

# Charles Darwin: Traveller, Author, and Naturalist

JANET BROWNE

Darwin, as a historical figure, means many things to many people. He can be an elderly bearded sage, an anxious father, a sickly recluse, or an atheistic revolutionary. Perhaps this is partly due to the rich documentary record that he left behind, comprising a large collection of personal papers and writings, his library, research materials, biological specimens, and a vast correspondence with naturalists all over the globe. Partly, there are many different ways in which to study evolutionary biology. And a wide variety of artists and literary figures also find inspiration in his ideas. But we should not forget that, above all else, Darwin published a series of extraordinary books that became the foundation of modern biology. Prime among these books is *On the Origin of Species by Means of Natural Selection*, published in London in November 1859.

Darwin is justly celebrated for this magnificent book, which made him one of the most prominent naturalists in the world, “first among the scientific men of England,” as the socialist philosopher Edward Aveling put it. As is well known, it generated intense attention when it was published, almost like a media launch today, not just for the powerful reach of the proposals, or Darwin’s careful analysis of the problem of animal and plant origins, and his weighty accumulation of evidence, but also for the shocking absence—for some people, the *liberating* absence—of any allusion to the biblical story of creation. Darwin proposed an entirely natural process to explain the characteristics of the living beings that we see around us. This extraordinary combination of features was guaranteed to generate argument in Victorian England, and ultimately the world over. Should divine forces be banished as an explanation for the apparent design and harmony of the world? What should human beings think about their own origins? Was Darwin suggesting that humans emerged in a natural manner from ape ancestors? These were deep questions that continue to be asked today. Indeed the avenues of thought opened by the theory of evolution by natural selection have guided and provoked research for 150 years. Today, greatly enhanced by the field of genetics and much diversified in intellectual scope, the principles of Darwinism remain at the cutting edge of scientific inquiry.

This essay aims to summarize where we currently stand in our historical understanding of Darwin as a thinker and writer. Over the last couple of

decades we have gained a much more sophisticated grasp on the controversy that emerged in England during the Victorian period, and can recognize that the conflict between science and religion was not solely about Darwin and his theory. Other major cultural transformations were taking place: transformations in religious thought, social structure, political organization, education, and industrial progress. We do not expect Darwin to be writing with an understanding of modern science. We can see that his use of the word “evolution” is not the same as ours. He did not have access to today’s sciences of molecular biology or the facts of modern paleontology. All this means that we are more easily able to recognize the debts he owed to the science of his own day and also to acknowledge the significance of other important evolutionary thinkers of the nineteenth century, particularly Alfred Russel Wallace, Robert Chambers, and Herbert Spencer.

What is also emerging from historical research into Darwin’s writings is the wide range of his scientific interests—from geology and coral reefs through detailed taxonomic studies of barnacles, human expressions, the domestication of plants and animals, to plant physiology, hybridization, and fertilization. Darwin was a superb experimentalist who designed many effective techniques to probe the natural world. Carried out with simple tools, these experiments provided insights into processes as diverse as the role of earthworms in recycling the land and the movements of climbing plants in their search for support. To look at Darwin as a traveller, as an author, and as practicing scientist provides an opportunity to get beyond the continuing uproar over evolution and celebrate the theory that he and Wallace put forward in the middle years of the nineteenth century.

## TRAVELLER

One longstanding question among historians is how did Darwin come to be the man who wrote the *Origin of Species*? The story has often been told. But there are always fresh perspectives to find in the comprehensive Darwin archives, mostly housed in Cambridge University Library, UK, but also in a fine collection at the American Philosophical Society, Philadelphia, and in other libraries and institutions around the globe. In 1831, when the invitation to travel on the *Beagle* arrived in Darwin’s hands, he had just completed his BA degree at Cambridge University in England and was expecting to return in the fall for theological training. This simple statement hardly conveys the intensity of family debate during the previous few years. Darwin’s father despaired of him ever settling to a useful career, for Darwin had opted out of medical school in Edinburgh, and once he got to Cambridge seemed (in his father’s eyes) to be specializing in hunting, shooting, and fishing. So Dr. Darwin decided that after

graduation his son should become a minister in the Anglican church, a decision with which Darwin more or less agreed, although he said he had some minor doctrinal doubts. Much later on he appreciated the irony of this possible future.

In fact Darwin was already an excellent naturalist. At university he longed to make a contribution to natural history at a time when science was not yet a structured profession. He spent so many of his university days collecting birds and beetles that he attracted the attention of Rev. John Stevens Henslow, the botany professor. Henslow introduced Darwin to some of the big issues in the biological sciences of the day and invited him to scientific evening parties to meet the famous men of the university. In this way Darwin became a young man of note. He was particularly inspired by the writings of Alexander von Humboldt, and early in 1831 began making plans to go on a natural history expedition that would follow Humboldt's journey to Tenerife. When this fell through, the professor of geology, Rev. Adam Sedgwick, took him as an assistant for two weeks on summer fieldwork examining the earliest known rocks in Wales. Sedgwick taught Darwin geology in the field and showed him the rationale for sound scientific decisions. These two weeks gave Darwin a life-long love for geology.

On his return to the family home in Shrewsbury, Darwin found a letter from Henslow offering him a voyage round the world on a British surveying ship, HMS *Beagle*. The invitation originated from Captain Robert FitzRoy who requested permission from the Admiralty to take with him a gentleman who could make good use of the journey for collecting natural history specimens. Such a gentleman would share the captain's facilities as a guest and was expected to pay his own way. Henslow recommended Darwin "not on the supposition of yr. being a finished Naturalist, but as amply qualified for collecting, observing, & noting any thing worthy to be noted in Natural History ... Don't put on any modest doubts or fears about your disqualifications for I assure you I think you are the very man they are in search of."

The prospect of travelling across the world's oceans in a British surveying ship ran far beyond the young man's wildest dreams. At first Dr. Darwin felt his son should not accept. The whole plan was "a wild scheme" he declared. Fortunately, Dr. Darwin was persuaded otherwise by his brother-in-law, Josiah Wedgwood, Jr. Closely linked by marriage and friendship, the Darwin and Wedgwood families had done much to transform British culture during the Industrial revolution during the previous 50 years. Dr. Robert Darwin had married Susanna, the daughter of the first Josiah Wedgwood. Charles Darwin was their son. Now the older generation discussed his character and his likely future, and then decided that he could go.

Today the multimedia fame of the *Beagle* voyage sometimes makes it hard to remember that its purpose was not to take Darwin around the world but

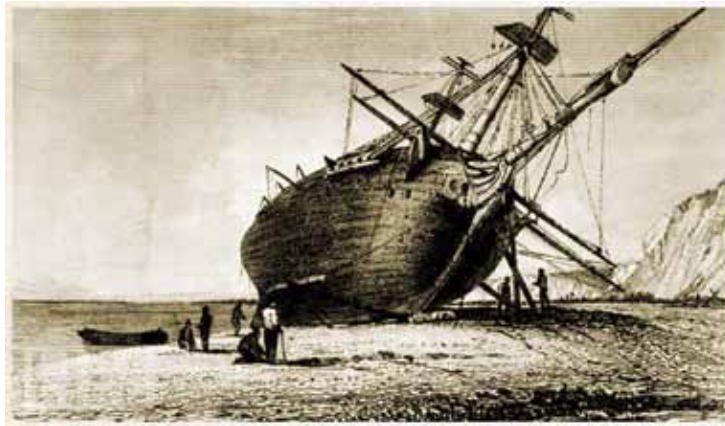


FIGURE 1 The *Beagle* laid ashore for repairs in 1834 at the mouth of the River Santa Cruz, Southern Patagonia (now Argentina). From Robert FitzRoy, *Narrative of the Surveying Voyages of HMS Adventure and Beagle* (1839). (Wellcome Library London)

to carry out British Admiralty instructions. The ship had been commissioned to complete and extend an earlier hydrographical survey of South American waters that had taken place from 1825 to 1830. FitzRoy had joined the *Beagle* two years into that former voyage. The area was significant to the British government for commercial, national, and naval reasons, and the ship was charged with making accurate naval charts of the coastline from Montevideo to Cape Horn. FitzRoy's interest in science encouraged him to equip the ship for its second voyage with several sophisticated surveying instruments and a number of chronometers (clocks calibrated with Greenwich Mean Time) for taking longitude measurements around the globe. The voyage lasted from December 1831 to October 1836, with most of the time being spent in South American waters. Excitingly for Darwin, the expedition was due to return via the Pacific and Indian oceans. It offered him a circumnavigation of the globe.

## OBSERVER

Funnily enough, however, Darwin's voyage on the *Beagle* was mostly on land. Wherever it was convenient FitzRoy put Darwin ashore so that he could collect specimens and make scientific observations. Such occupations were also adventurous. Darwin found that his hunting and shooting skills were as useful in South America as in England: "I am spending September in Patagonia, much in the same manner as I should in England, viz. in shooting." He was

exhilarated by the unconfined feeling of riding over boundless plains, sleeping out under the stars, penetrating into the depths of the tropical forest, and thrilling to the mountain scenery. He called himself a “grand galopador.” At prearranged intervals, he and FitzRoy would rendezvous and move along the coast to another area. This method of travelling allowed Darwin to make several major inland expeditions in South America and on occasion to rent a small house as a temporary base. His diary, later reworked into a travelogue, *Journal of Researches* (now usually known as the *Voyage of the Beagle*), describes his collecting excursions. At times he was accompanied for safety’s sake by a party of gauchos, making his way through local political rebellions. Or he joined members of the crew on shooting expeditions to get meat for Christmas dinner. In Tierra del Fuego, he saved some of the sailors by rescuing a rowing boat from a tidal wave. He saw the sea from the top of the Andes, climbed mountains in Tahiti, felt his blood boil over the injustice of human slavery that was still legal in Brazil, and splashed around in coral lagoons in search of evidence for reef formation. These exploits were all recounted in a series of letters home to his sisters that still exist in the archive. Over the years Darwin’s sisters saw his ambitions changing. Indeed they began to recognize that he wished to become a scientist not a clergyman. A frequent additional objective in these letters was to request money from his father. Because Darwin’s participation in the voyage was a privately funded enterprise, Dr. Darwin arranged for cash to be made available for his son at a succession of out-of-the-way places. Setting sail for Tahiti from the coast of South America, Darwin promised that he would be “deuced clever” to spend money while at sea. Amused, Dr. Darwin replied “but everyone tells me that you are very clever.”

During this voyage Darwin collected nearly 10,000 specimens of plants, animals, rocks, and fossils, and sent them back to England in wooden crates. He kept a detailed inventory of these specimens that would sustain years of study and publication. He also made extensive field notes and other records. Best of all, he developed a highly creative scientific imagination. Galloping, walking, sailing, or climbing, he had plenty of opportunity to let his mind range over the fundamental problems facing naturalists in the early years of the nineteenth century and reflect on what “plan” or “order” might underpin the natural world.

High among these problems was the question of the “design” of living beings. In Darwin’s day most naturalists believed that all organisms, including humans, were created in the shape most suited for the conditions in which they were to live. While there was debate over exactly how this might happen, and anxiety over those cases where animals or plants did not seem to be perfectly adapted to their intended place in nature, the general view was that all living beings, and the world itself, had been created by God, the ultimate divine force

in the universe. The world was thought to be constructed by God to present a harmonious collection of living kinds, a concept usually referred to as the balance of nature—although increasing numbers of radical critics and religious non-conformists were starting to put forward alternative suggestions, some of which were evolutionary (or transformist, in the terminology of the time). Early in the century, the theological author William Paley had fought against those dangerous alternatives with his “argument from design.” The existence of design in the natural world, Paley said, confirmed the existence of a designer. As he put it, the existence of a beautifully contrived mechanism, such as a watch, logically required the existence of a watchmaker.

Darwin’s ideas when he began the *Beagle* voyage were roughly the same. He had been impressed by Paley’s *Natural Theology* while a student at Cambridge. It is often said—rightly—that Darwin’s major intellectual achievement in the *Origin of Species* was to replace Paley’s ideas by setting out an entirely natural explanation for design based on the selection and preservation of adaptations. On the *Beagle* it seems that he was learning to move beyond the conventional Paleyan view in order to think about the origins of adaptations, especially of those that did not seem perfect.

Furthermore, few naturalists at that time believed in the old bible stories as a valid scientific explanation of the origins of the world. Belief in a strictly literal interpretation of the bible is only a relatively recent phenomenon. Long before Darwin’s time, theological modernization was encouraging believers to adopt allegorical understandings of the first few chapters of the Christian bible. And the rise of geological science in the eighteenth century had added new weight to that re-evaluation. Even so, Christian belief rested firmly on the doctrine that human beings were special, a miracle occurring outside the world of scientific fact. The issue as Darwin encountered it was to find ways of explaining the origin and design of animals and plants through natural “causes” while yet retaining a separate and sincere belief in the divine. His truly radical step in later life was to claim that humans too were the product of natural causes.

It is still debated how much of an evolutionist Darwin was during his time on board the *Beagle*. Recent research into his notebooks and other writings, the busy round of meetings, library researches, and scientific societies into which he threw himself after returning to England, and the more considered inspection of his specimens under the eyes of experienced naturalists in London and Cambridge, all add up to the conclusion that Darwin only became committed to the idea of transformism in the middle of March 1837, some five months after the *Beagle* docked in England. The image of Darwin voyaging alone through turbulent seas of thought as he paced the deck of the *Beagle* is an exaggeration. Reality was rather different.



FIGURE 2 Giant tortoise on the Galápagos Archipelago. From *Illustrated London News*, July 1850.

## THINKER

Without question, Darwin's travels provided the foundation for arriving at that momentous conclusion. In the preface to the *Origin of Species* he mentioned factors that he thought influenced him most during the voyage. First were the fossil mammals he found in Uruguay and Argentina, which displayed strong anatomical likeness to current species in the area. In an estuary by Buenos Aires he unearthed the remains of giant animals that turned out to be extinct versions of the capybaras, armadillos, and llamas that run around the pampas today. He wondered why animals should retain the same anatomical structures through vast epochs of time. Second, he laughed to recall how he discovered an unknown species of rhea—the South American ostrich. This bird had been shot for the cooking pot and was already half-eaten before he noticed it was much smaller than the usual sort. The salvaged remains accompanied him back to England and were later given the name *Rhea darwini*. Darwin's research suggested that the two species of rhea, large and small, occupied their own territories and did not mix. Later on, he came to believe that one species had diverged—evolved—from the other. These features of the animal world suggested to him some kind of underlying genealogical tree.

Third, and most important, were the Galápagos animals. Ironically, what proved to be the most famous collection of all, Darwin's birds from the Galápagos, was inadequately labelled. Except for the mockingbirds, Darwin did not pay much attention to the diversification of bird species on separate islands during the *Beagle*'s five-week visit. Identifying the skins consequently proved

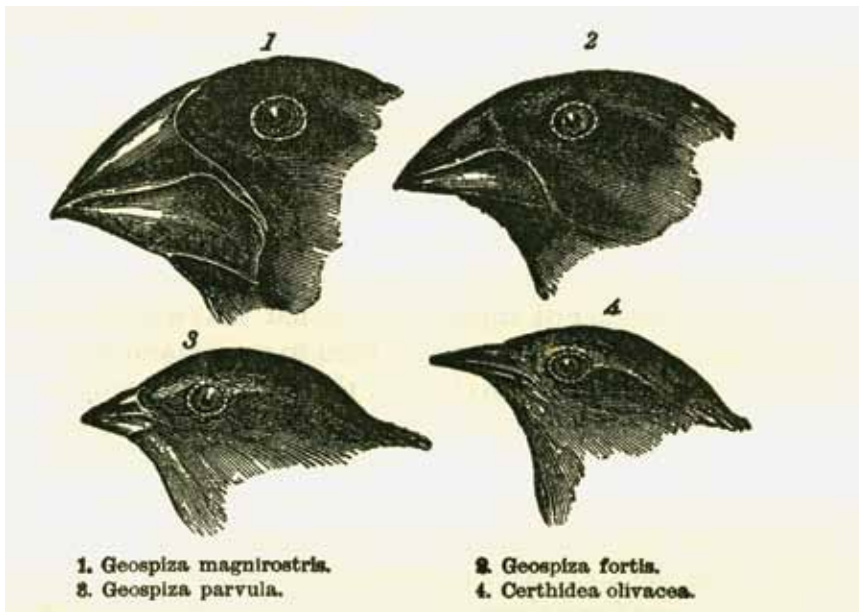


FIGURE 3 Examples of the different beak sizes in the finches of the Galápagos. From Charles Darwin's *Journal of Researches*, second edition 1845. By this time Darwin had formulated the idea of evolution by natural selection. (Wellcome Library London)

tricky when he returned to London and he had to ask some of his former crewmates if he could borrow their specimens. Nonetheless, the Galápagos Islands impressed him greatly. He was fascinated by the land and sea iguanas, the giant tortoises, the tameness of the animals, the cacti, as well as the volcanic geology and arid landscape. How had the animals got there? And why were they found only there? On the return voyage to England, he alluded in his ornithological notes to the likely relationship between birds of the islands and the mainland. These remarks, and remarks made in another notebook begun on the way home, show that he was beginning to wonder about the possibility of transmutation. At Cape Town in June 1836 he may have discussed the emergence of species by natural means with John Herschel, the British astronomer, who was there observing the Southern stars. Species originating through natural causes was an interesting idea already mentioned among British reformers and avant-garde scientists, although it ran counter to the biblical story of the Garden of Eden.

Less generally known is that Darwin regarded himself mostly as a geologist during the voyage. He travelled with Charles Lyell's book, *Principles of Geology*,



a path-breaking account of new ways of thinking about geological processes. This book was published serially in three volumes over the years 1830–1833, and Darwin (who was far away from British bookshops) asked his friends to send him each volume as soon as it was out. This book influenced Darwin greatly. He was convinced by Lyell's argument that all changes in the earth's surface were the result of a gradual accumulation of many small events. Darwin took this idea, applied it to biology, and turned it into a lasting methodology that lay at the heart of his *Origin of Species*. For the rest of his life, he remained committed to the concept that many small changes can add up to larger effects.

The most unsettling of Darwin's experiences was his encounter with the indigenous inhabitants of Tierra del Fuego. He was stunned by their naked, savage state, particularly in comparison with three Yaghan Fuegians who were travelling on board the ship. These three had been captured and taken to England by FitzRoy during the previous *Beagle* voyage, and educated and converted to Christianity at FitzRoy's expense. They were now being repatriated in a Protestant mission station that FitzRoy intended setting up in Tierra del Fuego. Darwin recorded that they were thoroughly Europeanized: "I would not have believed how entire the difference between savage & civilized man is. It is greater than between a wild & domesticated animal." He recognized that humans were all the same under the skin—it was only different levels of education and what he called "civilization" that separated them.

So what kind of man returned? Stepping off the ship in Falmouth harbor in October 1836, Darwin was tired of the sea but had experienced the time of his life. He had seen places and done things that few young men could hope to do. As a thinker he had stretched and matured. Only a few months later he engaged seriously with the challenging notion of evolution. And then, after two years of hard thinking and wide reading, he came across the concept of differential human survival in Thomas Malthus's theory of population. The idea galvanized him. This could be the mechanism he was seeking. In days, Darwin had developed the idea of natural selection. In his notebook he wrote that "favourable variations would tend to be preserved and unfavourable ones to be destroyed... The result of this would be the formation of new species." Here, then, as he recorded in his *Autobiography*, he had found a theory by which to work.

## AUTHOR

Darwin spent the next 15 years or so profoundly engaged with publishing his *Beagle* results and professional undertakings in the world of scientific expertise. In 1839 he married his cousin Emma Wedgwood and, three years later, moved to the countryside in Kent. At Down House, he and his wife eventually had 10 children, three of whom died in childhood. Financially, Darwin was fortunate

enough to inherit a substantial sum of money from his father and did not need to take paid employment. At home, he had household staff to assist him, and could spend his time writing and researching. During this extended period, however, he never lost sight of his theory of evolution by natural selection. He worked on the theory privately, in detail and in depth.

Darwin did not feel ready to write for publication until his friend Charles Lyell (the geologist from whose book he had learned so much on the *Beagle* voyage) urged him to begin. Both men were well aware of the controversial nature of Darwin's suggestions, and Darwin was extremely cautious about putting forward such radical views. Many of his fears were religious. His wife and some other friends were strong believers, although not tyrannically so. He did not wish to hurt them. Nor did he wish to be branded an atheist. Other fears rested on a personal anxiety that his theory might still be incomplete. He had gathered much evidence, and in his research he had tried to push the theory to its limits. Had he missed something? Nevertheless, on Lyell's advice, he started composing a big, densely packed book that he expected would be read only by scientists. He planned to call it "Natural Selection."

In an extraordinary coincidence, however, the naturalist Alfred Russel Wallace sent Darwin a letter. This contained Wallace's independent account of evolution by natural selection. Wallace was at that point in Malaysia collecting rare natural history specimens for the European museum market, and he and Darwin had struck up an intermittent correspondence about Wallace's publications. The essay that Wallace sent was unpublished. But it absolutely covered all Darwin's major points. Darwin was stunned. He had never imagined that anyone else might think of the same theory.

The date that Wallace's essay arrived in Darwin's hands will never be known for sure. And there are plenty of conspiracy theorists who think that something fishy must have been going on. All we know for certain is that late in the evening of 18 June 1858 Darwin wrote to Lyell to express his despair at being forestalled. "I never saw a more striking coincidence... if Wallace had my MS sketch written out in 1842 he could not have made a better short abstract!"

This dramatic event formed the backdrop to the composition and publication of Darwin's *Origin of Species*. Darwin and Wallace's views were made public in July 1858 in a joint paper submitted to the Linnean Society of London. Then Darwin rapidly set to writing the book that became the *Origin of Species*, drawing on his long manuscript for most of the material. It was published by John Murray in London on 24 November 1859, to a storm of controversy.

Darwin called the *Origin of Species* "one long argument." Few scientific texts have been so closely woven, so packed with factual information, and studded with richly inventive metaphor. He was cautious when discussing the role of a creator in the origin of species, sensitive to what his readers might believe, and



FIGURE 4 Charles Darwin in a photograph thought to have been taken around 1857. At that time he was busy writing a long manuscript on natural selection. (Private collection)

conscious that he was tearing down the edifice of harmony and design that William Paley had made so popular. He called the process by which species come into existence, the “mystery of mysteries,” drawing on John Herschel’s phrase. He replaced Paley’s vision of perfect adaptation with the law of natural selection acting on chance variations. Animals and plants should not be regarded as the product of a special design or special creation, he wrote. “I am fully convinced that species are not immutable,” he stated in the opening pages.

The underlying theme was gradualism. Everything happened little by little, just as Lyell had claimed in his geological books. Everything was linked by one and the same explanation. Time, chance, and reproduction ruled the earth. Struggle, too. Those readers who sought a radically new manifesto for the living world were sure to find it in Darwin’s words: no-one could afterwards regard organic beings and their natural setting with anything like the same eyes as before; nor could anyone fail to notice the way that Darwin’s biology mirrored the British nation in all its competitive, entrepreneurial, factory spirit; or that his appeal to natural law unmistakably contributed to the general push towards secularization and supported contemporary claims of science to understand the world in its own terms.

Another kind of narrative is there as well. Darwin wrote in the same likeable, autobiographical style he brought alive in his *Journal of Researches*. Much later on, his son Francis Darwin said this pleasant style of writing was characteristic of his father: “His courteous and conciliatory tone towards his reader is remarkable, and it must be partly this quality which revealed his personal sweetness of character to so many who had never seen him.” Darwin appeared in his books just as he appeared in life—as a reputable scientific gentleman, courteous, trustworthy, and friendly, a man who did not speak lightly of the momentous questions coming under his gaze, a champion of common sense, honest to his data, and scornful of “mere conjecture.” This humane style of writing was one of his greatest gifts, immensely appealing to readers. It served him well during the controversial years to come, defusing personal animosity and allowing even the harshest of critics at least to acknowledge his sincerity and meticulous investigation.

As an argument, *Origin of Species* was divided into two unequal halves. The first, shorter half set out the facts of variation as they were known to Darwin, and led up to Darwin’s presentation of the theory of natural selection in chapter four. The remainder of the book showed how the theory could explain or illuminate key biological areas such as embryology, classification, palaeontology, and geographical distribution. An evocative conclusion invited readers to consider his point of view without prejudice. Unusually for a scientific book, Darwin also provided a frank discussion of the many stumbling blocks that would probably occur to readers, in a chapter called “Difficulties on the Theory.” He admitted, “Some of them are so grave that to this day I can never reflect on them without being staggered...I have felt the difficulty far too keenly to be surprised at any degree of hesitation in extending the principle of natural selection to such startling lengths” (*Origin* 171, 188).

This structure was carefully thought out. Natural selection is not self-evident in nature nor is it the kind of theory in which one can say “look here and see.” Darwin had no crucial experiment that conclusively demonstrated evolution in action. He had no mathematical equations to establish his case. He did not use pictures, except for a diagrammatic chart of a hypothetical case of evolutionary divergence. There was not even an illustration of the great tree of life, a phylogenetic tree, such as would be in the pages of every biology textbook today. The tree image only came later, with the work of Thomas Henry Huxley, Ernst Haeckel and others. Darwin was not even able to speak of “evolution,” as such, because at that time the word was mostly used to describe the progressive unfolding of embryological structures; indeed it was the debate around his book that gave the word its modern meaning. In the *Origin of Species* Darwin generally referred to “descent with modification.” Equally, he did not use what ultimately became the most famous phrase of all, “survival of the fittest.” This

was coined a few years afterwards by Herbert Spencer in 1864, at which point Wallace suggested Darwin should substitute it for “natural selection.” All these verbal ambiguities would lead future readers in directions that Darwin did not intend.

What Darwin had was words—words of persuasion, revisualization, the weighing of probabilities, the likely outcome of the accumulation of minute favorable chances. He relied on an analogy between what was known and what was not known, between the selection of traits in domestic organisms by human intervention and the selection of traits in wild animals and plants by the action of competition and struggle in nature. The organisms “selected” to survive would be the parents of the next generation. Instance after instance of adaptation was said to be “quite inexplicable on the theory of independent acts of creation.”

The biggest problem here—and one that critics quickly noticed—was that Darwin had no knowledge of how the variations arose. He wrote the *Origin of Species* long before the modern science of genetics was developed. The only thing that he could do was to demonstrate that variation indisputably did occur in organisms.

However, in explaining why living beings are so different, one group from another, Darwin introduced one of the most powerful metaphors of his career. He characterized the history of all living beings as a tree. This tree represented extinct ancestral forms as the roots and trunk, the main groups of organisms as the branches, and all the multitude of species in existence at the present day as the green leaves and buds: a smoothly spreading evolutionary tree that linked nature and history into a single indivisible living whole, spanning the ages. “The great tree of life,” he declared, “which fills with its dead and broken branches the crust of the earth, and covers the surface with its ever branching and beautiful ramifications.” His ability to visualize the evolution of life in this way became almost synonymous with understanding it. For us today, it is almost impossible to think of evolution without having in our minds a tree of relationships. This was one of the most important organizing concepts that Darwin gave us.

Unusually Darwin provided a chapter that discussed the problems that would immediately enter a reader’s mind, such as the absence of intermediary stages in the fossil record or the difficulty of the gradual emergence of complex organs like the eye. Darwin himself had worried endlessly over exactly the same problems. “The eye to this day gives me a cold shudder” he confessed to his American friend, the botanist Asa Gray in 1860. The lack of intermediate forms in the fossil record could only be explained by what philosophers call a negative argument. Intermediary organisms would be so rare and transitory, and geological preservation so infrequent and accidental, that it would be highly

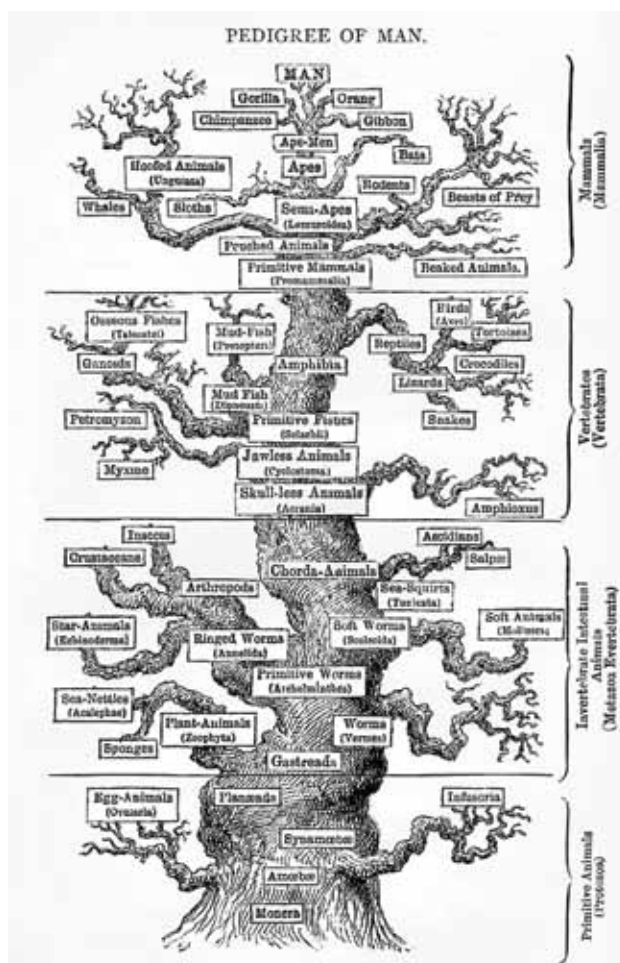


FIGURE 5 Ernst Haeckel was one of Darwin's strongest supporters in the German-speaking states. He was one of the first to publish a hypothetical evolutionary "tree." From Haeckel's *Anthropogenie* (1874). (Wellcome Library London)

unlikely to find specimens. Their absence, he stated, could not legitimately overturn his theory. As it happens, he was correct in this surmise. Even with the discovery of fossils like the *Archaeopteryx*, a bird-like reptile in the Solnhofen limestones of Germany, the incidence of missing links is still very limited.

Deliberately, Darwin omitted the two issues that would have occurred to everybody. He avoided any discussion of what evolutionary theory might have to say about human origins, and he avoided any debate about a divine pres-

ence in the natural world. No matter how seriously and cautiously he might treat evolutionary questions, he knew that anything he said about mankind was bound to ignite furious controversy. In this book, he was completely silent on the subject of human origins, although he did refer in several places to mankind as an example of specific biological details. Not wishing to appear too revolutionary or openly to attack the cherished beliefs of the faithful, he only remarked in the conclusion that, if his views were accepted, even only partially, “light will be thrown on the origin of man and his history.”

Similarly he avoided discussing the first origin of life. He had no theory of beginnings to offer, no primeval soup or creative spark, and only at the end of his book did he mention the likelihood of all ancestral organisms originating in one primordial form. Such ancient origins, he privately believed, were lost in the mists of time and were essentially irreclaimable. When he needed to, he spoke cautiously of the Creator, aware that his book might otherwise be labelled subversive. But he was careful also not to allow the Creator any active role in biological proceedings. In the first edition of *Origin of Species* Darwin mentioned the origin of a single primordial form as if it were an entirely natural process. In the second edition he used more obviously religious terminology, including an anonymous comment, in actuality made to him in a letter by the Rev. Charles Kingsley, that it was possible to conceive of a creator who allowed species to “make themselves”; and that the first organic forms had acquired life from the “breath of the creator.” He evidently did not wish to be perceived as a radical. For a book that would claim in its title to address the origin of species, Darwin’s text in fact refused to propose any theory of absolute origins.

So Darwin’s book was published without any theory of humans emerging from apes and no extended discussion of the role of God in the natural world. Yet these were at the heart of all the heated disagreement afterwards. Perhaps because of this hot controversy, few other scientific theories spread as far or as quickly as the theory of evolution by natural selection. Within 10 years of the publication of the *Origin of Species* there were 16 different editions in English (including the British Isles and North America), and translations into German, French, Dutch, Italian, Russian, and Swedish, accompanied by important commentaries, criticisms, extracts, and supporting texts by other authors. There would be many more to come. To date, there have been 255 editions in English and translations into 29 other languages, including Turkish, Hindi, Ukrainian, and Yiddish, and one edition in Braille (Freeman 1977). Through these means, people all over the developed world increasingly encountered Darwin’s work and were able, if they wished, to participate in what was to become one of the first truly international debates about science.

## EXPERIMENTER

In the years after the *Origin of Species* was published, Darwin continued to produce important books. Most significantly he attempted to answer the queries (and complaints) that critics were making. How did variations arise? How were they transmitted to the next generation? Darwin worked patiently on these and other deeply puzzling topics. He developed the theory of sexual selection. He devised a theory of inheritance. He explored co-adaptation between plants and insects for the purpose of fertilization, experimented on hybrid vigor in plants, documented the animal ancestry of mankind, and thought deeply about the adaptive purposes behind the evolution of the sexes. His major publications after the *Origin of Species* included an important study of variation under domestication (1868) that discussed heredity, variation, and the transmission of what would come to be known as genetic information. He made lasting contributions to the sciences of mankind in his *Descent of Man* (1871), and the evolution of human expressions in *The Expression of Emotions in Man and Animals* (1872). His minor publications ranged very widely from seed dispersal to the transmission of ancestral characteristics such as stripes through many generations of horses.

This is the Darwin who said in his *Autobiography* that he thought he was good at noticing those things that might usually escape attention. He said that he had to learn to be patient in getting results, and that a good dose of ambition never did any harm. “From my early youth I have had the strongest desire to understand or explain whatever I observed—that is, to group all facts under some general laws.” He was characterizing himself as an experimentalist in an age when laboratories were hardly in existence.

In this regard, Darwin’s house was without question his laboratory. Darwin’s study was its control center. This study was a scholarly space, but not directly comparable to an academic office. The room was completely domestic, full of Victorian furniture, with framed pictures of the people he most loved and respected above the fireplace, a comfortable chair or two, a red Turkish carpet, even a curtained lobby in a corner that marked off a small area which he used for washing and changing for bed. There he kept his shaving things (in pre-beard days) and a chamber pot. In this study he also conducted indoor experiments on plants, worms, and seeds, worked at his microscope, dissected, planned projects, and wrote all his books. His filing shelves were kept beside the chair, his chemical implements and simple microscope close to hand. He did not use a desk. He sat instead in a large leather-covered chair and wrote on a board over his knees. This space was not entirely sacrosanct. Darwin’s children felt able to run in and out of the study to ask for things that might be needed for their games. They sat on the wheeled stool, used by their father as his micro-



scope seat, and pushed themselves about the room with Darwin's walking stick. It was the room where Darwin spent so many years studying barnacles under the microscope that one of his sons, when a very little boy visiting another child to play, innocently asked where does *your* father do his barnacles (F.Darwin 1887, 1, 136).

It was also the room from which Darwin ran his entire research and publishing ventures. Although Darwin did not actively engage in public debate, much preferring that quick-witted friends like Thomas Henry Huxley should carry his theories into the eye of the storm, he nevertheless participated directly through correspondence. Current research into the history of Darwin's achievement, and the manner in which his evolutionary views came generally to prevail, shows that he actively embedded himself in a web of correspondence that materially advanced the reception of his work.

For these reasons, it is helpful to regard Darwin's working practices as an intensified form of daily life. He was fortunate to be privately wealthy. The research on which he based the *Origin of Species* reflected this personal world



FIGURE 6 Darwin's study at Down House. The photograph probably dates from the 1930s just after Down House was opened as a museum celebrating his contributions to science. (Wellcome Library London)



FIGURE 7 Darwin's researches into variability and inheritance led him to make many practical experiments on animals, birds, and plants. He kept a wide variety of pigeon breeds at home and interbred birds to track the inheritance of color markings and other traits. Color lithograph by A. F. Lydon, c.1870. (Author's copy)

of wealth and privilege: a world of gentleman landowners who were sufficiently well-financed and well-educated to pursue experiments in horticulture or land economy; a world in which plentiful correspondence was a vital link to contemporary opinion; a world of stability and prosperity where the many advantages brought by rapid industrialization and colonization were slowly becoming obvious in the countryside.

Darwin's botanical and animal experiments were carried out in his own stable yard, greenhouse, or garden. He used domestic organisms easily procured from the catalogues of nurserymen or through gentleman farmers. If he needed to carry out research using books or articles, he relied on his subscriptions to

private libraries or his membership of the elite scientific societies of London. Occasionally he yearned to acquire exotic species, and this yearning was the reason for Darwin's first exchange of letters with Wallace in Malaysia in 1856. Much of his botanical correspondence was dominated by the desire to obtain rare orchids or carnivorous plants for experimentation. Joseph Hooker at the Royal Botanic Gardens Kew (in London) was a loyal friend, for example, and often supplied interesting materials from the government glasshouses. On one occasion Darwin was distressed to realize that he had mistakenly destroyed a valuable *Oxalis* sent to him by Hooker for research into the "sleep" of plants. His was a highly domestic research environment. Investigations into the "fixity" of pigeon and poultry breeds turned into an admiration for the birds as pets. The family's dogs became the object of close observation when he began exploring animal expressions and emotions.

The point is worth emphasizing because it was partly this reliance on commonplace features of Victorian life—letters, and small-scale experimental inquiries involving relatively accessible animals and plants—that generated the remarkable body of factual material on which the *Origin of Species* rests. Darwin took a certain pride in this ordinariness. Yet we can retrospectively see something special. When compiling a chapter of recollections of his father for *The Life and Letters of Charles Darwin* (1887), his son Francis recorded that:

It was as though he [Darwin] were charged with theorising power ready to flow into any channel on the slightest disturbance, so that no fact, however small, could avoid releasing a stream of theory, and thus the fact became magnified into importance. In this way it naturally happened that many untenable theories occurred to him; but fortunately his richness of imagination was equalled by his power of judging and condemning the thoughts that occurred to him. He was just to his theories, and did not condemn them unheard; and so it happened that he was willing to test what would seem to most people not at all worth testing.

(F. Darwin 1887, 1, 149)

He also favored ingenuity and frugality. When the French naturalist Alphonse de Candolle went to visit Darwin at home in the 1870s he found the author of the *Origin of Species* in his greenhouse working on carnivorous plants with almost no tools except a schoolboy chemical balance and some tin plant markers. All the experimental chemicals that Darwin used in order to discern the power of plant digestion came from around the house—ammonia, beer, urine, spittle, and nicotine. Experimental plants were bedded out in the kitchen

garden and parts of the lawn were sectioned off for recording the number of species able to grow in a demarcated area. Yet such observations always ran hand in hand with hard thinking. Every day, Darwin would take a number of circuits around what he called his thinking path, the “Sandwalk,” to ponder whichever question was uppermost in his mind at the time.

Darwin did not work alone. A prominent characteristic of these projects was the help he requested from friends, relatives, and even enemies. His children became assistants from an early age. Darwin usually spent the summer months researching insect pollination, for example, and might use the veil of his wife’s hat to cover a particular plant. Or he could spend several hours a day closely watching ants or worms. At age five, his son Leonard ran to a garden flower and cried “I’ve got a fact to do”—a neat encapsulation of the way that Darwin’s work was focus of the household. The household staff was also accustomed to furthering their master’s researches.

Indoors, Darwin’s wife Emma often acted as his amanuensis, copying out sections of the *Origin of Species* before publication, as well as other works and helping with his correspondence when he was unwell. Emma Darwin read the proof sheets of the *Origin of Species*, a sure sign that her religious beliefs were not holding Darwin back in any practical sense. Later, when their daughter Henrietta was older, she acted as an editor for Darwin by going over his proof sheets for style. This female assistance is often ignored by historians. The proof sheets amended by Henrietta are now preserved in the Cambridge archive and we can see her comments in the margins: “this is a horrid sentence.” Henrietta corrected the proof sheets of the *Descent of Man* for her father, who was so grateful that he sent her a substantial gift of money. All the family were involved in his work one way or another. Even the children’s governess was prevailed upon to translate some difficult German biological tracts. In this manner Darwin’s researches became a family enterprise. He was one of the last gentlemen of science with sufficient private income to work at home, outside the developing academic institutions.

## A TALENT TO EXPERIMENT

Francis Darwin was convinced that much of his father’s talent lay in his urge to observe things for himself:

There was one quality of mind which seemed to be of special and extreme advantage in leading him to make discoveries. It was the power of never letting exceptions pass unnoticed. Everybody notices a fact as an exception when it is striking or frequent, but he had a special instinct for arresting an

exception. . . . Another quality which was shown in his experimental work, was his power of sticking to a subject; he used almost to apologise for his patience, saying that he could not bear to be beaten, as if this were rather a sign of weakness on his part. He often quoted the saying, "It's dogged as does it;" and I think doggedness expresses his frame of mind almost better than perseverance. Perseverance seems hardly to express his almost fierce desire to force the truth to reveal itself.  
(F. Darwin 1887, 1, 148,149)

The most important work Darwin did after the *Origin of Species* was undoubtedly that relating to human beings. During the *Beagle* voyage and beyond he had made extensive notes on humankind, asking himself penetrating questions about physical and cultural anthropology, the mental and moral life of humans, metaphysics, history, and demography. During the 1860s and 1870s he thoroughly reviewed these materials and expanded their scope dramatically. His preparatory research for the *Descent of Man* (1871) brought his concept of sexual selection to full development and required extensive documentation in the animal kingdom before he felt confident in applying it to explain the origin of human diversity. In that book he drew on correspondence

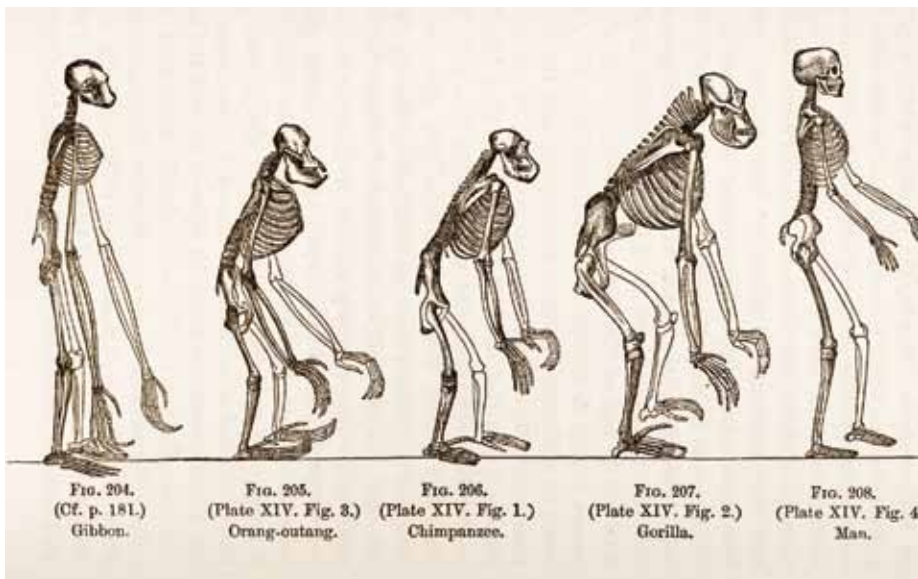


FIGURE 8 Thomas Henry Huxley was a spirited defender of Darwin's theory. This is the frontispiece to his book *Man's Place in Nature* (1863). (Wellcome Library London)



FIGURE 9 Darwin's later work included research into the expression of emotions in mankind and animals. He compared chimps and oranges in the London Zoo with his own children. From Darwin's *Expression of the Emotions in Man and Animals* (1872). (Wellcome Library London)

with anthropologists and travellers the world over to discuss the differences and similarities between humans. One objective was to show that the mental life of human beings could have derived from that of animals—and he corresponded widely about the origins of language, religious belief, and the moral sense, in order to gather evidence that animals possessed similar traits to a lesser degree.

The following year he brought out his book on the *Expression of the Emotions* (1872), a crucial follow up to the *Descent of Man*. In this he continued to argue for real links between humans and animals by documenting the mental life of human beings, and suggesting that the facial musculature, and by implication the emotions underneath, could be connected with those of our presumed animal ancestors (C. Darwin 1988, C. Darwin 2009). This book required a huge international research project that called on artists and photographers as well as anthropologists. One element of research support came from the many female members of the extended Darwin family who made personal observations for him on their children. Darwin also observed his own children very carefully when they were babies, having no conceptual problem in comparing them to the young orangutan that he saw in the London Zoo.

Darwin's experiments were necessarily small scale. The point was made with a sting when Francis Darwin went in 1875 to Württemberg to work with the great plant physiologist Julius Sachs. Sachs had the most advanced laboratory in Europe, filled with expensive physiological apparatus that made Francis envious. His father was not convinced that they needed any of these

instruments for their researches back at Down House, although he did allow Francis to buy a Zeiss microscope, which is still in the Darwin museum. On his return from Sachs' laboratory, Francis pursued a new line of investigation into the movements of plant roots and shoots, and showed his father how to improvise smoked paper on a rotating drum by fastening a small cylinder on an open clock face. When their joint book on the *Power of Movement in Plants* (1880) was published, Sachs savagely criticised the results by claiming that work done in a country house simply could not match the new experimental results emanating from a laboratory. Darwin was irritated, to say the least. Nevertheless some of his proposals about tropisms were proved correct in the 1920s and 1930s.



What can be made of Darwin's remarkable intellectual vision? He emerges as a magnificent and perceptive theorist, and as a gifted writer. We can see him as someone who worked within a vigorous social network rather than as a solitary heroic individual. We can admire his modesty, succinctly conveyed in a few words written to Huxley at the height of the debate about the *Origin of Species*: "I wish I could feel all was deserved by me."

But it is also good to remember his ability to connect observation with theory, his persistence, drive, and good humor, all excellent qualities to foster in modern laboratory practice. He was a fine experimental scientist. Writing after a visit to Darwin's home in 1878, the British journalist Edmund Yates felt sure that he had been in the presence of a very great investigative mind:

Without an atom of scientific jealousy, he is always ready to expound his views, to narrate the result of the delicate experiments on which he is perpetually occupied, and to assist other investigators from the stores of an experience that has ranged over the whole field of natural science, and the conclusions of a mind trained to reason closely on such facts as have been ascertained by actual observation. No naturalist of this or any other time has confined himself more strictly to well-ascertained facts, and devoted more labour to original investigation. The reason of this excessive care is to be found in the keystone of the Darwinian philosophy—*La vérité quand même*; the pursuit of truth through all difficulties, and without regard to consequences.

Even Alfred Russel Wallace, who independently formulated the same idea of evolution by natural selection, said that "Mr. Darwin has given the world

a new science, and his name should, in my opinion, stand above that of every philosopher of ancient or modern times.” As Wallace predicted, Darwin’s ideas came to lie at the heart of fundamental shifts in opinion that swept through the nineteenth century and beyond.

### SUGGESTED READINGS

- Barlow, N., Ed. 1958. *The Autobiography of Charles Darwin 1809–1882*. Collins: London. With the original omissions restored. Edited and with an appendix and notes by his granddaughter, Nora Barlow.
- Browne, E. J. 1995. *Charles Darwin: Voyaging*. Alfred Knopf, Inc.: New York. Volume 1 of a biography.
- Browne, E. J. 2002. *Charles Darwin: The Power of Place*. Alfred Knopf, Inc.: New York. Volume 2 of a biography.
- Browne, E. J. 2006. *Charles Darwin’s Origin of Species: A Biography*. Atlantic Books: London.
- Burkhardt, F. H., and S. Smith et al., Eds. 1985–. *The Correspondence of Charles Darwin*. 18 vols. Cambridge University Press: Cambridge, U.K.
- Chadarevian, S. de. 1996. Laboratory science versus country-house experiments. The controversy between Julius Sachs and Charles Darwin. *Brit. J. Hist. Sci.* 29:17–41.
- Darwin, C. R. 1859. *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. John Murray: London.
- Darwin, C. R. 1958. *On the Origin of Species: A Facsimile of the First Edition*. Harvard University Press: Cambridge, MA. With an introduction by Ernst Mayr.
- Darwin, C. R. 1988. *The Expression of the Emotions in Man and Animals*, 3rd ed. Harper Collins: New York. With an introduction, afterword, and commentaries by Paul Ekman.
- Darwin, C. R. 1989. *Charles Darwin’s Journal of Researches (1839)*. Janet Browne and Michael Neve, Eds. Penguin Classics: London.
- Darwin, C. R. 2004. *The Descent of Man, and Selection in Relation to Sex*. James Moore and Adrian Desmond, Eds. Penguin Books: London.
- Darwin, C. R. 2009. *Expression of Emotions in Man and Animals*. Joe Cain and Sharon Messenger, Eds. Penguin Classics: London.
- Darwin, F., Ed. 1887. *The Life and Letters of Charles Darwin: Including an Autobiographical Chapter*. 3 vols. John Murray: London.
- Desmond, A. J., and J. R. Moore. 1991. *Darwin*. Michael Joseph: London.
- Desmond, A. J., and J. R. Moore. 2009. *Darwin’s Sacred Cause*. Allen Lane: London.
- Freeman, R. B. 1977. *The Works of Charles Darwin: An Annotated Bibliographical Handlist*, 2nd ed. Dawson: Folkestone, U.K.



- Keynes, R. 2001. *Annie's Box: Charles Darwin, His Daughter and Human Evolution*. Fourth Estate: London.
- Wyhe, J. van. 2009. *Charles Darwin's Shorter Publications, 1829–1883*. Cambridge University Press: Cambridge, U.K.
- Yates, E. H. 1878. Mr. Darwin at Down. Celebrities at Home. *The World*, 223–230. From [www.darwin-online.org.uk](http://www.darwin-online.org.uk).