Listener
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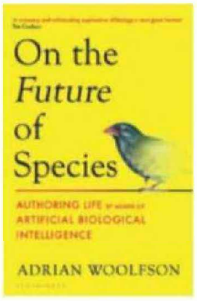
ON THE *FUTURE* OF SPECIES: Authoring Life by Means of Artificial Biological Intelligence
by Adrian Woolfson
(Bloomsbury, $40)



Letter perfect

Science is hard at work on bold new biological innovations, argues a leading geneticist, but will we get them right?

“Any component of a biological system can perform many functions; if you improve one thing you’ll often break something else.

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There’s a famous Jorge Luis Borges short story, *The Library of Babel*, that computer scientists, mathematicians and similar informational thinkers are often obsessed with. It imagines a universe-sized library filled with books that contain every possible combination of letters. It holds every book that can ever be written, an accurate history of your life, every possible scientific discovery, the true solutions to every philosophical problem. But they are all drowned out by an unimaginably vast ocean of gibberish. You could scour the shelves for many times longer than the lifetime of our universe and never encounter a shred of meaning.

Adrian Woolfson trained as a molecular biologist. His doctorate, awarded at Cambridge University, was on protein folding; today he’s a co-founder and CEO of a biotechnology company in California, Genyro. He’s a fan of Borges’ story. For Woolfson, the library is a natural way to think about genetics. Our genes are made up of four molecules represented by different letters, ACGT, and different combinations of the molecules

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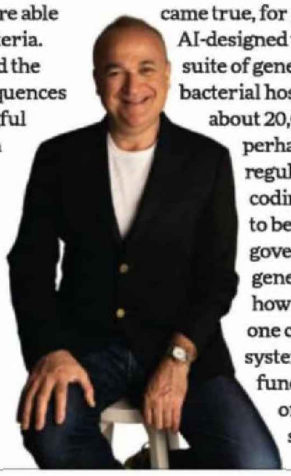
produce different proteins: hair, blood clotting factors, immune receptors. These all combine together to build humans, pangolins, fungi and every other organic creature that's ever lived. There is a library of possible genetic sequences and within that space exists every possible organism. But those sequences are tiny, remote pinpricks of meaning amid an infinity of nonsense. For the past four billion years, natural evolution has conducted a slow, blind exploration of that combinatorial space. Woolfson's argument is that our species – a recent product of that random process – is now exploring this library intelligently: learning its structure to navigate directly to meaningful sequences and generate new lifeforms. This is not a futurist text or a warning of technologies to come: it's something people are doing today, at companies like his.

The virus phi X 174 is tiny: 11 genes. It was first discovered in a Paris sewer in the early 1930s. It infects bacteria rather than complex organisms, hijacking their molecular tools to manufacture copies of itself. Because it's such a simple entity it was the first genome to be fully sequenced, in 1977. In September 2025, a team led by the Stanford biologist Brian Hie published a preprint paper describing a new virus designed using the Evo2 AI model – think ChatGPT but for genomic sequences instead of words. They used phi X 174 as a template, generated thousands of new candidate genes that could substitute for the gene's existing codes, and then synthesised 16 novel viable viruses. Some were able to kill antibiotic-resistant bacteria. Evo2 has learnt its way around the infinite library of genomic sequences well enough to write meaningful sentences that had never been written before.

For readers who find most of the last paragraph baffling, Woolfson provides a history of the science. He tracks three broad stages: the discovery of the genetic library, beginning with Darwin's *On the Origin of Species*, published in 1859, the 1953 Watson, Crick, Franklin, Wilkins paper on the structure of DNA, and the sequencing of genomes that began in the 1970s. Then there's the gene-editing phase that we're only a few decades into, featuring technologies like CRISPR, which can modify existing texts. But now we're moving past editing into composing novel genes.



Adrian Woolfson: Strong on genetics, weaker on policy.

Woolfson is good at telling this history. He has a gift for biography, introducing Friedrich Miescher, the Swiss chemist who first isolated DNA from hospital pus-soaked bandages in 1868 and who died of tuberculosis before anyone grasped what he'd found; Rosalind Franklin, whose X-ray photographs were shared with Watson and Crick without her knowledge or consent and who died of ovarian cancer four years before they collected their Nobel prizes; Har Gobind Khorana, born in a village in British India so poor that school was held under a tree, who taught himself to write in microscopic script to conserve pencils and went on to synthesise the first artificial gene. The MRC Laboratory of Molecular Biology in Cambridge, where Woolfson did his PhD, is the institution where more of this history happened than anywhere else, and he writes about it with evident affection.

The early 2000s – post the sequencing of the human genome – saw a torrent of speculation about the wonders and horrors of the coming age of biotechnology: eugenics, genetic elites, genetic discrimination, bioterrorism, synthetic humans. None of the predictions came true, for good or evil. The Hie lab's AI-designed virus can use its tiny suite of genes to replicate inside a bacterial host, but human cells have about 20,000 protein-coding genes, perhaps 10 times as many regulatory elements in the non-coding regions – what used to be called "junk DNA" – that govern when and how those genes are switched on and how they interact. And any one component of a biological system can perform many functions, so if you improve one thing you'll often break something else.

Woolfson writes that evolution's report card might read "inclined at times to be lazy, untidy, opportunistic, overly sentimental, transfixed by the past and prone to taking the path of least resistance".

How could a more intelligent designer improve on its works? He imagines microbes engineered to convert industrial carbon dioxide into jet fuel; crops reprogrammed to photosynthesize in near darkness (to feed the crews for the colonisation of Mars); redesigned adhesive proteins used by mussels and spider silk with the tensile strength of steel; consumer electronics – like smartphones – that are grown and replicated instead of manufactured.

Consider schizophrenia, one of our cruellest illnesses: its genetic roots are entangled in the same protein that prunes synapses in childhood and guards against autoimmune disease in adulthood – an evolutionary kludge that conventional medicine cannot fix. A rewritten genome, though, could theoretically circumvent it through AI-guided protein engineering. Or a cancer-resistant human cell line.

There's a vast distance between building a toy virus and any of these wonders, but they're the direction of travel.

The final quarter of the book is weaker. It pivots from science to policy, presenting an 11-part manifesto covering biosecurity protocols, germline editing moratoriums, global regulatory frameworks, the rights of humanised organisms, and proposals for a new international citizens' assembly. It reads exactly like the AI manifestos that floated around in the 2010s: worthy, intellectually respectable, totally redundant in the face of economic competition and geopolitical tensions.

In 1968, Har Khorana warned that "when, in the distant future, all this comes to pass, the temptation to change our biology will be very strong". We're not there yet. The library is vast, and we are only beginning to explore it, but everything that's chemically possible is in there, somewhere. Exploring it will be a ferocious race, not a dignified multi-lateral working group. That's how evolution has always worked, and there's no reason to believe this will change when it's driven by humans or AI instead of random mutation. ▮

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