ASTROBIOLOGY

Evolution on other worlds

Bound by finite natural laws, alien life may be more familiar than we imagine

Exotic earthbound creatures such as the short-beaked echidna offer hints about potential alien life.

By **Adrian Woolfson**

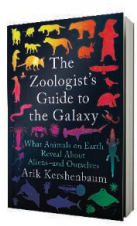
The late Harvard biologist Stephen Jay Gould speculated that the history of life on Earth was deeply influenced by chance events (*1*). In a classic thought experiment, he imagined rewinding the "tape of life" back to its inception and allowing life's history to play out again. The reemergence of humans, for example, was, in his view, a near impossibility.

Others have argued that life is more predictable and constrained. Evolution converges on the same solutions repeatedly, and its outcomes may have a certain inevitability (*2*). The eye, for example, has evolved multiple times in unrelated lineages.

Biologist Richard Lenski has turned Gould's conceit into an experimental research paradigm. His artificial evolution "replay" experiments, in which identical populations of microbes are allowed to evolve in parallel for tens of thousands of generations, suggest that the truth lies somewhere in between (*3*).

In his entertaining and thought provoking *The Zoologist's Guide to the Galaxy*, the Cambridge University zoologist and mathematical biologist Arik Kershenbaum—known principally for his studies of animal vocalizations—turns to astrobiology, a field concerned with the origins and persistence of life in the Universe, and provides readers with a tentative sketch of the nature of possible alien life on other potentially habitable planets. Kershenbaum assumes that evolution on other planets would likely play out in a manner recognizable to us earthlings because of the universality of the laws of physics, chemistry, and even biology and because there are a restricted number of behavioral imperatives to which all organisms are beholden. By focusing on behavior and prioritizing function over form, a generic set of "biological rules" can be inferred. He argues that these can be universally applied to potential alien beings, because the laws should be relatively insensitive to biochemical and morphological specifics.

Like a modern-day Dr. Doolittle, Kershenbaum searches for clues about what aliens might look like and how they might communicate, by interrogating the shared strategies of the species surrounding us. While beetles, bats, and birds have different evolutionary origins and body plans, all have converged on flight as a common approach to locomotion. And while wolves and dolphins inhabit different ecological niches, both species rely on continuously varying vocalizations to avoid signal distortion when communicating across large distances.



The Zoologist's Guide to the Galaxy
Arik Kershenbaum
Penguin Press, 2021. 368 pp.

Kershenbaum cautions against excessive anthropomorphism when attempting to evaluate potential alien communications. Human languages are impressively expressive, he concedes, but we should not assume that the electrical discharges of the South American knifefish or the disconsolate foot drumming of the kangaroo rat are not capable of encoding complex information.

Like their earthly counterparts, alien life-forms will face idiosyncratic evolutionary pressures that nevertheless channel their communication strategies in predictable directions. "On a dark, subterranean world, perhaps like the underground oceans of Enceladus, vision may be totally absent, and eyeless creatures could evolve a perfectly competent and rich communication using sound alone," writes Kershenbaum. "Conversely," he notes, "in the tenuous Martian atmosphere, acoustic communication just isn't a good option."

The fossilized bones and genome sequences of our relatives and ancient ancestors teach us that there are many different ways of being human. But if these extinct species were alive today, would we afford them human rights? If yes, Kershenbaum argues, then we implicitly accept that "humans are a collection of different species."

Defining a putative set of essential human features is, however, nontrivial. In situations where convergent evolution is marginalized by the imprint of historical contingency, alien morphology may deviate substantially from canonical human anatomy. Despite sharing many essential features with humans, such morphologically distinct aliens may not easily be recognizable as belonging to the extended human family.

The book's key thesis rests on the notion that all complex life, regardless of its site of origin, is rooted in the immutable logic of evolution by natural selection. However, it does not account for the fact that there may be species that have learned to rewrite their own genomes. These species may, as such, be disconnected from their evolutionary history and less sensitive to the mandates of natural laws. In the presence of such ingenious beings, Kershenbaum's guide might leave us lost in translation. But barring such a scenario, the author's assertion that the unshakable prerogatives of physics, chemistry, and evolutionary biology, coupled with the omnipresent agency of convergent phenomena, offer a reasonable prospect of inferring the nature of distant alien species is compelling. ■

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