Chapter 2
From Copernicus to Darwin (1473–1882)

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A small but fascinating country, Ecuador is probably one of the most interesting natural laboratories on the planet. Compact in its geography but diverse in all aspects, its territory hosts one of the most biodiverse settings available on the planet. Its mainland is covered with lush tropical rainforests, snow-peaked active volcanoes that reach the sky, and unique coastal region rich in marine life. The Galapagos Islands, some 600 miles west, speak for themselves. Throughout its history, its natural beauty as well as its rich human heritage has enchanted travelers, scientists, and adventurers. Endowed with diversity from indigenous tribes in the rain forest to modern universities in urban settings, it still is a natural encyclopedia waiting to be read and discovered.

Stretching our imagination, it is not hard to see how this unique place on the planet has provided scientific information that has contributed to rethink about our place in the universe. In a span of two centuries, adventurous scientific expeditions confirmed and kindled two of the major paradigm shifts in human thought: heliocentrism and evolution. Science cannot rely on common sense. Staring at the night sky from anywhere on the planet and especially from the high mountains of Ecuador, it is not hard to mistakenly conclude that we must be in the center of the universe. Not only are we in its center but also we should be unique, permanent, and immutable in this vast unknown, created by the works of a supreme being. These ideas were so embedded in human thought that it took millennia to challenge them. Philosophers and scientists developed intriguing and ingenious mechanisms and theories to explain current thought on the origin of the universe, the origin of life, and our place in the universe. One must admit the creative genius of humans in elaborating complicated models explaining "the majestic clockwork" of the universe as Bronowsky so elegantly describes in his inspiring book, *The Ascent of Man* (Bronowski 1973).

Human inventiveness has also allowed exceptional discoveries that have changed our view of the universe and ourselves based on keen observation with rudimentary or no instruments. Such is the case of a series of astronomers that through their

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observations, experiments, and hypothesis laid the foundations of modern science: Copernicus, Brahe, Galileo, and Kepler. Nicolaus Copernicus (1473–1543) challenged the view of the universe of his time. Deeply embedded in religious thought and described by Ptolemy (Claudius Ptolemaeus, c. 90–c. 168 AD), the geocentric model of the universe had gone unchallenged for centuries, although other Greek philosophers and astronomers had proposed a heliocentric view. In 1543, Copernicus published *De Revolutionibus Orbium Coelestium*, whose heliocentric model was to begin a series of scientific breakthroughs culminating with Darwin's grand Theory of Evolution and modern evolutionary biology. Be it coincidence or simply that Ecuador is a unique natural laboratory, these discoveries were intimately tied to a series of events that occurred in its territory between the eighteenth and nineteenth centuries leading to Darwin's visit to the Galapagos Islands. Following Copernicus, along with the incredible observations of Tycho Brahe (1546–1601) and the work of Johannes Kepler (1571–1630), Galileo Galiei (1564–1642) took forth upon himself to establish once and for all the Copernican model of the universe. History and science owe him a privileged place in the annals of knowledge. With the invention of the telescope, astronomy changed forever. Rigorous observation, experimentation, and measurement became key steps to scientific development. Measuring the Earth and observing life within Ecuador confirmed and sparked two major current scientific paradigms: we are not in the center and we are not immutable. Sir Isaac Newton (1643–1727), despite his genius, could not have guessed that his greatest work, the Theory of Gravitation, was to have a decisive vote in its favor, a few miles from a place that was probably unknown to him: Quito, Ecuador. With Newton, Copernicus, and Copernicus' followers, science had finally a consistent and elegant theory of planetary motion capable of placing man on the moon. And, as is true in case of all sciences, experimental evidence was necessary. Newton's law of universal gravitation predicted that the Earth should be flat at the poles and had a shape of an oblate spheroid. The equatorial radius should be larger than the polar radius. This was contrary to the Cartesian model defended by Giovanni Domenico Cassini (1625–1712), an Italian-born French astronomer (later Jean-Dominique) who, along with his son Jacques, carried out measurements in France suggesting that the Earth was elongated at the poles. Charles C. Gillispie in his book *Science and Polity in France: The End of the Old Regime* (Gillispie 1980) states: "*After the publication of Newton's Principia in 1687, it came to seem that such down-to-earth techniques of land surveying should, in principle, be competent to resolve the largest issue of cosmology, the choice between Cartesian and Newtonian theories of the world*." The Paris Academy of Sciences promoted a series of expeditions to resolve this issue. Gerald James Holton and Stephen G. Brush (Brush 2005) in their book entitled "*Physics, The Human Adventure*: *From Copernicus to Einstein and Beyond*" state: "*The results of this project, perhaps the first ever large cooperative government-funded effort to resolve a scientific question, provided a decisive confirmation of Newton's theory*." The French geodesic mission led by Charles Marie de La Condamine (1701–1774) was to measure the meridian arc at the equator, and Pierre Louis Maupertuis (1698–1759) led the mission to Lapland. La Condamine, Louis Godinand, and Pierre Bouguer arrived in what today is Ecuador in the early eighteenth

century accompanied by two Spanish overseers, Jorje Juan and Antonio de Ulloa. After a long 7-year stay, the results of their measurements, along with the results of Maupertuis in Lapland, confirmed Newton's predictions and discarded the Cartesian hypothesis of the Earth's elongation at the poles (Tristan 1999). La Condamine's return to Europe in 1744 via the Amazon River is considered one of the first scientific explorations of this vast tropical waterway. La Condamine's work influenced a young German naturalist, Alexander Von Humboldt (1769–1859), whose travels in the early nineteenth century allowed him to produce some of the most extensive works on geography and nature ever published. Humboldt's *Personal Narrative* refers repeatedly to La Condamine's journal. In 1802, Humboldt arrived in Ecuador and among other feats, attempted to climb mount Chimborazo, considered the world's highest peak, and reached an altitude of 5,875 m, the highest ever attained by a human at that time. His work as naturalist in the region and in the Ecuadorian territory acclaimed him to world fame. Humboldt is considered the father of ecology and modern geography. Humboldt visited Thomas Jefferson in Virginia, where left a lasting impression. In a letter to Caspar Wistar (Jefferson 1804), Jefferson states: "*I have omitted to state… the extreme satisfaction I have received from Baron Humboldt's communications. The treasures of information which he possesses are inestimableand fill us with impatience for their appearance in print*."

Humboldt's writings certainly influenced the young Charles Darwin (1809–1882) who had read most of the German scientist's works. Humboldt's *Personal Narrative* was a cherished companion in the Beagle and is continuously mentioned with appraisal in Darwin's Diary. In a letter to J. S. Henslow (Darwin 1985), Darwin writes: "*I formerly admired Humboldt, I now almost adore him; he alone gives any notion, of the feelings which are raised in the mind on first entering the Tropics*…." Charles Darwin arrived in what is today San Cristóbal Island in the Galapagos Archipelago in October 1835. Darwin's legacy of his observations in this Archipelago is without a doubt the major paradigm shift of modern science. In 1858, Alfred Russel Wallace (1823–1913), who had also read Humboldt and had traveled in the Amazon, proposed a similar theory of natural selection. Copernicus, Kepler, Galileo, Newton, La Condamine, Darwin, and Wallace are all major contributors to the paradigm shifts that altered the way humans think of their relevance in the universe. They all touched Ecuador, directly or indirectly. The year 2009, 200 years from Darwin's birthday and 150 years from Humboldt's death, provides a unique opportunity to celebrate these magnificent series of historical events.

Albert Einstein, at a young age, read both Humboldt and Darwin (Pais 1982)….

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