darwin's grandfather, the poet, philosopher, and physician Erasmus Darwin—suffered a similar fate, or were simply ignored by scientists. Lamarck, Erasmus Darwin, and many of the other early evolutionists seemed to revel in their outcast status—but Charles Darwin had no stomach for it. He craved acceptance within the scientific community even as he sought to overthrow one of its most basic beliefs: the fixity of species. So he labored on his theory virtually in secret for two decades, all the while keeping up appearances as a conventional Victorian gentleman scientist.

Darwin played the part well. In 1839, he married his wealthy first cousin, Emma Wedgwood, whose dowry (when coupled with his own family fortune) eliminated any need for him to earn a living. Three years later, the couple moved to a country home in Downe, which was near enough to London for him to participate (when he wanted) in its scientific culture, but rural enough for him to conduct breeding experiments with domesticated plants and animals designed to study the evolutionary process. Beginning soon after his return to Britain in 1836 and continuing until near his death in 1882, he produced a steady stream of scientific books and articles. Addressing a wide variety of topics in geology, biology, and psychology—from barnacles and South American fossils to pigeon breeding and the expression of emotions—they all contributed to Darwin's understanding of evolution. His scholarly publications and social standing gained him entry into Britain's elite institutions of science, including election at age thirty to the prestigious Royal Society of London.

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Darwin's conceptual breakthrough came in 1838, after he began considering the case of human evolution. For most

people concerned about the issue of transmutation (either pro or con), the key question is always the same: Did humans evolve from other primates? Darwin knew the literature on this subject, of course, and had directly confronted the matter during the *Beagle* expedition when he encountered the native peoples of Tierra del Fuego, who he deemed the lowest form of humanity on earth.[23] In 1838, while struggling to understand how evolution worked, Darwin's thoughts returned to the Fuegians and their apparent similarity to primates in the London zoo.

Those and other thoughts exploring supposed links between humans and animals pepper his private notebooks throughout 1838. "Let man visit orangutan in domestication, hear expressive whine, see its intelligence," Darwin wrote early in the year, "then let him dare to boast of his proud preeminence." Here he inserted the phrase, "not understanding language of Fuegian[s], puts [them] on par with Monkeys." Returning to this comparison later in the year, he added, "Forget the use of language, & judge only by what you see. Compare, the Fuegian & Orangutan, & dare to say difference so great." Darwin downplayed the language factor, as well. "The distinction as often said of language in man is very great from all animals—but do not overrate—animals communicate to each other," he noted in one of many entries attributing supposedly human powers to beasts. Just as frequently he speculated about animal origins of human traits, such as when he wrote, "One's tendency to kiss, & almost to bite, that which one sexually loves is probably . . . due to our distant ancestors have been like *dogs* to bitches." As for the vaunted "mind of man," Darwin concluded, it "is no more perfect, than instincts of animals." Human thought itself (like animal instincts) he attributed to brain structure, chiding himself "oh you Materialist!" for thinking so. Continually he probed the perceived boundary questions. "Does a negress blush? I am al-

most sure [the Fuegians] did," he asks himself at one point. "Animals I should think would not."[24]

Absorbed by such comparisons, Darwin immersed himself in books and articles about animal aspects of the human condition. During the course of this reading, he took up Thomas Malthus's classic *Essay on the Principle of Population.* All species, including humans, reproduce at unsustainably high rates, Malthus asserted. Lacking sufficient food to go around, "necessity, that imperious all pervading law of nature, restrains them within the prescribed bounds," he explained. "Among plants and animals its effects are waste of seed, sickness, and premature death. Among mankind, misery and vice."[25]

The practical implications of Malthus's so-called "principle of population" are profound, complex, and controversial. Focusing on humanity in his *Essay,* Malthus used it to argue against welfare programs for the poor, presenting handouts as a recipe for added human suffering in the long run. Extending the principle to all living things, Darwin saw in it a natural mechanism for evolutionary development. Beginning with the assumption that all individuals of every species naturally differ, he surmised that within each species a competitive struggle for existence would eliminate the weaker members and leave the stronger (or better adapted) ones to reproduce and pass along their beneficial adaptations to the next generation. "One may say there is a force like a hundred thousand wedges trying [to] force every kind of adaptive structure into gaps in the economy of Nature, or rather forming gaps by thrusting out weaker ones," Darwin wrote in a notebook entry dated September 28, 1838. "The final cause of all this wedging, must be to sort out proper structure & adapt it to change."[26] Describing the rush of comprehension four decades later in his *Autobiography,* Darwin remembered suddenly realizing that he "had at last got a theory by which to work."[27] He called his theory "natural selection."

Darwin equated the process to the artificial selection methods utilized by plant and animal breeders. These breeders created and sustained highly differentiated varieties by continually selecting for certain desired traits in the breeding stock, such as long ears in basset hounds or creamy milk in Jersey cows. Reasoning by analogy, Darwin saw intraspecies competition for food and mates creating new species within a given environment by continually selecting for traits that contributed to survival and reproduction, such as large, strong beaks for birds in places with hard seeds. "It is a beautiful part of my theory," he noted in late 1838 or early 1839, "that domesticated races of organisms are made by precisely [the] same means as species—but [the] latter far more perfectly & infinitely slower."[28]

For Darwin, a species simply constituted a population of physically similar individuals capable of breeding together, not an ideal, unchanging life-form. These similar (but not identical) individuals would necessarily compete with one another for the same limited resources in a Malthusian world, leaving the fittest among them to survive and reproduce their kind. He realized that different natural environments and ecological niches would favor different adaptations, so that species would not evolve in a linear, Lamarckian fashion. Rather, Darwin envisioned a branching process of evolutionary development, with various daughter species evolving in different directions from a common ancestral type to fill available geographic spaces and ecological niches. For Darwin, differential death rates caused by purely natural factors created new species. God was superfluous to the process.

Indeed, God became more than superfluous under Darwin's emerging view of origins—He became problematic. At the very least, the theory of evolution dispenses with the immediate need for a Creator to shape individual species, including humans. More critically, a natural-selection mecha-

nism relying on cutthroat intraspecies competition to evolve new species struck Darwin as incompatible with any reasonable notion of benevolent divine action. Darwin's long drift toward agnosticism gained momentum at this point in his intellectual pilgrimage, and perhaps was accelerated later by such personal experiences as his worsening physical ailments and the death in 1851 of his beloved ten-year-old daughter, Annie.[29] In his private notes, Darwin began attributing religious belief to instinct and love of God to brain organization. As for humans, he wrote shortly after his Malthusian breakthrough, "When two races of men meet, they act precisely like two species of animals—they fight, eat each other, bring diseases to each other, and etcetera, but then comes the more deadly struggle, namely which have the best fitted organization or instincts (i.e. intellect in man) to gain the day."[30] In his mind's eye, Darwin surely saw the forces of British imperialism triumphing across the globe.

Essential to Darwin's conception was a modern worldview influenced by ideas of utilitarianism, individualism, imperialism, and *laissez-faire* capitalism. Of course Malthus was a utilitarian-minded political economist who championed the *laissez-faire* ideal. Darwin also read the writings of Adam Smith and other utilitarian economists who presented individual competition as the driving force of economic progress. Perhaps more important, he lived in a society that embraced this view; Darwin himself came from a family of successful capitalists. Further, he rode on the rising tide of British economic, political, and cultural imperialism when he sailed aboard the *Beagle*. "In the unknown interlocking movements of the human mind," Darwin biographer Janet Browne concludes, "natural selection intuitively seemed the right answer to a man thoroughly immersed in the productive, competitive world of early Victorian England."[31]

Darwin conceived his theory in 1838, but he did not publish anything about it for twenty years. Recognizing the depth of opposition among scientists to the transmutation hypothesis, he spent much of this time endeavoring to anticipate and answer in advance objections to his theory. In the process, he perfected his thinking on the gradual divergence of varieties into distinct species through competition, marshaled evidence for evolution from comparative anatomy and embryology, fitted fossils into evolutionary series and distribution patterns, and tried to imagine intermediate stages in the development of the eye and other complex organs. Although largely irreligious himself, he also worried about the impact that revealing his theory might have on religious believers, particularly his wife. "What a book a Devil's chaplain might write on the clumsy, wasteful, blundering low & horridly cruel works of nature!" Darwin exclaimed in an 1856 letter to British botanist Joseph Hooker, as if to justify not doing so.[32] Hooker was one of the few scientists that Darwin told about his theory prior to announcing it publicly. Lyell and American botanist Asa Gray, who supplied Darwin with information about the geographic distributions of Pacific-Rim plant species, were two others.[33] All three of these key confidants expressed interest in Darwin's theory, and Lyell urged him to publish it promptly in full, but none of them was yet ready to abandon creationism.

By the 1850s, however, British public opinion was warming to the idea of evolution. Despite hostile reviews, Robert Chambers's 1844 *Vestiges of the Natural History of Creation* sold enormously well for more than a decade and stimulated widespread discussion of human evolution. Beginning with his 1851 book, *Social Statics*, the popular British philosopher Herbert Spencer picked up where *Vestiges* left off in linking an essentially Lamarckian view of organic evolution with a Malthusian vision of human social progress through struggle

Alfred Russel Wallace, from a daguerreotype made in 1848, shortly before his departure for the Amazon basin.

and competition. It was Spencer, not Darwin, who coined the term "survival of the fittest." Then, on June 18, 1858, Darwin received a manuscript from evolutionist Alfred Russel Wallace containing the core concepts of natural selection. Darwin would have to publish his theory or risk losing priority.

Like Darwin, Wallace was fairly well-known among British naturalists even before the joint announcement of their grand theory in 1858. Although the two men differed in background and temperament, they hit upon the idea of natural selection in nearly the same way. The parallels and perpendicularities between them are striking. Wallace grew up poor in rural Britain and was largely self-educated, whereas Darwin received the best education that money could buy. In their late teens, both men became fascinated with natural history. Exploiting the means open to them, both transformed this hobby into a career. Capitalizing on his social standing, family wealth, and university training, Darwin was chosen for the

Beagle expedition and thereafter settled comfortably into the life of a gentleman scientist. He never had to earn a living. From 1848 to 1862, Wallace embarked on bare-bones collecting trips, first to the Amazon basin with fellow collector Henry Walter Bates, and then to the Malay Archipelago, paying his own way by shipping back animal skins, pressed insects, and dried plants for sale to British collectors. He traveled by commercial steam or sailing ship from port to port and with native guides to places where few Europeans had ever gone. The inverse of Darwin, Wallace instinctively felt an affinity for the native peoples he encountered and a certain distance from European colonialists. Both men first gained scientific recognition for the specimens they sent or brought to Britain, and then secured wider fame by publishing popular accounts of their travels.

The transmutation hypothesis was widely debated but little accepted among European naturalists during the early nineteenth century. It had a revolutionary taint. Predisposed to embrace radical ideas in politics, religion, and science, Wallace instinctively accepted the idea that everything evolved; he pushed the range of his collecting trips in part to test his hypothesis that, under an evolutionary distribution pattern, similar (or nearly related) species should inhabit neighboring territories. This, he hoped, would serve as persuasive evidence for organic evolution. More conservative in his thinking, Darwin stumbled on just such a pattern for similar species of birds on the Galápagos Islands in 1835, and privately concluded that they must have evolved from a common ancestral type. Once convinced that species evolve, he was even more dogged than Wallace in trying to understand the process.

Their shared interest in the geographical distribution of species led Darwin and Wallace to begin corresponding in 1855, but neither initially told the other about his obsession

with finding the mechanism driving evolution. Each found his answer in Malthus. It came to Darwin in a comfortable London salon; it struck Wallace during the height of a malarial fever in a native hut at the village of Dodinga on what is now the Indonesian island of Halmahera. Applied to plants and animals in nature, Darwin and Wallace independently realized, Malthusian population limits provided a means to generate new species from preexisting ones through the survival of individuals with beneficial variations. Wallace immediately set down his insight in a clear, tightly reasoned essay and sent it to Darwin, who had earlier expressed interest in Wallace's work. Wallace asked Darwin to review the manuscript and, if he thought it had merit, pass it along to Lyell, whom Wallace admired but did not know. Darwin was stunned by what he read.

Wallace's essay opened with a restatement of Malthus's population principle. "The life of wild animals is a struggle for existence," he asserted. For every species, far too many individuals are born than can survive, and each one of them is different. "As the individual existence of each animal depends upon itself, those that die must be the weakest," Wallace wrote in a passage that could have been drawn from his own hard life, "while those that prolong their existence can only be the most perfect in health and vigour." A beneficial variation could provide the edge needed for survival, he suggested, and, if so, it would be propagated in the survivor's offspring. Turning the most famous example of supposed Lamarckian evolution on its head, Wallace explained with emphasis, "The giraffe [did not] acquire its long neck by... constantly stretching its neck... but because any varieties which occurred among its antetypes with a longer neck than usual *at once secured a fresh range of pasture over the same ground as their shorter-necked companions, and on the first scarcity of food were thereby enabled to outlive them.*" Such variations, preserved and

accumulated over time, would lead to new types, he reasoned. "Here, then, we have *progression and continued divergence* deduced from the general laws which regulate the existence of animals in a state of nature, and from the undisputed fact that varieties do frequently occur," Wallace concluded.[34] Darwin read these words as a precise summary of his theory.

Dejected, Darwin duly forwarded Wallace's manuscript to Lyell. "Your words have come true with a vengeance that I should be forestalled. You said this when I explained to you here very briefly my views of 'Natural Selection,' " Darwin wrote in his cover letter to Lyell. "I never saw a more striking coincidence. If Wallace had my manuscript sketch written out in 1842 he could not have made a better short abstract!... So all my originality, whatever it may amount to, will be smashed."[35] In his initial despair, Darwin somewhat exaggerated the identity between his well-worked theory and Wallace's burst of insight. Closer inspection would show that Darwin emphasized the role of individual competition in natural selection, for example, while Wallace stressed the selective power of ecological factors working on varieties. Lyell recognized the contributions of both men, and together with Hooker arranged for the Linnean Society of London to publish Wallace's essay jointly with two earlier writings in which Darwin had privately outlined his theory of natural selection. Darwin cooperated in this arrangement by supplying his writings; Wallace knew nothing about it at the time, but later expressed his satisfaction with it. The three items were read to the society at its meeting on July 1, 1858 (in alphabetical order by the author's last name), and Darwin promptly set about composing a more complete account of his theory. It appeared a year later as the book *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life.* Darwin had preserved his priority in publishing the idea of the century.