Naturalizing History

Naturalizing History:

A Biocultural Theory of Human Progress

By

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Needless to say, all the judgements and contentions in this book are my own, as are all its errors and flaws.

Since family looms so large as this book's conceptual Polaris, I'd like to dedicate this book to my loving and patient wife Maria, my son Daniel, my daughter Leah Porter, her husband Nick, and my two young granddaughters, Lily, and Elanor.

INTRODUCTION

E.O. Wilson spoke of the need for consilience between the humanities and the physical sciences, suggesting how bridges might be built between them. Other evolutionary and social scientists, and some humanists, have added stones, often connecting a threshold event (e.g., the domestication of fire) or some presumably evolved capacity (e.g., “Machiavellian intelligence”) with major biocultural consequences. Several have attempted to weave biocultural history into a single grand narrative, sometimes encompassing the whole history of life as in what is called “Big History,” (works like David Christian *Big History: Between Nothing and Everything*, first edition, 2014, McGraw-Hill Education), sometimes limited to humanity (works like Yuval Harari *Sapiens: A Brief History of Humankind, Harper 2012* and *Homo Deus* 2017, Harpers*)*. Impactful books informed by evolutionary theory, works like Steve Pinker’s *Enlightenment Now,* and Matt Ridely’s *The Evolution of Everything: How Ideas Emerge*, have argued for a progressive view of history based on the steady advancement of reason and cultural development.

This book takes a further step, fashioning an altogether new and broadly comprehensive theoretical framework for understanding human history and society in the most encompassing evolutionary terms. Combining an evolutionary perspective with a broad-based historical analysis of the world’s major civilizations, it attempts to put historical and social science inquiry on a new footing, integrating it conceptually with the entire history of life. It is, in short, an ambitious attempt to take social theorizing in a new direction and to a higher level.

It responds to the narrowness of much current academic history and social science scholarship by offering a reinterpretation of the human story of mammoth proportion. I’m not, of course, without scholarly colleagues of comparable ambition, as will be obvious from my notes and bibliography, but in contemporary scholarship the dominating tendency is to think small with an accompanying loss of the interpretative context indispensable to reasonable judgment about particulars. I here offer a counterweight.

Drawing upon the three and a half billion-year record of biological evolution, a domain whose larger structure is becoming increasingly well-mapped, this book attempts to reconceive of human history as its supercharged extension. In attempting to establish this relation and describe the character of the human-driven acceleration, it exports concepts from the evolutionary sciences into human history and formulates new concepts of dual application currently unknown to researchers in either field. Each of these kinds of conceptual transfers seemed useful to me in the search for common frames. If I've found such frames and they have interpretative value, we'll not only better comprehend what makes human history most fundamentally tick, but have located new directions for social research, directions whose bearings I'll suggest at this book's end. While evolutionary biologists may find my contentions of interest, they're primarily directed at historians, political theorists, social scientists and members of the general public interested in the study of humankind. My hope is to broaden their thinking by showing the new illuminations the naturalization of history can bring to well-worn historical topics.

A book with big ambitions must be prepared to take intellectual chances in realizing them. Accordingly, I'm willing to make speculative leaps where I think they can illuminate, if not necessarily settle, major questions pertaining to nature's, and humanity's, past and present. That more readers may regard this as a flaw than a virtue is another hazard I'm willing to accept. I want to provoke thought even at the risk of appearing to some premature or perhaps foolhardy. And if I don't end up providing completely convincing answers to every question I ask, I'll settle for a simpler achievement, persuading my readers that there's real value to be had in looking at the history of life and the history of humanity as integrated processes with shared structures whose exploration can be deeply illuminating.

Although humans have been practicing the craft of history much longer than paleontology and evolutionary science, in comparison with those natural disciplines, history is theoretically undeveloped. This is partly due to the perceived sterility of previous grand historical theorizing, even if ideas it produced, especially of the evolutionary kind, can still be mined for insight. Another factor is the misuse of grand historical theorizing during the twentieth century by extremists on both the left and right.

There are good reasons why theorizing about human history is a more daunting venture than doing the same about the history of life. First and foremost, we expect different things from the life sciences than we do from historical writing. We certainly want far more information about particular events in the latter than the former. Our brief lives are immersed in history's longer flow, beneficently shaped or painfully mutilated by its twists and turns. We thus want to interrogate these in exquisite detail and be repaid by answers of equal specification.

For purely cognitive reasons we also generally prefer answers that come incorporated in stories over those to be inferred from abstract models. It was probably such concrete narratives that absorbed the campfire conversation of our Paleolithic ancestors, because these provided the most cognitively accessible way of transmitting the knowledge they needed to survive. And, by and large, that's what traditional history writing also evolved to deliver.

The lack of demand (and possibility) for the history of life to operate on a delicate scale has released it to take a panoramic view and, mostly, eschew narrative for analysis. I know of no equivalent in the history of life to individual biography, though shows about nature keyed to popular audiences often follow the lives of individual animals. Not anchored in the explanation of particulars—though it has to be tested by reference to them—evolutionary science has been able to develop abstract concepts of general application such as "inclusive fitness," "ecological release," "symbiogenesis," and, indeed, "natural selection" that find no corollaries in standard accounts of human history. In addition, it can employ more in the way of mathematical, chemical, physical, microscopic and radiological analysis than can be applied to human history, cliometrics and various archeological techniques notwithstanding. More grandly architectural and analytical than human historical writing, the "language" of the history of life sounds very different from that of its human counterpart. (It does share with it, however, the carving of chronology into "eras," "epochs" and so forth.)

Conceptual cross-fertilization must always be undertaken with caution. Still, once human history is seen as an integral part of the larger history of life, all sorts of new questions and opportunities for conceptual borrowing and redefining open themselves. I hope this book excites interest in those questions and opportunities.

Two key ideas shape the arguments made in this book. First, biological and cultural evolution are understandable as learning processes. Second, human behavior is mainly a function of what tends toward inclusive genetic fitness - the ability of an individual to transmit his or her genes to subsequent generations, including genes shared with near relatives[1]. Particular human behaviors flourish when particular cultural and physical environments select for them, giving them greater fitness yields than other behaviors.

The former idea explains what I see as evolutionary directionality, or "progress," as well as the many correspondences exhibited by human history and the history of life. The latter addresses human history's recurrent patterns and constrained possibilities.

A relatively recent departure in historical interpretation styled "cliodynamics" shares this book's biological view. Cyclic episodes of state breakdown are seen through its lens as expressions of biological crowding, with high rates of population growth intensifying familial competition at both the mass and elite levels thereby putting political institutions under stress.[2] What's usually assumed, but here made explicit, is that the pursuit of inclusive fitness underlies this competition.

I try to enlarge inclusive fitness's explanatory scope by attempting to show how it can clarify a broader range of phenomena than just state crises. Furthermore, this book is more concerned with the cumulative rather than the oscillatory character of biocultural evolution, as I seek to examine not just its perturbations but its thrust.

There are others who have been walking this same path, most conspicuously American journalist and author Robert Wright, who in *Nonzero: The Logic of Human Destiny* brilliantly laid out the sequential cumulative character of biological and cultural evolution more than two decades ago.[3] Acknowledging my debt to his work, among others, I nonetheless believe this book to be distinct in several respects.

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[1] Anna Szala, Todd K. Shackelford (2019). "Inclusive Fitness," in *Encyclopedia of Animal Cognition and Behavior, eds.* Jennifer Vonk & Todd K. Shackelford (Edinburgh, U.K. Springer, Cham, 2019) https://doi.org/10.1007/978-3-319-47829-6_1997-1.

[2] Three of the most notable proponents of this kind of analysis are Jack A. Goldstone, Peter Turchin, and the team of Aurelio J. Figueredo, Steve Hertler and Mateo Penaherrera, whose work I draw upon at various points in the book.

[3] Robert Wright, *Nonzero: The Logic of Human Destiny* (New York: Pantheon Books, 2000). My own first effort at developing the thesis that cultural evolution is part of a biocultural continuum was in an article published at the beginning of my foray into academic activism, "Metaevolution and Biocultural History," *Journal of Social and Biological Structures* 12, no. 4 (October 1989): 303–18, https://doi.org/10.1016/0140-1750(89)90025-0.

First, I give my unifying framework much more elaboration than do others who have made the same journey. This involves an integrated system of concepts, including “metaevolution,” “phenocracy,” and “postdaption,” meant to highlight key evolutionary features of human history, some of which it shares with the history of life. Other concepts, like “ecological release,” with already established definitions in the biological sciences, have been imported into the system where I believe they can do useful explanatory work. Some readers may tire of these neologisms, verbal transpositions, and terms unfamiliar to conventional humanistic discourse, but, with apologies, I think them warranted in light of my systematizing goals.

Moreover, I don't share the optimism of many other writers about humanity’s capability to carry the torch of evolutionary learning further forward.[4] One great impediment lies in the selective filter of inclusive fitness, which chronically undermines human aspirations to achieve the common good. Another resides in humanity’s biocultural hybridity, which chains our newer foresighted powers of reasoning to our older, more myopic, yet essential, promptings of animal passion. My pessimism isn’t absolute. It's possible we can cognitively and morally bootstrap ourselves to a point where progress becomes open-ended. But given our past record and the fundamentals of our biology, this will require a clear-sightedness about the human situation that goes against our cognitive grain.

In the book's second and third parts, I present three detailed case studies of historical episodes that played key roles in the world’s breakthrough to modernity, the secularization of millennialism, the Scientific Revolution and the emergence of what I call The World-Safe-for-Making, (hereafter referred to as WSM), a social order based on wealth production instead of wealth extraction. These three episodes, each of great inherent importance, have been studied in depth by many others. What I attempt to do here is show how their "naturalized understanding" can shed fresh light on why they occurred and the changes they produced.

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[4] In addition to Wright I’m thinking especially of the recent works of Steven Pinker, notably, *The Better Angels of Our Nature: Why Violence Has Declined* (New York: Penguin Books, 2011) and *Enlightenment Now: The Case for Reason, Science, Humanism, and Progress* (New York: Viking, 2018), and most emphatically of David Sloan Wilson, *Does Altruism Exist: Culture, Genes, and the Welfare of Others* (New Haven, CT: Yale University Press, 2015).

The book concludes with a review of key concepts and their use as guides for future historical and social science research, emphasizing metaevolutionary importance, the interplay of inherency and contingency, and human hybridity.

PART I

THE HISTORY OF LIFE AND THE HISTORY OF HUMANS

CHAPTER 1

LIFE AS LEARNING

Seven times a trumpet sounds, the first six calls eliciting a quarreling chorus of answering woodwinds. A final appeal yields no response at all, except for the remote murmuring of strings, the indifferent music of the spheres. We're listening to *The Unanswered Question,* the musical meditation of the great American composer Charles Ives (1874-1954), which premiered in 1908.[5] It is a deeply poignant piece: humans yearn to know who they are, why they were born, where they are living, and where, if anywhere, they're heading. But no answer comes.

It is a safe bet that humans are the first and only of Earth's creatures ever to have considered such questions. Yet, in a sense, implicit inquiries about them were being made long before humankind's rise. For ages these queries pertained solely to the practicalities of physical existence: by what means, essentially via what chemical reactions, could something by all ordinary rights impossible—a living thing—survive and reproduce itself? As it turned out there were many serviceable answers to this question, sometimes conflicting with one another, sometimes neatly complementary. And somehow these sounding replies slowly meshed into a swelling organic symphony.

Eventually an "I" entered into the exchanges, living things recognizing themselves as integral parts of the environments they needed to master. "Inside" qualities now had to be considered separately from those of the ambient "outside," as when a cheetah appraises how fast it can run while deciding whether or not to pursue a given prey at a given distance. Questions of *what to do* were thereby conjoined to and complicated by those of *what am I?*

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[5] Charles Ives, *The Unanswered Question*, originally paired with *Central Park in the Dark* as *Two Contemplations* (1908); score (New York: Southern Music Publishing Co., Inc., 1953). Ives (1874–1954) was himself a tribute to the versatility of human learning, achieving distinction both as an innovative composer and insurance executive.

The answers to these allied questions gradually became stratified, some lower and of limited factual scope, others of more general signification. In our own time the questions asked, and the answers received, have assumed awesome sophistication, often only expressible in mathematical terms. If we don't yet feel, as Ives certainly didn't, that the answers in hand altogether satisfy, we may at least be gaining a sense of slowly drawing closer to that long-awaited moment of spiritual relief.

I believe that we are indeed getting closer. In fact, I think we are so close that we can discern the answers to the main "what" and "where" questions, albeit still only schematically. Some of these may inspire us, others deeply trouble, but their contours are ever more visible. We can also discern the directions of the inquiries we must pursue to fill in the elements still missing, gaps that when closed may finally integrate our understanding of the world's past, present, and future. The quest for this knowledge increasingly requires a convergence of natural and humanistic questioning, the "consilience" E. O. Wilson foresaw.[6]

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As already proposed, human history can best be understood as a "supercharged" extension of the history of life. The continuation is more than just a matter of chronological sequence, or a chain of causation, or a useful metaphor. It is in my view literal. This is because both the history of life and the history of humans are instances of a single underlying phenomenon, *learning*. Evolution, biological and cultural, has been a sequence of questions asked, and answers received, most fundamentally about what needs to be done if unusually complex objects are to survive within a universe relentlessly driven to simplify. The accumulation of pertinent answers has now reached the point where we humans can not only wax philosophically, but, like Ives, musically, about the larger meaning of life, albeit in a note of despair. What other animal knows enough to experience such melancholy about its history and future? Possessing this angst is itself a surpassing achievement.

There are, of course, various ways one can look at history, each possessing some advantage and interest. It can be viewed as human drama, contests among people and groups, better and worse, noble and plebian, to advance

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[6] Edward O. Wilson, *Consilience: The Unity of Knowledge* (New York: Vintage, 1999).

in life's struggle or leave some mark upon the world. This is the standard approach, "history as story." And, generally speaking, this is history's most useful form, because we've evolved to attend to, learn from, and enjoy stories.

History can also be viewed as the reflection of a higher purpose. This is the kind of history that most often appeals to intellectuals and the regimes they frequently serve. Finding larger meanings in the flow of things has helped put kings on their thrones and bread on scholarly plates. (Whether any waiter will arrive at my table remains to be seen.)

Yet another way of viewing history is as a continuum of aggregates, which "cliometrics" labors to usefully collate. Here we usually meet enumerations of goods, activities, and people, time-ordered to measure changing states of affairs, quantities interesting in themselves but meant to reflect more basic transformations in the qualities of human life. Collecting this data is an enterprise very useful to historians as professionals, but likely to leave the public's eyes glazed over.

History can even be boiled down to an entirely chemical process, an almost-as-old-as-the-Earth reaction, ramifying in every direction so as to cover the terrestrial surface in a deep organic broth heated by the Sun above and the planetary core below. Coalescing within this broth, and sometimes burbling up out of it, are nodules that gradually become more complex inwardly and active outwardly. This "soup and dumplings" view of life may not be to everyone's taste. Few want to be potstickers, however choice. But in purely physical terms it has a discomforting accuracy.

Or, with cantankerous agnosticism, history can simply be derided as "one damn thing after another," which in fact expresses something quite real about it, a baseline indeterminacy that explanation can never fully penetrate.

All of these views of history have virtues though, unlike the others, belief in history as the reflection of a higher purpose requires the existence of "things invisible." The attraction of the view developed here—history as a learning process—is that it explains history's apparent direction by reference to what most deeply steers it, without resort to any teleological magnet pulling it forward. (Although our state of knowledge doesn't allow us to altogether dismiss teleology.)

Believing that both human history and the history of life progress will strike many evolutionary theorists, though fewer historians, as problematic. Why then do I subscribe? Because if something cumulatively learns, layering new knowledge upon earlier, it can be said within the common meaning of the term to "progress."

That this should be a vexed question is a bit surprising. Providing we divorce the idea of progress from metaphysics or morals and restrict its application to observable trends in the development of technique, the existence of progress in both human history and the history of life appear incontrovertible, as one would expect if learning is what most fundamentally defines them.

The existence of progress is less controversial within human history, the high-tech wonders of modernity having clinched the case for all but the most nihilistic, postmodern, or primitivist of thinkers. Most historians even see ancient civilizations as advances over what preceded them, despite the regress they actually constituted in the status, freedom, and often material welfare of ordinary people.

Among students of the history of life, however, the idea of progress has been beset by determined opponents, most famously the late paleontologist Stephen J Gould.[7] Many aspects of life's history are commonly cited to deny the existence of progress within it. Evolution, we're correctly told, doesn't necessarily favor the complex over the simple nor the big over the small. (Parasites tend to devolve toward structural minimality.) Nor does evolution favor traits that are humanlike or, for that matter, humans like. Big brains are an energy-soaking evolutionary luxury and most species, with more pressing adaptive needs, refrain from cerebral maximization. (Once anchored to the ocean floor sea squirts actually eat their brains!) Furthermore, catastrophes worldwide and local can undo tens of millions of years of evolutionary learning in a geophysical flash, with smaller, simpler, more generalized species having better chances of weathering their storms than do larger, complex, more specialized ones. Extreme climatic changes, like the drying and deoxygenation that overtook early Mars, or the runaway

[7] See for instance, John Maynard Smith and Eörs Szathmáry, *The Major Transitions in Evolution* (Oxford: Oxford University Press, 1997), 4–5; Norman A. Johnson, David C. Lahti, and Daniel T. Blumstein, "Combating the Assumption of Evolutionary Progress: Lessons from the Decay and Loss of Traits," *Evolution: Education and Outreach* 5 (2012): 128–38, https://doi.org/10.1007/s12052-011-0381-y; Jordi Paps and Christina Guijarro-Clarke, "Evolution: That Famous 'March of Progress' Image Is Just Wrong," *The Conversation*, March 20, 2020, 10:13am EST, https://theconversation.com/evolution-that-famous-march-of-progress-image-is-just-wrong-132536.

greenhouse effect that made a hell of Venus, can cause biospheres to drastically contract or even die out, as they might conceivably have done on those very planets a long time ago. In a billion years or so, as the sun heats up and expands, Earth life will also decline in diversity, decrease in terrestrial extent, and ultimately disappear, absent some super-sophisticated scientific fix. And, at that point, it's *finis* to progress.

So, mute the horns and muffle the drums. I won't commit the error of proclaiming that life marches inexorably forward toward some preordained cosmic triumph, though as I'll assert at the book's close, the possibility exists. Nor will I contend that evolution is bent on maximizing some particular quality. Nor that selection invariably favors progress according to any idiosyncratically favored objective. Biological innovations aren't selected for their contribution to total biomass, improved integration of the biosphere, or some peak cleverness. They certainly don't seek to strengthen "Gaia," understood as Earth's total biosphere. Evolutionary learning solves immediate adaptive problems within evolving lineages, solutions that might well create adaptive problems for other lineages and even massive destruction across the biosphere. In the past, some have triggered spectacular worldwide life crises, as when photosynthesis oxygenated the atmosphere, the source of a great dying of life forms for which oxygen was poison. Only later did adaptation manage to turn oxygenation to life's advantage.

Teilhard de Chardin (1881–1955), the evolutionary perfectionist *par excellence*, memorably proposed the concept of an "Omega Point" of unified flawlessness toward which evolutionary progress was bound.[8] This idea, while psychologically appealing and not demonstrably false, doesn't need to be true for the argument I'm making to succeed.

Nor am I supposing that evolutionary learning let loose elsewhere in the cosmos would proceed along the same lines as it has on Earth, ending with beings resembling us. Neither in human history nor the history of life is evolution narrowly deterministic. What is learned is a function of variable circumstance and prior commitments. Specific adaptive histories, biological or cultural, not only depend on the peculiarities of the settings in which they unfold, but tend toward path dependency, their trajectories constrained by earlier evolutionary "decisions" that restrict later possibilities. To be sure, as paleontologist Simon Conway Morris has shown, in diverse lineages

[8] Pierre Teilhard de Chardin, *The Human Phenomenon: A New Edition and Translation of* Le Phenomene Humain, trans. Sarah Appleton-Weber (Paris: Éditions Du Seuil, 1955; Brighton, UK: Sussex Academic Press, 1999).

evolution frequently arrives at the same solution to similar challenges, for example, the separately evolved "camera eyes" of octopi and mammals.[9] Although no necessity exists, encounters with physical reality, which one supposes a seamless web, often channel life's historical course, both natural and human, in similar directions. Hence, life on an Earthlike planet, though not evolving doppelgängers, would probably assume many features we'd find familiar.

Finally, we have no strong empirical basis for believing that "intelligent design" is responsible for the progress of evolutionary learning. Intelligence certainly contributes to human history's flow, since the individuals whose stories comprise it, and whose choices it partly reflects, possess rational capacity. But this exercise of rational faculties happens *within* history and is far from responsible for the totality of its outcomes. Many of these reflect unconscious or only semiconscious human motivations, the force of aggregate social phenomena, natural events, or mere human accident. So even within human history design is often fictive, though obviously not always.

Does my theoretical claim that evolution displays progress have evidentiary support? Yes, residing in the fact that both the biological and cultural spheres have over time tended to become materially more massive, internally more complicated, informationally more sophisticated, and increasingly better equipped to draw energy from their environments. These are just the outcomes we should expect from cumulative learning systems.

To see this let's step back and take as comprehensive a view as possible. For the history of life this means its 3.5-billion-year (possibly longer) sweep - a complete read, so to speak - of Gaia's voluminous biography. For human history, the survey needs not be so vast. The emergence of *Homo sapiens* about 300,000 years ago can be our start, the point at which human cultural evolution kicks into high gear.

If judged from these ample perspectives, with caveats duly noted, most scientific observers would, I believe, agree on the empirical reality of the trajectories I'll now describe. allowing for numerous interruptions and fluctuations as well as uncertainties as to whether maxima are occurring *right now* or have occurred at some point, by either geologic or historical standards, in the not so very distant past. Even if many evolutionary

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[9] See Simon Conway Morris, *The Runes of Evolution: How the Universe Became Self-Aware* (West Conshohocken, PA: Templeton Press, 2015).

scientists remain loath to use the "P" word, I don't think they'd demure at what I take to be its concrete reality according to the following metrics.

First, Gaia's biomass (the mass of all living things) has increased, although it may not be higher today than it was during the warm and wet Carboniferous, which ended 298 million years ago.[10] (But keep in mind that if the Carboniferous truly wins the laurels, that peak would still have occurred after 92 percent of life history had elapsed.)

Second, the number of genera the biosphere contains has increased, their diversity growing slowly during the Precambrian and then more rapidly, with occasional sharp reverses, from the very late Precambrian to the present. ("Genera," a somewhat broader categorization of living things than "species," are used to measure past diversity because the variation among genera in the fossil record is easier to detect than variation among more scantily preserved species.[11])

Third, because of the increase in the number of genera (and presumably

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[10] See Sean McMahon and John Parnell, "The Deep History of Earth's Biomass," *Journal of the Geological Society* 175, no. 5 (September 2018): 716–20, http://dx.doi.org/10.1144/jgs2018-061; University of Washington, "Less Life: Limited Phosphorus Recycling Suppressed Early Earth's Biosphere," *ScienceDaily*, November 27, 2017, www.sciencedaily.com/releases/2017/11/171127152032.htm; Paul Aheron and T.C. Liew, "An Assessment of the PreCambrian/Cambrian Transition Events on the Basis of Carbon Isotope Records," in *Early Organic Evolution: Implications for Mineral and Energy Resources*, ed. Manfred Schidlowski, Stjepko Golubic, Michael M. Kimberley, David M. McKirdy, and Philip A. Trudinger (Berlin: Springer, 2012), 212–23; Werner Von Bloh, Christine Bounama, and Siegfried Franck, "Cambrian Explosion Triggered by Geosphere-Biosphere Feedbacks," *Geophysical Research Letters* 30, no. 18 (January 1963; 2003): n.p., https://doi.org/10.1029/2003GL017928. There is, however, a contrary view that posits high levels of biomass during the Proterozoic, and even Archean, with a major spike during the Cambrian and then steady decline. See Siegfried Franck, Christine Bounama, and Werner Von Bloh, "Causes and Timing of Future Biosphere Extinctions," *Biogeosciences* 3, no. 1 (March 2006): 85–92, https://doi.org/10.519 4/bg-3-85-2006. Unsurprisingly, there exists some dissent about these trend chronologies, though I think I'm adhering fairly closely to the scientific consensus.

[11] M. J. Benton, "Diversification and Extinction in the History of Life," *Science* 268, no. 5207 (April 7, 1995): 52–58, https://www.science.org/doi/10.1126/ science. 7701342; Peter Ward and Joe Kirschvink, *A New History of Life: The Radical New Discoveries about the Origins and Evolution of Life on Earth* (New York: Bloomsbury Publishing, 2014), 158–59. "Genera" (the plural of genus) comprise the taxonomic rank immediately above "species."

species), the overall complexity of the biosphere as expressed by the variety of relationships among the organisms it comprises, the structural disparity of the organisms within it, and the complexity of its food chains, has also grown.

Fourth, the number of geophysical zones the biosphere contains - at least with respect to multicellular organisms – has increased as follows: first shallow seas, then deeper waters, then land for plants, then for insects, then for vertebrates, initially along the terrestrial margins, then moving into the continental interiors, then into the air. And this ignores the less well-understood but well-evidenced penetration of life into Earth's crust.

Fifth, the peak levels of organic complexity have risen if judged by the number and differentiation of parts within the most complicated living organisms during any given period.[12] The earliest known life forms may have been nothing more than naked molecules, conceivably just self-sustaining chemical reactions (metabolism arising before replication in the view of some). These were followed by prokaryotes (tiny, simple unicellular organisms such as bacteria and archaea), then eukaryotes (much larger, more complex cells with internal organelles), then metazoans (multicellular organisms knitting specialized eukaryotic cells together) with specialized organs, reiterative segments, reproductive systems, nervous systems, brains, and complex learning abilities. Complexity can thus be said to have increased not only within the biosphere as a whole but along its complexity frontier as well.

Sixth, the number of external energy sources upon which life draws has multiplied. The earliest living things were likely chemotrophs, organisms ultimately obtaining their energy from geothermal sources. Later, photosynthesis permitted energy to be extracted directly from sunlight by photosynthesizing bacteria. The resulting oxygenation was initially a mass killer, but life invented the means to turn oxygen into yet another energy source, first by bacteria, then plants, which absorbed the bacteria, and afterwards by animals that ate the plants or other plant-eating animals. (The appearance of predation, along with parasitism, as adaptive strategies also presented a new way of harvesting or, better said, stealing energy by one organism from

[12] Börje Ekstig, "Complexity, Natural Selection and the Evolution of Life and Humans," *Foundations of Science* 20, no. 2 (June 2015): 175–87, https://doi.org/10.1007/s10699-014-9358-y. This is the view at least of a majority of life history scholars, dissents registered mainly about complexity's definition and whether it is driven by active selection for complexity or through a "random walk" process.

another.[13]

Seventh, life's information technologies have become more sophisticated. The mechanisms of cellular information storage, translation, transmission, recombination and testing upon which life's learning system rests have all experienced cumulative enhancement. The neural and communication systems upon which "within-lifetime" learning, and eventually cultural learning, depend have also gradually become more sophisticated. Specific examples from the history of life include the increasing durability of molecular information storage, with RNA taking over from something cruder and then assuming an information transfer function as the more durable DNA took over RNA's storage role. DNA, moreover, first scattered within the cell body was, after eucaryotes appeared, gathered behind an insulating nuclear membrane. Especially consequential was the development of meiotic cell division, by which paternal and maternal genetic material in sexually reproducing organisms could be shuffled into new testable combinations over generations.

Eighth, homeostasis is an observed feature of many ecological systems. When something disrupts them, they frequently restabilize. This is not, to be sure, an invariant property of living systems, nor an attribute of the biosphere as a whole. There have been occasions of massive self-inflicted wounds in the history of life.[14] Nevertheless, some self-repair capacity is to be expected if evolution is a learning process. This is not only a matter of organisms being able to heal themselves. When particular ecological components go missing, adjacent lineages are likely to undertake an evolutionary exploration of how to repopulate the emptied spaces. New conditions won't permit discarded lifeways to be altogether revived, but given sufficient time, learning processes often find new ways of doing at least some of the old things, such as when mammalian megafauna filled the browsing, predatory and scavenging niches previously occupied by dinosaurs. Systemic resiliency is another reflection of life's ability to learn.

With respect to the long-term evolution of the biosphere the evidence thus points to the following trend lines: increasing biomass; increasing varieties of species and occupied habitats; increasing peak levels of morphological complexity and interrelatedness; increasing varieties of energy sources and energy capture; increasing peak levels of bio-information technology; and

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[13] This is nicely covered in Christian, *Origin Story*, 75–156.
[14] Peter Ward, *The Medea Hypothesis: Is Life on Earth Ultimately Self-Destructive?* (Princeton, NJ: Princeton University Press, 2009), 55–90.

an increasing operative resiliency.

Evolution's advance along these dimensions not only depends on its ability to retain useful adaptations once made, but on the fact that adaptations frequently build upon adaptations made earlier. From its earliest pre-cellular stages when it involved the interaction of strands of "naked" chemicals[15] to the highly elaborated ecosystems of today, life has been autocatalytic. Put another way, life has fed upon itself, with adaptive innovations generally adding more than they subtract from the world's total of "life opportunities" because it is usually more adaptively efficient to take advantage of preexisting adaptations than to destroy them and start anew.

Sometimes this stems from the fact that an adaptation turns out to have wider applications than represented by its first use, i.e., feathers probably having served as thermal insulation before they enabled flight. At other times it happens because adaptive innovations provide "free rides" to other organisms, as when the invasion of land by plants opened the way for animals to follow by providing a terrestrial food source. The appearance of predation on a large scale during the Cambrian, while bad for caught prey, had the larger effect of erecting a multilevel food chain that greatly increased the habitats possible for plants and animals to occupy.

Evolutionary expansion has a supply as well as a demand side. Exploring available adaptive opportunities depends on the power of the learning systems at life's disposal. In the fullness of evolutionary time breakthroughs occur here, too. The "invention" of sexual reproduction, allowing for a scrambling of gene combinations generation by generation, is a major example. Another is the "invention" of nervous systems permitting "within-lifetime adaptation" by multicellular organisms.

Even negative interactions such as competition and predation frequently result in stabilizing counter-evolution, as in predator-prey arms races wherein operative efficiency is enhanced on both sides. Competitors may also reduce their mutual interferences by evolving less conflictual and more specialized forms of niche exploitation, a form of ecological expansion called "character displacement," which allows for the more efficient use of available resources overall. (In the human sphere this often occurs among rival businesses, which differentiate their products from one another to reduce competition.)

[15] Smith and Szathmáry, *Major Transitions in Evolution*, 27–37.

From here on I'll use the term *metaevolution* to refer to those changes in life's information technologies, energy accessing systems, and mechanical arrangements that have had major impacts on the power of evolutionary learning systems.[16] I'll also apply the concept to similar types of human cultural innovations.[17]

To better set that stage, let's do a quick overview of human history's trend lines, comparable to what we just did for the history of life as a whole. Doing so, we find that like the history of life, human history has witnessed:

First, a strong long-term trend toward increased biocultural mass (in this case the combined biological masses of humans and domesticated animals,

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[16] There is a similar term, "evolvability," to which the same meaning is sometimes attached but is mainly used to denote the potential of specific lineages to evolve. For example, segmented organisms can be hypothecated as being more evolvable than non-segmented ones. I prefer metaevolution because it places greatest emphasis not on characteristics of lineage architecture, but on a more general phenomena like information technology and energy utilization that helps organize our understanding of the entire history of life, including culture. For evolvability see Richard Dawkins, "The Evolution of Evolvability," in Christopher G. Langton, ed., *Artificial Life: The Proceedings of an Interdisciplinary Workshop on the Synthesis and Simulation of Living Systems Held September, 1987 in Los Alamos, New Mexico* (New York: Routledge, 1989), 201–20; Jeremy Draghi and Günter P. Wagner, "Evolution of Evolvability in a Developmental Model," *Evolution: International Journal of Organic Evolution* 62, no. 2 (February 2008): 301–15, https://doi.org/10.1111/j.1558-5646.2007.00303.x; and Joshua L. Payne and Andreas Wagner, "The Causes of Evolvability and Their Evolution," *Nature Reviews Genetics* 20 (January 2019): 24–38, https://doi.org/10.1038/s41576-018-0069-z. I first used the term in this way in "Metaevolution and Biocultural History." For a similar, even earlier utilization, see Erich Jantsch, *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution* (Oxford: Pergamon Press, Ltd., 1980.)

[17] Major metaevolutionary advances have some overlap with what evolutionary theorists John Maynard Smith and Eörs Szathmary have called "the major life transitions," of which they count eight—replicating molecules, their grouping in chromosomes, DNA supplanting RNA, emergence of eukaryotes, sex, multicellularity, sociality, and language—all of which represent big innovations in information technology. I add nucleation, perhaps a small point, and the development of nervous systems, a larger one. Smith and Szathmary, *Major Transitions in Evolution*. See also the discussion in Peter J. Mayhew, *Discovering Evolutionary Ecology: Bringing Together Ecology and Evolution* (Oxford: Oxford University Press, 2006), 12–15. An interesting argument that major life and cultural history transitions, including metaevolutionary ones, involve the incorporation of preexisting operating systems in larger new ones, is found in Tyler Volk, *Quarks to Culture: How We Came to Be* (New York: Columbia University Press, 2017).