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Converging all the way to the (tangled) bank
A review of Simon Conway Morris, *Runes of Evolution: How the Universe Became Self-Aware*

A rune, saith the *Oxford English Dictionary* (no slight intended to the "other place", from which famed paleobiologist Simon Conway Morris hails), is a character or symbol to which is attributed a mysterious or magical significance. For our author, rampant similarities among functional traits across living things, together with strong threads of continuity extending back from today's creatures into the far reaches of evolutionary history, are runic in that they hint at something metaphysical. They hint that the evolution of life might have traced patterns that are to some extent inherent in the nature of the universe, and thus we might be justified in thinking that much of life is predictable, even perhaps inevitable, including the capacity for thought and imagination that are instantiated in their most extreme form in our species but are built on evolutionarily well-established building blocks.

Perhaps it is because of the boldness of making a connection between ordinary scientific findings and the meaning and purpose of life that the author announces "…here is a book that is prepared to be heterodox" (p.3). But if it is heterodox in that way, most popular evolutionary books are. Remember a certain 1975 book that called morality "a secretion of the brain" and said that "the organism is only DNA's way of making more DNA"? Or a 1976 book that began with the statement that "We are survival machines—robot vehicles blindly programmed to preserve the selfish molecules known as genes"? For one more example, in the book *Wonderful Life* that was inspired largely by the work of our present author in the fossil beds of the Burgess Shale, S. J. Gould takes from the Cambrian explosion a lesson that evolution is entirely unpredictable and radically contingent and, by extension (as we already knew from his previous books) we humans are cosmic accidents and so there cannot be any significance or meaning to our existence or nature other than by our own free and deliberate invention. These are all heavily metaphysical positions, in all cases considered by the authors to be indicated by the scientific data. In this light Conway Morris' book is hardly heterodox. The main difference between this book's connection to metaphysics and those others' is that this one suggests that metaphysics might be worth doing, whereas those others claim it to be dead even while they are employing it. Those other books insist that evolution destroys ultimate meaning in the cosmos, whereas the present book finds evolution to permit or even suggest it. In fact Conway Morris is more careful, as he warns us in the beginning that his own reading of the runes is speculative; whereas Wilson, Dawkins, and Gould have tended to characterize their contrary speculations as plain fact.

So far this review, and indeed the title and subtitle of the book, would lead one to believe that this cosmic inkling is a major explicit feature of *Runes of Evolution.* In fact it enters into the book only fleetingly, like Wordsworth's intimations of immortality or Lewis' experiences of joy. Mainly these are presented in flanking Chestertonian bookends that draw a tantalizing but necessarily only partly articulated connection between the empirical stuff and cosmic meaning (he who has ears to hear, let him hear). By weight as opposed to significance, the book is mainly a copious celebration of convergent evolution in nature—the plethora of situations where similar traits evolve independently in similar environmental circumstances. The main architecture of the book is as follows: The octopus is immediately set forth as the epitome of convergence with vertebrates, what with its camera eye, advanced cognition, armlike tentacles, and giant axons. The next two chapters provide historical context, argue for the ubiquity of convergence more generally, and relate this concept (too) briefly to others such as ecomorphs, irreversibility, inherence, and inevitability. Then comes the fascinating ecotour: 21 chapters cover examples of convergence, and to a lesser extent preadaptation, either topically or taxonomically, as follows: capturing prey, teeth, locomotion, gripping, eyes, vision, chemoreception, other senses, fungi, plants, arthropods, agriculture, flight, birds, reproduction, tetropods, nervous systems, brains, cerebral cortex, cognition, tool use and play. Then there is a final meaty but racing chapter on intelligence, thought, self-recognition, and awareness of death, followed by a claim that this story as a whole is most consistent with universal perception of objective entities in the universe. The middle of the book sports 50 color plates highlighting remarkable organisms. There is also a wonderful nerdography at the back: I will definitely be using the

index of genera… and the notes (including bibliographic information) comprise literally half the book—a few of them are chapter-length! The book might have broken a world record somewhere around here.

This volume, together with the author's previous book *Life's Solution*, represents the first time anyone has sought seriously to document instances and patterns of convergent evolution in nature. This makes these two books together a scientific monument aside from their higher philosophical aspirations. Indeed I have not read a work that reveals such an encyclopedic knowledge of organisms and their traits since George Williams' 1966 *Adaptation and Natural Selection*. There are many natural history works out there, but most can be written by knowing a few good stories. The chief and rare value in this work, and the reason why such a book hasn't been written before, is that the topic of convergence is all-encompassing and cannot be addressed with even an impressive litany of isolated examples. To tell a student that the Australian megapodes bury their eggs beneath rotting vegetation for incubation and exhibit no direct parental care, is an interesting bit of natural history. But if a student asks if that is the *only* bird that does not exhibit direct parental care, a correct answer here is much more difficult, as there are over 10,600 bird species. Very few biologists could write a book like *Runes* because to answer the question of whether a trait is unique or shared by analogy among different lineages one must be aware of just about *everything that is out there*. Only by such knowledge can Conway Morris, aside from his specific intended lessons, convince us more generally that nature is rich but understandable, that there are millions of stories but many fewer themes. Bravo.

The notion of convergence is central to this book, and I agree with its importance—in fact, natural selection by its very nature is going to produce convergence. The environment of organisms is what exerts selection, and insofar as environments are similar the traits that are useful in those environments will often be as well—we shouldn't be surprised to see unrelated white animals in the Arctic. There do indeed seem to be a limited number of evolutionary answers to particular challenges. Still, I would argue that the opposite phenomenon, divergence, is more fundamental, and explains why most evolutionary works starting with the *Origin of Species* have focused on it and given only passing reference to convergence. This book does the very opposite, so perhaps I might not be out of place in making a short plug for divergence for the sake of balance. You don't even need selection to produce divergence (though it helps and of course is ubiquitous); just evolution and physical separation of lineages. All living things so far discovered descend from a single common ancestor. Thus all living things today have the same length of evolutionary history behind them. Divergence is the main reason why we don't have just one kind of organism today, but millions. Divergence is the main reason why even within any one of those millions of organisms there are hundreds to billions of variants. Among humans for instance at this very moment there are 7.3 billion different living variants (subtracting out roughly 100 million identical twins if we insist on including only genetic variation, but it's not clear we need even to do this), and every second sees the creation of 4.3 more. And even within a single organism things get different over development as the individual interacts with its environment. It is only against this backdrop of spectacular divergence that convergence is interesting or indeed has any sense to it. Again, this is not so much a criticism of the book as a counterpoint to it.

One of the author's motivations in laying out the panoply of convergence was a desire to ounter the perception that there is an "area of neo-Darwinian thinking" that "insists on the randomness of evolution and the unpredictability of the outcomes". In one place Conway Morris even suggests that this is "received wisdom". To this I would offer my condolences and respectfully suggest that the author has been subjected to too much Gouldian flimflam from the likes of paleontologists, systematists, and molecular biologists, in other words those who do not actually study adaptation, which is the fount of convergence. Those in evolutionary ecology (who study trait evolution and the functional relationship between organisms and their environments) have no truck with this randomness-mongery. Pick up any issue of *Behavioral Ecology*, *Evolutionary Ecology*, or the several relevant papers in any issue of *Evolution* or *Proceedings of the Royal Society of London B* and the general format of the papers will be "We predict X should evolve in this situation, and we have observed or experimentally created this situation, and indeed X happens (or doesn't)". Conway Morris lauds R. D. Alexander for predicting multiple features of a

eusocial mammal if there were one (and there did end up being one), and this was indeed a stellar case, but this is a rather typical perspective for those who study traits of organisms in ecological context. Evolutionary ecology is an experimental and predictive discipline, whether we are using nature as the laboratory (in which case the controls can be weak but ecological relevance strong), or whether we are conducting experiments ourselves (in which case the controls can be strong but the ecological relevance weak). By a combination of field and lab research, evolutionary biology is constantly laying out more of that map about which Conway Morris so thoroughly and richly writes. In fact, studying adaptation goes further than marveling at convergence. It asks the question of when certain alternatives rather than others will tend to be exploited, i.e., whether we expect convergence or divergence. Humans conceal their ovulation. Most other primates do not—they advertise it. When do we expect to see concealed ovulation versus advertisement, or anything else on that continuum? Questions like this exemplify the Darwinian realizatoin (or hunch) that every widespread and functionally integrated trait has an explanation, that they are not just fruitful but arbitrary gifts; they tend to have a logic to them. Those in Conway Morris' wing of biology need to be reminded of this, and so I am glad one of their own has done it.

The word "inevitable" comes up from time to time in the book, though not forcefully. Still, one receives a clear message that the author believes much of what we see today, perhaps especially our minds, to have been inevitable, and—mind you, here is the controversial part—that the empirical data indicate this in some way, albeit indirectly. The rampant convergence, the argument goes, betrays a pattern, like a blueprint, and this pattern, this form, is probably inherent in evolved life. "Plato and Darwin embrace" (p.297). Life does not invent itself as it goes along, so much as discover surprisingly specified possibilities that are laid out before it. As I mentioned, I am definitely a flag-waver for the predictability of evolution; but I still think evolution stochastic enough (in an earthly sense at least) and the possibilities numerous enough, for prediction not to reach the point of inevitability. I am happy to ignore the black box of physiology and molecules when I make evolutionary predictions, and I like many others are more surprised when the predictions do not come true than when they do. Still, there are so many moving parts, so many selective forces impinging, and despite the restricted set of pathways still often a toolkit of adaptive options available for many organisms given an environmental challenge, that I would hesitate, probably permanently, before using the term "inevitable". And while we're on the subject, I think that much of the predictability of evolution on this planet derives from the fact that all life shares our biosphere and a common ancestry; I am generally much less confident that our evolutionary understanding of Earthborn life would be as effective at predicting other possibilities—"other" to an unknown extent—that we could observe if life independently began on Perelandra or Dune or Hoth. Perception of light will be fundamentally the same because light is the same everywhere; but I am less confident than Conway Morris that it will necessarily be rhodopsin that does the job.

The book's metaphysics doesn't stop at inevitability, but as Conway Morris gives mainly hints and suggestions, I'll let them rest there for the reader to find and handle appropriately. The book ends as it begins, at an Italian lagoon, with a confident character Mortimer—surely that same scientist who is predicted to win the Nobel Prize in 2056 for having revealed important aspects of the nature of mind and its inherence in the universe (see Conway Morris in *New Scientist*, 2006). Mortimer challenges the narrator, and the reader, to think about all this convergence and consider seriously whether it ought to change our view of the universe and mind's place in it. Most readers of *SCB* will largely be convinced already of some robust purpose in the cosmos, and the precise degree and nature of convergence in living systems will be unlikely to make much difference one way or the other to this commitment. Back in late antiquity into the Middle Ages it was the extraordinary fruitfulness, the plenitude, the exuberantly diverse overflow of creativity that stirred the spirituality of the intellectual faithful contemplating nature. If today some find similar inspiration in consistently revisited patterns of such creativity in different evolutionary lineages, in the predictable map of organismal solutions to environmental challenges, so be it!

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