The Lasting Contribution of Alexander von Humboldt to Our Understanding of the Natural World*

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A polymath and ahead of his time, Alexander von Humboldt had numerous interests and insights that have shaped modern science. His holistic viewpoint on nature founded the principles of several branches of sciences such as comparative biology, ecology, and biogeography, and inspired scientists who went on to make notable contributions during and after his time. From geologists to founders of evolutionary principles, poets to anti-colonial revolutionists, Humboldt was an inspiration to generations of thinkers. In this article, we attempt to highlight a few of his notable discoveries that influence biologists today.

Alexander von Humboldt was a polymath with interests and knowledge that spanned geology, natural history, zoology, botany, social sciences, statistics, and economics [1, 2]. His contributions to the natural sciences, especially ecology, are immense. Although interested in Nature ever since a child, Alexander von Humboldt (henceforth just Humboldt) started his career as a mining inspector around the summer of 1872 [3], after finishing his education in a college of mining [see the Article-in-a Box in this issue]. This career was chosen in deference to his mother’s expectations (not different from societal pressures we face today), but the job provided him a platform to hone his skills in mapping and geology. Apart from his contributions to geology as a mining inspector, he also started the first technical school for young miners in Germany. Seeing the detrimental conditions under which miners worked, he came up with several ideas for improving mining

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*Vol.26, No.8, DOI: https://doi.org/10.1007/s12045-021-1207-z

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techniques and working conditions, which included inventing a miner’s lamp and respirator. He also described numerous species of subterranean plants that he encountered in mines across Germany.

Humboldt inherited a substantial amount of money after the death of his mother, allowing him to pursue his interest in travelling across the world, especially to the tropics. He secured permission to travel to South America, which turned out to be one of his most important expeditions, from which he derived most of his theories and ideas. Apart from South America, Humboldt also travelled across Europe and Russia. Each of these expeditions shaped his scientific and philosophical outlook.

**Humboldt’s Influence on Our Current Understanding of Natural Sciences**

Much of what Humboldt discovered in his time has become so fundamental to ecology, biogeography, geography, and evolution today that we often do not consider that they required ‘discovering’. The 18th and 19th centuries were the age of enlightenment in Europe. Despite an ever-increasing understanding of the laws of Nature, the origins of life and diversity remained a mystery. During this period, most naturalists were engaged in systematically classifying taxa as every voyage brought new discoveries. Humboldt was among a few who were interested in a more holistic picture of Nature. He believed in an interconnected and unified idea of Nature and sought to find these through his observations and data. He was not only interested in collecting specimens, but also interested in the environment that the species were found in, and took copious measurements of these environmental parameters. Owing to this, he obtained an understanding of how Nature is structured, organized, and functions. For instance, on observing the Mauritia palm (*Mauritia flexuosa*) in the tropical grassland plains of Las Llanos in South America, he was fascinated by how a single individual could support a high diversity of organisms. In modern ecology, such a species is referred to
as ‘keystone species’; one that has a disproportionately important role in the ecosystem in relation to its population size.

When locals complained of decreasing water levels in Lake Valencia, Venezuela, Humboldt collected data to understand what was causing this decline. One obvious reason was the diversion of water for agriculture. But his examinations led him to another reason. He noticed that the forest canopy protected the soil from the sun’s rays, resulting in water retention in the soil. He noted the role of the forest in maintaining soil moisture, and in turn regulating the water levels in the lake. Today, we recognise the ecosystem functions that forests play in maintaining soil moisture. It was after these observations at Lake Valencia that Humboldt first articulated his thoughts on human-induced environmental and climate change [1].

In piecing together why species are distributed where they are, Humboldt invoked the role of geography and environment, emphasising that God alone could not have achieved the ordered chaos observed in Nature. Because he measured environmental factors everywhere he went in South America, he was able to correlate these with the occurrence of organisms in specific environments. This kind of data was non-existent in his day, as most collectors only noted the location and habitat but did not quantitatively measure ambient environmental conditions such as temperature. The alpine regions of the Andes were particularly exciting as they gave Humboldt a chance to compare plants in these regions with the ones in similar environments of Europe. As a consequence of this comparison, he hypothesized the role of climatic conditions in shaping biodiversity. His training as a mining officer and his incredible mapping skills equipped him to portray species distributions in relation to their environments. Whilst observing temperature measurements from across continents, Humboldt also came up with the idea of isotherms, lines that connect regions of similar temperature across the world. Furthermore, he observed that latitude alone does not explain temperature variation across the globe, as elevation and distance to the sea also affect temperature. This allowed geographers and
naturalists to examine global patterns in temperature, and draw parallels with the distribution of life forms, laying the foundation for the study of biogeography. Thus the field of biogeography owes its birth to Humboldt’s insights that natural processes determine species ranges, especially in the context of adaptation to local climatic conditions.

Humboldt’s writing on Nature was not of just facts and figures, he was a romantic and inspired famous literaries of his time through his descriptions of the wild. His depictions of specimens and landscapes were both detailed and inspirational. Humboldt’s holistic understanding of Nature is evident from his ‘painting of Nature’ or ‘Naturgemälde’—a painting of the Chimborazo mountain in the Andes—depicting the elevational distribution of different plant species, along with information on the abiotic conditions (you can see a picture of Naturgemälde on the cover of this issue). This not only reflected a new way of thinking about a unified Nature but was also the basis of the field of ecology [5]. This was also the first description of elevational gradients in biodiversity, which is now a well-known concept in ecology.

His observation and questioning led him to many insights that spanned a diverse range of topics. For instance, Humboldt observed differences among the females of two species, Arrau turtle (Podocnemis expansa) and the Orinoco crocodile (Crocodylus intermedius), in their vulnerability to predators and linked it to differences in reproductive strategies used by these species [4]. In another instance, he speculated about the role of mosquitoes in spreading diseases to humans and thought about how their population could be controlled by modifying habitats. Apart from biology, Humboldt was also keenly interested in geology (after all, he was trained in geology!). Humboldt hypothesized that the earthquakes in South America were unusual and not always associated with the underlying volcanoes. As you can see from these examples, Humboldt has had a profound influence on many fields of science!
Humboldt’s Publications and Influence on Popular Understanding of Science

Humboldt published many books and monographs as part of his illustrious career, including Essays on the Geography of Plants and Views of Nature, both of which outline his thoughts on the organisation of natural systems. In fact, one could consider the Essays on the Geography of Plants as one of the first ecological books written! He also published personal narratives of his travels, along with the descriptions of plants and animals encountered during his travels. He wrote and published about 22 volumes from his travels in the Americas between 1807–1838, much of which comprise beautifully illustrated accounts of places, people and biodiversity. Apart from publishing books, Humboldt also delivered 61 free-to-all public lectures between 1827 and 1828. These lectures were so popular that they had to be held in a public hall to accommodate the thousands of people who turned up to listen to Humboldt talk about physical geography. German historians give credit to these lectures for their initiation of scientific works in Germany, which then surpassed the French. It is remarkable that Humboldt educated the many (the public), rather than limiting scientific discoveries to a few elite scientists [6].

Humboldt’s magnum opus Cosmos summarized his insights into the natural world. It consisted of five volumes, the fifth of which was published after his death [6]. The first volume was published in German in 1845; it was later translated into at least 10 different languages and soon became one of the most-read works of that time. The first volume focussed on the physical aspects of our world, from celestial bodies and the formation of the Earth to life on Earth. He summarized everything that was known at that time, weaving disparate topics with a philosophical and poetic writing style. Humboldt worked with numerous people from around the world to gather material for Cosmos, therefore, it is a work of worldwide collaboration. In the second volume of Cosmos, he focussed on the history of the Earth, civilizations, art and other aspects of human civilization that made this world a ‘cosmos’. Cosmos was not a work of just science or art, it is a story of the
universe, based on facts and figures, inferred through feelings and philosophical reflections, through the eyes of humans and finally, expressed through artistic writing.

Although his works were based on facts and figures, they also included discussions on the philosophical aspects of human nature and our connection with this natural world. It is a good time to mention that Humboldt never believed that ‘feeling’ must be removed from scientific investigations, and he recognized that much of our research is driven by intuitions and ideas that take shape, and even though these ideas are based on facts and figures, the direction of thought is subjective to our eye. This discussion continues in the 21st century because as objective as science attempts to be, science is driven by scientists’ curiosity, intuition and feeling.

Humboldt weaved apparently disparate topics together through his writing and speeches, providing perspectives that few works could have aspired to. Through his works, Humboldt discussed everything, from galaxies to geomagnetism to organic life and the web of life. He touched upon diverse concepts spanning the breadth of modern-day ecology; from barriers to dispersal (including habitat barriers like deserts and mountains) to population dynamics of prey species driven by predators. It would be a challenging task to truly quantify Humboldt’s contributions to science because his conversations and ideas have inspired several notable scientists of his time and continue to inspire us today. Humboldt, through his work, showed how one needs to be more than a geologist or a botanist to be able to understand nature and its complexity.

Humboldt’s Influence on Other Scientists

Right around the time when Humboldt was writing books based on his travel explorations in South America, Charles Darwin¹, a young man in England was getting interested in the natural world and its ways. Humboldt’s Personal Narrative thoroughly inspired Charles Darwin to travel to South America; it was among one of

his most-read books and always by his side on the HMS Beagle. Although Charles Darwin observed life through the lens of evolution, several fundamental ideas stemmed from Humboldt’s ecological observations and writings. While these two wealthy, educated, curious men were making their mark, Alfred Russell Wallace was an even younger boy from a modest family who was also inspired by Humboldt’s *Personal Narrative*. Wallace grew up to become one among a handful of naturalists of that time who could combine the knowledge of biodiversity distribution with underlying geological features of land and sea alongside Humboldt. Humboldt and Wallace were the founding pillars of the field of biogeography, and they could do this only because of their multifaceted interests and extensive knowledge.

Charles Lyell also followed Humboldt’s steps in extending the scientific understanding of isotherms and was inspired by his conversations with Humboldt. Lyell went on to write one of the most celebrated works in geology, *The Principles of Geology*. Both Humboldt’s and Lyell’s books went on to become bedrocks upon which Darwin built his own theories of evolution and species distributions.

Modern biogeography is aided by one other key theory, that of continental drift, formulated in 1912 by Alfred Wegener that was not known during Humboldt’s time. Today, the continental drift theory is a basic scientific fact. It posits that the Earth’s lithosphere consists of continental plates that are in a state of constant flux and movement. We understand that the plates were once connected, forming landmasses such as Pangea. The continental drift theory resolved several unanswered questions about species origins and distributions that puzzled 18th and 19th-century naturalists. This knowledge was unavailable to Humboldt, Darwin, and Wallace when they were formulating their ideas regarding the distribution of species. It is really astounding that even without this information, they were able to obtain insights into fundamental processes that structure biodiversity that form the basis of the fields of ecology and biogeography!

Humboldt was ahead of his time in multiple ways, certainly not
Humboldt was ahead of his time in multiple ways, certainly not just in his scientific thoughts, but also in the way he viewed and treated indigenous people. Colonization driven by industrialization in Europe was at its peak during Humboldt’s time. This is what also allowed Humboldt to reach the faraway lands that he constantly dreamt about. But he was unique for his times in recognizing the colonial exploitation of native people and the biodiversity of those lands. While the vast majority of European explorers and aristocrats referred to indigenous people as ‘savages’, ‘barbaric’ or ‘uncivilized’, Humboldt believed otherwise. He was fascinated by and respected, indigenous people and their extensive knowledge. He even considered them way more advanced than the society he came from! Early on in his travels, Humboldt had realized that the indigenous communities living across different parts of South America were extremely knowledgeable about their surroundings. Unlike many of his colleagues, Humboldt treated these people as his equals. He attempted to communicate with them through a series of translators, had intellectual conversations about his latest scientific ideas and questioned them about their perspectives. Humboldt did not place aside his political beliefs as he conducted his scientific expeditions; this is also reflected in his views about ecological destruction in South America [7]. Such a radical perspective was translated into work on the ground through his key role in abolishing slavery in his home, Prussia. As one can imagine, his political views created ripples in the courts of Prussia, where he was disliked. However, despite some resentment, his noble background and distinguished contributions made him invaluable to the court.

Anthropogenic climate change is an inescapable reality of our lives today. Environmentalists everywhere are demonstrating to decision-makers how human-driven climate change is eliminating native species, and disrupting the natural climate cycle. Whether Humboldt grasped the global implications and magnitude of human-made changes to nature, we might never know, but he did understand the effects of deforestation in changing microclimatic conditions. Apart from climate and environmental change, Humboldt also noted the loss of biodiversity, especially due to overharvest-
ing. For instance, he highlighted the overexploitation of nestlings of guácharos/the oilbird (*Steatornis caripensis*), which were collected for their fat and used to produce oil for the missionaries [8]. He also noted the depletion of turtle populations due to excessive harvesting of turtle eggs by the recently arrived missionaries. On the other hand, local people who had been harvesting these eggs for generations had not depleted turtle populations, simply by not overharvesting. He may have been one of the first in his times to focus on such human-induced changes to climate and biodiversity.

Humboldt was an extraordinary polymath, a possible downside of which could be that he simply did not have enough time to delve into many of his unsolved quests in depth. He dabbled in geography, geology, biology, climatology, human and animal demographics, and instrument science to name a few. Today we can identify his contributions in various ‘modern’ scientific fields that have benefited from often path-breaking research he conducted about 200 years ago [9]. Only this knowledge that spanned various fields could have given birth to his magnificent vision of Nature’s workings. Humboldt connected the dots between apparently unrelated processes or observations because of his curiosity, keen observational skills, a hypothesis-driven approach, and the vast data that he collected! We owe much to Alexander von Humboldt, and yet, he is often forgotten. As scientists of the 21st century, we are intensely immersed in one narrow field of science we study, both because of the way academia works, and because there is simply not enough time to assimilate all the information. Yet, reflecting on Humboldt’s life and the mere fact that we are trying to fathom the surface of a deep ocean called science, we find ourselves questioning the need for specialization. If there is one takeaway from Alexander von Humboldt’s life, it is to never limit ourselves with a tunnel vision.
Acknowledgment

We owe much of our insights into Alexander von Humboldt to a book by Andrea Wulf.

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