ANTHRONOTES®

MUSEUM OF NATURAL HISTORY PUBLICATION FOR EDUCATORS

VOLUME 29 NO. 2 FALL 2008

AN EVOLVING GENIUS: THE EXTRAORDINARY EARLY LIFE OF CHARLES DARWIN

by Douglas W. Schwartz

❖ ❖ ❖

Shakespeare, Mozart, Da Vinci, Einstein—how did they become so brilliant that they were capable of creating those supreme human achievements we recognize as hallmarks of genius? There are many paths to brilliance. I've been studying one of them—the early life of Charles Darwin and what led to his development of evolutionary theory.

I have followed Darwin's trail around the world searching for how, before the age of thirty, he made important advancements in geology and created a theory that underlies the entire field of modern biology. For those committed to a secular explanation, Darwin's theory illuminates the fluorescence and diversity of all life.

Young Darwin

Darwin spent his youth with loving sisters and a brother who lived in the era of Jane Austin's *Pride and Prejudice*. Their home, near the Welsh border, was in the quaint market town of Shrewsbury, England, where Charles was born 200 years ago on February 12, 1809, when Britain was launching its industrial revolution. Darwin's mother died when he was only 8. Some research suggests that a parent's death when a child is young encourages a quality of independence, which Darwin possessed in full throughout his life whatever its origin might have been. Darwin's father was a successful physician, a tall, enormous man of 350 pounds—the biggest man Charles said

Map of Beagle Voyage. Illustration courtesy Marcia Bakry. Based on Wikimedia.

he had ever seen. After his wife's death, Dr. Darwin grew melancholy, quick-tempered, and domineering and sent Charles to a strict Anglican school that stressed rote learning. Young Charles grew bored with this method of learning and soon became a lackluster student. But his life was full of other stimulation, including his father's library full of books on natural history, a collection of old bones and animal skins, and a greenhouse overflowing with plants.

The Darwin home by the Severn River was above a tangled bank of trees with spider webs, vines, paths leading to woodlands, and pastures that Charles loved to explore. One of his favorite books was Rev. Gilbert White's early classic *The Natural History of Selborne*. He was inspired by White's patient natural history observations of neighborhood plants and animals. On his long solitary walks, Charles began watching butterflies and birds and collecting eggs, minerals and rare insects. By the age of ten, Charles, the inept student, was becoming a keen pupil of natural history, prompting his uncle to describe him as having "an enlarged curiosity."

Charles loved to fish and when he was 15 an uncle taught him to shoot and hunt. These activities along with horseback riding and hiking over the nearby hills became Charles' passions, which he pursued with energy and enthusiasm—qualities that characterized all his early years. His fascination with butterflies, birds, insects, hunting, chemistry, hiking, horseback riding, and fishing unexpectedly became valuable skills for him, but his strict father saw them only as distractions from his school work. In a rage that Charles remembered word-for-word throughout his life, his father roared: "You care for nothing but shooting, ...and rat-catching, and you will be a disgrace to yourself and all your family" (Darwin 1959: 30). These were harsh words for a boy with no mother to comfort him. There has always been a question whether Darwin's father contributed a "tension" that was related to Charles' desire to achieve.

Darwin at Edinburgh and Cambridge

In exasperation over Charles' lackluster studies, his father withdrew him from school at age 16 and sent him to the University of Edinburgh to study medicine. Being a dutiful son, Charles threw himself into his class work. But, again, he became disenchanted by monotonous lectures and was appalled when he watched a gruesome surgery on a screaming child (at this time painkillers were not in use). Now, he was more determined than ever that he would not become a physician.

Charles returned to his passion for natural history and met a professor of invertebrate zoology, Dr. Robert Grant, who regularly took students to the Scottish coast to collect invertebrates, dissect and study them, write up their results, and deliver and discuss papers at a student natural history society. This was Darwin's first formal taste of science and he was exhilarated. Grant also advocated the unpopular theory that species could transform and was an admirer of the book *Zoonomia*, written by Darwin's grandfather in the late 1700s, which described species transformation. This book was soundly ridiculed since church doctrine at the time held that species were immutable. Robert Grant became the first of Darwin's many mentors—men who were influential in helping Charles with guidance, advice, support, tutoring and inspiration.

After two years of loathing medicine, Darwin left Edinburgh without a degree. But, instead of returning home, he traveled, hunted, and visited with relatives. His exasperated father, who insisted that Charles still needed a profession, directed that he enroll in Cambridge University to become a clergyman. Charles was ambivalent about this decision but reluctantly agreed. Once more he tried to be a dutiful student but again found the lectures uninspiring.

At this time there was a popular new hobby, competitive beetle collecting, which caught Charles' lively interest. Charles wrote about his enthusiasm in pulling bark from an old tree, seeing two rare beetles, and seizing one in each hand. Then, seeing a third, a new kind, which he couldn't bear to loose, but with no hands free, he popped it into his mouth. The beetle ejected an intensely acrid fluid, which burnt Charles' tongue so that he spit it out and regrettably lost it.

At Cambridge, Darwin read Alexander von Humboldt's thrilling account of his South American explorations in his *Personal Narrative of Travels to the Equinoctial Regions...*, which became a model for the romantic tone of Darwin's future popular writing and also inspired a plan of traveling to the tropics, which did not materialize. Darwin also met the inspiring professor Rev. John Henslow, who became another extremely important mentor and influenced Darwin's "whole career more than any other" (Darwin 1959: 44). Henslow was an outstanding botanist and his ability "to draw conclusions from long-continued minute observations" particularly impressed Darwin. He

was so inspired by Henslow and the writings of others that he wrote of a "... burning zeal to add...the most humble contribution to...natural science" (Darwin 1959: 47). But, Charles' interests in natural history had led him to neglect his four years of class work and only after last minute cramming did he graduate though without honors.

Just as Darwin was graduating, Professor Henslow recommended that he be an assistant to a leading English geologist, Professor Adam Sedgwick, who was studying the ancient rock strata of northern Wales. Charles accepted enthusiastically and for three weeks the two hiked over the "wild places" of Wales, which gave Charles an exceptional opportunity to learn the identification of rock types, interpret and map rock strata, and study fossils. Darwin's energy and stamina were obvious to Sedgwick who became another of Darwin's mentors. After observing how Sedgwick worked, Darwin wrote "nothing before....made me....realize....that science consists in grouping facts so that general laws....may be drawn from them" (Darwin 1959: 48).

"The Most Important Event in my Life"

As the Wales project was ending, Darwin received a second amazing invitation, which highlights the role serendipity played in the development of his career. A letter from Professor Henslow informed Charles that Capt. Robert Fitzroy was looking for a "scientifically inclined gentleman" volunteer to serve as a naturalist-collector and companion on his ship the *Beagle* that for two years would chart the South American coast, and then return by way of the Pacific Ocean to England. Darwin was elated and accepted what became "... the most important event of my life" (Darwin 1959: 51).

"The beetle ejected an intensely acrid fluid, which burnt Charle's tongue." Illustration courtesy Gene Lawrence, artist. Published in Anne Weaver's book, "The Voyage of the Beetle."

The *Beagle* was a 90 ft. long, square-rigged brigantine that had been ordered to make accurate coastline charts in support of Great Britain's expanding maritime empire and to record any new resources they discovered. Darwin was 22 years old in December 27, 1831, when the *Beagle* left England and headed into the Atlantic, where it immediately encountered one of the worst storms Capt. Fitzroy had ever experienced. For days Darwin lay in the hammock of his tiny cabin, severely seasick and drinking only tea. But, as soon as the *Beagle* entered calm tropical seas, Darwin was eagerly on deck netting plankton, jelly fish or whatever he could catch, study and draw. The voyage gave him a great deal of time to read through the ship's extensive scientific library, including a newly published book, *Principles of Geology,* by a leading geologist named Charles Lyell, that Capt. Fitzroy had given him at the beginning of the voyage. Lyell hypothesized the geological history of the earth not as shaped by great catastrophes but rather as an ever changing system of rising and falling land masses regularly eroding and filling, just as uniformly happens in the contemporary world. This approach came to be an anchor of all Darwin's future geological work.

Cape Verde Islands

After three weeks at sea the *Beagle* arrived at the Cape Verde Islands, an archipelago of old volcanoes 450 miles off the west coast of Africa. The ship landed at the Port of Santiago where Darwin was about to enter a world totally different from his green English homeland. He landed on a rugged, black coastline, saw remnant volcanoes, and the "rich colors of

the lush tropical vegetation in its few irrigated valleys." For Darwin just to hear ".... the notes of unknown birds" made it a glorious day "like giving a blind man eyes" (Darwin 2001: 23).

The majority of Santiago was sparsely vegetated, making it an ideal place for Darwin to practice his newly acquired geological skills. Santiago's dramatic geology motivated him to go far beyond mere description. He was anxious to know how this unique landscape was formed, a good example of how time and again Darwin chose the right research question to ask. He first studied the shoreline and collected washed up pieces of shell and coral that were mixed with volcanic rocks. Then he discovered a striking white band in the cliff above him and wondered why it was there. Looking for the larger story, as he regularly did, on closer inspection he found the band was composed of millions of tiny coral and shell fragments that had been baked into a hard layer. In the interior he examined old volcanic cones and consolidated lava flows.

From these observations he formulated a hypothetical sequence of geological events, which suggested that on the ocean floor at the edge of the original volcano there accumulated a deposit of coral and shell fragments. These were later covered by ash from a subsequent volcanic eruption, which also raised the whole island above sea level, exposing the white band under a layer of volcanic debris. Darwin further recognized that the shells in the white band were like those he had found near the shore, leaving him to conclude that the islands' volcanic activity must have been quite recent. This conclusion ran counter to the then current geological thinking that assumed all volcanic activity was quite ancient. Thus, within the first two days of Darwin's first overseas visit, he had built on the work of others, added his own original insights, and proposed an elegant explanation for an intricate geological puzzle. In addition, he was already challenging scientific authority, a quality that would be common in all his later work.

Darwin was elated with his "white band" theory, and since in the young science of geology there had been little research in the far corners of the world, it dawned on him, as he recorded decades later in his autobiography: ".... I might.... write a book on the geology of the various countries (I) visited, and this made me thrill with delight" (Darwin 1959: 55). Thrill, because now as he traveled over the world he had a clear sense of purpose, a purpose that would motivate and direct his efforts for the rest of the voyage. During only two and a half weeks on this desolate Cape Verde Island, Darwin had found a profession.

The Jungle

The *Beagle* now sailed southwest across the Atlantic Ocean, landing at the romantic tropical port of Bahia, Brazil. While Fitzroy focused on charting the coastline, Darwin went ashore where he found another new world. On February 29, he wrote: "walking in the forest ...the day passed delightfully....the .... luxuriance of the vegetation... elegance of the grasses, the novelty of ... parasitical plants, the beauty of the flowers, (and) the glossy green of the foliage ..." Since most geological formations were covered by lush vegetation, Darwin concentrated on the "sublime grandeur of lofty trees, radiant flowers and fruits, bizarre plants, fantastic birds and strange insects" (van Wyhe: 116). But, even with all this abundance he was careful to collect only specimens he had time to tag, record, and pack for shipment back to England. In the Brazilian jungle Darwin's interests in biology broadened and over the next six months he immersed himself in the profusion of Brazil's tropical animals and plants.

Patagonia

When the *Beagle* repositioned to the south and began its longest assignment, charting the coast of Patagonia, Darwin was again in a new environment, a raw frontier scarcely known to Europeans but which was surprisingly productive for him. He recorded more strange animals like the armadillo, and he was intrigued by the rheas and the guanacos. The rhea is a shy, solitary flightless bird, a distant South American relative of the ostrich, with a smaller relative living in an adjacent territory to the south. The guanaco is a species of South American camel, a wild relative of the domesticated llama, which he found also had a smaller variety in an adjacent territory. In both cases this juxtaposition of small and larger animals prompted him to question why two different but related types would live so close to one another. One of a growing number of small puzzles Darwin set aside to examine later.

One of his aspirations was to discover some large fossils since in all the collections of Europe there was only a single giant fossil from South America. If he could find more such fossils, he thought it would help him "...take his place among the men of science" (Darwin 1958: 83), a reflection of his deep desire to excel. The sparse vegeta-

tion of Patagonia made it a perfect place to search for fossils, and with Darwin's amazing luck he soon discovered a treasure trove. He found a huge Megatheriam skull, which means "great beast," not a dinosaur but a large, strange-looking Ice-Age ground sloth that is related to the tiny modern tree sloth. Its powerful claws could pull down whole trees in search of food. He also found the nearly perfect skeleton of another large ground sloth and a huge, extinct armadillo, plus a Toxodon, a short-legged rhinoceros-size animal related to the small modern capybara, and a large camel-like animal related to the modern tapir plus the remains of several mastodons.

Since the bones he was finding were mixed with fossilized seashells similar to species he recovered along the nearby shore, Darwin speculated these big animals were geologically quite recent. He felt even more sure of that when he found the skull of a Mylodon, another big ground sloth, with "... bones .....so fresh...that they contain animal matter" (Darwin 1961: 147). Based on the large number of bones he was recovering, Darwin concluded that: "...the whole area of the pampas is one wide sepulcher of these extinct gigantic quadrupeds" (Darwin 1839: 174). He reasoned that some of these large fossils were "antecedent" to modern, smaller "allied races." These two concepts, "antecedents" and "allied races," led him to conclude that the large animals who once lived in Patagonia died off but had smaller descendants who are living today. But, then, how could species die off and change if they were supernaturally created? Another thought he filed away for later.

When the *Beagle* sailed further south, it hit a submerged rock, and Fitzroy decided to stop at the mouth of the Santa Cruz River so the ship could be beached, checked, and its keel repaired. During this time Fitzroy, Darwin, and some other crew explored the river basin, a broad canyon cut through the Patagonian tableland. Its fast flow and "fine blue color with a slightly milky tinge" suggested it had a glacial origin in the Andes. This long, hard expedition gave Darwin an unusual opportunity to examine a nearly complete east-west cross-section of southern South America. He found a landscape of stepped strata that stretched all the way west to the Andes. Near the coast he saw a surface apparently laid down on the sea floor, while further inland he encountered great lava beds that also had originated in the ocean and then gradually had risen above the water. Darwin hypothesized that all the way from the Straits of Magellan north for 1200 miles "...the whole of the east coast of southern South America has been elevated from the ocean...one grand formation...that... began from seas too deep for life...were rapidly elevated and ... within a proper depth life commenced.. The elevations rapidly continued, land was produced on which great quadrupeds lived" (Herbert: 159). Darwin had taken a broad continental view and proposed a bold geological story.

Megatherium americanum ("Great Beast") stands about 12 feet high on display at NMNH. Photo courtesy Smithsonian Institution.

After more than two years charting the coast of Eastern South America, the *Beagle* now sailed south to the waterways of Terra del Fuego and into its turbulent seas, moving through gloomy channels where wind and tide ran together in the Magellan Strait, a recently discovered and seldom traveled passage. Moving through the channel, the *Beagle* encountered temperatures far below freezing, plus dangerous icebergs that had calved off the enormous blue glaciers, thrusting out from the base of the massive snow-covered south-

ern Andes. For days the *Beagle* sailed in waters of "overpowering force," and the crew was constantly worried they might crash into hidden rocks and sink or drown in the freezing waters. Finally, and happily, they reached the Pacific Ocean and turned north for a 1700 mile sail toward Valparaiso, Chili.

The Andes

From the ship Darwin watched the Andes and wrote, "who can avoid admiring the wonderful force, which has upheaved these mountains....and .... the countless ages ... it must have required ...." (Darwin 2001: 285). These were the two questions he now was pondering: what force caused the Andean uplift? and how long had it taken? As they sailed along the southern coast of Chile, Mount Osorno came into view—a massive 7,000 foot-high perfect snow-covered volcano, standing in front of the main Andean range, when suddenly it began "spouting ... volumes of smoke," then on January 15, 1835, there was a spectacular, fiery eruption. Later, he heard that several other volcanoes in the region erupted simultaneously. Darwin was seeing the full force of nature that few European geologists had experienced, which made his observations another major contribution to modern geology.

Further north, Darwin was exploring a forest near Valdivia, Chili, when on February 20, 1835, he felt the ground shake violently below him. It was a gigantic earthquake during which he sensed: "the world... move beneath our feet like a crust over a fluid...." (Darwin 2001: 292).This enormous quake completely destroyed the nearby town of Concepcion, Chile, and seventy other outlying villages. After the quake, he examined the shoreline near Concepcion and found that shells once on the beach had been forced up some nine feet, just what he had envisioned for Patagonia, a land mass dramatically raised out of the sea. With the Orsorno eruption and the Valdivia quake, Darwin experienced first hand natural forces instantly transforming the earth. He wrote: "The earthquake and volcano are parts of one of the greatest phenomena to which this world is subject." He was anxious to know how all this related to the origin and building of the Andes.

Leaving the coast and traveling inland with horses and guides, he set off on a dangerous, determined 22-day journey across the Andes, searching for clues to the mountains' origins. He was frequently in danger from deep precipices, altitude sickness, and blizzards, but this did not deter him from seeing the beauty that was everywhere around him. He wrote, "... the sky an intense blue, the profound valleys, the wild broken forms...the bright coloured rocks, contrasted with the quiet mountains of snow, a scene I never could have imagined...this ... view stands distinct in my memory from all others" (Darwin 1890: 385).

On cliff tops 1,000 feet high he found recent seashells and at 12,000 feet fossilized seashells that suggested "....the enormous mass...peaks...are so very modern...as to be contemporaneous with the plains of Patagonia." Also high in the Andes Darwin found evidence of the force behind the uplifts —large masses of red granite that was once molten lava and had been extruded from deep below the surface, elevating the overlying rock by a long series of spectacular upheavals. Here were "... manifest proofs of excessive violence" suggesting ".... the world (was) older than geologists think" (Darwin 1959: 232). This conclusion made Darwin one of the mid-19th century geologists who established our understanding of deep geological time (Eldredge: 112). He had conceived of his "great system" of Patagonian uplift long before the concept of tectonic plates was developed, an illustration of his growing originality, self confidence, and readiness to explore how the accumulation of little changes can produce significant results wherever they occur.

The Enchanted Islands

The *Beagle* sailed away from the Andean coast and traveled 600 miles west with Darwin looking "... forward to the Galapagos with more interest than any other part of the voyage" (Darwin 1959: 234). This was in anticipation of their famed volcanic geology. He had no idea at the time the influence the plants and animals of the Galapagos would have on his future. At first landfall Darwin discovered a shoreline of black, dismal looking heaps of lava starkness. He reasoned this shoreline had originated from the eruption of sub-oceanic volcanoes that had risen out of the open sea to create remote new lands, which he compared to newly formed planets. The unique animals he found were nearly fearless with so few predators on the islands. This gave Darwin an exceptional opportunity to observe and collect many important new species, including the marine iguanas that lived nowhere else in the world. In the forested inland he found a large, land-based, cactus-eating iguana. On the mountaintop of one island he discovered a high cloud forest with lichen-draped trees and giant tor-

toises, which weighed up to 200 pounds, some seven feet in circumference. As he roamed the islands Darwin wondered where these unusual species came from, and he wrote, "....it will be ...interesting to find...to what centre of creation the...beings of this archipelago must be attached" (Darwin 2001: 356).

At first he thought the islands were too far from the mainland to have "effectively... receiv(ed) any migratory colonists." So, perhaps these animals were newly created when the islands emerged from below the sea. This conclusion would have been consistent with the then current opinion about the origin of new life. While Darwin was not ready to abandon special creation as an explanation, he was gradually opening up to other possible causes. He wondered if the local Galapagos species of mockingbirds might be related to those he had seen on the mainland of South America. But then why were the Galapagos species different?

As he walked over the nearly unexplored islands he found other new species of animals and plants and finch-like birds with a diversity of eating habits. Some were feeding only on cactus, some searching on the ground for plant seeds, and others fed in trees, eating insects and leaves. He noticed that the different kinds of feeders had dissimilar beaks, adapted he thought to what they ate. Local residents also told him that each island had its own type of tortoise with distinctive shell coverings, and that mockingbirds were different from island to island as were many of the trees. But this island species diversity, while intriguing, did not at the time cause an epiphany in Darwin's thinking. The deeper meaning buried in the Galapagos species came only much later after he had time to put together more clues.

Tahiti!

After less than a month the *Beagle* left the Galapagos and sailed west 2500 miles to Tahiti, where Darwin discovered the kind of place he had dreamed of as a boy, a tropical island with long brilliantly white beaches overhung by coconut palms. Disembarking, the crew were greeted by a joyful throng of islanders. While he was on Tahiti for only eleven days, Darwin made another major scientific breakthrough—the geological origin of coral reefs and atolls. He climbed a 3000 foot-high mountain and saw awesome waves break over the outer edge of the encircling reef. He knew from earlier studies that the coral polyp animals only live in the warm water, close to the ocean's surface where ocean currents brought food. This observation became part of Darwin's new idea of how coral reefs form. He canoed out to the reef and was amazed that these tiny coral polyps had built such a mountainous ring around the island, leaving the lagoon inside the reef glassy calm.

Thinking back over his work in Chile, Darwin reasoned that there must have been an equilibrium in the earths' masses. If the Andes rose by a series of massive uplifts, then this movement should have been balanced by the adjacent Pacific basin slumping. Based on this hypothesis, Darwin envisioned that a volcano erupting on the ocean floor would grow until it rose above sea level. Then coral would grow in the shallow water around its base. As the sea floor subsided, the volcano would then gradually descend lower and eventually disappear under water's surface, while the encircling coral would grow upward to stay in the shallower, warmer water. Finally, only a ring of coral would show above the surface as an atoll.

In this work, Darwin was developing a research style that would emerge later during his work on evolution. It involved combining insights from several fields of inquiry, including geology, zoology, botany, and oceanography. Each of these disciplines stimulated his thinking in

Coral reef, Tahiti. Photo courtesy Douglas W. Schwartz.

the other areas, with all contributing to his final conclusion regarding the origin of coral reefs.

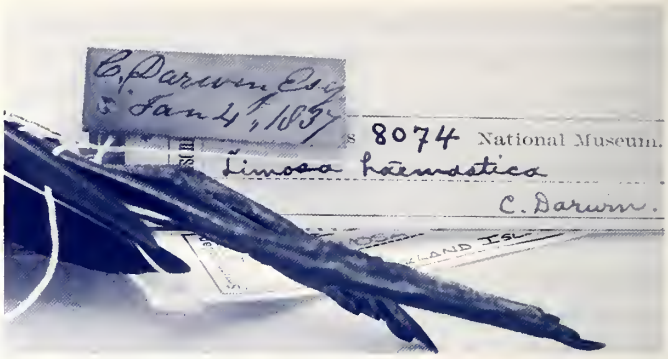
Homeward Bound

After Tahiti, the *Beagle* began its much anticipated return to England by way of New Zealand, Australia, the Indian Ocean and the island of Mauritius. The *Beagle* voyage had changed Darwin forever. He had left England, a land of peace and green pastures, to discover a world of violent volcanoes, earthquakes, powerful glaciers, rising mountains, turbulent seas, jungles, and vast open spaces, during which his "....love for science gradually preponderated over every other taste" (Darwin 1958: 53).

From Mauritius, the *Beagle* sailed to the South Africa's Cape of Good Hope because Darwin wanted to visit the famous philosopher Sir John Herschel whose writings had influenced him at Cambridge. In their conversation Herschel may have used his phrase "mystery of mysteries," an expression which resonated with Darwin's growing interest in species transformation and stayed with him for decades as he developed his evolutionary theory.

Sailing on to the island of Ascension, where they picked up mail, Darwin received word that some of the technical letters he had sent to Prof. Henslow during the voyage had been read by Henslow at a scientific meeting and had been widely praised. Darwin's fossil finds also were considered very important. Darwin was thrilled, revealing, as he wrote, "how ambitious I was" (Darwin 1959: 55). But, his ambition had a wider aspiration for in thinking about his future, he wrote that he was looking forward to "...a harvest however distant...when some fruit will be reaped, some good effected" (Darwin 1961: 482). What Darwin did not know was that at just this time his geology mentor Prof. Sedgwick had visited Darwin's family and expressed the opinion that Charles should take a place among the leading scientific men.

The *Beagle* then sailed back to Brazil so Fitzroy could recheck his measurements, another long trip that gave Darwin more time to rethink his observations. Reconsidering the Galapagos, he wrote in his ornithological notebook that if the mockingbirds on the Galapagos were similar to those in Chile, but different on each island, then this idea "... would undermine the stability of species" (Barlow: 262), a clear indication that he was now much more open to the idea of what he was now calling species transmutation, which he much later called "evolution."



A label written in Darwin's handwriting attached to a Godwit, a bird captured in the Falkland Islands. Photo courtesy Chip Clark, NMNH.

A Theory by Which to Work

At the beginning of August 1836, the *Beagle* finally turned toward England, carrying home a young man who, over the past five years and fourteen thousand miles, had changed from a casual collector of nature into a full-fledged scientist. On October 2, 1836, when the *Beagle* reached England, Darwin moved to London immediately to begin "the most active...[two years] which I ever spent" (Darwin 1959: 56) and perhaps his most creative. Darwin became a very public scientist, unpacking his thousands of carefully tagged specimens and distributing them to various specialists for analysis. He delivered papers on geology at scientific meetings and edited his *Beagle* journal for publication.

As the experts' analyses of his specimens arrived, everything changed. They reported that the Galapagos mockingbirds were separate species from those on the mainland and were in fact three different species. The large fossils were indeed antecedent to related smaller existing species in South America. The Galapagos finches were, in fact, twelve distinct new species related to species on the mainland. The land iguanas were distinct species from island to island, as were the giant tortoises.

These results represented an explosion of speciation. In the face of this overwhelming evidence, Darwin accepted the dangerous idea of species transmutation as a matter of fact and immediately began a secret effort to determine how that process might work. The nature of his thinking process is revealed by a branching diagram he drew at the time, which represented for him how new species might arise in a pattern of continual diversity. However, he was not yet positive about this and added to his sketch the words "I think." This visualization led the psy-

chologist Howard Gruber to characterize Darwin's thinking as "favoring images of wide scope," just as on Cape Verde, in Patagonia, the Andes, and Tahiti, Darwin thought about the larger picture and looked for answers as to how it came about.

Darwin had observed that among all species there was individual variety and, when food was in short supply, there would be competition between individuals, what Lyell had called a "struggle for existence." But Darwin, while convinced that species transmutated, could not yet tie all of these pieces together. He began searching for ideas, reading books on philosophy, science, and metaphysics. Then, on September 10, 1837, he read a book on social welfare by Thomas Malthus called *Essay on the Principle of Population*. Malthus maintained that much of human suffering occurs because its population increases faster than the food supply, leading to famine, disease, and conflict. The concept of over-population was the missing factor Darwin had been seeking. He recognized that not just humans but all species overproduce offspring and given the variation among individuals in any species during times of food shortage, there would be a struggle to survive. The weak die and the most fit would survive and pass their superior qualities to their offspring, allowing them to evolve. As Darwin wrote: "...favorable variations...(are) preserved and unfavorable ones...destroyed. The result...the formation of a new species" (Smith: 65).

Finally, at the age of 29, Darwin had a theory by which to work, one that would cause a sea change in the history of ideas. It is often assumed that the inspiration for his evolutionary theory came either from the Galapagos finches or his reading of Thomas Malthus. But, for me, the foundation of his colossal creativity arose from a much more complex web of interrelated factors, including independence, enlarged curiosity, energy, tension, mentors, in-depth knowledge, serendipity, originality, desire to excel, determination, web of inquiry, and the asking of profound questions. It was only when all of these qualities coalesced that there emerged this enormous creative ability during the extraordinary early life of Charles Darwin.

References Cited

Barlow, Nora, ed. 1963. Darwin's Ornithological Notes. *Bulletin of the British Museum* (Natural History). History Series 2, p. 262.

Darwin, Charles. 1839. *Narrative of the Surveying Voyages of His Majesty's Ships Adventurer and Beagle...1832-1836.* Henry Colburn.

Darwin, Charles. 1890. *Journal of Research into the Natural History and Geology of the Various countries visited by HMS Beagle.* John Murry.

Darwin, Charles; Francis Darwin,ed. 1959. *The Life and Letters of Charles Darwin: Including an Autobiographical Chapter.* Basic Books.

Darwin, Charles. 1958. The Autobiography of Charles Darwin: 1809-1882. W. W. Norton & Co.

Darwin, Charles. 1961. The Voyage of the Beagle. J.M.Dent and Sons. 1901, 1839.

Darwin, Charles. Keynes, R. D., ed. 2001. *Charles Darwin's Beagle Diary.* Cambridge University Press.

Eldredge, Niles. 2005. *Darwin: Discovering the Tree of Life.* W. W. Norton & Co.

Herbert, Sandra. 2005. *Charles Darwin, Geologist.* Cornell University Press.

Smith, David. 2007. *The Most Dangerous Animal.* St. Martin's Press.

Van Wyhe, John, ed. 1979. *Darwin's Beagle Diary.* Genesis Publication.

Websites

http://darwin-online.org.uk/
http://www.amnh.org/education/resources/rfl/web/darwinguide/
http://aboutdarwin.com/index.html
http://www.pbs.org/wgbh/evolution/darwin/origin/

Douglas W. Schwartz is president emeritus and senior scholar of School for Advanced Research, Santa Fe, New Mexico.