



ESD Ideas: To address planetary crises, we must understand our place on Earth

Daniel Duzdevich¹, Arwen E. Nicholson², Raphaëlle D. Haywood²

5 ¹ Department of Chemistry, The University of Chicago, Chicago, IL 60637, USA

² Department of Physics and Astronomy and Global Systems Institute, University of Exeter, Exeter, EX4 4QL, UK

Correspondence to: Raphaëlle D. Haywood (r.d.haywood@exeter.ac.uk)

10 **Abstract.** Studying the origin of life and its prevalence in the universe offers a perspective that compels us to look after our irreplaceable home in the cosmos. An entrenched conception of humans as distinct from Nature prevents us from seeing and embracing our place in space and time, to our catastrophic detriment. We call on our colleagues to harness this unique perspective to connect their research with broader problems facing humanity, while leveraging the trust, credibility, and privilege of the scientific enterprise.

Life is deeply embedded in Earth history

15 How life began remains one of the biggest unanswered questions in science. There is no fossil record of life's emergence on Earth: weathering, plate tectonics, and the carbon cycle collude to obliterate the imprints of biology as time passes. Nevertheless, we know more about our planetary history than even a few decades ago, partly because we are learning more about other planets both in the solar system and beyond. We also have the example of extant life. The great achievement of modern biology is the insight that all living things are essentially the same at the molecular level, having evolved from a common primordial ancestor. The Last Universal Common Ancestor (LUCA) possessed the fundamental features we associate with living cells (Koonin, 2003). Our primary tool for experimentally studying the origin of life in the laboratory is the understanding that however life started, it must have harbored the potential to form LUCA. Research into the origin of life thus points to an ancient event, not long after the birth of our planet (Pearce et al., 2018), that transformed chemistry into a durable biology.

Acknowledging our place in the biosphere

25 Everything we know in our daily lives, and all the biology teeming around us, has spread from the emergence of life on our planet billions of years ago. Our relatedness is profound: life is one family sharing one home. Biology has covered the planet very thoroughly: from rock deep beneath the ocean floor to the high reaches of the atmosphere (and even on space probes!), every niche that can support life—and even some that would seem inhospitable—is inhabited (Rothschild, 2001). The biosphere as a whole has shown striking resilience throughout Earth's history, adjusting to cataclysmic changes in its planetary environment over time (Corsetti, Olcott, & Bakermans, 2006). Humans are latecomers to this story. Our very existence is



enabled by the expansive diversity of life that preceded us and that is actively creating and maintaining the niche we occupy. We are inextricably embedded in something much bigger than our instincts can register. If we want to ensure a sustainable future for humanity, then we must first acknowledge our place in the biosphere's planetary playground and epic history.

Our planet and biology are interlaced

35 Life has become integrated into Earth's planetary-scale workings over billions of years. Life, the oceans, atmosphere, and land interact with one another through massive feedback mechanisms. The result is homeostasis: the Earth system acts to stay in equilibrium and is resilient to small, slow perturbations (Lovelock & Margulis, 1974; Lovelock, 2016). For example, the carbon cycle acts as our planet's thermostat and stabilizes Earth's climate over millions of years (Isson et al., 2020). Life increases resilience to climate perturbations and thus actively contributes to maintaining habitable temperatures on Earth's
40 surface (Schwartzman & Volk, 1989; Vicca et al., 2022).

Acknowledging our place in the Earth system

All species alive today are the products of an equally long stretch of evolution: from bacteria to conscious beings, each species has evolved to fit a particular environment. Humans evolved to fit a narrow niche, but, in the grand scheme of things, we are a part of the planet in the same way as every other living organism. Planet and Life co-evolve together (Schwartzman,
45 Jorgensen, & Fath, 2008): we are not apart from or above this system we call Nature. *Humans would not survive without Life on Earth: it is our life support system.*

Life shapes Earth's astronomical identity

Our planet, only one among billions of others in the galaxy, is alive. Its biosignatures are visible at astronomical distances (Schwieterman et al., 2018). What about life on planets beyond our solar system? We are now able to determine exoplanetary
50 composition and equilibrium temperature, and, for some of the closest and largest exoplanets, we can examine their atmospheres and identify constituent gases. If Life is ubiquitous, we will detect it on terrestrial, temperate planets in the next decades (Seager, 2014; NAS, 2019).

Astronomical context is essential for building a sustainable future

Although we occupy a privileged and exciting moment in our understanding of the universe, *we will not find another haven to
55 escape our planetary and humanitarian crises.* The search for exoplanets and Life is to gain knowledge and perspective about the planet we live on. For example, we are using observations of planets in our solar system and beyond to test and validate models of Earth's climate (e.g. Pierrehumbert, 2011; see further works in the review by Shields, 2019). Observations of (exo-)planets show us what different possible futures could look like. Although Venus is Earth's sister, it has taken a very different path to a runaway greenhouse. Examining other planets informs models of planetary evolution with direct observations. As
60 we head into uncharted trajectories over the coming decades, building a statistical sample of planetary snapshots will provide



insights into the mechanisms that determine stable climate states (Scharf, 2014). Our models of the Earth system, informed by the data of new frontiers in astronomy, can guide policy decisions, *servng as civilization's compass for navigating rapid planetary changes*.

Calling our fellow scientists to inspire and lead

65 We are explorers of the origin and fate of life and planets. Our research community offers a unique and powerful perspective on humanity's most acute intergenerational challenges. Humans are a part of Life, embedded in the Earth system, among billions of planets in the galaxy. Acknowledging our story of deep resilience and interdependence is the first step to mapping a sustainable future. This perspective confers immense responsibility. Scientific credibility and academic freedom come with a duty to highlight not only the cosmic perspective, but to ensure that it serves as a basis for action. Let us educate and inspire,
70 inform and act.

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