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BIOENGINEERING

The scope of biological possibility expands

A synthetic biologist looks to the future, probing the promise and peril of "artificial biological intelligence"

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Adrian Woolfson
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480 pp.

ON THE FUTURE OF SPECIES | In *On the Future of Species*, synthetic biologist Adrian Woolfson considers whether the emergent capacity to write and rewrite genomes might transform how life itself is understood, from planetary ecosystems to human nature. Across 12 chapters, the book asks whether advances in artificial intelligence (AI) could enable not only human-directed biological authorship but also a broader reimagining of evolution's trajectory.

Woolfson, whose experience spans academic research and genome design in industry, approaches these questions from both historical and practical vantage points. Much of the book's distinctiveness lies in this historical sensibility. His discussion of DNA synthesis is particularly effective: By foregrounding figures such as Alexander Todd, Har Gobind Khorana, Stanley Cohen, and Arthur Kornberg, he shows that the ambition to construct genetic material has accompanied molecular biology since its earliest days. The uncertainty that once surrounded recombinant DNA—including whether synthetic genes would function at all—serves as a useful counterpoint to the current confidence surrounding large-scale genome engineering.

A recurring theme throughout the book is contingency. Woolfson emphasizes that biological systems are shaped less by optimal design than by historical accident. Familiar examples such as Stephen Jay Gould's spandrels; the circuitous, recurrent laryngeal nerve; and vestigial structures like the coccyx are paired with man-made analogies including the inefficient placement of the Tappan Zee Bridge. Woolfson's turn to engineering reflects the possibility that intentional design might move beyond its current incremental editing toward the capacity to refactor "whole sections of genetic code," selectively reworking biological complexity rather than endlessly inheriting it.

This sets the stage for Woolfson's broader claim about the scope of biological possibility. He imagines a vastly larger universe of possible biological sequences, one in which extant life reflects only a narrow and provisional outcome of evolutionary exploration. Drawing on analogies such as Borges's *The Garden of Forking Paths* and Hipparchus's lost star catalog, he emphasizes how much biological possibility has never been observed or recorded.

This attention to contingency extends to the molecular scale. Woolfson highlights pleiotropy and epistasis to show how biological components routinely interact with each other and serve multiple roles across contexts, an apparent efficiency that comes with "a risk of dysfunction." As he observes elsewhere, most biological components "moonlight" across contexts, forming densely interconnected systems.

The difficulty of disentangling such systems motivates Woolfson's turn to engineering in a comparative framework. Here, he uses the software design concept of refactoring to describe how genomes might be redesigned. However, the limits of the analogy are underscored: Unlike software, genomes cannot be rewritten wholesale. Evolution offers no mechanism for clearing accumulated "technical debt" or simplifying what Woolfson characterizes as "convoluted, chaotic and barely manageable" biological code.

Woolfson treats recent successes in deep learning–based protein folding models as evidence that AI can learn meaningful biological regularities. However, this is not equivalent to designing proteins that function reliably within living systems, where expression levels, interaction networks, and cellular context matter. Folding thus serves as both an illustration of progress and as a reminder that prediction does not necessarily translate into control.

This sensibility also shapes Woolfson's treatment of genetic disease. He traces a progression from Mendelian inheritance through Fisher's statistical frameworks to contemporary genome-wide association studies, including efforts to characterize highly polygenic traits such as height. These sections emphasize both the explanatory power and the limits of association-based genetics, particularly where disease risk emerges from interacting genes and environments.

The book's forward-looking vision is encapsulated in Woolfson's concept of artificial biological intelligence (ABI), which he describes as "the biological equivalent of artificial general intelligence." ABI refers to systems capable of learning and generating biological designs across contexts. More than a simple framing device, the analogy carries strategic weight. Woolfson suggests that "the writing and rewriting of the genomes of species may…serve as a means to safeguard humanity from the potentially even greater existential risks posed by…artificial general intelligence."

Woolfson offers no blueprint for how life will be authored, nor does he suggest that biological design can escape the constraints he documents. Yet the book closes with a more than 30-page manifesto outlining governance principles for biology's conversion into "a predictive engineering material." Here, Woolfson is notably measured about the safety of AI and ABI, focusing less on abstract risk than on practical control measures. That is, material instantiation, rather than intelligence alone, emerges as a plausible locus for regulatory oversight. Whether or not genome authoring ultimately fulfills its promise, *On the Future of Species* makes clear that the question is no longer whether biology can be written but which biological possibilities must remain unwritten. □

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