PERSPECTIVES

ESSAY

Humboldt for the Anthropocene

Humboldt's fusion of science and humanism can address contemporary challenges

By **Stephen T. Jackson**

The ecology and environment of mountains are closely associated with Alexander von Humboldt, born in Prussia 250 years ago this month. His 1807 environmental profile of Chimborazo (*1*), the highest peak in the equatorial Andes, is iconic (*2*, *3*). He later aligned it with similar mountain profiles to show the environmental and ecological parallels between elevation and latitude (*4*). Although mountains, climate, and vegetation were central themes in Humboldt's thinking for six decades (*1*, *5*–*7*), his scientific contributions and intellectual vision extended far beyond those relationships, spanning nearly all the natural sciences and extending deeply into the social sciences and humanities. Indeed, virtually every part of the Earth, environmental, and geographic sciences stands on foundations established or inspired by Humboldt.

Humboldt's contributions owed much to his skillful navigation between the opposing poles of breadth and depth, between minute particulars and far-reaching patterns, and between general theory and brute-force observation. His grounding in the physical, chemical, mathematical, and astronomical sciences imparted an appreciation for universal laws. But his wide-ranging curiosity, keen observational abilities, and early experience as a botanist and geologist led Humboldt to recognize that the world is diverse and complex, and that the details and deviations are important, both intellectually and aesthetically. Humboldt's insight that spatially and temporally referenced observations—whether of species occurrences, air temperature, ocean salinity, or strength and direction of Earth's magnetic field—could be aggregated to identify regional to global patterns (which in turn would reveal relationships and mechanisms) is now a core principle of the Earth and environmental sciences (*1*–*3*, *8*). Humboldt recognized that theories to explain Earth and its inhabitants, including humans, would necessarily be laden with contingencies arising from spatial irregularities, historical events, and complex interactions, but he was confident that broad principles were, ultimately, attainable.

Much of Humboldt's understanding derived directly from systematic measurements

Julius Schrader's portrait (1859), "Baron Alexander von Humboldt," shows Chimborazo and Cotopaxi in the background.

and observations made during his travels in Europe, his voyage to the New World with French botanist Aimé Bonpland (1799–1804), and his trip across Siberia to the Altai Mountains (1829). However, he also relied heavily on a global network of collaborators and correspondents to expand his observational capacities. His scientific works were built on information obtained from hundreds of scientific and scholarly correspondents, and he mined data from accounts and anecdotes of travelers, traders, diplomats, sailors, soldiers, and priests. He also made extensive use of indigenous and local knowledge (*5*, *8*–*10*). Humboldt recognized that such phenomena as weather, climate, ocean circulation, earthquakes, volcanism, and geomagnetism could be understood only through systematic monitoring, and he used his collegial networks to build a distributed, global, geomagnetic observatory, the first international scientific cooperative of its kind. He also organized the first modern scientific society, which became the model for others.

Humboldt was far more than a natural scientist, though. He was a pioneering social scientist and, above all, a humanist. His volumes on Venezuela (*9*), Cuba (*11*), and Mexico (*12*) integrate physical, cultural, historical, and economic features. *Views of the Cordilleras* is an ingenious synthesis of art, anthropology, history, linguistics, geology, and geography (*10*). Humboldt argued that all the diverse peoples of the world were a single species, with no peoples or cultures a priori superior to or dominant over others (*7*). He was also a passionate and vocal opponent of imperialism, colonialism, and slavery (*8*, *11*, *12*). Humboldt's humanistic views were radical; in his lifetime, slavery flourished across the Americas, and imperialism expanded under a seldom-challenged notion that the "advanced" peoples of European descent had a right, even a duty, to subjugate other cultures and peoples across the globe.

Although Humboldt's pursuit of scientific knowledge was driven by curiosity, ambition, and a desire to contribute to human welfare, it was part of a larger vision encompassing nature and the human mind. Throughout his work, he explored the fundamental tension between the external world of nature and the internal world of human sensations, perceptions, and emotions (*1*, *5*, *7*). As a scientist, he assumed that the natural world is comprehensible, despite its particularity and complexity. As a humanist, he recognized that our understanding of the natural world is a product of the human mind, filtered through sensations and emotions. His awareness of the diversity of nature and the essence of the mind and senses led to his own feeling of intellectual humility. He noted that, "Experiential sciences are never completed, the abundance of sensory perceptions can never be exhausted; no generation will ever be able to pride itself on possessing an overview of the entirety of phenomena" (*13*).

Humboldt was fascinated by the diverse ways in which human cultures have explained and engaged with the natural world, but also by the emotional reactions held in common by cultures separated widely in time and space—awe, reverence, inspiration, fear, and delight (*7*). His vision of the cosmos was a never-ending program of applying the tools of science to understand nature, while simultaneously applying the practices of the humanities—art, poetry, literature, music—to appreciate nature and to deepen our understanding of it (*1*, *7*, *8*). Science is an important way to know the world, but it is one among many. Knowing of the world intellectually and aesthetically is enriching and empowering, and strengthens our bonds with nature and humanity, and our respect for both.

"Knowing the world intellectually and aesthetically...strengths our bonds with nature and humanity..."

Aesthetics and science were inseparable in his works. The 1807 Chimborazo profile was a fusion of art and science (*1*), as were the subsequent botanical monographs (*14*) and graphic inserts [e.g., (*4*, *9*–*12*)]. His most rhapsodic works for general audiences are jammed with scientific digressions and details (*5*, *9*), and his most technical works are interspersed with passages of lyrical, often passionate prose (*1*, *4*, *11*). Humboldt inspired artists, poets, and writers through the 19th century—a small sample includes Frederic Edwin Church, Herman Melville, Henry David Thoreau, Margaret Fuller, Karl Bodmer, and Walt Whitman (*8*, *15*).

Humboldt's works led to several decades of "Humboldtian science" in the United States and elsewhere, characterized by systematic exploration and mapping of territory, measurement, or description of physical, geological, biological, and often cultural phenomena, collection of materials for detailed study and institutional curation, and efforts to identify patterns and draw broad inferences (*3*, *8*, *15*). In the course of the 19th century, Humboldtian science often became a tool of empire and conquest, and his humanistic vision was largely overshadowed. Near the century's end, Humboldtian science disintegrated as unexplored territory diminished and the constituent sciences became balkanized into distinct, territorial disciplines. Global-network science expanded, but largely within disciplines (e.g., oceanography, meteorology, geophysics).

Since the mid–20th century, many elements of Humboldt's original vision have reemerged, though irregularly and not without conflict. Interdisciplinarity has proliferated, driven by fundamental scientific opportunities and the complex and multifaceted challenges of environmental and societal change. During and since the Cold War, international scientific collaboration served as a diplomatic tool and agent of peace, and in recent decades has grown to address such global concerns as climate change, biodiversity, and environmental sustainability. The scientific community has diversified along many dimensions, including gender, ethnicity, nationality, and culture, driven by changing societal and community values. Indigenous and local knowledge is now being explicitly valued and utilized in scientific assessments (*16*). These are all hopeful trends, as are the broadening public appreciation for science and concern over the future of nature under climate change and other threats.

Scientists are now involved in a debate over whether the Anthropocene should be recognized as a formal geological epoch. The Anthropocene discussion focuses attention on a fundamentally Humboldtian observation: Humanity and nature are deeply intertwined. Humans have been influencing the natural world at local, regional, and perhaps global scales for many millennia. The changing natural world has had reciprocal influences on human welfare and activities. Nature and humanity are now locked in lopsided coevolution—that is, nature would persist in the absence of humanity, but humanity cannot exist without nature (*16*). Accelerating human impacts, together with sequential appearance of novel activities (e.g., fire, cultivation, fossil-fuel combustion, synthesis of polymers and pharmaceuticals), draw the fates of nature and humanity ever closer.

Alexander von Humboldt's vision, linking science with the broader human experience, is essential for addressing the grave environmental and societal challenges that we face in the Anthropocene. That vision places science in proper perspective as an imperfect but aspirational human endeavor—one that is necessary but not sufficient to foster a healthy relationship with the natural world.

Southwest Climate Adaptation Science Center, US Geological Survey, and University of Arizona, Tucson, AZ, USA. Email: stjackson@usgs.gov

It also emphasizes that all people have a stake in nature and in science. Humboldt was optimistic that everyone could understand and appreciate nature and science (*5*, *7*), and he regularly engaged the public in his writings and lectures. These were more than pronouncements from a mountaintop. Olympian as he was intellectually, Humboldt conversed with and learned from mine laborers, peasant farmers, subsistence hunters, seamen, and indigenous peoples wherever he encountered them. Although he was unapologetically liberal, he engaged with slaveholders, aristocrats, colonial bureaucrats, emperors, and kings. Humboldt's combination of empathy, humility, confidence, and rigor can serve as a model for engaging the public on matters of urgent concern. Active valuing of nature can come from linking emotional responses and sensual experience with intellectual curiosity and scientific understanding. Extending the understanding to encompass the past, and to envision alternative futures for nature and humankind in the Anthropocene, can motivate hope and action. Rekindling Humboldt's vision, and building on his legacy, can provide not only solace and inspiration, but also maps and narratives toward a better future for nature and people. ■

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ASTROPHYSICS

An expanding controversy

An independently calibrated measurement fortifies the debate around Hubble's constant

By **Tamara Davis**

One of the most fundamental and controversial measurements in cosmology, Hubble's constant (H_0), informs scientists about how rapidly the Universe is expanding. The debate about the value of H_0 has heated up recently as increasingly precise measurements from different techniques are converging on different values for H_0. This discrepancy either means that the H_0 measurements have systematic errors larger than astrophysicists can explain, or it reveals something profound about the physics underlying our universe. On page 1134 of this issue, Jee *et al.* (*1*) present a new way to measure H_0, by combining information from strong gravitational lensing and the motion of stars within the lens galaxy, to calibrate supernova luminosities.

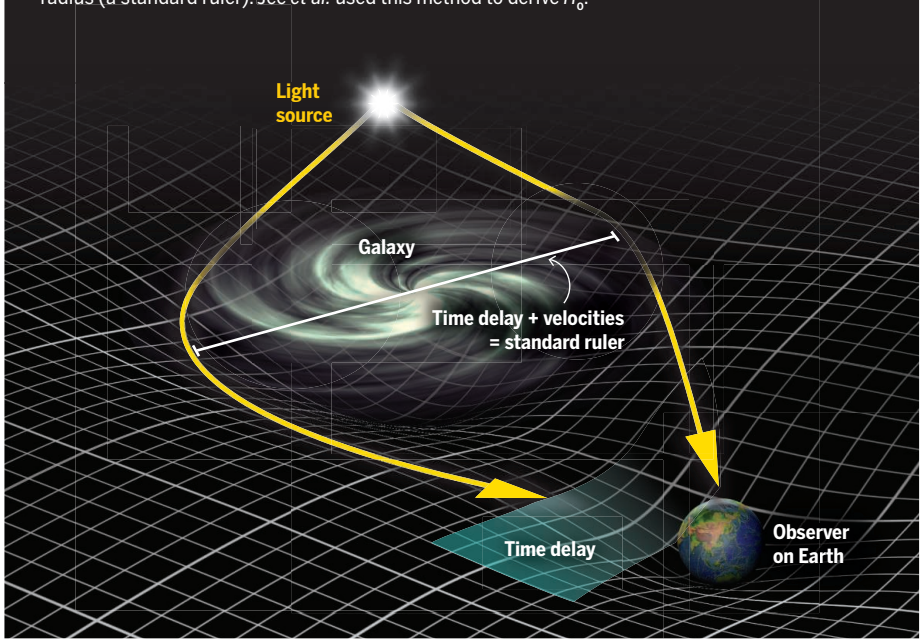
In the 1920s, astrophysicists Georges Lemaître and Edwin Hubble independently discovered that the Universe is expanding by noting that the more distant a galaxy, the faster it is receding from Earth, as encapsulated in the Hubble-Lemaître law: velocity = H_0 × distance. The value of H_0 thus sets the current expansion rate of the Universe. To derive H_0, one must know both the distance of a cosmic object and its recession velocity.

Velocities can be calculated from the shifting of spectral lines caused by the expansion of the Universe (redshifts). However, measuring accurate distances has been the bane of astrophysicists. It is difficult to distinguish between a bright or large object that is far away and a faint or small one that is nearby. To overcome such difficulties, one must know the intrinsic properties of the object being measured. With a standard candle (an object of known luminosity) or standard ruler (something of known size), cosmologists can use their apparent brightness or size, respectively, to estimate an object's distance.

Lemaître and Hubble derived the earliest estimates of H_0 (~500 km s^{-1} Mpc^{-1}) in the late 1920s, when the distances to galax-

Multiple paths to Hubble's constant

The strong foreground lens, a galaxy, bends the path of light from a background supernova, so that light arrives at Earth by two routes of different lengths. Thus, the observer detects one image before the other. This time difference allows calculation of the lens's mass. The velocity of stars orbiting in the lens galaxy reveals the gravitational potential. Together, these values yield the lensing system's radius (a standard ruler). Jee *et al.* used this method to derive H_0.



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