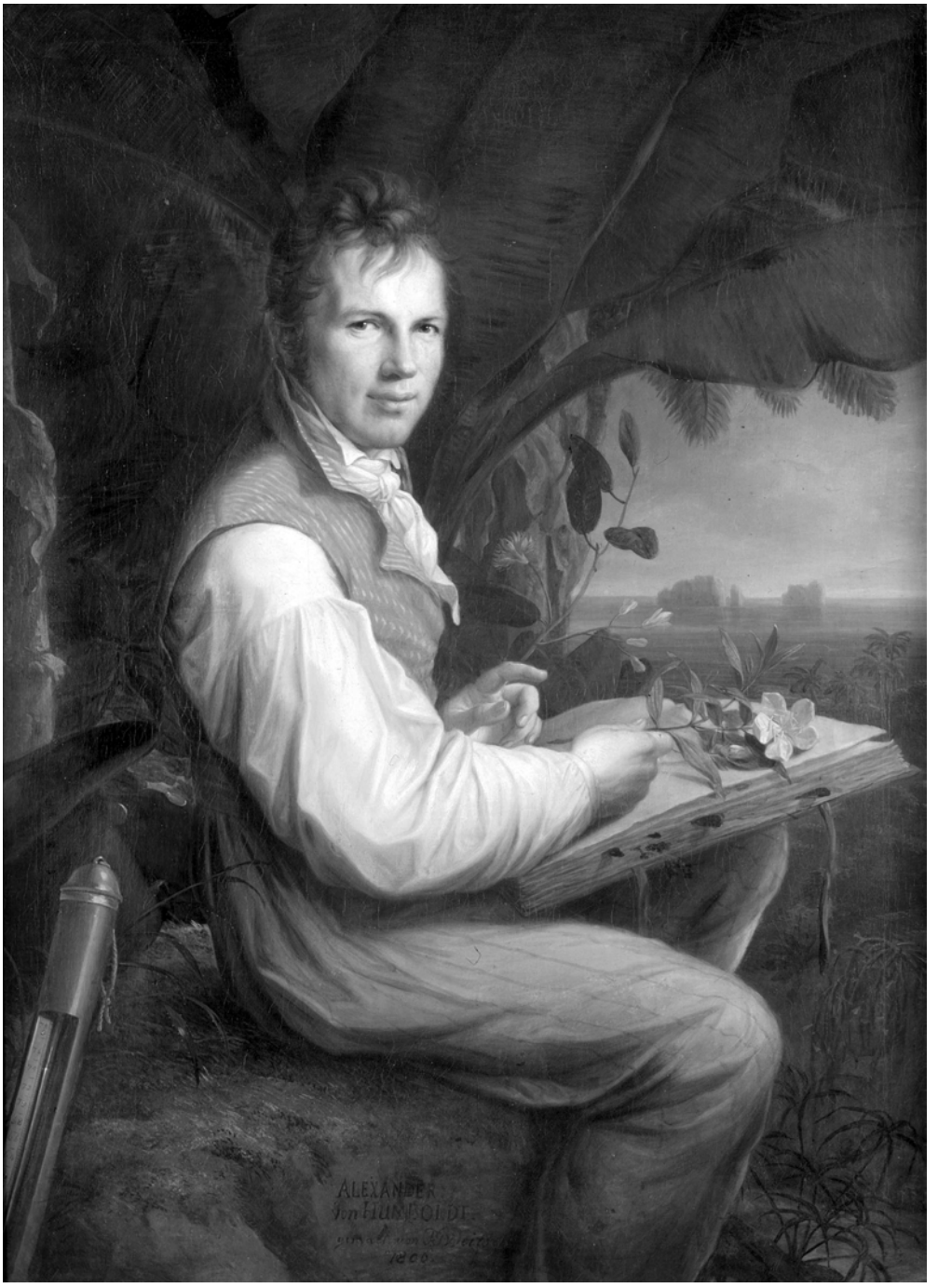


Portrait of Alexander von Humboldt, by Friedrich Georg Weitsch.

12

"HE, LIKE ANOTHER SUN, ILLUMINES EVERYTHING I BEHOLD"

ALEXANDER VON HUMBOLDT AND THE NEW AGE OF SCIENTIFIC INQUIRY

"The first impression made by Humboldt's face was that of broad, genial humanity. His massive brow bent forward, overhung his chest like a ripe ear of corn, but as you looked below it, a pair of clear blue eyes, almost as bright and steady as a child's, met your own. You trusted him utterly at first glance. I had approached him with a natural feeling of reverence, but in five minutes I found that I loved him." So remembered the American traveler Bayard Taylor (1825–78) of the man Thomas Jefferson declared to be "the most scientific man of his age."[1] The American transcendentalist poet Ralph Waldo Emerson (1803–82) went even further, calling Humboldt "one of those wonders of the world, like Aristotle, like Julius Caesar, . . . who appear from time to time, as if to show us the possibilities of the human mind, the force and the range of the faculties—a universal man."[2] Even Charles Darwin (1809–82) considered Humboldt his mentor and tutor in the ways of science. "I formerly admired Humboldt, I now almost adore him."[3] "He, like another sun, illumines everything I behold."[4] "I shall never forget that my whole course of life is due to having read and re-read as a youth his [book] *Personal Narrative*."[5] One can well argue that Humboldt was to the nineteenth

1. Botting, *Humboldt and the Cosmos*, 279; and Nichols, "Why Was Humboldt Forgotten?," 2.
2. Walls, *Passage to Cosmos*, 254–56.
3. Charles Darwin, as cited in Buttimer, "Bridging the Americas," vii, and Walls, *Passage to Cosmos*, viii.
4. Charles Darwin, as cited in Walls, *Passage to Cosmos*, viii.
5. Helferich, *Humboldt's Cosmos*, xxi.

century what Albert Einstein (1879–1955) became to the twentieth century: "the iconic scientist, whose intellect was so far beyond the ordinary as to seem mystical, superhuman, fabulous, yet curiously benign."[6]

Such tributes as these could be multiplied for the man who personifies the scientific spirit of the time and who, during the age of 1820, was at the apex of his brilliant career. More than any other of his prestigious colleagues, Humboldt brought the study of science into the realm of popular respectability and paved the way for Darwin and the modern age of enlightened scientific inquiry.

And yet there was so much of the enigmatic in the character of this great Prussian who despised his native land and adored his adopted France instead, who loved many but never married, and who comprehended the deepest recesses of space and nature but may have failed to understand himself. Although he was a mentor to thousands and the key supporter of a whole new generation of scientists, Humboldt—the "Napoléon of science"—was essentially a loner. Mysteriously, modern history has all but forgotten him. This chapter will challenge that omission by reclaiming one of the finest minds of the nineteenth century and, while so doing, introduce other contemporary pillars of science whose discoveries and inventions continue to influence modern society.

"THE LITTLE APOTHECARY": HUMBOLDT'S CHILDHOOD AND EARLY LIFE

Friedrich Wilhelm Karl Heinrich Alexander von Humboldt was born in Berlin on 14 September 1769, the same birth year as Napoléon, Lord Wellington, and William Wilberforce. His father, Major Alexander Georg von Humboldt (1720–79), married Marie-Elisabeth von Colomb (1741–96) a forlorn widow of Huguenot descent who had inherited from her first husband an estate at Schloss Tegel, twelve miles north of Berlin. Unfortunately, young Alexander's father, a jolly, imaginative, and life-affirming soul, died young when Alexander was only ten years old, and his aristocratic mother—a cold, distant, self-sufficient Calvinist and a puritanical woman—raised him and his slightly older brother, Wilhelm von Humboldt (1767–1835), in what one of his leading biographers, Douglas Botting, calls "an emotional wasteland."[7]

Frau Humboldt did, however, see to it that her two sons received the very best education. Privately tutored first by Joachim Campe (1746–1818) and later by Gottlob Kunth (1757–1829), both boys developed early on a love of languages, mathematics, history, and the liberal ideals later enshrined in the French Revolution. Young Alexander grew up in the intellectual shadow of his older brother, who showed outstanding promise as a linguist, politician, and diplomat. Wilhelm soon became the idol of the household for his remarkable intellectual prowess, and his mother saw to it he that he was trained for high office.

6. Nichols, "Why Was Humboldt Forgotten?," 412n1.
7. Botting, *Humboldt and the Cosmos*, 11.

Alexander, on the other hand, seemed destined for lesser things. He was slower or at least more deliberate, more reserved, and certainly more aloof, guarded, and reflective. In fact, there was nothing in his childhood bespeaking exceptional talent or hinting of true genius, save for three telling characteristics: his vivid, yearning imagination; an incredibly keen sense of observation; and a boundless passion for reading. His most enjoyable outlet was to escape from the castle boredom at Tegel and wander the delightful grounds and nearby gardens, studying and collecting, cataloging and drawing various leaves and flowers, butterflies, and beetles, so much so that he was nicknamed "the little apothecary."

Portrait of Alexander von Humboldt, by Joseph Karl Stieler.

Of these formative childhood longings, Humboldt later said, "The child's pleasure in the form of countries, and of seas, and lakes as delineated in maps; the desire to behold the southern stars; . . . the representation of palms and cedars of Lebanon as depicted in our illustrated bibles, may all implant in the mind the first impulse to travel into distant countries."[8] He had "a peculiar predilection for the sea."[9] With a mother who remained distant and detached, the two brothers became intensely close, showering visitors and the occasional playmates with nonstop chatter and animated conversation. The emotional deficit the two Humboldt brothers felt from their mother was one that Wilhelm overcame through a most felicitous marriage to Karoline von Dacheröden (1766–1829) in 1791, but one that Alexander, restless and emotionally insecure, could never fill.

Missing from their education, as for most young men of the age, were any lessons in science. In fact, the word *scientist* had not even entered the language. It was a subject not then part of the cultural and educational environment, and had Alexander, at the age of sixteen, not had the good fortune to meet Marcus Herz (1747–1803), a Jewish physician who had studied Kant, he may never have gone on to become a scientist. Alexander owned the uncanny ability of meeting the right person at the right time, especially in his early life. Herz presented a series of stimulating illustrated lectures at his home on physics and philosophy

8. Humboldt, Cosmos, 1878 ed., 2:370.
9. Humboldt, *Cosmos*, 1878 ed., 1:310.

in which he elaborated upon the latest scientific breakthroughs, theories, and discoveries, including Benjamin Franklin's lightning conductor. Humboldt sat enthralled.

Two years later, in October 1787, the two Humboldt brothers, accompanied by their watchful guardian, Kunth, began their university education at nearby Frankfurt an der Oder. Soon they transferred to the far more prestigious Göttingen University, where Wilhelm read law. Uncertain and still searching his own interests, Alexander dropped out of school for a year to collect his thoughts and regroup. During that time, he became a close friend of Karl Ludwig Willdenow (1765–1812), four years his senior, who had just published his *Flora of Berlin*. Until Willdenow, Alexander had never even heard the word *botany*.

In the spring of 1789, Alexander rejoined Wilhelm at the University of Göttingen, where he shared a room with Count Metternich, the future Austrian prime minister who would play so dominant a role in the Congress of Vienna (see chapter 3). That same year, Alexander made his first trip of exploration up the Rhine to Heidelberg. While studying at Göttingen, Alexander met Georg Forster (1754–94), his true mentor and guiding star, and, although Forster was twice Alexander's age, he became the most important single influence on Alexander's life.[10] Forster had sailed with Captain James Cook on his second around-the-world voyage, where he mastered the business of careful, systematic note-taking. Upon his return, Forster wrote up his findings and adventures in his elegantly written, highly popular *A Voyage Round the World* (1777).

Anxious to return to London to secure a publisher for a second book, Forster invited his new young friend and protégé to come along. In 1790, the two men traveled down the Rhine and arrived in Paris during the apex of a celebration for the hard-fought gains of the French Revolution. From there they traveled westward through Holland and Belgium, where at Dunkerque (Dunkirk), Alexander gazed out at the sea for the first time—a childhood dream fulfilled but a longing never satiated. All along the way, Forster taught his traveling companion the importance of making careful observations of everything from ferns to factories and meticulously recording nearly all they saw and experienced.[11]

Although Forster failed to find a publisher for his book, he did promote his young Prussian friend to such leading lights as William Bligh (1754–1817), the cast-off captain of the *Bounty* on Cook's third and final voyage; Henry Cavendish (1731–1810), prominent physicist and chemist who had determined the density of the earth and established that water is a compound; Sir William Herschel (1738–1822), the foremost astronomer of his day; and Sir Joseph Banks (1743–1820), a leading English naturalist and longtime president of the

10. Botting, *Humboldt and the Cosmos*, 16–19.
11. For more on Forster's profound influence, see Ackerknecht, "George Forster," 83–95. "Forster was able to impress upon Humboldt some of his basic approaches: his all-embracing tendency in science and his combined literary and scientific method. The influence of Forster's 'Voyage' is easily recognized in Humboldt's 'Voyage.' Humboldt's famous 'Kosmos' is a grandiose elaboration of Forster's 'Blick ins Ganze der Natur.' Forster remained the better writer, while Humboldt became by far the greater scientist. Nobody has been more explicit as to his indebtedness to Forster than Humboldt himself." Ackerknecht, "George Forster," 87.

Royal Society. Banks immediately recognized in the young Humboldt a kindred spirit. An avid botanist and inveterate collector, Banks had also accompanied Captain Cook aboard the *Endeavour* and later sailed to Iceland and Newfoundland. He became a lead player in establishing the Royal Botanic Gardens at Kew, near London. Banks took special tutorial delight in showing his younger visitors his magnificent herbarium (then the largest in the world) and his vast botanical library.

Upon their return to their homeland, Forster could not refrain from preaching the liberal reforms and ideals of the French Revolution to a wary, suspicious, and much more autocratic Prussia, so much so that he was arrested and branded a traitor to Germany. Tragically Forster died not long afterward in miserable circumstances at the age of forty.

Forster's sad end taught Alexander a stark lesson of another kind—to separate science and the study of nature from the more unpredictable, unforgiving, and unsavory variables of human politics. While he may have held deep liberal convictions, he understood that discretion would be the better part of discovery and quiet, measured common sense the best friend of scientific observation. He saw early in his career that science had its enemies, be they the jealousies and political intrigues among nations and peoples or the long-established doctrines and traditions of some religions that resisted any new theories or findings that might cast doubt on their particular claims to biblical authority.

Alexander became "almost manic about learning," spending his days and nights reading and researching, comparing and analyzing, working late into the night, rising early, eating quickly, and forging study habits that would last a lifetime. Before he was twenty-five, he had authored three books and a dozen articles. He thrived on doing many things at once. As Wilhelm put it, "Alexander maintains a horror of the single fact. He tries to take in everything."[12] And as Alexander himself admitted, "There is a drive in me that, at times, makes me feel as though I am losing my mind."[13]

Rather than follow his mother's wishes for him to prepare for a career as a civil servant, in 1791 he opted to study mining and geology at the Frieberg Mining Academy under the tutelage of the highly popular Professor Abraham Gottlob Werner (1749–1817), a founder of German mineralogy and the Neptune school of geology. Alexander completed this normally three-year course of instruction in less than twelve months, whereupon he became a mining inspector, though of a distinctly different sort than most. While mastering the practical problems of subsurface mining, he was always recommending improvements, including safer gas masks and better safety lamps. While wandering the drifts and stopes below ground, he was as much geologist as he was mining engineer. He studied plant crystallizations underground with the same furious interest and avidity as he did plant clusters above ground. It was while working underground that he began to formulate correlations between the world above and the one below, between living plants and their petrified cousins, and between subterranean gases and the quality of the atmosphere. Because of his sensationally

12. Helferich, *Humboldt's Cosmos,* 9.
13. Helferich, *Humboldt's Cosmos*, 14.

detailed reports and "heroic perseverance and exuberance," Humboldt quickly gained the respect of his supervisors and became assessor in the Prussian Mining Service at age twenty-two. Before long, he became superintendent of mines in two duchies and found time to write a mining textbook.[14]

In 1794, the famed German poet Johann Wolfgang von Goethe (1749–1832) sought Humboldt out. Though he was yet to write *Faust*, Goethe had already fashioned an almost godlike reputation. The two men hit it off famously. Alexander's zest for discovery and the accurate recording of scientific data led Goethe to describe him as "our conqueror of the world." Goethe gushed in saying, "what Alexander says in one hour could not be read in eight days reading."[15] Alexander rekindled Goethe's interest in plants and biology, while Goethe, for his part, instilled in his new friend the Romantic ideal that a "primeval principle"[16] and essential unity infused all nature and that nature needed more than mere measurement—it required contemplation, deep enjoyment, and poetic expression.

Goethe's colleague, the Romantic poet Friedrich Schiller (1759–1805), was far less impressed. Coarchitect of the natural philosophy school of thought, Schiller believed that the scientific measurement of nature was an irreverent distraction from its primary purpose of shedding inspiration and revelation on the human soul. Any effort to simply study and measure nature in a scientific way was to him mere rubbish and a waste of time, like measuring the dimensions of the *Mona Lisa* without savoring the sublime beauty of the painting.

For his part, Humboldt considered Schiller and the natural philosophy school of thought to be sentimental sloppiness. Humboldt was a man given to facts and careful observations, not to poetry and vacant imaginations, what Botting called "the difference between a romantic poet and an empirical scientist."[17] Yet such a contrast is probably overblown. For the truth is, Alexander was deeply impressionable. For him, the quest for the scientific knowledge of nature was inspiration enough. He and Goethe would remain in contact one with another for years to come.

"HIS APPRENTICESHIP WAS OVER": IN SEARCH OF A MISSION

In 1796, when Humboldt's mother died of breast cancer, he found it hard to grieve her passing. "My heart could not have been much pained by this event," he later admitted, "for we were always strangers to each other."[18] Her death, however, opened new and unlimited horizons for him and his brother, Wilhelm, because they inherited the family estate and a sizable fortune.

14. McCrory, *Nature's Interpreter*, 36–40.
15. McCrory, *Nature's Interpreter*, 51.
16. McCrory, *Nature's Interpreter*, 50.
17. Botting, *Humboldt and the Cosmos*, 40.
18. Helferich, *Humboldt's Cosmos*, 16.

Gladly quitting his mining position, Humboldt, then only twenty-seven, visited his brother and family in Jena, climbed Mount Vesuvius in Italy, then eyed a trip to the West Indies. In gleeful preparation for further adventures, he purchased a vast assortment of the latest magnetic, geographical, and meteorological instruments. He also spent time in Austria and Paris in company with such other leading scientists as Professor Franz Porth and the eccentric geologist Leopold von Buch (1774–1853). Buch taught him how to use a sextant, how to calculate elevation and precise readings of longitude and latitude, how to measure barometric pressure and fluctuations in temperature, how to determine the oxygen and carbon dioxide content of the air, and much more. It was an outdoor schooling in the Tyrolean Mountains of meteorology at its scientific best. Because of it, Humboldt developed a program of readings that was to become "the universally accepted procedure for meteorological observations all over the world."[19]

When word came that the English Navy, wary of Napoléon's intentions, had barricaded the West Indies, Humboldt was invited to join the notorious Lord Bristol, bishop of Derry (1730–1803), on a caravaning expedition up the Nile. But Napoléon's massive military buildup and surprise 1798 invasion of Egypt spoiled even that attempt.

All dressed up with nowhere to go, a frustrated but still determined Humboldt returned to his beloved Paris. As the intellectual, artistic, and social capital of Europe, the city was teeming with artists and scientists from all over the world, many of whom were already acquainted with his work. Georges Cuvier (1769–1832), founder of comparative anatomy, had just published his *Tableau élémentaire de l'histoire naturelle des animaux* (1798) on the classification of various groups of animals. Cuvier would go on to become famous for studying extinct mammals and reptiles, and by 1820 he had laid the foundation for modern paleontology. Cuvier advised Humboldt on equipment purchases and drew his attention to the need of studying the earth's magnetic fields. With plenty of time on his hands, Humboldt also studied with Jean-Baptiste Delambre (1749–1822), a leading mathematician and historian of astronomy; Claude Louis Berthollet (1748–1822), a chemist; and the famed Jean-Baptiste Lamarck (1744–1829), a renowned zoologist, botanist, early evolutionist, and chair of zoology at the Jardin du Roi. Lamarck's study of invertebrates—a term of his own invention—and his conclusion that "the production of a new organ in an animal body results from a new need" foreshadowed Darwin's evolutionary thesis by fifty years.[20]

Meanwhile, the busy Paris rumor mill had it that the French government was about to dispatch the famous navigator and explorer Louis-Antoine de Bougainville (1729–1811) on a five-year voyage of discovery to the Pacific Ocean, the unchartered waters of Antarctica, and the lands of South America, Mexico, California, and Africa. Bougainville, one of Humboldt's childhood heroes and one who had fought in 1759 with Louis-Joseph de Montcalm-Grozon, marquis de Montcalm, against Major General James Wolfe and the British at the Plains of Abraham, approached Humboldt and invited him to join his scientific staff. Overjoyed at the

19. Botting, *Humboldt and the Cosmos*, 53.
20. Williams, *Biographical Dictionary of Scientists*, 303.

prospect, Humboldt eagerly agreed but at the moment of departure, Bougainville was suddenly replaced by the much lesser known Captain Nicolas Baudin (1754–1803). Humboldt's dreams of discovery were shattered once again when Napoléon invaded Austria and diverted the monies that had been earmarked for the expedition into supporting his military conquests. No one walked down the ship's gangplank with a heavier heart than did our crestfallen Humboldt.

Determined not to let a minor detail such as Napoléon's conquest of Europe get in his way, Humboldt hurriedly made other plans. While staying at L'Hotel Boston in Paris, he had the good fortune of meeting Baudin's ship doctor and botanist, Aimé Jacques Alexandre Bonpland (1773–1858), four years his junior. A cheery sort of man with dreams of adventure almost as bold as Humboldt's, Bonpland would prove the perfect partner. The two men soon became fast friends and together planned to make their own kind of conquests by sailing to Algeria on board a neutral Swedish packet boat and then on to Cairo to join up with Napoléon's army of scientists, where they would then travel up the Nile (see chapter 2).

Alas, that plan also failed to materialize when the promised vessel ran aground off of Portugal. So now what? Paris was a troop encampment, Berlin was braced for a coming invasion, London was madly preparing for war, and Algeria was imprisoning French civilians—where else to go but Spain? It was worth a try, so the two men, with their bulky instruments, quit Marseilles and crossed over the Pyrenees on foot. In the best Forster tradition, they took more careful scientific observations of the Spanish peninsula than had ever before existed. Their expedition proved that Spain's interior was one high continuous plateau, and in the process, Humboldt and Bonpland earned a reputation for themselves as Europe's "most meticulous and well-trained travelers." As Botting succinctly concluded, "Humboldt's apprenticeship was over."[21]

Once Humboldt and Bonpland arrived in Madrid, the Saxon ambassador to Spain, Baron Philippe de Forell (1756–1819), introduced Humboldt to the Spanish prime minister, Mariano Luis de Urguijo (1769–1817), who in turn introduced Humboldt and Bonpland, as Humboldt's "secretary," to King Carlos IV (1748–1819) and Queen Maria Luisa (1751–1819) at the Court of Aranjuez in March 1799. Sensing that this was the opportunity of a thousand lifetimes, Humboldt determined to make the best of it. Speaking fluent Spanish and showing his wonderfully detailed new maps of Spain, he proposed a plan to visit the Spanish-American colonies and the Philippines and to make key studies and observations for the Spanish crown, all at his own expense, if necessary.

Convinced that they were not spies, the king listened sympathetically, but for other reasons. Humboldt's reputation as a mining engineer and explorer had preceded him, and the king, sensing that Spain was lagging behind the other European powers in science and technology, saw in Humboldt the potential for charting new territories, encouraging science, and discovering new gold and silver mines. So here we find this incredible spectacle of a Prussian Protestant and a French sailor being granted royal passports and unlimited

21. Botting, *Humboldt and the Cosmos*, 62.

Alexander von Humboldt and Aimé Bonpland at the Foot of the Chimborazo Volcano, by Friedrich Georg Weitsch (1806).

permission to visit, study, and observe every Spanish colony from Cape Horn to California—the entire Spanish Catholic empire in the Americas! And all at Spain's expense! And Humboldt, who was not given to religious devotions, could only kneel in gratitude. In over three hundred years of Spanish rule, no other man had ever been given such permission and such an incomparable opportunity.

THE SCIENTIFIC DISCOVERY OF THE NEW WORLD

Humboldt's and Bonpland's five-year exploration of South America and Mexico was to Latin America what Lewis and Clark's expedition became to the United States and what Alexander Mackenzie's expedition became to Canada—a portent of the discovery and creation of a national identity. But similar to Captain James Cook, Humboldt's and Bonpland's quest for pure scientific knowledge, their meticulous observations, and their careful mathematical readings and measurements established a standard of excellence, a strident methodology for all such future expeditions. Far more than mere travelers and explorers, Humboldt and Bonpland became the prototype of scientific adventure. They laid the cornerstones of

climatology, meteorology, oceanography, geomagnetism, anthropology, geology, and modern plant science. Rapidly becoming the leading naturalists of their day, they would set a standard for all to follow.

Humboldt's devotion to writing and illustrating his adventures and discoveries and their publication in newspapers all over Europe and in North America made him an international celebrity. He popularized the world of scientific observation as never before. To this day, more places on the earth and on the moon are named after him than any other figure in history.[22] Humboldt's and Bonpland's adventure is, indeed, one for the history books. They set sail from A Coruña, Spain, on 5 June 1799 on board the corvette *Pizarro*, bound for the New World like a modern Columbus.

Laden with sextants and quadrants, balances and compasses, barometers and thermometers, telescopes and microscopes, hygrometers and magnetometers, rain gauges and theodolites, Humboldt and his loyal assistant proved a fascinating spectacle for sailors and sojourners alike—a veritable floating scientific laboratory. And Humboldt soon lived up to his reputation. Spending his days and nights sounding sea depths and ocean salinity, making astronomical readings, and gauging changing ocean temperatures, Humboldt kept meticulous notes on most everything. He was especially interested in studying and mapping ocean currents, those rivers of moving waters—like jet streams—beneath the surface of the sea that moderate temperatures and affect sea life throughout the oceans. "Every motion is the cause of another motion in the vast basin of the seas,"[23] he penned. When once the ship captain ordered all lanterns out lest they be detected by nearby British naval ships, no one was more frustrated at this waste of time than Humboldt was. So he went on deck and studied the starry firmament.

At their first port of call in the Canary Islands, dressed in his customary open-necked shirt, loose striped trousers, short jacket, high black hat, and tall boots with the tops turned over, Humboldt gave hint of things to come when he spent his shore leave climbing the 12,200-foot volcano Mount Teide on the isle of Tenerife—his first volcano climb of many. Twenty days later, after picking up the trade winds and following the same route of Columbus's first voyage, they crossed the equator into the southern hemisphere. One night, while out on deck, Humboldt put down his telescope to record his feelings at seeing the Southern Cross constellation for the first time. "Nothing awakens in the traveler a livelier semblance of the immense distance by which he is separated from his country, than the aspect of an unknown firmament."[24] When at length they reached the West Indies, they chose not to disembark at Havana, Cuba, as per their original plan, because of a typhus epidemic. The ship changed course, reaching Cumaná, Venezuela, on 16 July 1799, the oldest continuously inhabited settlement in South America.

22. Helferich, *Humboldt's Cosmos*, xvii, 25.
23. Humboldt and Bonpland, *Personal Narrative*, 1:19.
24. Humboldt and Bonpland, *Personal Narrative*, 1:134.

Humboldt and Bonpland were giddy with excitement at having seen the tropics and the southern night sky for the first time. The sights and sounds, fruits and flowers, and rocks and mountains of the New World beckoned them onward. There they began to collect the first of what would be tens of thousands of plant specimens to eventually take or send back to Paris, many of which had never before been classified. "It might be said," Humboldt recorded, "that the earth, overloaded with plants, does not allow them space enough to unfold themselves."[25] The only thing that marred their stay at Cumaná were the notorious slave markets, a spectacle of human indignity that the liberal-minded Humboldt detested and decried. He hated slavery and racial prejudice of any kind but was careful not to mix politics with science, lest their ever-watchful Spanish authorities renounce their passports.

From Cumaná the expedition moved on to Caracas, where, after a short stay, they temporarily gave up the idea of going to Cuba and instead set out southward to explore the rain forests of the Amazon and the upper reaches of the Orinoco River. The Orinoco was to Venezuela what the Amazon was to Brazil, and local legend had it that "he who goes to the Orinoco either dies or comes back mad."[26] To reach their goal, they would first have to traverse the feared Llanos, a plains region larger than France. Come the rainy season, it was transformed into a sea of infinite archipelagos teeming with crocodiles, snakes, electric eels (*tembladores*), giant rodents, jaguars, venomous bats, piranhas, mosquitoes, and millions of other insects—not a journey for the fainthearted, as even Bolívar discovered. When their horses were crossing a stream, they were stung almost to paralysis by swarms of electric eels. Humboldt once picked up one of the eels barehanded to measure the six-hundred-volt transfer. It almost killed him. Their security dogs were sometimes carried off at night by prowling jaguars, and only their nighttime bonfires kept hungry crocodiles and deadly vipers at bay. While on the rivers, they traveled with natives in large canoes (*lanchas*) through piranha-infested waters, their makeshift, screen-covered cabin headquarters at the rear, often with anacondas swimming at their sides. For Humboldt, who could not swim, the rivers proved most challenging, and those on the expedition were indeed fortunate to survive. As one scholar has rightly noted, "Against some of the most inclement conditions to be found anywhere on earth they were armed with nothing but their sense of humour, their *joie de vivre*, and their unquenchable enthusiasm for scientific discovery."[27]

Choosing not to sail down the Amazon into Brazil, a Portuguese colony that would not have recognized their Spanish passports and likely would have thrown both Humboldt and Bonpland into jail, they explored the Rio Negro (see map on p. 210), portaging around great cataracts and endless rapids. They eventually proved the existence of the Casiquiare Canal, which connected the Orinoco River basin with the Amazon River Basin. At almost every stop, Humboldt recorded his observations in such a hurried scrawl and in so many different languages (though mainly in French) that few others besides himself would be able to

25. Humboldt and Bonpland, *Personal Narrative*, 1:216.
26. Helferich, *Humboldt's Cosmos*, 124.
27. Botting, *Humboldt and the Cosmos*, 104.

decipher them.[28] Seventy-five days and 1,500 miles later, they finally reached the port city of Nueva Barcelona at the end of August 1800 with a collection of twelve thousand specimens of plant and animal life—and almost an equal number of stories to tell.

After sending his manuscripts, herbariums, geological specimens, native skeletons, caged monkeys, and much more back home to Europe on three different ships for fear of the British naval blockade, sinkings, piratings, and any number of other potential calamities, Humboldt and Bonpland set sail for Cuba, their original destination.[29] From there Humboldt's plans were to explore Mexico, the west coasts of America, the Philippines, and the East Indies before returning home.

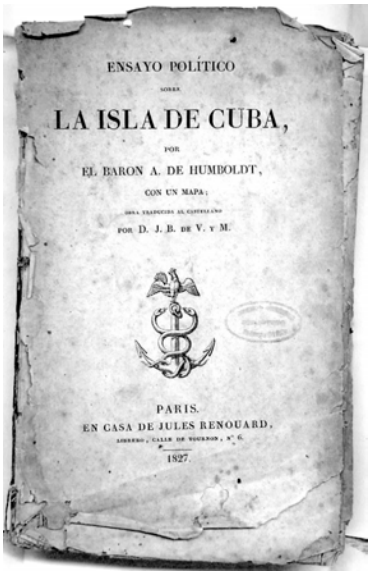
En route to Havana, Bonpland and Humboldt had the hair-raising misfortune of being attacked and seized by pirates but then the great fortune of being liberated almost immediately thereafter by a British sloop of war under the command of a Captain Garnier. As fate would have it, Captain Garnier was a devotee of his celebrated prisoner, having read almost every newspaper account of Humboldt's South American exploits. Spending hours together, the two men became fast *bons amis* and relished in their mutual good fortune.

Upon reaching Cuba near the close of 1800, Humboldt spent several weeks surveying the entire island, recalculating local latitudes and longitudes, improving and correcting maps, sounding out depth readings of Havana harbor, studying sugar cane and slave-holding plantations, and completing enough other studies to eventually publish his *Political Essay on the Island of Cuba* (1828). Never had anyone so carefully studied the "pearl of the Antilles" as did this "second discoverer of Cuba."[30]

When word came that Captain Baudin's around-the-world exploration had been funded after all, Humboldt abandoned his North American plans. The projection now was that after a three months' exploration of the Andes and some of the highest volcanoes in the world, they would rendezvous with Baudin in Lima, Peru. So they turned around and set sail for South America once again.

Humboldt had a clear plan of what he wanted to accomplish in his "Andes project." By carefully studying volcanoes, Humboldt planned on correlating what species of plant life existed at similar elevations and in comparable climates. He planned to test his theory of isothermal ranges of plant geography and hoped to show cartographically that similar plant life existed at the same elevations, zones, and temperatures all over the world in surprisingly consistent isothermal lines and patterns. Later publishing his findings in his *Essay on the Geography of Plants* (1807), complete with its stunning tables and illustrations, he was the first to systematically study why different plants grew where they did, such as deciduous and broadleaf trees on lower hills and conifers at higher altitudes.

28. Helferich, *Humboldt's Cosmos*, 142.
29. His collection of insects was lost at sea, and another collection was captured by the British Navy, but thanks to Sir Joseph Banks it was eventually returned to its rightful owner.
30. Helferich, *Humboldt's Cosmos*, 203.


ENSAYO POLÍTICO
SOBRE
LA ISLA DE CUBA,
POR
EL BARON A. DE HUMBOLDT,
CON UN MAPA:
PARIS.
EN CASA DE JULES RENOUARD,
1827.

Political Essay on the Island of Cuba, by Alexander von Humboldt.

As for volcanoes, to Humboldt, each merited study. Comparing their perpendicular heights to their base circumferences and climbing and exploring almost every foot of terrain, the intrepid Humboldt was most interested in studying lava formations and outcrops at all levels of the mountainside, since currents of volcanic lava as often as not poured out of the cracks at the base of such mountains as at the top. His daring solo climb of Mount Chimborazo, at 20,702 feet then considered the highest mountain in the world, and of Mount Pichincha and others earned him lasting fame as the world's foremost mountain climber and one whose hands were often frost bit from the cold air but whose feet were on fire from the heat of the volcano.

From his many ascents, Humboldt revolutionized the science of geology by arguing in his three-volume *Personal Narrative of Travels to the Equinoctial Regions of America* (1818) that the "Neptune theory" of volcanic origin, that is that volcanoes were ancient accidents of subterranean coal fires, was false. Rather, Humboldt proposed that volcanoes are the result of far more modern, even current, extensive and interconnected worldwide geological activity and that they originated as violent lava upheavals from fissures or cracks along the crust or platelets deep within the earth. This explained why volcanoes were often found in clusters or series, such as along the west coasts of the Americas. Humboldt thus came to espouse uniformitarianism, the scientific theory that the processes that shaped the earth are still at work, constantly changing the earth's landscape and topography. His findings anticipated those of Sir Charles Lyell (1797–1875), the most famous geologist of the later nineteenth century, and Darwin's more zoological-based study of ever-evolving organic species and life formations.[31] While studying in Peruvian mountaintops, Humboldt also discovered the location of the earth's magnetic equator and the existence of magnetic storms, which are caused by sudden releases of ultraviolet radiation from the sun.

Eventually reaching Lima, Peru, in October 1802, some 1,600 miles from Cartagena, a leaner, lighter Humboldt and his well-nigh exhausted partner, Bonpland—who had foregone the pleasure of volcanic climbing for collecting plants at lower altitudes—rested, but not for very long. Upon learning that Baudin had changed courses and was not coming after all, the ever-resourceful Humboldt took the disappointing news in stride by studying intently the ancient Incan civilizations, starting at the palace Tapayupangi. Although it had been conquered relatively recently by Pizarro and the Spanish conquistadores in the 1530s,

31. Helferich, *Humboldt's Cosmos*, 231.

the ingenious Incas had once wielded enormous power and influence in establishing their civilizations in the very tops of the Andes. From his careful study of their language, and miles and miles of roads, architecture, and gardens, Humboldt argued that such peoples were not the blighted and backward natives some insisted on but rather were once "a very advanced civilization."[32]

Humboldt was among the first to argue that these indigenous people had migrated from eastern Asia long ago, likely crossing the Behring Straits and establishing colonies of various advanced civilizations from north to south and along the western coastal regions of the hemisphere. "A darker shade of skin color [was] not a badge of inferiority," he asserted. His writings speak less of differences between races and more of similarities. He saw all humankind, whether ancient Egyptians or the more modern Incas, as brothers and sisters in one vast network of humankind. More than a casual anthropologist, this "self-proclaimed child of the French Revolution" was "the first prominent European to appreciate the great indigenous cultures of the New World."[33]

Humboldt pursued the same kind of anthropological studies among the Aztec ruins of New Spain (or Mexico)—the crown jewel of Spain's New World—where he and Bonpland arrived in late March 1803. After spending most of the year studying gold and silver mines, Humboldt made several recommendations for King Carlos IV on how Mexico—then a country of 5.2 million people—could be even more productive and profitable. Just as he had done previously in Spain and in Cuba, his careful land and typographical surveys of Mexico from Acapulco to Mexico City and eventually to the east coast city of Veracruz formed the basis of future cartographic Mexican studies for decades to come. As much as he saw a bold future in Mexican mining, he saw even more potential and wealth in developing Mexican agriculture. Humboldt's work left such a profound impression on Mexico that he was offered a ministerial position in the government. Just fifteen years later in 1820, leaders of Mexico's independence movement adopted Humboldt as their national hero because of his republican ideals and faith in their future, calling him the "benefactor of the nation."[34]

One of his primary interests in Mexico was his study of the ancient Aztec empire and its people. Like the Incas, the Aztec empire flowered relatively recently, with Montezuma II on his temple throne in their capital city of Tenochtitlán—later Mexico City. A violent and religious people, the Aztecs had once sacrificed hundreds of thousands of hapless victims to their great sun god on the steps of their soaring temples. Like the Incas, the Aztecs had no wheeled vehicles, no arches, and no metal tools, but they were magnificent builders and astronomers. Especially advanced in reckoning time and the movements of the earth around the sun, the Aztecs had devised a solar calendar year of 365 days, divided into 18 months, each of 20 days, with the final five days of the year added at year's end. Each day of the month

32. McCrory, *Nature's Interpreter*, 101.
33. Helferich, *Humboldt's Cosmos*, 261–62.
34. Helferich, *Humboldt's Cosmos,* 291–92. For a much fuller discussion of Humboldt's contributions to "New Spain" (Mexico), see Helferich, *Humboldt's Cosmos,* 264–87.

had its own name. The Aztecan festivals were all based on their solar calendar.[35] Conquered by a ruthless Cortes in 1519, which resulted in the slaughter of some 250,000 people, the Aztecs quickly declined and their past glory was but a memory by Humboldt's time. A fan of neither Pizarro nor Cortes, Humboldt was just as critical of their Roman Catholic successors, whose dogma and ceremonies, he believed, were no better than those that lay at his feet in ruins.

Humboldt was to ancient Latin America what Champollion had become to ancient Egypt—the pioneer of discovery (see chapter 2). From his careful study of Aztecan art and writings, Humboldt concluded that they were "the debased remnants of a more advanced nation."[36] He also believed that their hieroglyphics, if not an alphabet, were a system of symbols to perpetuate memories of their past as well as to represent the state of the soul after death. His careful studies became the inspiration for a long list of later scholars who were interested in uncovering the deeper secrets of the ancient Aztec Empire.[37]

In his *Political Essay on the Kingdom of New Spain* (1814), Humboldt wrote that the "nations of America . . . form a single race," that they crossed over the Behring Straits, and that they owned a striking resemblance to the Mongol nations from which they most likely

Storming of the Teocalli by Cortez and His Troops, by Emanuel Leutze.

35. Humboldt, *Researches*, 1:390–93.
36. Helferich, *Humboldt's Cosmos*, 237.
37. Humboldt, *Researches*, 1:147, 160.

sprang.[38] He ended his study of modern Mexican native populations with a plea for equality: "The prosperity of the whites is intimately connected with that of the copper-colored race, and there can be no durable prosperity for the two Americas till this unfortunate race, humiliated but not degraded, shall participate in all the advantages resulting from the progress of civilization and the improvement of the social order."[39]

"HALF AN AMERICAN"

Humboldt's six-week visit to the United States of America on his way home to Europe left an indelible impression on the young republic. An ardent admirer of the aims and ideals of the American Revolution and of President Thomas Jefferson (1743–1826), who was a student of science himself, Humboldt first visited the American Philosophical Society in Philadelphia. There he met with such leading American naturalists, linguists, and scholars as Caspar Wistar and Samuel Latham Mitchill, the latter of whom was arguably America's foremost naturalist and whom Jefferson once called "a chaos of knowledge."[40]

Humboldt and Bonpland then traveled on to Washington, DC, the nation's capital since only 1800. Humboldt and Jefferson spent many hours together in Washington and at Monticello. Jefferson, who had just completed the Louisiana Purchase and whose own Lewis and Clark expedition was then exploring its way up the Missouri River, had intently followed Humboldt's Latin American exploits and was particularly interested in his maps of Mexico and his studies of Mexican land claims, extremely valuable information which Humboldt freely shared. To Humboldt's way of thinking, all scientific knowledge should be freely communicated. From this brief meeting, a lifelong friendship developed between Humboldt and Jefferson, to be marked by a lively exchange of ideas in twenty years of correspondence.[41] Of their meetings Humboldt wrote, "I have had the good fortune to see the first Magistrate of this great republic living with the simplicity of a philosopher who received me with that profound kindness that makes for a lasting friendship."[42]

Humboldt saw in America a political model for the realization of his liberal ideals. Furthermore, he greatly admired the new republic's rapid progress in the sciences, education, and culture. As Humboldt often said of himself, he was "half an American."[43] Only the

38. Humboldt, *Researches*, 1:147.
39. Humboldt, *Political Essay*, 240.
40. This same Professor Samuel L. Mitchill in February 1828 met with Martin Harris, early scribe to Joseph Smith's translation of the Book of Mormon. Mitchill compared the characters that Harris showed to him and to his younger colleague, Charles Anthon, to the writings of Champollion, and set them down to an ancient, "delicate" people who once lived in the America's but who long ago had been destroyed by the "Tartars," a more warlike Asiatic people. For more, see Bennett, "'Read This I Pray Thee,'" 178–216.
41. Rebok, "Enlightened Correspondents," 328–69.
42. Malone, *Jefferson the President*, 421–22.
43. Rebok, "Enlightened Correspondents," 333.

continued existence of slavery—America's tragic flaw—marred his otherwise glowing regard of the new nation.

Humboldt's work would live on in America for years to come. Henry Thoreau (1817–62), Washington Irving (1783–1859), Walt Whitman (1819–92), Ralph Waldo Emerson (1803–82), and Albert Gallatin (1761–1849), Jefferson's secretary of state, studied Humboldt intently. He became the inspiration for the expedition of Zebulon Pike of 1806, and his work with the Aztecs later motivated John Lloyd Stephens (1805–52) to rediscover the Mayas. The great American landscape painter Frederic Church (1826–1900), of the Hudson River School (see chapter 5), owed much of his inspiration for his masterpiece *Heart of the Andes* and other paintings to Humboldt. Humboldt's reputation in America lived on till as late as 1869, when Oliver Wendell Holmes called him the "hero of knowledge" and the "peaceful conqueror."[44] It would take the decline of transcendentalism, two world wars against Germany, and the rise of anti-German xenophobia to dismantle and disfigure America's nineteenth-century admiration for the great Prussian discoverer.[45]

Humboldt had come to personify the careful study of nature, the making of discoveries, and the laying down of new scientific laws that had caught the imagination not only of Americans but of the whole world. Many since have called his approach Humboldtian science, with its key elements being exploring, collecting, measuring, and connecting.[46] To these he would later add publishing, lecturing, promoting, and encouraging. Just as Charles Lindbergh (1902–74) would herald a new age of international flight and aeronautics in the twentieth century, Humboldt was changing the way the early nineteenth century looked at science by trusting in those new discoveries and emerging technologies that would change the world.

THE BUDDING AGE OF SCIENCE

Our study of Humboldt begs at least a cursory overview of the world of science as it stood in the era of 1820. Professional scientific journals were just beginning to appear, and scientific associations were forming on a broad international scale. The age was witnessing the beginnings of a new era of accelerated revolutionary advances and discoveries, only a few of which can be studied here.

Nineteenth-century astronomy obtained its most spectacular results in positional astronomy. This included the study of celestial mechanics—with its mathematical research into the perturbations of planetary motion and the motion of the sun—of stellar distances and of the charting of stars, galaxies, new nebulae, and even black holes. Best remembered for his fundamental contributions to mathematical physics and celestial mechanics and for

44. Walls, *Passage to Cosmos,* 310.
45. Walls, *Passage to Cosmos*, 129, 165–67, 224, 252, 268, 302, 310. Walls's work is probably the most definitive study yet written on Humboldt's influence on American thought.
46. Walls, *Passage to Cosmos*, 126–27.

proving the stability of the solar system was Pierre-Simon Laplace (1749–1827). A worthy successor of Sir Isaac Newton (1642–1727), Laplace developed stunning mathematical methods for calculating the disturbances of planets and moons by their gravitational forces. His work included the development of lunar and tidal theory and a careful study of the moon's gravitational impact on the motion of the earth and on the long-term stability of the solar system. In his *Mécanique Céleste* and his *Théorie analytique des probabilités*, the latter published in five volumes between 1799 and 1825, Laplace developed the "calculus of probability" based on his theory of "enchained probabilities," upon which nearly all later developments in the theory of probability are based.

Karl Friedrich Gauss (1777–1855), the "prince of mathematics," must be compared to Archimedes and Newton. "With few peers and none in the theory of numbers," Gauss was led to the study of advanced algebra and differential and hyperbolic geometry. Director of the Göttingen Observatory for many years, Gauss fathered the Quadratic Reciprocity Theorem. Much of modern mathematical physics and Einstein's theory of gravitation would hardly have been possible without Gauss's pioneering mathematical work.[47] Gauss's calculations in astronomy led to his discovery of a wide band of asteroids and planetoids between the orbits of Mars and Jupiter and to the eventual mathematical discovery of the planet Neptune.

The leading figure in nineteenth-century astronomy was undoubtedly the German-born Sir William Herschel (1738–1822). A professional optician, Herschel developed a passion for the study of mirrors and for constructing bigger and better telescopes. Peering through his seven-foot telescope, he discovered the planet Uranus in 1781. Later on, with his twenty-foot telescope, he embarked upon a lifelong, systematic quest to catalogue and classify the distribution of the stars by their brightness down to the fourteenth magnitude. Herschel named and located over five thousand new stars, and his stellar maps and minute study of the Milky Way are foundational to the mapping of modern astronomy. He furthermore suggested the name *asteroids* for those tiny fragments of planets long ago shattered by explosions. Through careful, persistent charting of the heavens, he proved that the sun and stars are not fixed but are moving through space.[48]

The year 1790 began one of the "most brilliant periods in the history of science," culminating in the discovery of the battery and current electricity and of the relationship between electricity and magnetism—in short, "the birth of the modern electrical industry."[49] One could argue that the present-day computer age, based as it is on electricity, began in this age 1820. The four leading pioneers in this scientific revolution were Italy's Alessandro Volta (1745–1827), Denmark's Hans Christian Ørsted (1777–1851), France's André-Marie Ampère (1775–1836), and England's Michael Faraday (1791–1867).

While electricity was well known before the nineteenth century, it had never before been created in a laboratory setting. No other source for it besides the atmosphere and lightning

47. Williams, *Biographical Dictionary of Scientists*, 207–9.
48. Taton, *History of Science*, 102–28.
49. Taton, *History of Science*, 178.

had yet been discovered. Thus, any continuous or controlled use of it had not been achieved. It was Alessandro Volta who harnessed, controlled, and generated electricity as never before. Building on the earlier experiments of his fellow countryman Luigi Galvani (1737–89), who worked on the electrical stimulation of animal muscles, Volta discovered in 1796 that certain series of metals (zinc, carbon, and copper) suspended in an aqueous acidulated solution could create a steady current of electricity. His voltaic pile, or early electric battery, provided a steady and reliable new source of energy that allowed for the study of the phenomena of flowing electricity and what could be accomplished and achieved with it. With his electrometer and condenser, Volta was able to measure the flow and intensity of atmospheric electricity. Some contend that his letter of discovery on 20 March 1800 to the Royal Society of London ushered in the age of electricity.[50]

Sir William Herschel and Caroline Herschel, by A. Diethe.

Hans Christian Ørsted's subsequent accidental discovery of the magnetic effects of electric currents in 1819 owed much to Volta's battery. Ørsted clearly saw that the newly discovered electrical currents moved in circles around the conductor, thus showing that an electric current produces a circular magnetic effect as it flows through a wire. Electricity, therefore, and magnetism were intimately related one to another.

André-Marie Ampère of Lyons took Volta's and Ørsted's pioneering work to the next level. While Volta supplied a new reliable source for electricity and Ørsted a new way to apply it, Ampère found in September 1820 that parallel currents in the same direction attract one another, while those in opposite directions repel one another. From this discovery he demonstrated that parallel currents acted as magnetic poles and that currents could be made to attract or repel one another, thereby changing the direction of the flow of electricity. With wires bent into circular form and with coils consisting of many circular windings, Ampére was able to set contrasting magnets into spinning motion, giving rise to the study of electrodynamics. The potential applications of his discovery were enormous.

50. Lenard, *Great Men of Science*, 158–67.

In the following year, thirty-year-old Michael Faraday, carried out a series of magnificent experiments on electromagnetic rotation. A laboratory assistant of Sir Humphrey Davy, Faraday proved that a magnetic pole can be made to spin or rotate around a wire carrying an electric current. He thus essentially produced electricity from magnetism and in the process created the first electric motor. His work with electromagnetic induction led him into an investigation of the laws of electrolysis, an entirely new method of producing electric currents that opened the way to the new world of electrodynamism.[51]

Contemporaneous advances in chemistry were hardly less impressive than those in astronomy and electricity. The Quaker John Dalton (1766–1844) in his *New System of Chemistry* proposed his "atomic hypothesis," where he stated that each atom within a certain chemical compound has a "characteristic relative weight."[52] Dalton concluded that heat is not so much the result of friction as it is the property of gases, thus providing for "the classical hypothesis of the atomic constitution of matter."[53] This laid the foundation for the modern constitutional theories of chemistry.

Using the Voltaic battery and building upon Dalton's studies, Jacob Berzelius (1779–1848) of Sweden was the first to show that properties of the atom appeared capable of deduction and that atoms of a particular element are held together in molecules by electric forces.[54] Berzelius is credited for devising the modern chemical tables so popular today when in 1818 he published his *Essays on the Cause of Chemical Proportions*, which contained a table of Latin initial letters of atomic weights with the combination of gases by volume—for example, H_2O or CO_2.

Humphrey Davy (1778–1829), a friend of Southey and Coleridge (see chapter 6) and as much a poet as he was a scientist, was already well known for his studies with nitrous oxide, or laughing gas. By using Volta's new source of battery-powered electricity, Davy was enabled in 1807 to separate chemical elements on a scale larger and at speeds faster than ever before. His pioneering work with electrochemistry led to isolating elements never before separated and inspired his discovery of potassium and the separation of sodium from many chemical combinations. Davy discovered that light was not a modification of heat as much as it was a constituent of oxygen and that heat was not a substance but a form of motion. Thus, Davy was a pioneer in the study of electrolysis, which has led to such modern activities as copper, silver, and gold refining, electroplating, electrotyping, and other beneficial commercial processes.[55]

In the field of light and fundamental optics was Thomas Young (1773–1829), who competed with Champollion in decoding the Rosetta Stone (see chapter 2). Building on Newton's *Optics* and the earlier works of Pierre Bouguer and Joseph von Fraunhofer's spectrum

51. Kendall, *Michael Faraday*, 114–20.
52. Taton, *History of Science*, 270–73.
53. Greenaway, *John Dalton and the Atom*, 3.
54. Lenard, *Great Men of Science*, 195.
55. Hart, *Makers of Science*, 227.

analysis, Young pursued lengthy studies of light and its various inherent colors. Young is to be credited for the discovery of light waves.

In the budding field of photography, in 1816 Nicéphore Niépce (1765–1833) laid the groundwork for successfully fixing images on paper coated with silver chloride, and in 1826 he obtained the first permanent photograph. Eleven years later, his partner, Louis Daguerre (1787–1851), developed a process that included a silver-plated copper sheet that was coated with silver iodide that led to daguerreotypes, the earliest stable and enduring photographic images.

Meanwhile, the development of the binocular microscope was to zoology what the telescope had become to astronomy. Herschel's equal in the biological sciences was Carl von Linné, often referred to by his Latin name Linnaeus (1707–78). In his encyclopedic *Systema Naturae*, first published in 1735, Linné not only counted thousands of new species of animals but also catalogued and divided them by way of a whole new system of nomenclature. Using binomial Latin terms such as *homo sapiens* and *plantago lanceolata*, he subdivided the major classes of life-forms—such as Mammalia, Aves (birds), Amphibian (including reptiles), and Pisces (fish)—into a much more specific, comprehensive, and convenient system of nomenclature.

As the numbers of discovered species of both plants and animals skyrocketed in the early nineteenth century (some seventy-two thousand new species of plants were found and described between 1798 and 1850), interest in zoology and botany intensified from mere classification and description to the inevitable study of their origins. Jean-Baptiste Lamarck, who coined the term *biology*, was as much a geologist as he was a biologist. Through his careful studies of plants, especially invertebrate fossils in widely separated geological strata, he recognized more clearly than many the enormous age of the earth and nature's slow and continuous process of change. An early evolutionist, Lamarck gradually abandoned his belief in the immutability of species and adopted a view that stressed activity and "processes of small extent acting over vast periods of time to produce immense effects."[56]

His rival and fellow countryman was Georges Cuvier. Cuvier is considered the father of modern paleontology and comparative anatomy on account of his masterful comprehensive study of the whole animal kingdom, living and dead. He successfully argued for the principle of "organic correlation" and the interrelationship of one internal organ to another. Cuvier likewise recognized that species had changed over time and that many had become extinct. In contrast to Lamarck, however, Cuvier believed in the "fixity of species," positing a theory of catastrophism in which change came suddenly and not gradually over millions of years.

It was Lamarck's view, however, that gained the ascendancy. Lamarck's courage in presenting an evolutionary uniformitarian view of geology clearly "prepared the public consciousness" for Darwin's later *Origin of the Species*[57] and his theory of organic evolution

56. Jack, "Jean Lamarck," 16.
57. Jack, "Jean Lamarck," 31.

based on natural selection, variations within species, competition, and the "survival of the fittest" concept.[58]

In 1795, L'Académie des Sciences in Paris became the focus of French science. Four years later, Benjamin Thompson (1753–1814), aided by Sir Joseph Banks, founded the Royal Institution of Great Britain for the "promotion, diffusion, and extension of science and useful knowledge." In 1815 the Swiss Natural Science Association began. In America, where technology advanced more rapidly than the study of pure science, the American Geological Society was formed in 1819. And in 1829, James Smithson, a British chemist, gave 100,000 pounds to establish the Smithsonian Institute in Washington DC.

Napoléon's defeat, however, and with it the defeat of many of the aims of the French Revolution, played into the hands of those scientists who were perceived to be opposed to religion, and arguably led to a decline in scientific research post-1820. In France and Prussia, during decades of ensuing conservative monarchial rule, scientific progress slowed to a virtual crawl.[59] For the rest of his life, Humboldt, to whom we must now return, fought a rearguard battle with reactionary forces bent on turning back the clock.

"THE NAPOLÉON OF SCIENCE"

By the time the thirty-five-year-old Humboldt returned home to Europe in the summer of 1804, his name had become a household word, "a blend of mental brilliance and physical daring," thanks to the numerous published accounts that had preceded him.[60] Humboldt was welcomed first in Bordeaux and then in Paris by large and adoring crowds as a conquering hero, revered by all—except Napoléon. The two men met for their first and only time in December at a gala ball right after Bonaparte's coronation. "So I understand you collect plants," the emperor brusquely said. "So does my wife."[61] And with that preemptory remark, he turned his back and walked contemptuously away. Feigning suspicion that he thought Humboldt was a Prussian or Spanish spy, the truth is Napoléon was jealous of sharing the national spotlight with anyone—especially a Prussian. Thereafter Humboldt adamantly refused to attend any of Napoléon's weekly receptions.

During the week of Napoléon's coronation, Humboldt crossed paths with yet another man destined to change the world of 1820—Simón Bolívar—whose exploits and accomplishments we have already examined (see chapter 10). Bolívar was but a very young man

58. Humboldt very much encouraged Darwin. "You have an excellent future ahead of you," Humboldt wrote in an 1839 letter to the younger scientist. "Your work is remarkable for the number of new and ingenious observations on the geographical distribution of organisms, the physiognomy of plants, the geographical structure of the earth's crusts. . . . What progress indeed has been made in science by those who like you are eloquent interpreters of it." Barrett and Corcos, "Letter from Alexander von Humboldt," 163, 165.
59. Taton, *Science in the Nineteenth Century*, 550–70.
60. Helferich, *Humboldt's Cosmos*, 300–301.
61. Botting, *Humboldt and the Cosmos*, 179.

at the time. The two men shared similar republican views, and Humboldt came away impressed. Bolivár never forgot their encounter and counted himself a friend and admirer of Humboldt, lauding him as "the true discoverer of South America."[62]

It is tempting to argue that at this point Humboldt's greatest contributions were behind him when, in truth, his finest works still lay ahead. In mid-October 1804, he presented the first of many reports to the Institut Nationale des Sciences et Arts and the following year was elected a member of the Berlin Academy of Sciences. After spending the next two years visiting Switzerland, Italy, and Berlin, Humboldt returned to Paris to begin the task of writing up what he had seen and accomplished in the New World. What he initially believed would be three volumes over three years eventually took thirty years and thirty volumes and earned him the title of "Napoléon of Science."

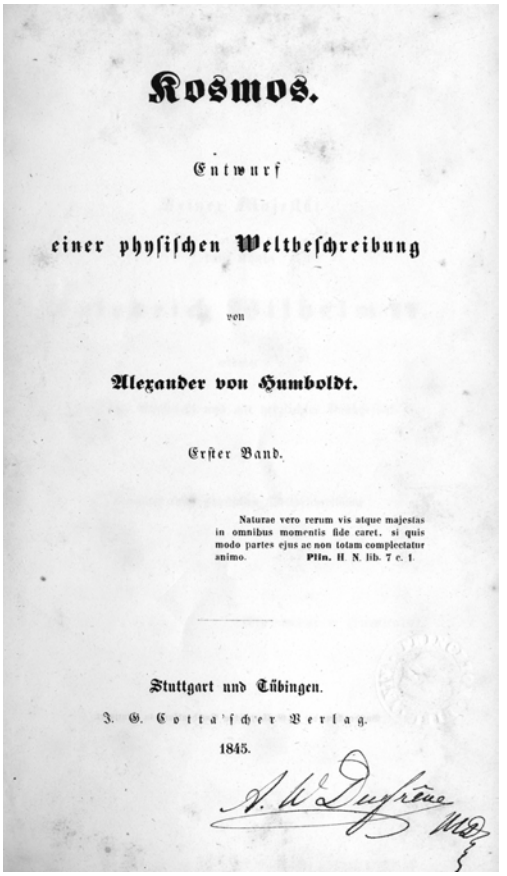
Relying on his voluminous field notes, written mostly in French scrawl with types of scribbled shorthand only he or a Champollion could ever decipher, he went feverishly to work. His first volume was *Essays on the Geography of Plants* (1807). The year 1808 saw the publication of his immensely popular *Views of Nature*, and in 1810 he published *Research, Concerning the Institution & Monuments of the Ancient Inhabitants of America*. The following year his three-volume *Political Essay on the Kingdom of New Spain* appeared. His most popular work—*Personal Narrative of Travels to the Equinoctial Regions of the New Continent*—came out in three volumes between 1815 and 1819. A perfectionist with an inner frenzy to achieve, Humboldt spent his fortune having his works carefully edited, paying friends and respected colleagues for peer reviews, and employing artists and designers for hundreds of exquisite sketches and engravings, plates, prints, and maps.

Had it not been for Napoléon's invasion of Moscow and his resultant inglorious retreat in 1814, Humboldt may well have seen his other dream fulfilled of visiting Russia, Tibet, China, India, and the Himalayas. Instead of leaving Paris, Humboldt—"never the patriot, always the scientist"—found himself welcoming Tsar Alexander I and Wilhelm, Humboldt's brother, now Prussian ambassador, as part of the conquering Russian-Prussian-Austrian forces as they marched into Paris in April 1814. Had it not been for Humboldt literally barring the doors, Alexander's conquering armies would likely have ransacked and destroyed the Académie des Sciences and other great Paris museums.[63]

For much of the rest of his life, Humboldt was forced into the lucrative role of tutor, academic adviser, and chamberlain to the king of Prussia. It was a mutually beneficial relationship. Humboldt needed the money since by now his family fortune had been long spent. Ironically, King Wilhelm III (1770–1840) of Prussia and later his successor, King Wilhelm IV

62. Helferich, *Humboldt's Cosmos*, 303.

63. Wilhelm went on to participate in the Congress of Vienna as a special Prussian envoy. Later, in 1819, he became Prussia's Minister for Home Affairs, but his more liberal views led to his dismissal in 1820. Kellner, "Return to Berlin," in *Alexander von Humboldt*. Though Wilhelm was much more pro-Germany than his brother, he and Alexander remained in close contact with one another throughout their lives. Wilhelm's death in 1835 was a devastating blow to Humboldt.



Kosmos.

Entwurf

einer phyſiſchen Weltbeſchreibung

von

Alexander von Humboldt.

Erſter Band.

Naturae vero rerum vis atque majestas in omnibus momentis fide caret, si quis modo partes ejus ac non totam complectatur animo. Plin. H. N. lib. 7 c. 1.

Stuttgart und Tübingen.

J. G. Cotta'ſcher Verlag.

1845.

Title page of vol. 1 of *Kosmos: Entwurf einer physischen Weltbeschreibung,* by Alexander von Humboldt (Stuttgart and Tübingen: Cotta, 1845–62) .

(1795–1861), trusted him implicitly, while the Prussian secret police suspected his French-leaning, revolutionary sympathies. King Wilhelm indulged Humboldt's desire to spend much of his time in Paris, but by 1827 the king insisted that Humboldt return to live permanently in Berlin.

That same year Humboldt's long-cherished dream to travel to Asia began to be realized when the new Russian tsar, Nicholas I (1796–1855), invited him to make a six-month summer expedition to create a series of new maps of Russia and to study mining and geology in the Urals and further east, all at Russian expense. Two years later, Humboldt embarked upon the second great expedition of his life, one that eventually took him, like a modern Marco Polo, to the gates of China. Braving late winter blizzards, ice flows, spring floods, terrible roads, and never-ending changes in horses and wagons, Humboldt and his entourage of three dozen Russian mining officials and local politicians forged their way across the Siberian steppes, discovering iron, copper, topaz, gold, platinum, and even diamond mineral deposits in the process. These were the first diamonds ever found outside the tropics. Within ten years of Humboldt's visit, Russia would become the world's top exporter of gold. He finally reached the Russian-Chinese border in late August 1829 before turning abruptly west and heading home, lest the expedition become trapped in a Siberian winter. Arriving back in Moscow on 3 November, after a grueling journey of 9,700 miles—much of it on foot—the sixty-year-old Humboldt was widely honored and acclaimed "as the Prometheus of our day."[64] "Your sojourn in Russia has been the cause of immense progress in my country," Tsar Nicholas I exulted. "Wherever you go you spread a life-giving influence."[65] As was his custom, Humboldt would later publish a three-volume recitation of his Russian exploits and adventures in his *Asie Centrale* (1843).

64. Kellner, *Alexander von Humboldt*, 139.
65. Botting, *Humboldt and the Cosmos*, 252.

Humboldt's Russian expedition paid rich dividends. Besides his mining discoveries, he proposed the establishment of a chain of geomagnetic, meteorological observation stations all across Russia and eventually throughout the British Empire, including Canada, Australia, and New Zealand. Such stations recorded magnetic dips and declinations, isothermal readings, barometric pressure, temperature and humidity readings, wind directions, and moisture levels—all of which laid the foundation for modern meteorology and zonal geography.

As for Bonpland, Humboldt's trusted and loyal assistant, he proved a much better field botanist than a writer. Sadly, the two men gradually drifted apart. After working as a gardener to Napoléon's wife and empress, Bonpland returned to South America, where he married a native woman, raised a family, and lived in Uruguay, if not in poverty, certainly in obscurity. Humboldt eventually secured a government pension for his longtime friend, who believed he never got the full credit he deserved as Humboldt's partner. "Unmourned and unsung, but loving life to the last," Bonpland died in 1858 at the age of eighty-five.[66]

Despite Napoléon's defeat and Wilhelm's constant invitation to return to Berlin, Humboldt soldiered on in his beloved Paris. Confirmed bachelor that he was, Humboldt craved companionship, especially from men. Much has been written, often of a speculative and psychological nature, of his alleged homosexuality. The evidence is inconclusive. His language of love and affection is not altogether out of character of the wording many used at this time to describe two men working in close and harmonious relationships. Throughout Humboldt's life he had many intense friendships with other men, but perhaps none more fervent that that he forged with Dominique François Arago (1786–1853). Arago was a friend of Ampère and a leading physicist whom Humboldt met in 1809. Although the two men communicated with each other for forty-four years, in the end, it was also the most disappointing relationship of Humboldt's life.

The sadness of their relationship sprang from its lopsidedness and inequality of affection. For every letter Arago wrote Humboldt, Humboldt wrote back ten. "Could it be that you ever doubted my invariable attachment?" Arago once said to Humboldt. "Be it known to you that I should consider the slightest doubt upon this point a most cruel offense. Beyond the immediate circle of my own family, you are, without comparison, the person whom, of all others, I love the most dearly."[67] After Arago's marriage, the distance between the two men lengthened, while Humboldt desperately held on, as if to a dream or will-o'-the-wisp. When Arago died in 1853, Humboldt, starving for affection, lived on in loneliness and retracted further into himself.

Humboldt still remains something of an enigma. On the one hand, he developed "a true genius in friendship."[68] An infallible judge of scientific talent and an avid supporter and benefactor of hundreds of scholars all over the world, Humboldt became a living legend. Free of jealousy or rancor of any kind, he enjoyed the success of others. Importuned for

66. Botting, *Humboldt and the Cosmos*, 207.
67. Francois Arago to Humboldt, 12 March 1841, in Kapp, *Letters of Alexander von Humboldt*, 94.
68. Ackernecht, "George Forster," 93.

money, advice, and references virtually daily, Humboldt spent much of his influence and fortune helping the unknown and the poor, protecting the persecuted and bringing recognition to those who deserved it.

On the other hand, the greatest emptiness in what otherwise was a remarkably full life was his failure to form close human relationships. Blame it on his cold and indifferent mother or on a father who died too young—whatever the cause, Humboldt never found lasting happiness in any other human being. He never married. His closest friends were men, many of whom took advantage of his kind support and interest. The tragedy of his life is that while he understood nature, he never did, or never could, allow another human being to venture too close. In the end, nature was his mistress.

COSMOS

Humboldt could easily have spent the remainder of his days supporting and encouraging his fellow scientists had it not been for his flint-like determination to depict in a single work the entire material universe—from the phenomena of heaven and earth to the tiniest plants and organisms. Thus Humboldt set out as early as 1820 to write his most enduring masterpiece—*Cosmos*.

A study in five volumes, the first of which appeared in 1845 and the last of which appeared posthumously, *Cosmos* (taken from the Greek word *Kosmos*, meaning heaven and earth) was an intensely scholarly attempt to regard all nature as part of one majestic, unifying whole. His primary purpose was to show that one spirit "animates the whole of Nature," including stones, plants, animals, and even humankind itself, and that everything is in relation to something else, "which is the reason for its being."[69] *Cosmos* showed that Humboldt was a scientist with Goethe-inspired romantic convictions. He believed that nature, from Dalton's atoms to Herschel's solar system, functioned according to unified and unifying principles. Though his book never mentions God or a creator—indeed, Humboldt never let religion influence his scientific conclusions—it was all about intelligent design. Humboldt saw nature as a harmoniously ordered unit. If there was not divine design in the creation of nature, there was nonetheless an essential unity or unifying force among all life-forms, botanical and zoological. His pioneering work ironically led to specialization, but he himself was a towering generalist, a universal polymath who yearned to see the interrelatedness of everything and an endless series of cause and effect in nature. Far more than the mere sum of its parts, nature manifested a unifying, undergirding, and all-enveloping wholeness that only poets could fully fathom. As Humboldt understood, nature was a "harmoniously ordered whole," a "unity in diversity of phenomena; a harmony, blending together all created things, however dissimilar in form and attributes; one great whole animated by the breath of life."[70]

69. McCrory, *Nature's Interpreter*, 122–23.
70. Humboldt, *Cosmos*, 1877 ed., 1:24.

Though there was more to the cosmos of nature and its beauty than what is beheld by one's senses, Humboldt believed it was the "inward mirror of the sensitive mind which reflects the true and living image of the natural world." Almost Platonic in his views, he thought there was as much reality of nature or essential meaning in the human soul as on a distant landscape and that there was a mysterious communion between the beholder and the beheld, with place for both scientific observation and artistic expression, poet and scientist, language and mathematics.[71]

As one of his biographers has concluded, *Cosmos* was "the last great work of the last great universal man: It captured all of Humboldt's thoughts and discoveries from South America to Siberia, and the discoveries of the many other leading scientists of his age."[72] Though later superseded by the modern era of scientific specialization, *Cosmos*, in its attempt to discover the overriding realities of all of nature, must go down still as one of the greatest works of the nineteenth century.

The book also captured his sometimes hidden, or at least unexpressed, social and political convictions. Liberal, democratic, and cosmopolitan in his thinking, Humboldt, ever the humanist, stood for freedom, equality, and justice—a German prince of the ideals of the French Revolution. He opposed colonialism and despised slavery and racism in all their sordid expressions. Like Wilberforce, More, and Bolívar, he regarded slavery as the vilest of all the evils that afflict humanity. He argued for the unity of humanity, calling different races "varieties" of humankind and rejecting all and every notion of superior or inferior races. "While we maintain the unity of the human species," he wrote, "we at the same time repel the depressing assumption of superior and inferior races of men. . . . All are in like design, designed for freedom."[73] Whether discussing the Aztecs of Mexico, the enslaved blacks of the Southern states, or any other relegated and despised people, Humboldt preached the gospel of human dignity and racial equality.

Some may argue that Humboldt, supported in his expeditions by such autocratic and totalitarian regimes as Spain and Russia, was either too timid or two-faced in waiting so long in his career to make his genuine feelings and criticisms widely known. In his defense, he was, we must remember, a careful diplomat whose first love was science, not politics. He was astute enough not to criticize his followers and sponsors. Fortunately, he lived long enough to make his true feelings known, and with his reputation at a lifelong high, his criticisms took on even greater meaning. Likewise, he deplored the destruction of the environment. Arguably the founder of the modern ecological movement, Humboldt fought for the preservation and respect of nature everywhere.

Cosmos was an instant popular success and reprinted in multiple editions, with sales in the tens of thousands. By the late 1850s, it was the most translated book in the world next to the Bible. Still writing almost every day until three in the morning, Humboldt suffered

71. Humboldt, *Aspects of Nature*, 2:208.
72. Botting, *Humboldt and the Cosmos*, 260.
73. Humboldt, *Cosmos*, 1877 ed., 1:358.

Study of Alexander von Humboldt in Berlin, Oranienburger Steet, 67, by Eduard Hildebrandt.

a small stroke in 1858. Johann Siefert, his servant to the last, ran Humboldt's household arbitrarily and decided who could or could not see the great scientist. Tragically, most of Humboldt's correspondence was inexplicably destroyed. Finally on 6 May 1859, twenty-four years after his brother Wilhelm's passing, Humboldt died of completely natural causes at age eighty-nine, almost penniless. His dying words were: "What glorious beams of sunlight! They seem to be calling the earth up to heaven."[74] He was buried back in his childhood haunt: Tegel. His many lingering debts were quietly paid for by the king.

It has been said that when a great man dies a library burns down. In Humboldt's case, he gave rise to a whole series of new libraries full of a great many discoveries and findings from a remarkably rich and varied life. His lasting contributions were the sheer magnitude of his writings and the highly measured and captivating appeal of his scientific studies to an uninformed but interested reading public. Capturing the essence and the mystery of faraway places, with the "courage to become the hero of his own life,"[75] he drew a generation of readers into his scientific world. A path breaker and a giant, gentle genius, Humboldt made sense of science and brought it out of the realm of suspicion into a bright new day of acceptance. In

74. McCrory, *Nature's Interpreter,* 216.
75. Helferich, *Humboldt's Cosmos*, xxii.

so many ways he was the catalyst for modern science. Ultrareligionists castigated him for not speaking of God and of his creation, yet Humboldt was neither atheistic nor anti-Christian. He simply religiously adhered to what can be seen, measured, and known by the senses. Yet he always believed in "an underlying cosmic intelligence" that governs all.[76]

The prophet and pioneer of the scientific investigator, Humboldt presaged the coming age of science. One can argue that the age of 1820 saw the discrediting of religion amongst the educated, that the "vision of all" lay in fostering the future of scientific discovery, not in preserving the past of religious tradition. It is certain that for some religionists, the coming controversies over creation, evolution, and the very meaning of human existence would spell endless debate, doubts, and anxiety. Nevertheless, those new revelations that saw little or no conflict between science and faith, that encouraged the seeking of truth no matter where it is found, welcomed and embraced the many and varied beneficial advances in science and every other field as heralds of a new and better day. As one of Joseph Smith's early revelations stated: "Teach ye diligently . . . of things both in heaven and in the earth, and under the earth; things which have been, things which are, things which must shortly come to pass, things which are abroad, . . . and a knowledge also of countries and of kingdoms—that ye may be prepared in all things" (Doctrine and Covenants 88:78–80).

The cult of Humboldt reached its zenith in America in 1869 in honor of his hundredth birthday, with celebrations everywhere, from Boston to San Francisco. Banquets and banners, concerts and parades, speeches and celebrations all heralded him as the greatest man of the century, with Oliver Wendell Holmes calling him "the hero of knowledge" and "the peaceful conqueror."[77] Humboldt's reputation soon faded, however, as Darwin's discoveries took hold and the age of specialization replaced Humboldt's more generalized approach to the study of science. Furthermore, the First and Second World Wars poisoned negative attitudes in America toward all things German. However, today Humboldt's reputation, like that of Napoléon, is deservedly on the ascendancy.

Humboldt was a towering intellect, a man who constantly overcame one obstacle after another to fulfill his deepest dreams and ambitions. A person of enormous discipline, courage, restlessness, and conviction who loved nature, Humboldt changed the world and the way we look upon it. He regarded everyone through the lens of dignity, humanity, and equality. As one of his most recent biographers has concluded, Humboldt "pointed to the future, not to the past: to universal peace and healing after decades of war and revolutions, to the reign of reason, to the liberation of the human mind, to the dawn of a new age."[78]

76. McCrory, *Nature's Interpreter*, 185.
77. Walls, *Passage to Cosmos*, 310.
78. Walls, *Passage to Cosmos*, 312.