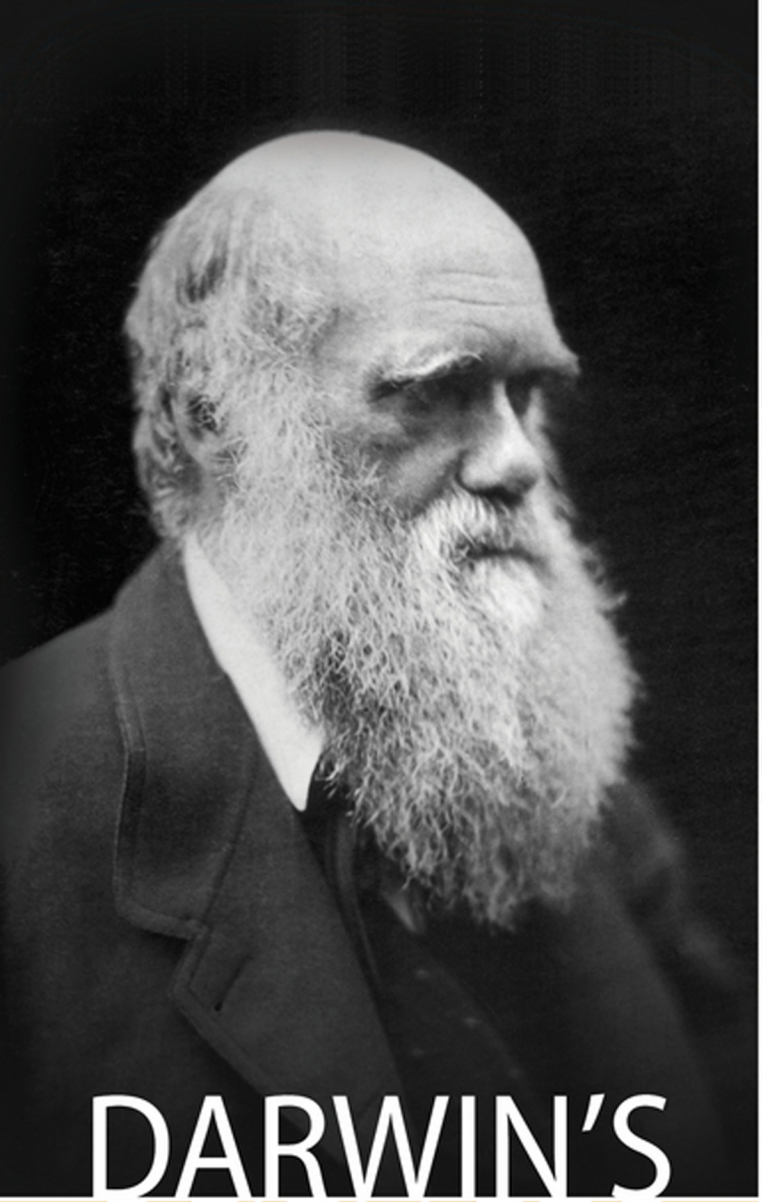

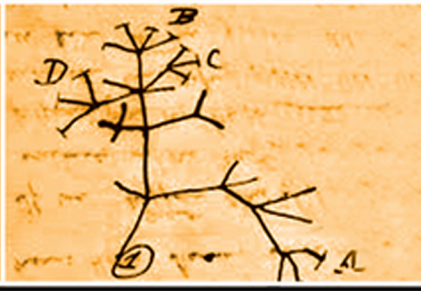

DARWIN'S SCIENCES

Duncan M. Porter and Peter W. Graham

WILEY Blackwell

Darwin's Sciences

Darwin's Sciences

How Charles Darwin voyaged from rocks to worms in his search for facts to explain how the earth, its geological features, and its inhabitants evolved

Duncan M. Porter and Peter W. Graham

WILEY Blackwell

Registered office:
John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices:
9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
111 River Street, Hoboken, NJ 07030-5774, USA

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell.

Library of Congress Cataloging-in-Publication Data

Porter, Duncan M., author.
Darwin's sciences : How Charles Darwin voyaged from rocks to worms in his search for facts to explain how the earth, its geological features, and its inhabitants evolved / Duncan M. Porter & Peter W. Graham.
pages cm
Includes bibliographical references and index.
ISBN 978-1-4443-3035-9 (pbk.) – ISBN 978-1-4443-3034-2 (cloth) 1. Darwin, Charles, 1809-1882. 2. Naturalists–Biography. 3. Natural history. 4. Evolution (Biology) I. Graham, Peter W., 1951- author. II. Title.
QH31.D2P67 2015
508.092–dc23
[B]

2015010081

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Cover image: Charles Darwin photograph by Julia Margaret Cameron, taken at Freshwater, Isle of Wight, August 1868 (Courtesy of Google Images 2013).

Marine iguana photograph by Duncan M. Porter, taken on Hood Island (Isla Española), the Galapagos, 1967.

"Tree of Life" – Darwin's first drawing of a genealogical diagram, made in his *Transmutation of Species Notebook B* in July/August 1837, (DAR 121: 36), (Reproduced by kind permission of the Syndics of Cambridge University Library).

Title page image. Charles Darwin at age 22 before he sailed on the Beagle voyage. Sculpture in the new Darwin Garden at Christ's College, Cambridge, where he was a student from 1828 to 1831. Sculpted by Christ's student Anthony Smith, unveiled on Darwin's 200th birthday, 12 February 2009. (Photo by Duncan M. Porter, 2009.)

Set in 9/11pt Minion by SPi Global, Chennai, India

1 2016

Contents

Preface vii
Acknowledgments xi

1 Introduction 1

2 Darwin the Geologist 12

3 Darwin the Zoologist 44

4 Darwin the Botanist 93

5 Darwin the Social Scientist 152

6 Coda: Darwin, Worms, and the World 208

Bibliography 218
Index 237

Preface

Biologists hear the name Charles Darwin from an early age. This was no exception for DMP, who became aware of him in high school biology class, albeit without much understanding of how evolution took place, but an awareness that it did. My biology teacher at Ventura Senior High School, the charismatic Bob Rollins, kindled an interest and opened the doors to the natural world. At Ventura College, botanist/microbiologist Tom O'Neill introduced me to plants, which I fell in love with; zoology was not there pursued because one had to dissect a rat in the beginning course laboratory. Transferring to Stanford University, I came under the spell of some excellent botanists: mycologist Bob Page, plant physiologist Win Briggs (whose first lecture began with a discussion of Charles and Francis Darwin's plant hormone experiments), evolutionist Dick Holm (the best teacher I have ever had), and taxonomist and ecologist Ira Wiggins, who became my MA advisor. A group of biology students there also influenced me greatly, especially undergraduate Curt Givan and graduate students John Thomas and Wally Ernst, all of whom became good friends. My undergraduate advisor Bob Page suggested that I apply to Harvard University to study for a PhD, which I did and, surprisingly to me, was accepted. In the 1960s, Harvard Graduate School was much less stressful for students than now, although perhaps I found it so because of already having spent two graduate years at Stanford. Curt Givan followed me to Harvard, and he and fellow graduate students Beryl Simpson, Jim Walker, Garrison Wilkes, and Steve Young continued to add to my botanical education. As at Stanford, Harvard produced a number of influential professors, especially paleobotanist Elso Barghoorn, ethnobotanist Dick Schultes, and my PhD advisor, plant systematist Reed Rollins, in whose courses I was a teaching fellow (graduate assistant). It was while I was working on my dissertation that I first encountered Darwin's plant specimens, because one of the species of the genus I was monographing is endemic to the Galapagos Islands. More were studied during a postdoc back at Stanford working on the flora of the Galapagos with Ira Wiggins.

My initial motivation to pursue research on Darwin was supplied by Cambridge University Herbarium assistant curator Peter Sell. After he showed me some Darwin plant specimens from the Galapagos during a visit by me and my wife Sarah in the spring of 1973, I said "But most of these have not been identified." Peter answered: "No one at Cambridge has ever been much interested in the flora of South America. Why don't you identify them?" On that same trip, we visited the Royal Botanic Gardens, Kew, where botanist Gren Lucas also urged me to identify the Galapagos plants, the second set of which is in the Kew herbarium. On a visit in 1976 to examine the Galapagos collections, I met Darwin experts zoologist Sidney Smith, librarian Peter Gautrey, and botanist David Kohn, at Cambridge University Library, who encouraged my interest in Darwin. At lunch after I presented a talk on Darwin's *Beagle* plant collections at London's Natural History Museum in 1979, Smith, Kohn, and school headmaster and Darwin aficionado David Stanbury urged me to identify the rest of the *Beagle* plants. When I demurred, saying, "I am not prepared to do so," I was answered: "No one else is prepared to do so. You do it!" A grant from the National Geographic Society led to a Visiting Fellowship at Clare Hall, a graduate college of Cambridge

University, where the family and I lived for 10 months in 1980–1981 while I examined Darwin's specimens. I spent 1 week a month with Gren and Shirley Lucas and their family studying the Kew Darwin specimens. Over the years, all these led not only to the study of Darwin's Galapagos Islands plants and those collected elsewhere on the voyage of HMS *Beagle*, but also to the historical record of his geological, zoological, and botanical collections and interests. Research was pursued almost every summer at Cambridge and Kew. Eventually, I became a senior editor and then for 9 years director of the Darwin Correspondence Project at Cambridge University Library. I was well immersed in what another Harvard influence, evolutionist Ernst Mayr, called the "Darwin Industry." Along the way, I met my peerless collaborator Peter Graham, and we began teaching an honors colloquium on "Darwin: Myths and Reality".

PWG, for his part, also first encountered Darwin in a high-school Advanced Biology course, heard more of him at Davidson College, but first studied Darwin's writing (*On the Origin of Species*, as edited by Morse Peckham) in Clyde de L. Ryals's magisterial Victorian course in the English graduate program at Duke University. Later, as a Lilly Post-Doctoral Fellow studying the then-new field of Medical Humanities in the University of Florida's Humanities Perspectives on the Professions program, I met David Locke, a science writer turned English professor who was offering an innovative course applying the methods of literary analysis to iconic texts of science: Harvey's *De motu cordis*, Newton's *Optics*, Freud's *Interpretation of Dreams*, Einstein's *Relativity*—and, most pertinent to me in the long term, Darwin's *Origin*. The chance to teach *Origin* to David Locke's undergraduates kindled my keen interest in Darwin as a person and a writer, an interest that resurfaced a few years later when Duncan and I, both fairly new faculty members at Virginia Tech in Blacksburg, serendipitously met at the local Episcopal Church. Our team-taught University Honors Colloquium on "Darwin: Myths and Reality" rose out of several long and engrossing conversations on Darwin the man and his works. This course worked well from the get-go, given that its two teachers, a scientist and a humanist, came at Darwin from different disciplinary perspectives but shared a belief that it was crucial to understand Darwin as much more than just the author of *Origin*, itself a text more invoked than actually read. Thanks in great measure to another serendipitous event, an introduction offered by Bert Moyer, a distinguished historian of science and chair of the History Department at Virginia Tech, collaboratively teaching Darwin led us to being enlisted by Viking Penguin as editors of *The Portable Darwin*. This challenging task led us both to read far more comprehensively—and then with great regret to excise, first selectively, then radically—in order to settle on some 600 pages to represent Darwin's intellectual achievement in our anthology.

My scholarly interests have varied widely over time. They have ranged over topics in literature and medicine and in British Romanticism (especially the works of Lord Byron and Jane Austen)—and they have also included Charles Darwin. Attempting to account for this eclecticism to a more single-minded colleague, I hit on a tentative explanation: "Byron and Austen appeal to me because they're the two English Romantics with a sense of humor, and Darwin's in the mix because he is, like them, one of the great British empiricists of the 19th century." That improvised formulation eventually resulted in a comparative book, *Jane Austen* & *Charles Darwin*: *Naturalists and Novelists*. This intertextual conversation juxtaposes two thinkers and writers, superficially quite different but in some respects surprisingly similar, who share an inclination to look with a clear eye at the concrete particulars of the world before them, to form opinions on the basis of attentive observation rather than of transmitted opinion and to say what they have seen in accessible, often elegant prose. During the years when I was writing the four long essays that would become *Jane Austen* & *Charles Darwin*, Duncan and I were sporadically engaged in designing a Darwin biography to supplement *The Portable Darwin* and fit the needs of our undergraduate students,

who sometimes drowned in the details of whatever biography (we assigned a number of the finest) we taught in our colloquium. Determined that our students would come to know Darwin as a man with a long, complex arc of scientific accomplishment, not just a one-book star, we envisioned a slim volume organized according to Darwin's different categories of scientific research: geology, zoology, botany, and the social sciences. Over the years, this slim volume substantially expanded — to that extent, we found ourselves following in Darwin's footsteps — as it appeared ever more important to represent Darwin's intellectual accomplishments in their totality, to examine all his books, many of his scientific papers, and his remarkable, revealing correspondence, more of which was becoming accessible each year, thanks to the ongoing efforts of the Darwin Correspondence Project. Over the years of reading, researching, and writing, we have learned a great deal from other Darwinists and from one another — but the debt's not symmetrical, and I am the more deeply indebted party. It has been a great blessing, delightful and edifying in equal measures, to collaborate with a scientist and scholar who has walked in Darwin's footprints and who offers the distilled essence of a life-long scholarly devotion in what he has contributed to our manuscript.

Duncan M. Porter
Peter W. Graham
Blacksburg, Virginia
July 2014

Acknowledgments

Unfortunately, most of those mentioned in our Preface as mentoring us throughout our careers are now deceased. Fortunately, however, most of those mentioned in the following paragraphs are still living, active, and in contact with us.

We are particularly grateful to William Huxley Darwin for permission to quote from the Darwin letters and manuscripts. We also thank the Syndics of the Cambridge University Library for permission to quote from Darwin manuscripts and reproduce several drawings in their possession (Figures 3.1 and 3.4), facilitated by Adam Perkins.

Quotations from *The Correspondence of Charles Darwin* (© Cambridge University Press 1985–2013) and Richard Darwin Keynes's editions of *Charles Darwin's Beagle Diary* (© Cambridge University Press 1988) and *Charles Darwin's Zoology Notes & Specimen Lists from H.M.S. Beagle* (© Cambridge University Press 2000) are reprinted with the permission of Cambridge University Press. Erasmus Barlow kindly granted us permission to quote from the publications of his mother, Lady Nora Barlow, aided by her granddaughter Claire Barlow. Peter C. Lack (The Estate of David Lack) granted us permission to reproduce Figure 3.3 from his father's *Darwin's Finches* (Copyright © David Lack 1947), with the aid of Sophie Wilcox of The Alexander Library of Ornithology, University of Oxford.

At Cambridge University Herbarium, the late Peter Sell, David Briggs, Gina Murrell, John Parker, and Christine Bartram supplied encouragement and information about Darwin's plant specimens, and Christine kindly provided us with a photo of Darwin's first known plant collection, reproduced as Figure 4.2. At Clare Hall, the late Jim Council, Bob Ackerman, Dame Gillian Beer, Richard Eden, Michael Loewe, Martin Rudwick, David Sacks, and Ekhard Salje all provided keen interest and verbal engagement in our project; David Gosling provided that as well as information on Darwin's influence in India. The late Richard Darwin Keynes, a superb student of his great-grandfather, also showed great interest in our planned book.

At Virginia Tech's Department of Biological Sciences, successive Department Heads Bob Jones and Brenda Winkel provided encouragement and an office. T. F. Wieboldt expertly photographed illustrations from various books for us, and Valerie Sutherland kindly digitized slides. Richard Bambach, formerly in the Virginia Tech Department of Geosciences, shared his knowledge of Darwin as a geologist and evolutionist. Dick Burian and the late Marjorie Grene, of the Department of Philosophy, asked and answered many questions about Darwin and evolution. Newman Library's Interlibrary Loan department was very helpful in obtaining copies of books and papers needed for our research.

At John Wiley & Sons, Alan Crowden and Ward Cooper encouraged us from the beginning, when they were employed by Cambridge University Press. Our Project Editor, Kelvin Matthews, has been not only encouraging, but also very patient with us. Assistant Editor Laura Bell designed our beautiful cover and Prasanthi Mahalingam provided helpful copy-editing.

Our text was read and commented on by Anna Altizer, Michael Ghiselin, Sandra Herbert, Heather Pierce, Tony Pierce, Sarah Porter, and David West (by most more than

once!). Sandra (author of *Charles Darwin, Geologist*), Michael (author of *The Triumph of the Darwinian Method* and editor of *Darwin and the Galapagos*), and David (author of *Fritz Müller: A Naturalist in Brazil*) all provided insightful commentary from their wide backgrounds in history and the natural sciences; this book's integrity has been increased by their input. Anna, Heather, Tony, and Sarah are nonscientists, who were asked to test the readability and understandability of the book; we hope that their contributions have helped make it more accessible to those who know little or nothing about the historic Darwin. We are greatly indebted to them all, as we are to our students in University Honors 3004, Charles Darwin: Myths and Reality, over the many years we have taught it. These honors students, the collective human inspiration for our project, were encouraged to enroll in the colloquium by Jack Dudley and Terry Papillon, successive directors of the Virginia Tech Honors Program. Frank Sulloway, of the University of California, Berkeley, has long been a helpful source of Darwinian information, particularly on the Galapagos Islands

We are especially indebted to Gren and Shirley Lucas, who helped start all this by providing DMP with a home away from home sporadically for many years, while he was pursuing research in England on Darwin, and treated him as a member of their family. Permission to use Figure 6.1 was granted by them and their children, to whom this book is dedicated.

1 Introduction

Reflecting back on his childhood while in his sixties, Charles Darwin wrote in his autobiography that by the age of eight "my taste for natural history, and more especially for collecting, was well developed." He recalled that he "collected all sorts of things, shells, seals, franks, coins, and minerals. The passion for collecting, which leads a man to be a systematic naturalist, a virtuoso or a miser, was very strong in me, and was clearly innate, as none of my sisters or brother ever had this taste" (*Autobiography*: 22 – 3). It is clear that this innate trait led him to accumulate during his lifetime not only natural history specimens, but also voluminous notes on them and on relevant subjects, numerous publications, and a vast correspondence with naturalists and others around the world. These documents have left subsequent generations a vast treasure trove of information about Darwin, his interests, and his family that we have mined in producing this book.

Today, many people picture Charles Darwin as a solemn, black-cloaked, gray-bearded Victorian patriarch staring at them with rheumy eyes, as seen in the well-known photographs Julia Margaret Cameron had taken in 1868 (Figure 1.1). However, he was only 22 when he embarked on the life-altering voyage of HMS *Beagle* in December 1831 and 28 when he began his notebooks on transmutation of species (evolution) in March 1837 (Figure 1.2).

The narrative that follows will not be the usual chronologically organized biography about Darwin's life. For comprehensive biographical details, the reader should seek out the recent books by Adrian Desmond and James Moore (*Darwin*. *The Life of a Tormented Evolutionist* 1991) or Janet Browne (*Charles Darwin*. *Voyaging* 1995; *Charles Darwin*. *The Power of Place* 2002). Or, for recent studies of certain aspects of Darwin's life, see Keith Thomson (*The Young Charles Darwin* 2009), which leads up to his theory of evolution by natural selection; Randal Keynes (*Annie's Box* 2001) on Darwin's loss of his favorite daughter; or Edna Healey (*Emma Darwin* 2001) and James and Kent Loy (*Emma Darwin*. *A Victorian Life* 2010) on his domestic life; Andrew Pattison (*The Darwins of Shrewsbury* 2009) and Tim Berra (*Darwin and His Children* 2013) on the family; Richard Keynes (*Fossils*, *Fishes*, *and Fuegians* 2002) on the *Beagle* voyage; Thalia Grant and Greg Estes (*Darwin in Galápagos* 2009) on where he went and what he saw in these islands; Rebecca Stott (*Darwin and the Barnacle* 2003) on his research with barnacles; Daniel Pauley (*Darwin's Fishes* 2004) on his research with fishes; and Sandra Herbert (*Charles Darwin*, *Geologist* 2005) on his career in geology. All these readable books rely heavily on the definitive, multivolume *Correspondence of Charles Darwin* (*Correspondence* 1985 – 2013), as henceforth must all research on Darwin's life and work. So does our study — which is the first biographical treatment to emphasize his lifelong research in various fields of endeavor, what he did, why he did it, and what its implications were and are for his time and ours. This account, ordered by topic rather than chronology,

Darwin's Sciences: How Charles Darwin voyaged from rocks to worms in his search for facts to explain how the earth, its geological features, and its inhabitants evolved, First Edition.
Duncan M. Porter and Peter W. Graham.

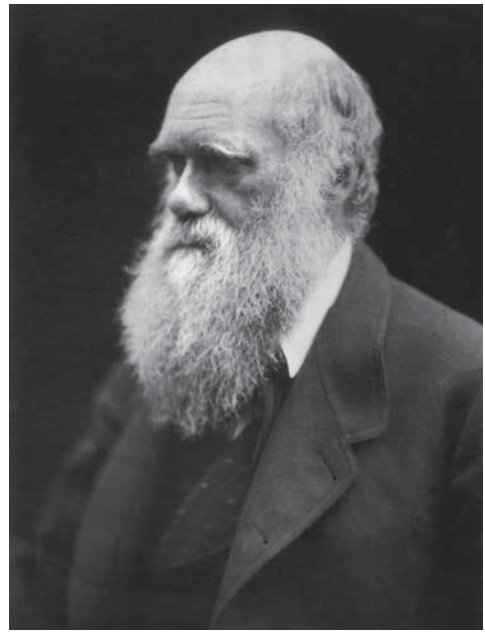

Figure 1.1 Photograph of Charles Darwin at the age of 59, by renowned photographer Julia Margaret Cameron at Freshwater, Isle of Wight, August 1868. (Courtesy of Google Images, 2013.)

Figure 1.2 Charles Darwin at the age of 22 before he sailed on the *Beagle* voyage. Sculpture in the new Darwin Garden at Christ's College, Cambridge, where he was a student from 1828 to 1831. Sculpted by Christ's student Anthony Smith, unveiled on Darwin's 200th birthday, 12 February 2009. (Photo by Duncan M. Porter, 2009.)

logically follows our earlier book (*The Portable Darwin* 1993), which reprinted and discussed a number of his research papers and excerpts from his books. Above all, we aim to help our readers understand that Darwin's career did not build toward — and then subside from — one grand idea (natural selection or evolution) but instead involved many long-standing projects, some distinct and some interrelated, which together served to generate, support, and enrich his understanding of change as the great constant of the natural world.

First, we must set the stage with some family background. Much of the information in the following three paragraphs is from the new, first unabridged, edition of *The Life of Erasmus Darwin*, written by Charles Darwin in 1879 and edited by King-Hele (2003). The first known Darwin ancestor of Charles Darwin lived in the early sixteenth century, near the River Trent in Lincolnshire, in east-central England. Here, in the village of Marton, just south of Gainsborough near the border with Nottinghamshire, dwelt several generations of Darwins. Through marriage, in the late seventeenth century, the family seat became Elston Hall, Newark, Nottinghamshire. It was here that Robert Darwin, Charles' great-grandfather, was born in 1682.

Robert Darwin and his wife Elizabeth Hill had seven children in seven years. The youngest of these was the famous physician, poet, and philosopher Erasmus Darwin, born at Elston Hall in 1731. In 1750, Erasmus entered Cambridge University, as did his older brother John, but left without receiving his Bachelor of Arts degree. He entered Edinburgh Medical School in autumn 1753 and returned to Cambridge in 1755 to take a Bachelor of Medicine degree. Although Erasmus apparently never completed his M.D. (King-Hele 1999), until the fame of his grandson outstripped his own a century later, when one spoke of "Dr. Darwin", one referred to Erasmus, not Charles.

Erasmus Darwin first attempted to practice medicine in Nottingham, where as a fledgling physician, he attracted no patients. Several months later, he moved to Lichfield in Staffordshire, where he was more successful, and in 1781, to the city of Derby in Derbyshire. He eventually became so successful that King George III is reported to have asked, "Why does not Dr. Darwin come to London? He shall be my physician if he comes" (King-Hele 2003: 69).

Erasmus was married twice and fathered 14 children, five by his first wife Mary Howard, two after she died by his son's nursemaid Mary Parker, and seven by his second wife Elizabeth Pole. The fourth child of his first marriage was Robert Waring Darwin, Charles' father, born in Lichfield in 1766. Like his father, Robert became a physician, studying medicine at Edinburgh Medical School, probably beginning in 1782 (King-Hele 1999), and receiving his M.D. from the University of Leiden in 1785. He returned to Edinburgh for another year, and in 1786, Erasmus settled him in the market town of Shrewsbury, county seat of Shropshire, in northwestern England, where he soon became even more financially successful than his father. In 1796, Robert married Susannah Wedgwood, the eldest child of the renowned potter Josiah Wedgwood, founder of the famed ceramics firm of Josiah Wedgwood & Sons Ltd. and a good friend of Erasmus Darwin.

Six children resulted from this first Darwin – Wedgwood union: Marianne (1798 – 1858), Caroline Sarah (1800 – 1888), Susan Elizabeth (1803 – 1866), Erasmus Alvey (1804 – 1881), Charles Robert (1809 – 1882), and Emily Catherine (1810 – 1866). Marianne married Dr. Henry Parker in 1824, Caroline her first cousin Josiah Wedgwood III in 1837, and Catherine the Rev. Charles Langton in 1863; Susan never married. Erasmus, who also never married, trained as a physician at Edinburgh University like his father and grandfather, but never practiced. Charles, of course, is the main subject of our story.

Charles, to whom we will subsequently refer as CD, following the Darwin Correspondence Project's usage, was born at the Mount, Robert and Susannah's substantial house on the edge of Shrewsbury on the 12th of February 1809. This auspicious day was also the

birth date of Abraham Lincoln, born on a farm near Hodgenville, Hardin County, Kentucky, under rather different circumstances. Lincoln's parents were illiterate farmers, whereas CD was from the start of life securely situated in the rich and privileged British upper middle class. Both grandfathers were members of the free-thinking Lunar Society of Birmingham, and Dr. Erasmus Darwin articulated — in such works as *The Loves of the Plants*, *Zoonomia*, and *The Temple of Nature* (E. Darwin 1789, 1794–1796, 1803) — the most prominent eighteenth-century English case for evolutionary development. For a fascinating look at the Lunar Society see Uglow (2002), and for more on CD's grandfathers see Wedgwood and Wedgwood (1980), and King-Hele (1999).

In his *Autobiography* and elsewhere, CD disavowed the influence of his grandfather Erasmus's transformationist speculations on his own. However, CD's first Transmutation Notebook (*Notebooks*), "commenced about July 1837" (170), began with the title "*Zoonomia*" and with a discussion of asexual and sexual generation and references to that earlier book. Despite his apparent reluctance to acknowledge Erasmus's influence on him, CD recapitulated a family pattern in his choice of problems and projects, if not in his particular conclusions, just as his marriage in 1839 to his first cousin Emma Wedgwood conformed to the precedent of his father's and his older sister Caroline's marriages to Wedgwoods.

The young CD's early life followed a well-worn path in other ways. Like his older brother Erasmus, CD was sent to Shrewsbury School, where a classical curriculum centered on Greek and Latin offered little to interest a boy whose passions were such rural pastimes as hunting, shooting, and collecting rocks and insects. Hoping that his second son could be molded into a professional man of his own sort, Dr. Robert Darwin in 1825 sent CD to join Erasmus, who was already pursuing a medical degree, in studying medicine at Edinburgh University. Edinburgh's medical faculty and curriculum were as distinguished as any in Europe, but CD's interests lay elsewhere: in the gathering, dissecting, and stuffing of new specimens for his collections, and in the papers presented at meetings of the Plinian Society, a student club that focused on topics in natural history. A crucial relationship in CD's Edinburgh days, as we shall see, was with the Lamarckian zoologist Dr. Robert Grant, who introduced him to the study of marine invertebrates. In his second year at Edinburgh, CD decided against medicine as a career. The brutality of nineteenth century operations revolted him. CD recalled having "attended on two occasions the operating theatre in the hospital at Edinburgh, and saw two very bad operations, one on a child, but I rushed away before they were completed. Nor did I ever attend again, for hardly any inducement would have been strong enough to make me do so; this being long before the blessed days of chloroform. The two cases fairly haunted me for many a long year" (*Autobiography*: 48).

Recognizing that CD did not have the makings of a medical man, his father settled on the gentlemanly alternative of holy orders and the comfortable, undemanding life of a country clergyman as offering a congenial future for his less-than-promising second son. And so, Christ's College, Cambridge became the next academic institution to accept the young CD, who did what was necessary to pass his examinations but saved his energy for more favored pastimes: the sporting pursuits of undergraduate gentry and his old love for natural history. The latter now took the form of competitive beetle-hunting in the company of such fellow enthusiasts as his second cousin William Darwin Fox. Other new and important friendships established at Cambridge were with two clergymen who also had scientific interests. The Woodwardian Professor of Geology, Reverend Adam Sedgwick, who at the time was engaged in research that resulted in his Cambrian time scale (see Secord 1986), took CD on an excursion through North Wales. He stimulated the younger man's interest in sedimentary stratification, possibly laid the foundation for his conversion to geological gradualism, that large changes are accumulations of smaller changes over time, and certainly convinced him, as no mere book had yet done, "that science consists in grouping facts so that general

laws or conclusions may be drawn from them" (*Autobiography*: 70). The Professor of Botany Reverend John Stevens Henslow's influence on CD's development was even more crucial. His son Francis Darwin later wrote (F. Darwin 1917: 86): "Cambridge was a turning point in his scientific life, chiefly through Professor Henslow's discovery that the youth whom his father Dr. R. W. Darwin thought likely to be a mere sporting man and a disgrace to his family, was really a remarkable person, possessed by a burning zeal for science." CD became known at Cambridge as "the man who walks with Henslow" (*Autobiography*: 64); thanks to Henslow's intervention, CD was considered for the post of companion to the captain and unpaid naturalist on HMS *Beagle*, a naval vessel about to return to southern South America to complete coastal surveys begun in 1826. For more on Henslow and CD, see the latest Henslow biography, by Walters and Stow (2001).

There were obstacles to CD's embarking. The most substantial was his father, whose strong (but malleable) opinion that the adventure would spoil CD's chances of settling down to a clerical life was overcome by uncle Josiah Wedgwood II, who argued for natural history being suitable for a clergyman. Once family support was secured, there was doubt as to whether Commander Robert FitzRoy, the aristocratic and staunchly Tory captain of the *Beagle*, would make the offer. But in December 1831, CD did set out on the *Beagle*, a small, rebuilt barque whose surveying expedition, planned to last 2 years, actually took almost 5 years. Despite formidable obstacles — tedium, isolation, perennial seasickness and crowding on shipboard, clashes of temperament with the volatile and politically and religiously conservative FitzRoy — CD found the voyage transformative. "The voyage of the *Beagle* has been by far the most important event in my life and has determined my whole career" (*Autobiography*: 76).

The *Beagle*'s voyage took her through the Canary and Cape Verde Islands to the east coast of South America (Figure 1.3). While the coastal surveys proceeded, CD disembarked at such places as Bahia, Rio de Janeiro, and Montevideo for long expeditions into the countryside, where, as on the ocean (when it was calm), he was tireless in gathering geological, zoological, and botanical specimens. The luxuriance of exotic life-forms in the rain forest of Brazil particularly overwhelmed him and made his mind "a chaos of delight" (*Beagle Diary*: 42). The ship surveyed the coast of Patagonia, the Falkland Islands, and the windy, desolate headlands of Tierra del Fuego, where it left an English missionary and three Fuegians, who had been indoctrinated in British culture and Christian values. CD's first contact with native Fuegians in their "untamed" (*Correspondence* 1: 302) state filled him with feelings as strong as, but antithetical to, those aroused by the tropical rain forest's flora and fauna. He returns to the contrast repeatedly: a characteristic instance appears in a 30 March 1833 letter from the Falkland Islands, where CD wrote to his sister Caroline "an untamed savage is I really think one of the most extraordinary spectacles in the world. – the difference between a domesticated & wild animal is far more strikingly marked in man" (1: 302–3). We will return to the Fuegians and CD's powerful reaction to their circumstances in a later chapter.

Battered and buffeted by strong winds, the *Beagle* succeeded with some difficulty in rounding Cape Horn, and while the Pacific shore was being charted, CD left the ship to explore Chiloé Island, the Chilean coast, and the Andes. In the volcanic Galápagos archipelago off the South American coast, he encountered populations of tortoises, lizards, mockingbirds, and finches that differed slightly but distinctly from island to island. Although he did not realize it at the time, these varying populations offered compelling evidence of evolutionary divergence. The voyage continued across the Pacific to Tahiti and New Zealand, then on to several landfalls on the southern edge of Australia and Tasmania, the Cocos (Keeling) Islands, across the Indian Ocean to Mauritius, and from the Cape of Good Hope to St. Helena and Ascension Island. From there, the *Beagle* did not proceed north to England, but back across the Atlantic to Brazil, to recheck longitude measurements.

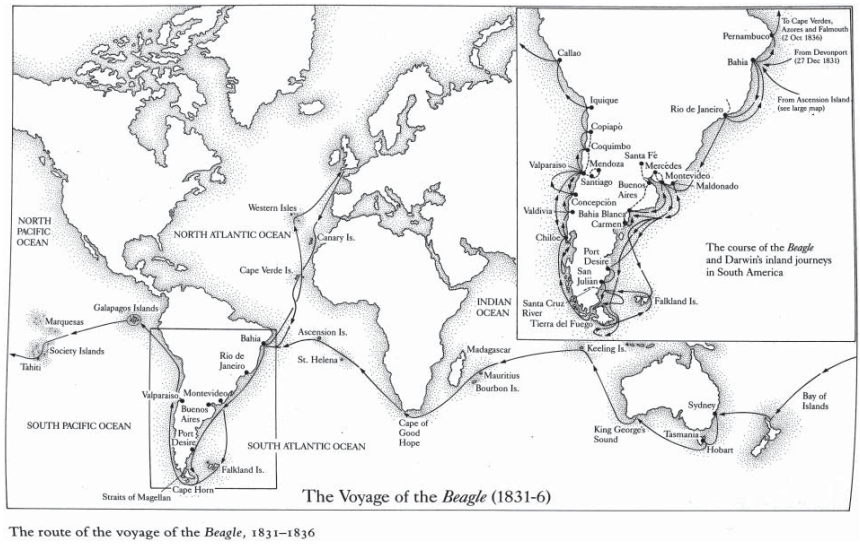

Figure 1.3 Map of the *Beagle's* circumnavigation of the world, December 1831 – October 1836, drawn by Laszlo Meszoly. (Reprinted by permission of the publisher from *One Long Argument*: *Charles Darwin and the Genesis of Modern Evolutionary Thought* by Ernst Mayr, Cambridge, Massachusetts: Harvard University Press, Copyright © 1991 by Ernst Mayr. Photo by T. F. Wieboldt, 2014.)

Heading home after this detour, CD and his shipmates returned to England in October 1836, almost 5 years after leaving her shores. CD would not leave Britain again — but like many a British connoisseur back from the Grand Tour or imperial adventurer returned from a tour of duty in the colonies, he carried home exotic collections and recollections that would enrich, and entirely alter, the rest of his life.

Back in England, CD found that his expedition had made him, if not famous, at least a rising star among the naturalists. The many crates of specimens (some brought back on the *Beagle*, others shipped home at Dr. Darwin's expense) now needed to be unpacked, arranged, and studied. Over the next few months, he found specialists eager to help with this vast project: John Gould of the British Museum took on the birds, Thomas Bell of King's College, London, studied the reptiles and amphibians, Richard Owen of the College of Surgeons, later to be a hostile critic of CD's evolutionary views, examined the fossil mammals from South America, George R. Waterhouse, curator at the Zoological Society, described the living mammals, and naturalist Reverend Leonard Jenyns the fishes. Their monographs were published in *The Zoology of H.M.S. Beagle*, edited by CD. Others wrote a number of shorter papers on the basis of his collections.

Established in London and increasingly involved with the Geological and Zoological societies, CD began to make intellectual order of 5 years' worth of impressions and observations. At the same time, he solidified social and collegial alliances of the sort that would serve his needs. CD took up again with his Cambridge mentor Henslow, dined with the liberal intellectuals of his brother Erasmus's circle, and became friends with Sir Charles Lyell, whose three volume *Principles of Geology* had been a key work in CD's shipboard library, one that helped him to see the brave new world encountered on his voyage through the eyes of a geological gradualist. Most importantly, he gave up the life of a bachelor. The chosen bride: his musical, intelligent, rich, and completely familiar Wedgwood cousin Emma. CD's health, robust enough during the terrestrial portions of his travels, broke down under the bustle and pressure of metropolitan scientific preoccupations. With his wife (and sometime nurse), Emma, he soon withdrew from London life to the convenient yet secluded rural village of Down in the chalk hills of Kent. There, as squire and lady of Down House, they would raise a large family, and CD would produce a succession of books and monographs, some of which profoundly disturbed the Victorian world in which the Darwin family was so comfortably sheltered. From 1842 on, the outward form of his life was set.

Reflecting back on his childhood at Down House, Francis Darwin, the seventh child of 10 and the third son, wrote:

> As children, we, my brothers and sisters, were treated by our parents in a way the very reverse of the pitiless 18th and early 19th century manner — the spirit of those surprising stories such as the *Purple Jar*, where the child is deceived by her abominable parent [Edgeworth 1809]. In fact, a chief characteristic of our parents' treatment of us was their respect for our liberty and our personality. We were made to feel that we were 'creatures whose opinions and thoughts were valuable to them.'

Beginning a discussion of his own education, Francis continued: "The happy relations with our elders which we enjoyed in the holidays to some extent counter-acted the evil effects of going to school" (F. Darwin 1917: 79). Other of the children made similar remarks in their unpublished notes and memoirs now in the Darwin Archive at Cambridge University Library.

Although CD had gone to Cambridge to study for holy orders, by the end of the *Beagle* voyage any idea of a clerical vocation had been given up. In his autobiography, CD wrote that, over time, he went from believer, to deist, to agnostic, but never to atheist. He never

wrote about attending church after the voyage. However, Francis has left us an amusing account of the family at their parish church, St. Mary the Virgin, Down:

> I have no idea at what age we began to go to church, but I have a general impression of unwillingly attending divine service for many boyish years. We had a large pew, lined with green baize, close beneath the clergyman's desk, and so near the clerk that we got the full flavour of his tremendous amens. … In looking back on the service in Down church, I am astonished at the undoubted fact that whereas the congregation in general turned towards the altar in saying the Creed, we faced the other way and sternly looked into the eyes of the other churchgoers. We certainly were not brought up in Low Church or anti-papistical views, and it remains a mystery why we continued to do anything so unnecessary and uncomfortable.
>
> F. Darwin 1919a: 52

Note that there is no mention that CD attended these services, although presumably he at least attended the baptisms of his children Mary Eleanor (and her funeral) in 1842, Elizabeth in 1847, Leonard in 1850, Horace in 1851, and Charles Waring in 1857, and Henrietta's marriage in 1871 (Moore 1985). The other children were baptized elsewhere. Historian of science and religion James Moore (1985: 467) states that CD "himself eventually ceased to attend," but continued to support the church and its activities, including taking up other secular parish responsibilities. There has been a long controversy as to when CD lost his belief in Christianity, although of course beliefs ebb and flow intermittently, despite apparent "watershed" events. In a carefully reasoned essay based on comparing the heavily edited 1887 version of his autobiography and the unexpurgated version published in 1958, plus contemporary correspondence and manuscripts, Moore (1989) dates this loss of belief as following the death of his eldest daughter Annie in 1851.

The form CD's life took warrants some comment, for popular perceptions of his years as the "sage of Down" tend to dwell on certain oversimplifications or exaggerations fostered by CD himself. One such oversimplification might be called the myth of CD the recluse. In letters, CD sometimes characterized himself as living a hermit's life; and while it is true that his world-wandering days ended when he disembarked from the *Beagle*, his decision to leave London and settle at Down was far from eccentric — it was even conventional, given his class and financial situation. In CD's day, financially secure gentlemen fled jobs or professions rather than seeking them. After spending their early adult years broadening their minds or fattening their purses in the wide world or the metropolis, gentlemen who could afford to do so — particularly those who had married and begun families — were likely to settle on country estates. Here, like CD, they could pursue their individual interests with maximum freedom, at the same time serving their communities as vestrymen, magistrates, or parliamentary representatives. CD's scientific research at Down was by no means conducted in solitude, or even in merely domestic company. Such allies and disciples as his tenacious "bulldog" zoologist Thomas Henry Huxley, the botanist Joseph Dalton Hooker, and young naturalist John Lubbock from the local manor were regular visitors; and as the years went by, a steady and international stream of the eminent flowed in and out of CD's study. CD kept in touch with a larger circle of far-flung colleagues and an extensive group of informants through personal correspondence and through letters and queries to journals. Furthermore, as his journal shows, CD ventured forth more than is popularly supposed. He occasionally attended scientific meetings, went up to London for lectures, exhibits, and entertainments, took vacations with his growing family, and patronized the fashionable hydropathic spas in his search for improved health. In short, CD preferred staying at home in the country, but his tastes and habits were quite usual for his class and time, and they by no means isolated him from the scientific community.

The image of CD as invalid is no less vivid—and ultimately not much more helpful to our understanding of his achievements—than is that of CD as recluse. It is undeniable that once the intrepid explorer of rain forests and volcanic islands had returned to England, his health was intermittently bad for the rest of his life. CD's bouts with boils, eczema, dizziness, and especially nausea, vomiting, and headaches are perennial motifs in his and Emma's private writings. For long periods of time, he was in daily distress. But it remains true that he accomplished an extraordinary amount of experimenting, data-gathering, theorizing, and writing, that he fathered 10 children, and that he survived to the age of 73. As has been variously argued, CD may have suffered from Chagas disease caused by a blood protozoan transmitted by the "great black bug of the pampas," or from hyperventilation, or from arsenic poisoning, or from allergies, whether from the organisms he studied (pigeons for example), chemicals he used, or to the food he ate (Emma's cookery book reveals that the Darwins's diet was rich and heavy, typical of their class and day), leading to the latest hypothesis by Thomas Jefferson University gastroenterologist Sidney Cohen that CD suffered from multiple illnesses during his life, from cyclic vomiting syndrome to Chagas disease and peptic ulcer disease (Beck 2011). His "tormented evolutionist's" mind may have punished his body; indeed, most of his health problems were somatic complaints that can have psychological causes. He may have been victim of the self-generated, and partly self-protective, hypochondria common among Victorian intellectuals and virtually endemic among generations of Darwins and Wedgwoods. Several or all of these causes may have contributed to CD's life of ill health. The reader who is interested in pursuing the subject in detail should consult psychiatrist Ralph Colp Jr.'s *Darwin's Illness* (2008). The psychomedical mystery is fascinating in its own right, important to an understanding of CD the man, but not directly relevant to the development and expression of his ideas. Perhaps CD gave up geology because ill health made fieldwork impossible, but otherwise, his physical condition seems to have had little effect on his scientific work—neither on his choice of problems, procedures, and perspectives nor on the quantity or quality of what he accomplished.

If misunderstandings of CD's secluded life at Down and overemphasis on his bad health can obstruct a balanced view of his intellectual achievement, so can the tendency to see CD's list of publications, and the scientific problems they address, as intellectually diffuse. According to this view, CD becomes a man with one overwhelmingly important achievement (*On the Origin of Species*, of course), a few other notable ones (such as *The Structure and Distribution of Coral Reefs* in 1842, *The Voyage of the Beagle* in 1845, and *The Descent of Man* in 1871), and a great many minor pieces, each essentially independent. The facts are quite different. CD's first works rose directly out of his voyage, whether they involved scientific observations made on the *Beagle*, travel impressions in the style of Alexander von Humboldt, whose *Personal Narrative* (1819–1829) was a lens through which CD saw his own journey, or articulation of theories (as in his book on the developmental history of coral islands and reefs or in the various geological works of the 1830s and 1840s) related to his shipboard observations, readings, and meditations. Even when engaged in these projects, though, CD was compiling a series of notebooks on "Transmutation of Species." He sketched out his views in a 35-page 1842 manuscript unknown until well after his death. In 1844, this was expanded into a 231-page essay, which was later read by Joseph Hooker, put aside that same year when the anonymous *Vestiges of the Natural History of Creation* (by the scientific populariser Robert Chambers) provoked deep controversy, and wrestled with for years in a vast project he intended to publish under the title *Natural Selection*. In 1858, the now legendary arrival of naturalist Alfred Russel Wallace's manuscript on variation and evolution pushed him, at the advice of his scientific friends Hooker and Lyell, into the joint Darwin-Wallace publication "On the Tendency of Species to Form Varieties, and on the Perpetuation of Varieties and Species by Natural Means of Selection" that first put his

evolutionary ideas before the public. It is important to recognize that *Origin* itself, appearing in 1859, was very far from being the book CD had envisioned. He saw *Origin* as only a summary of ideas and data that had developed slowly and through an exhaustive intellectual apprenticeship of observation, information gathering, reading, and experimenting.

Thus, the projects preceding *On the Origin of Species* bear on it in various ways. For instance, through his meticulous 8-year study of barnacles, CD established beyond doubt his reputation as what we would today call a systematic zoologist. In addition, he established his credentials in the various branches of zoology (taxonomy, comparative anatomy, comparative embryology, biogeography, and the fossil record) that would allow him to speak with authority on matters relevant to evolution. Similarly, the books subsequent to *Origin* expand, illustrate, or modify CD's evolutionary ideas. *The Variation of Animals and Plants under Domestication* of 1868, for example, presents the minute details of how artificial and natural selection have operated in different plant and animal groups—material essential to his theory but too extensive and particular to fit into the abstract that is the *Origin*. *Variation* was the first volume of a planned three-volume expansion of the data that the *Origin* summarized. *The Descent of Man* and *The Expression of the Emotions* of 1871 and 1872 extend evolutionary theory to include the human race, thereby fulfilling CD's promise in *Origin*: "Light will be thrown on the origin of man and his history" (488). Books on such subjects as the power of movement in plants, the ways insects pollinate orchids, and the role earthworms play in forming vegetable mould show CD, decades after *Origin* was first published, still concerned with how adaptive change operates in the plant and animal world. The post-*Origin* books address, in a pioneering way, subjects that have in our time become specialized disciplines, but all of these interests branch out in different ways from one root: his preoccupation with evolution. Indeed, it might be said that adaptive radiation is as much an operating principle in CD's scientific career as it is in the development of new life forms.

Although Charles Darwin died over 130 years ago, his name remains as familiar to the general public as it was in his own time. One reason is that the essential ideas of evolution remain compelling. No one has yet advanced a scientific theory that successfully challenges CD's assertions that the earth slowly but constantly changes, that forms of life therefore must change in order to survive, that random variation among the individual members of a species occurs naturally, and that in the unceasing struggle for existence, the best adapted individuals survive to pass on their characteristics. But CD's name is also known to many people who lack firsthand knowledge of his scientific writings or the theories they advance. The religious and ideological implications of CD's theory engage diverse audiences by raising a variety of questions, some that CD himself addressed and some that he refrained from handling. What is the nature of humanity in an evolutionary world? How are we related to other organisms? What are our responsibilities to one another and to other forms of life? Do the implications of natural selection extend into human societies? Is there a place for God in a naturally evolving world? If so, what kind of God? All these questions are of more than academic interest—and it seems worth emphasizing that over the years religious, philosophical, social, political, and racial attitudes have played important roles in how different individuals or groups accept, reject, or modify CD's thesis. But whatever our particular orientations, we must take CD's ideas into account. In the long conversation that is natural history, CD spoke neither the first word nor the last one; nevertheless, the questions he asked, the observations he made, the experiments he devised, and the answers he offered changed the subject in a profound and enduring way.

The following chapters on geology, zoology, botany, and social sciences, appear in the order in which these subjects were taken up by CD, from the inanimate to humans. The first

three fields were all lifelong interests succeeding one another as dominant research interests for CD; his considering himself a geologist first, publishing next on important animal topics supporting variation and the evolutionary argument, then using botany to bolster the case for natural selection. His interests in anthropology, psychology, and ethology began when he was in his 20s and 30s, but were no less important to him. The final chapter focuses on CD's last major publication, which is devoted to how worms have served to change the earth through their role in forming vegetable mould. This cross-disciplinary or ecological topic draws on CD's earlier interests in geology, botany, zoology, and social sciences alike.

2 Darwin the Geologist

Shrewsbury

Our Introduction mentioned that CD wrote in his autobiography of May to August 1876 that by the time he went to Unitarian Reverend George Case's day school in Shrewsbury at age eight, his "taste for natural history, and more especially for collecting, was well developed." He "collected all sorts of things, shells, seals, franks, coins, and minerals. The passion for collecting which leads a man to be a systematic naturalist, a virtuoso, or a miser, was very strong in me ...." (*Autobiography*: 22, 23). An earlier autobiographical fragment of August 1838 put it this way:

> I had thus young formed a strong taste for collecting, chiefly seals, franks & [etcetera] [Unless indicated otherwise, words or phrases in brackets within quotations have been inserted by the present authors.] but also pebbles & minerals, —----one which was given me by some boy, decided this taste. ... It was soon after I began collecting stones, i.e. when 9 or 10 I distinctly recollect the desire I had of being able to know something about every pebble in front of the Hall door----it was my earliest----only geological aspiration at that time.
>
> *Correspondence* 2: 439

Unfortunately, the boy who gave him the mineral is unidentified; he initiated a great career.

Between the ages of 9 and 16, CD attended Shrewsbury School, where the headmaster was the famous educator Dr. Samuel Butler. There, CD described his educational experience as, "Nothing could have been worse for the development of my mind than Dr. Butler's school, as it was strictly classical, nothing else being taught, except a little ancient geography and history. The school as a means of education to me was simply a blank." However, "With respect to science, I continued collecting minerals with much zeal, but quite unscientifically—all that I cared about was a new *named* mineral, and I hardly attempted to classify them." (*Autobiography*: 27, 45).

Although he does not mention it in his autobiography, the young CD also collected fossils. There is a curious memorandum book in the Darwin Archives at Cambridge University Library with entries written in the style of letters, which are dated 1 – 12 January 1822, when

Darwin's Sciences: How Charles Darwin voyaged from rocks to worms in his search for facts to explain how the earth, its geological features, and its inhabitants evolved, First Edition.
Duncan M. Porter and Peter W. Graham.

CD was 12. The letters are "To Dear Friend" and contain comments on his brother and sisters and family life and events; it is conjectured that they were meant for his younger sister, Catherine, then aged 11 (*Correspondence* 13: 339). In the second letter, of 2 January 1822, CD wrote: "I hope you will help me in looking out and washing the fossils out of the plate closet, as soon as you can conveniently" (13: 340). In a footnote, the editors of the correspondence show that CD, Catherine, and Erasmus shared an interest in fossils and that Erasmus also used the plate closet to store scientific books.

Although Erasmus apparently had little interest in collecting, he did introduce his younger brother to chemistry, the handmaiden of mineralogy:

> Towards the close of my school life, my brother worked hard at chemistry and made a fair laboratory with proper apparatus in the tool-house in the garden, and I was allowed to aid him as a servant in most of his experiments. He made all the gases and many compounds, and I read with care several books on chemistry, such as Henry [Henry 1810] and Parkes' *Chemical Catechism* [Parkes 1806]. The subject interested me greatly, and we often used to go on working till rather late at night. This was the best part of my education at school, for it showed me practically the meaning of experimental science. The fact that we worked at chemistry somehow got known at school, and as it was an unprecedented fact, I was nicknamed "Gas." I was also once publicly rebuked by the head-master, Dr. Butler, for thus wasting my time over such useless subjects; and he called me very unjustly a "poco curante," [an indifferent, or nonchalant, person] and as I did not understand what he meant, it seemed to me a fearful reproach.
>
> *Autobiography*: 45–46

Erasmus continued to write to CD about chemistry (including experiments), their laboratory, minerals, and fossils following his matriculation at Christ's College, Cambridge in 1822. For example, on 25 October, Erasmus wrote that he had obtained "a very nice little blow pipe made of glass for 1"6 [one shilling and sixpence] which gives a great deal of heat" and on 14 November that he had "ordered a small goniometer (an instrument to measure angles) so that we shall be able to separate the different crystals in your cab[inet]" (*Correspondence* 1: 2, 3). The presence of these instruments in their laboratory indicates that CD learned their uses in chemistry and mineralogy some years before he employed them to examine minerals on the *Beagle* voyage. Indeed, a fellow Shrewsbury School student, Jonathan Henry Lovett Cameron, wrote to Francis Darwin after CD's death in 1882, "He spent some time, most evenings, with a blow-pipe at the gas-light in our bedroom." (*Correspondence* 1: 112).

In his letter of 14 November to "Bobby," as the family called CD at this time, Erasmus mentioned Adam Sedgwick, Woodwardian Professor of Geology at Cambridge, and James Cumming, Professor of Chemistry. As an aspiring medical student, Erasmus would have attended their lectures. He wrote of Sedgwick saying that there were a great number of rock specimens at the nearby Gog Magog Hills and that Erasmus could procure some for CD. Of Cumming, Erasmus related that he had written down all the chemistry experiments that Cumming had entertained the students with and that he and CD could try them out themselves.

CD's interests at this time can be determined from a letter of June 1823 from his sister Catherine: "How snug the Laboratory will be in Winter! How does Mineralogy, Botany, Chemistry and Entomology go on?" (*Correspondence* 1: 8). We will return to botany and entomology in the next two chapters. From October 1822, when Erasmus arrived at Cambridge, until October 1825, when Erasmus and CD, aged 21 and 16, respectively, left for Edinburgh University together, there are a dozen known letters between the brothers. Unfortunately, all are to CD, and none of his answers survive. Nevertheless, we can see by Erasmus's questions, and his answers to CD's questions and comments, that they carried on spirited