

DARWIN'S SPECTRE

*Evolutionary
Biology in
the Modern World*

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1 DARWIN

The Reluctant Revolutionary

DARWINISM is an outgrowth of the mind of Charles Robert Darwin. There is still no experience more bracing for a young evolutionary biologist than reading Darwin's own words, particularly his *Origin of Species*. Thus the starting point for any discussion of Darwinism must be the man himself, as he grew up in Regency England. To some extent, this is a refreshing story, because Darwin was no intimidating prodigy. He was a sound lad growing up in the landed gentry, a better character for a romance novel than science fiction. And yet, there is much in his background that points directly to the great scientific figure he would later become, even to the very substance of his scientific discoveries.

Here the bare narrative of Darwin's life will be supplied, supplemented by a few remarks about his scientific work, conceived broadly. Darwin's scientific work will then be treated in more detail in chapters 2, 3, and 4. However, it should be understood that this entire volume lies within Darwin's shadow. Little of our discussion could be said to lack the distinctive stamp of the man who returned from the voyage of H.M.S. *Beagle* in 1836.

DARWIN'S CULTURAL AND FAMILY HERITAGE

To understand Darwin's background, it is necessary to understand the significance of the Enlightenment of the eighteenth century for British culture. While the Enlightenment in France was characterized by bold and provocative writers, in Britain less colorful figures like David Hume, Edward Gibbon, and Adam Smith laid the foundations for modern philosophy, modern history, and the new field of economics. If there was any single trailblazer in this group, it was Hume.¹ The second son from meager Scottish nobility,

Hume did more to clear the ground for British thought during the Enlightenment than any other person. Key to this role were Hume's anonymous and posthumous arguments against religion. The first of the moderns, which is to say skeptical, epistemologists, for Hume nothing was to be taken on faith, especially not Faith itself. There is a story about pre-Revolutionary France, in which the mistress of a Prince of the Blood came upon him reading Hume on his death-bed. She immediately burst into tears, and demanded to know how he could read such heresy so close to his death. The Prince replied, "When you have led the life I've led, this is very comforting." Hume himself frequented the French Court, where his charm earned him the nickname "Le bon David." In fact, he had a famous mistress there, though he shared her with a prince. For some reason, he did not literally lose his head, despite his figurative loss of the same structure. Hume did not even renounce his atheism as he lay dying of cancer in 1776, the year his friend Adam Smith published *The Wealth of Nations* and Thomas Jefferson drafted the Declaration of Independence, both classics of the Enlightenment, at least in the British style.

The importance of thinkers like Hume and Smith to Darwinism was that they developed a style of reasoning which would prove to be fundamental to Darwinian thought. In this style, the writer reduces a situation to its barest elements, an approach akin to reductionism, and then attempts to set these elements "in motion" according to some simple dynamical principles. A classic example of this approach is Adam Smith's analysis of the market in terms of individual manufacturers. Such analyses can be characterized in terms of their clarity, logic, and daring. It should also be noted that these were by no means hallmarks of British thinking at the time. The writings of Voltaire, Casanova, and other "Continental" men and women of letters had the same quality.² Indeed, the very speech of eighteenth-century Europe took a turn away from polite obscurity toward provocative clarity: logical, didactic, and incisive. It was truly the temper of the age, and the temper of Charles Darwin's grandfather, Erasmus.

Charles Darwin was one of the greatest intellectual revolutionaries of all time. Surely such a man must have been a fire-breathing, nonconformist, outrage of a human being? Well, as we will see, he wasn't. But his paternal grandfather, Erasmus, was indeed made of cloth that fit this pattern.

Erasmus Darwin (1731–1802) was a leonine figure from profligate times, the eighteenth century. Among his contemporaries were Voltaire, Frederick the Great, Giacomo Casanova, Mozart, and David Hume. Like them, he lived a “big” colorful life. Like them, he also left a trail of personal debris and confusion.

Erasmus was first and foremost a physician. Like his sons and grandsons, Erasmus studied medicine at Edinburgh University, the leading medical school of the day. Despite, or perhaps because of, the low intellectual quality of medicine at that time, Erasmus had an extremely fertile mind. He was full of speculations about engineering as well as both physical and biological science, including schemes for making money from these ideas. This intellectual vitality led Erasmus to form a club for upcoming members of the new scientific and technological elite, the Lunar Society. Among the members were Josiah Wedgwood, James Watt, Benjamin Franklin (who would later become one of America’s Founding Fathers), and Joseph Priestley, notable figures in ceramics, engineering, physics, and chemistry, respectively. These connections, together with some chemical experiments, led to the election of Erasmus to the Royal Society, England’s premier scientific organization. Erasmus Darwin was one of the first chemists to abandon the phlogiston theory of combustion, now known to be erroneous. Erasmus published epic works on biology and geology, including *Zoonomia* and *Phytologia*, which incorporated proto-evolutionary speculations, though of an ill-formed kind. These works were quite influential at the time, and sold well. Mary Shelley acknowledged the inspiration of this Dr. Darwin in the Preface to her novel *Frankenstein*.³

In all this activity, Erasmus Darwin epitomized the helter-skelter creativity of many of the leading minds of the eighteenth century. This Enlightenment was a Promethean time when, it was then thought, the powers of Reason would lay bare the secrets and possibilities of Nature. This was an epoch when long-standing tradition was seen primarily as an impediment, a time when people began openly speculating about entirely secular societies and the overthrow of religion or monarchy. And of course many of these things were actually happening in places like the new United States of America and the first Republic of France. If history were logical, then this would have been the time when a full-blown theory of evolution would have been developed and published, most likely by Erasmus Darwin. As history is not a well-crafted novel, but “a

tale told by an idiot," Erasmus Darwin did not found evolutionary biology. That would be left to a grandson he never saw.

One final anecdote: The intermittent madness of King George III due to porphyria, an inherited metabolic disorder, led to desperate attempts to find a suitable physician for his condition, in effect a psychiatrist. Something of this desperation is conveyed in the film *The Madness of King George*. Erasmus Darwin was such an eminent physician at the time, and so well known for his advanced understanding of the human mind, that he was offered the post of the King's personal physician, a job that would inevitably have led him to be installed in the aristocracy. But Erasmus turned the offer down.

Darwin's other grandfather was also famous: Josiah Wedgwood (1730–95). His family's trade was pottery, at which he worked from the age of nine. In his twenties he became dissatisfied with the poor quality pottery that was then produced in England, and he attempted to develop the field of ceramics by a course of extensive experimentation. One of his inventions was an improved type of earthenware, called "creamware," which sold quite well, even to the royal family. This led to the rapid expansion of his business and the beginning of the Wedgwood fortune. Josiah Wedgwood was a self-made captain of industry, a man of little formal education, with a great instinct for self-improvement and the improvement of manufactures. Nonetheless, Wedgwood was a nonconformist and radical like Erasmus Darwin, always searching for new ways to understand the world by the effort of his own mind, rather than authority. Wedgwood was initially one of Darwin's patients. Friendship between the Wedgwoods and Darwins began over the funding of the Grand Trunk canal, for which Josiah Wedgwood sought Erasmus Darwin's help. The ten years it took to fund and build the canal cemented an alliance between the two families which was to last for more than a century.

But the children of these two great men were not to have the same kind of doughty optimism. Robert Darwin was one of Erasmus's older children, the second to survive past the age of twenty-one. Though he was of squeamish bent, his father forced him to attend medical school at Edinburgh. And then, when it became necessary for Robert to buy into a medical practice, the assistance from his father was scant. This situation arose because Erasmus adored conceiving and raising children. Thus, on the death of Robert's

mother, Erasmus set about fathering various bastards and then married again, keeping his illegitimate children with him, with additional children soon following. This was a considerable pack of mouths to feed, clothe, and house, and Erasmus had little time or funds for a grown-up son. Like a Californian caricature from the 1960s, Erasmus was profligate, charismatic, and randy, while somewhat lacking in foresight. Robert was left with little to receive by way of settlement or inheritance.

Robert had to make his way in the world unaided, eventually finding a country medical practice in Shrewsbury. His working life was characterized by a great aversion to the physical side of medical practice. He appears to have been an early psychotherapist, instead, talking his wealthy patients out of their misery. In addition, he very carefully husbanded and invested his funds, becoming an important capitalist and building a great family fortune. He lived quite abstemiously for his wealth, which was not fully comprehended, even by his own family, until some decades after Dr. Robert had become extremely rich. He was, in fact, something of a miser. But he loved his children deeply, despite a brusque manner. A tall man to begin with, he became immensely fat, crowding his environment with a quiet, saturnine bulk.

One of the major factors making for Robert Darwin's somewhat funereal attitude must have been his wife, Susannah or "Sukey." Susannah appears to have suffered from poor health her entire adult life, though quick-witted and extroverted. She spent very little time with her youngest son, Charles. Child-bearing was apparently very difficult for her, and might have occasioned post-partum depression. She died at the age of fifty-two, possibly of peritonitis, after some twenty-one years of marriage and six children. Robert Darwin never remarried.

THE YOUNG ANGLICAN NATURALIST

Periods of extravagance in Western Civilization are usually followed by periods of retrenchment and conservatism. When one contrasts the bacchanal of the 1960s and early 1970s with the subsequent conservatism of the 1980s and 1990s, one sees something of this contrast. But before the twentieth century, time flowed with greater leisure. The period from 1648 to 1789 could be de-

scribed as a high point for European civilization. The subjugation and exploitation of much of the world was proceeding unchecked, from the wilds of the two American continents to the vast Siberian hinterlands of Russia. Plague was receding from the European experience, with the last major outbreaks coming in the early 1700s. Feudalism was dying, and everywhere prosperous townsfolk and landholders were building up a bumptious middle class. A flowering of thought and publication was continuing the momentum begun by the Renaissance. This was the gestation period for the modern world.⁴

Inevitably, the party came to an end, with a wooden thunk. The execution of the French royal family by guillotine in 1793 marked the end for many upper-class Europeans. Where before there had been a great continuum among the “progressives,” as we might now call them, the beheading of Marie Antoinette soured the social climate. Whigs like Edmund Burke, who had defended the causes of American independence and Irish liberation, became staunch critics of revolution. William Pitt (Prime Minister, 1783–1801, 1804–6), otherwise a liberal, introduced emergency powers for the suppression of rebellion and suspended habeas corpus in 1794. Lord Liverpool himself watched the storming of the Bastille and the slaughter of the defending garrison during the French Revolution. The effect this had on his fifteen years (1812–27) as Prime Minister is clear; the public order was to be maintained at all costs. What before had been the rush of humanity toward ever greater enlightenment, peace, and freedom, in the eyes of Whigs and their allies, now threatened to become a pell-mell stampede in which all humane Christian values were in danger of being trampled, as far as the conservatives were concerned. It had become time to put an end to radical ideas and radical behavior, or at least to compromise them to the point of harmlessness.

Due to the madness of George III, the future George IV came to the monarchy via the compromised route of a Regency, in which the son ruled in place of the father. While the youthful sympathies of George IV had been with the Whigs, by mid-life he had given up any strong allegiance to them. Indeed, much of England was by that time disgusted with radical politics, particularly as it was associated with the excesses of the French Revolution and the loss of the American colonies. George IV satisfied himself with the pursuit of wine, women, and oriental curios. The last pursuit was

physically embodied by the Royal Pavilion built for George in Brighton. In retrospect, the building can be seen as a forerunner of the taste and discretion of modern-day theme parks, done to George's taste.

The first thirty years of nineteenth-century England are known to us now overwhelmingly in terms of two great cultural landmarks. One is the stentorian history of the Napoleonic Wars. The other historical reference point is provided by the novels of Jane Austen, one of the greatest of English authors, despite her aversion to strenuous philosophizing and hysterical dramatization. In their place, Austen presents the orderly world of the Regency landed gentry. Unlike the period of the Enlightenment, the Regency was to be characterized by the avoidance of intellectual conflict and indeed ideas in general. This was the time when English charm and gentility were perfected, from dress to manners to euphemism. The elements had been there before, particularly in the Bath of Beau Brummel, but now they were to coalesce and lock English culture into a vise from which it would not escape until WWI. Rarely have so many people enjoyed such material comfort without the burden of despotically oppressing vassals. It was a time when an excess of well-educated, well-off but not actually rich, people could agonize about their amorous prospects. This era, and its fiction, has become one of the main influences on modern romance novels.

The Darwins and the Wedgwoods could have been lifted wholesale from their lives and plunked into the middle of one of Jane Austen's novels and no one would have been the wiser. In this we are singularly fortunate, because there are few feats of the imagination more difficult than understanding a person of a different historical period "from the inside." In particular, it is hard to understand a person before he or she has become "Great," and thus heavily documented by their own writings and those of others. This is the task that we are presented with when we try to understand the young Charles Darwin. This is where Jane Austen comes to our rescue.

Born in 1809, Charles Darwin had lost his mother by the age of eight. However, this unfortunate event seems to have had little effect on him. Her invalidism had left him hardly knowing her. He had been cared for instead by his older sisters and servants. By all reports, the young Charles was engaging, but not brilliant, affectionate, but not gushing. He had a broad face and a proper British

beak of a nose, of which he was quite ashamed. He stammered and was somewhat spoiled by the sisters and servants. His father prevented him from going completely soft by sending the nine-year-old Darwin to a Dickensian boys school in Shrewsbury, in which privation, physical abuse, and classical learning were the main features of its traditional educational system. After that, Charles accompanied his older brother, Erasmus, to Edinburgh University in 1825, where they both studied medicine. This was the same medical school that two previous generations of Darwins had attended. Indeed, one of their uncles had died there of septicemia as a result of a classroom cut. Just like his father Robert, Charles found dissection and surgery nauseating, and had occasion to flee from the operating theaters. Charles was utterly repelled by medicine, and resolved to abandon the profession.

At this point, a very different element of Charles's background came to the fore. As a boy, he had had an intermittent passion for nature and science, much encouraged by both his father and older brother. At Edinburgh, this passion surfaced strongly. He began to take courses in natural history, and joined the Plinian Natural History Society, a student group, in 1826. It was at this time that Darwin started to exhibit his lifelong habit of forming friendships with professors and others interested in natural history. At that time he even made a minor contribution to a published work on marine biology, discovering some unusual specimens in the Firth of Forth. But Darwin's abandonment of medicine made his continuation at Edinburgh pointless, and he returned to the family home in 1827, at the age of eighteen.

At that point, Charles Darwin was a young Regency gentleman whose family had considerable wealth and comfort, but it remained unclear what profession was to be his in the world. His sisters were full of exhortations and his father, though taciturn, had high standards for his sons. Jane Austen affords us a snapshot of a fictional character from *Sense and Sensibility*,⁵ Edward Ferras, which could be offered as a reasonable rendering of the young Charles Darwin:

[He] was not recommended to their good opinion by any peculiar graces of person or address. He was not handsome, and his manners required intimacy to make them pleasing. He was too diffident to do justice to himself; but when his natural shyness was overcome, his behavior gave every indication of an open, affectionate heart. His

understanding was good, and his education had given it solid improvement.

It was at Cambridge University that Charles Darwin's life began to come together. He went up to university to become a clergyman, following his father's second choice for Charles's career, after medicine. At that time, in his own words, Charles "did not then in the least doubt the strict and literal truth of every word in the Bible."⁶ Darwin was a lukewarm Anglican, and hardly as radical as his brother, father, or grandfather Erasmus, where religious matters were concerned.

Though Cambridge University around 1830 continued in the heavily classical vein of Darwin's boyhood education, he spent a great deal of his time and energy on natural history. His second cousin, William Darwin Fox (1805–80), introduced him to the joys of beetle-collecting, a promising hobby given the vast numbers of beetles to be collected. He also spent time hunting, drinking, and laying about, like a good upper-class twit. But in Darwin's case, these skills were to prove invaluable in his early career. On the other hand, Darwin also associated with his more scientifically oriented professors, particularly Botany Professor the Rev. J. S. Henslow (1796–1861), gathering knowledge in the course of conversation, and taking their courses.

Darwin's great opportunity to escape the tedium of English provincial life came in 1831. Captain Robert FitzRoy, a descendant of one of Charles II's illegitimate children, wanted a naturalist as a companion on his naval survey vessel, the *Beagle*, but it was important that the naturalist be a gentleman. Some lower-class drone who knew all the relevant biology and geology wasn't enough. No, it had to be someone from the gentry. Despite the fact that the main purpose of the voyage was to be the collection of natural history specimens and data, it was the class background of the ship's naturalist that was paramount. Here was where Darwin's background as a proper Regency layabout came in perfectly: he was the twit to fit FitzRoy's prig. Darwin badly wanted to go; his more charismatic professors had filled his head with dreams of travel to the tropics. His father rightly feared that this course of action would disrupt Charles from settling down to a quiet parsonage. But Charles's uncle, Josiah Wedgwood II, strongly favored the idea, and successfully persuaded Dr. Robert to let his son go.

The ship set out in December 1831, on a trip that was to last almost five years and circumnavigate the world. Darwin left a callow young man. He came back a proficient naturalist. He collected warehouses of biological specimens, many shot with his own hand or netted out of the ocean from the deck of the *Beagle*, together with rocks and fossils of all kinds. Most of the collected materials came from South America, that continent being the Royal Navy's particular interest for the trip. These materials constituted one of the more considerable treasures of natural history collected to that point.

But Darwin did not return to England in 1836 an evolutionist. He did not have any great insights into the origin of species while serving the Royal Navy. His main scientific speculation concerned the role of coral reefs in the formation of tropical islands, an idea that led to one of his first publications. This reflected the influence of Charles Lyell's *Principles of Geology*, which Darwin read on board the *Beagle*. The story that Darwin had the idea for evolution during the voyage of the *Beagle*, particularly on the Galapagos Islands, is a myth. Great ideas instead come while napping in suburban gardens or in studies.

A THEORY BY WHICH TO WORK

Upon his return to England in 1836, Darwin first settled in London. His exploits during the voyage of the *Beagle* had been spread about by family and academic friends. This gave him a new status. No longer a young man of uncertain parts, he had "arrived." He was made a Fellow of the Geological Society in 1836, and would later become its Secretary. In 1838, he was elected to the Athenaeum, the London highbrow's club. And in 1839, he was elected to the Royal Society, like his grandfather before him. In Charles's case, the chief basis for his scientific reputation was his extensive collections from the voyage of the *Beagle*. These were, at that time, one of the principal wonders of the London community of naturalists. Darwin began to circulate widely in intellectual circles, becoming acquainted with a range of notable figures, from Thomas Carlyle, a polemical historian, to Charles Babbage, the inventor of a mechanical computer.

In 1839, Darwin published his *Journal* describing the voyage of the *Beagle*.⁷ This book was marked by fascinating natural history

and lucid prose, becoming a best-seller for its day. On a more serious level, Darwin was busy editing the numerous monographs produced by specialists studying the specimens that he had collected on the voyage. It was this work which led him to the theory of evolution. The crucial finding was quite inadvertent. Darwin and others on the *Beagle* had collected numerous bird specimens while in the Galapagos, including mockingbirds and finches, noting the island from which each came. Darwin had thought that many of the different forms were mere varieties, rather than species. But zoologist John Gould, who knew much more about birds than Darwin did, concluded in March 1837 that different islands had different species of birds. Interestingly, all of these birds seemed to be similar to mainland forms from South America, from which the ancestors of these birds could have flown to the Galapagos Islands. This was a bombshell for Darwin, who had been uncertain as to the status of the birds. He quickly deflected his uncertainty onto the phenomena themselves, concluding that the island species had somehow been derived from the birds of the mainland species that had come to the Galapagos Islands, by a process of gradual "transmutation." Soon he hit upon the idea of a "tree" connecting different life-forms, each undergoing transmutation or, as we would say, evolution.

Darwin was by that time a sophisticated man of science. He knew that it wouldn't do to merely suppose some unspecified transmutation process. It was also incumbent upon him to discover a well-defined mechanism by which evolution could proceed: "a theory to work with." Solving this problem racked his brain, and he spent feverish months trying out one idea after another. The next breakthrough came in September 1838, when Darwin read Thomas Robert Malthus's work on population growth.⁸ The economist Malthus was concerned that human population size tended to grow geometrically, while food supplies increased at most in a linear fashion, or so he assumed. But granting this assumption, it is then inevitable that population size would come to exceed the supply of food, resulting in famine, disease, and generally disagreeable behavior (war, cannibalism, etc.). In so reasoning, Malthus would make his reputation as one of the founders of economics as a "dismal science." Darwin was interested in the consequences such a calamity would have for different members of populations of plants and animals. His reasoning was that the better-adapted organisms would survive this calamity, and thus be better represented among the

parents of the next generation. Granting only the supposition that like gives rise to like, the offspring of these superior survivors should themselves be superior, at least by a small increment. Carried on generation after generation, this process would lead to natural selection of fitter descendants.

THE GREAT PROCRASTINATOR: MARRIAGE AND THE *ORIGIN*

The problem with keeping detailed notebooks of one's thoughts is that they can later prove to be very embarrassing. How would Darwin feel if he knew how many biographers have satirized his handwritten agonies about marriage? According to his notebooks, he didn't want to be a neutered worker bee, with nothing but work. But marriage threatened to involve children, quarreling, and, worst of all, less time for work. And then there was the risk that his wife wouldn't like living in the city, and would banish him to the idiocy of rural life, a sentiment Darwin then shared with Karl Marx. On the other hand, marriage would supply someone to take care of the house, "chit-chat," music, and so on.

But there were other issues as well. Darwin's success as a scientific personage in London had greatly impressed his father, so there was no more talk of Darwin becoming a country parson. Dr. Robert Darwin was willing to support Darwin and his scientific work even if he married, removing the obstacle of parental disapproval. As a married man, Darwin would be allowed to remain without profession.

Perhaps a point of greater importance was whom was Charles to marry? He had spent almost his entire adulthood in the company of men, most especially on board the *Beagle* for five years. Even in London, he had not frequented fashionable parties or balls. Being a member of the landed gentry, however, tended to solve problems like these. Families, family connections, and family friends were everything. In particular, he had been infatuated with the Wedgwood family and its convivial socializing most of his life, not only visiting with them, but also corresponding frequently. His mind made up, his father's permission secured, in 1838 he set out for the Wedgwood home, Maer, and began to court Emma Wedgwood. The marriage took place in January 1839.

The young Emma was attractive and lively, if her portraits and contemporaries are to be believed. But she was also Charles Darwin's first cousin on his mother's side, just a few months older than Charles, the youngest daughter of Josiah Wedgwood II. "Josiah II" was the man who got Darwin on board the *Beagle*, over Dr. Robert Darwin's objections. Charles's sister Caroline had married Emma's brother Josiah Wedgwood III. Genetically, this is all rather unsettling, since first cousin marriages give progeny with a greatly increased frequency of birth defects, among other problems. But the Anglican rite does not frown on the practice, and the nineteenth-century English landed gentry were nothing if not Anglican.

Around the time of his arrival in London, Charles began to suffer from a variety of baffling medical complaints. These included heart palpitations, gastric upsets, and headaches. Almost all of 1840 was given over to ill-health. This year apparently persuaded the Darwins that they had to move to the country for the sake of Charles's health. So, despite his earlier fears of being dragged off to the countryside by a relentless wife, in 1842 Charles shuffled off to Down House, in Kent, quite willingly. Notwithstanding the medical motivation, in clear country air Darwin suffered ill-health for the rest of his life. However, in the Victorian tradition, he suffered with conspicuous bravery, and a little morbid obsessiveness, until the age of seventy-three, producing thousands of pages of scientific manuscripts en route to his much-delayed grave.

Some have attributed Darwin's ill-health to neurotic hypochondria arising from fear about the reception that his theory of evolution would receive. Darwin knew that his views on the transmutation of species, or evolution, flew in the face of settled opinion among both clergy and the scientific laity. And being a stammering, sincere kind of Regency gentleman, the last thing that he was suited to was causing a social rupture. This was a man who could deal with his father only on terms of virtual prostration. That Darwin would repeatedly delay the publication of his theory of evolution by natural selection is not the least surprising. Grandfather Erasmus Darwin, on the other hand, would have published and be damned.

However, Charles Darwin was also concerned that his great achievement should be acknowledged by future generations. With that in mind, he prepared two brief sketches of his ideas, one in 1842, and again at greater length in 1844. The second work was about fifty thousand words. He arranged for its publication in the

event of his death. While this work was never published, he did show it to some scientific friends, though by no means all of his scientific acquaintances. Many of them did not learn of Darwin's theories until they read the first edition of the *Origin of Species*, in 1859.

In the years between 1844 and 1855, Darwin set about developing his understanding of biological detail, most notably in a mammoth study of barnacles which resulted in the publication of two thick volumes on this most adhesive of crustaceans. During this time he received the Royal Medal from the Royal Society for his work on coral reefs and barnacles. By 1855–56, he was finally settling down to write an even more massive presentation of his ideas about evolution. Though his colleagues tried to persuade him to publish a brief summary first, he was adamant about the need to be truly exhaustive. As events turned out, Darwin was not going to have any leisure for further hesitation.

And then it finally happened. In June of 1858 Darwin received a letter from zoologist Alfred Russel Wallace, together with a brief paper outlining a theory of variation and natural selection together acting to produce evolution. Wallace was a collector of natural history specimens who traveled through the tropics, as well as an author of scientific papers and a fairly popular book somewhat in the same spirit as Darwin's *Beagle* journal. (William Adamson, the hero of A. S. Byatt's novella *Morpho Eugenia* [later made into the film *Angels and Insects*] shares some biographical features with Wallace, including a relatively modest background and the loss of a ship's worth of specimens at sea.)⁹

Darwin had a great crisis when he read Wallace's manuscript, because he had been asked by Wallace to communicate it further to Sir Charles Lyell, with a view to publication if deemed worthy. But Darwin didn't want Wallace to be known as the sole discoverer of the idea that he, Darwin, had been sitting on for almost twenty years. Darwin appealed to Lyell for advice, and Lyell suggested that Wallace's paper be communicated together with one from Darwin, so that they could have codiscoverer status. Accordingly, two papers were presented before the Linnean Society in 1858, one from Wallace and one from Darwin. Neither author was present, and there was little discussion.

Wallace having burst his bubble, and being left in public view on the evolutionary question, Darwin hurried to come up with some-

thing that would defend his views better than a mere paper could. Thus, he prepared an “abstract” of a few hundred pages, the *Origin of Species*, first published in 1859. Subsequent generations must be grateful to Wallace, because Darwin’s original plan would have run to many volumes. While Darwin was a fairly good writer by Victorian standards, it would have been unlikely that any but the most dedicated would have bothered to read his presentation of evolution in the form he originally intended. As it turned out, the *Origin* is a historical milestone: a book that revolutionized a large scientific field, but which intelligent lay people can read profitably.

The *Origin* is notable for the extent to which it directly conveys the structure of its own arguments and likewise the extent to which presumed opponents of these arguments are dispatched by substantive refutations. It does not dutifully and painfully muster particular “facts” of natural history, one point at a time. Rather, it has a boldness and clarity that are almost shocking compared to other scientific publications of its day.

The reaction to the *Origin* is famous in the history of science. Some pompous prelates attacked it, while rising young scientific stars rallied in its defense. T. H. Huxley made a reputation for himself as “Darwin’s Bulldog” by defending Darwin against Bishop Samuel Wilberforce (“Soapy Sam”). Magazines published caricatures of Darwin. Darwin became a cult hero for leftists, revolutionaries, anticlericals, and the like. Karl Marx wanted to dedicate *Das Kapital* to Darwin, who politely declined. Darwin certainly had no idea of the bizarre historical junction that this proposal constituted, an exchange between the two most important thinkers of the nineteenth century. The scientific community rather liked the idea of evolution, but the concept of natural selection proved more difficult to swallow. However, such things are the concern of the next three chapters.

ON TO WESTMINSTER ABBEY AND IMMORTALITY

What could Darwin do for an encore? As discussed in chapter 2, he went on to wrestle extensively with the problem of heritable variation. Though he probably was as expert in that field as anyone then alive, bar one—Mendel—he never properly sorted out the mechanics of inheritance.

Darwin also worked on other biological problems that were of interest to him, such as sexual selection, orchid fertilization, animal behavior, earthworms, and the evolution of humans. Darwin's views on man were somewhat parochial, but he had some impressive intuitions, such as the location of human origins in Africa. All his work was characterized by superb attention to both detail and significance.

Though to contemporary eyes having ten children, the last when Emma was forty-eight, seems like an ungodly number, such fecundity was in fact fairly common in the era before birth control and modern hygiene. And as in that era generally, it is not surprising that two children died in infancy and one in childhood. Whether the genetic problems of a first-cousin marriage played a role in the medical problems of their children is to some extent unknowable. Anecdote has it that the Darwin family had a number of odd but persistent medical complaints. Some authors are of the opinion that the Darwins were a pack of hypochondriacs.

Of perhaps greater psychological significance was the long-standing issue of religion within the Darwin family. Charles Darwin gradually became an atheist, while his wife remained devout her entire life. Darwin died believing that that would be the end of him, for good and all. There are stories of a deathbed conversion to Christianity by Darwin, but they are entirely apocryphal. Darwin was buried in Westminster Abbey, his corpse finding a final resting place near the bones of Isaac Newton, one of his few peers in history. His gravestone gives his name, date of birth, 12 February 1809, and date of death, 19 April 1882. While others entombed around him have been accorded panegyrics chiseled into stone, his stone has none.

What then is Darwin's historical standing as a scientist? There are three broad features of life which were puzzling before Darwin: relatedness of species, diversity of species, and adaptedness of species. Darwin provided the basic explanations for these phenomena still used by biologists today. Each of these points will be central to this book, but their essential outline is easy to provide now.

The problem of the similarity of mammalian species to each other, or insect species to other insect species, was one which, before Darwin, was solved only by appeal to theological or philosophical ideas. Darwin's solution to this problem is that species are related evolutionarily, so that they resemble each other in some-

thing like the way three brothers resemble each other; they have a common ancestry. On the long-term evolutionary scale, species descend from each other by a process of slow and gradual change, in which the relics of common ancestry will usually be visible. Ultimately, all life is to be traced back to one or a few original ancestors, whose features define some of the basic limits for life itself.

Life is perversely diverse. Why should there be over half a million species of beetles, far more than the number of terrestrial vertebrate species? Why should life be so abundant, so varied, so lavish? And then there is the problem that these different species are not necessarily just minor variations on a theme, though such of course exist. Some mammals fly, some swim in the deep ocean, while others burrow in the ground. This too Darwin was able to explain using the same branching tree of evolutionary derivation. From the branching comes diversity, and often selection will foster this diversity, pushing species to great extremes to escape ecological competition in the ancestral habitat. (This will be explained more later.) In Darwin's scheme, diversity becomes not merely explicable, but unsurprising.

Finally, there is the adaptedness of life, the way it seems to operate by marvelously efficient contrivances. This was the seat of the strongest argument for the existence of God known to the pre-Darwinian mind, the argument from design. This argument amounts to the necessity of invoking a creator to explain these marvelous contrivances, given the implausibility of their arising by accident. This adaptedness Darwin explained using natural selection, the differential reproduction of those with varying fittedness to the environment. The faster horse that can outrun its predators will tend to have more progeny, on average, and progeny somewhat like itself. Thus the average speed of the horses increase. Darwin's natural selection made adaptedness such a plausible result of evolution that some biologists have if anything a tendency to overdo it, seeing adaptation everywhere. Whatever the errors that such scientists fall into, adaptation is in no way a difficult problem for biologists to explain using evolution by natural selection.

In total, Darwin provided a foundation for biology which was completely free of religious elements. For molecular biologists, this contribution is very much in the background. They can just go on with experiments whose rationale derives more from principles of organic chemistry than evolutionary biology. But the fact that they

do not need to bow toward Rome or Canterbury, by way of scientific piety, is largely the result of Darwin's achievement. And away from those biological fields where straightforward molecular analysis is enough to unravel all problems, the evolutionary reasoning first provided by Charles Darwin is often the central means of intellectual analysis, defining problems, suggesting alternative solutions, and deciding among competing hypotheses. Modern biology would be inconceivable without Darwinian theories and findings.