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Can Synthetic Biology Save Us? This Scientist Thinks So.

Drew Endy is squarely focused on the potential of redesigning organisms for useful purposes. He also acknowledges significant challenges.

By Steve Lohr

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This article is part of our latest DealBook special report on the trends that will shape the coming decades.

When the family house in Devon, Pa., caught fire, Drew Endy, then 12, carried out his most cherished possession — his personal computer.

Years later, as a graduate student, Mr. Endy was accepted to Ph.D. programs in biotechnology and political science.

The episodes seem to sum up Mr. Endy, a most unusual scientist: part engineer, part philosopher, whose conversation is laced with references to Descartes and Dylan, as well as DNA.

He's also an evangelist of sorts. Mr. Endy, a 51-year-old professor of bioengineering at Stanford University, is a star in the emerging field of synthetic biology. He is its most articulate enthusiast, inspiring others to see it as a path to a better world, a transformational technology to feed the planet, conquer disease and combat pollution.

The optimism behind synthetic biology assumes that biology can now largely follow the trajectory of computing, where progress was made possible by the continuous improvement in microchips, with performance doubling and price dropping in half every year or two for decades. The underlying technologies for synthetic biology — gene sequencing and DNA synthesis — are on similar trends.

As in computing, biological information is coded in DNA, so it can be programmed — with the goal of redesigning organisms for useful purposes. The aim is to make such programming and production faster, cheaper and more reliable, more an engineering discipline with reusable parts and automation and less an artisanal craft, as biology has been.

Synthetic biology, proponents say, holds the promise of reprogramming biology to be more powerful and then mass-producing the turbocharged cells to increase food production, fight disease, generate energy, purify water and devour carbon dioxide from the atmosphere.

“Biology and engineering are coming together in profound ways,” Mr. Endy said. “The potential is for civilization-scale flourishing, a world of abundance not scarcity, supporting a growing global population without destroying the planet.”

That idyllic future is decades off, if it is possible at all. But in the search for the proverbial next big thing over the next 20 years, synthetic biology is a prime candidate. And no one makes the case more persuasively than Mr. Endy.

He sees synthetic biology as a sweeping force that can reshape the sciences, society and culture — as the personal computer and internet have — rather than just a new industry. Yet Mr. Endy was a founder of two start-ups (one acquired, one folded) and his wife, Christina Smolke, an adjunct professor at Stanford, is chief executive of Antheia, a start-up that uses synthetic biology to make ingredients for essential medicines.

As a nascent industry, Mr. Endy says he believes we are at a turning point — one essential to its future. “For the first time ever, synthetic biology companies are on the verge of making money instead of consuming money,” he said.

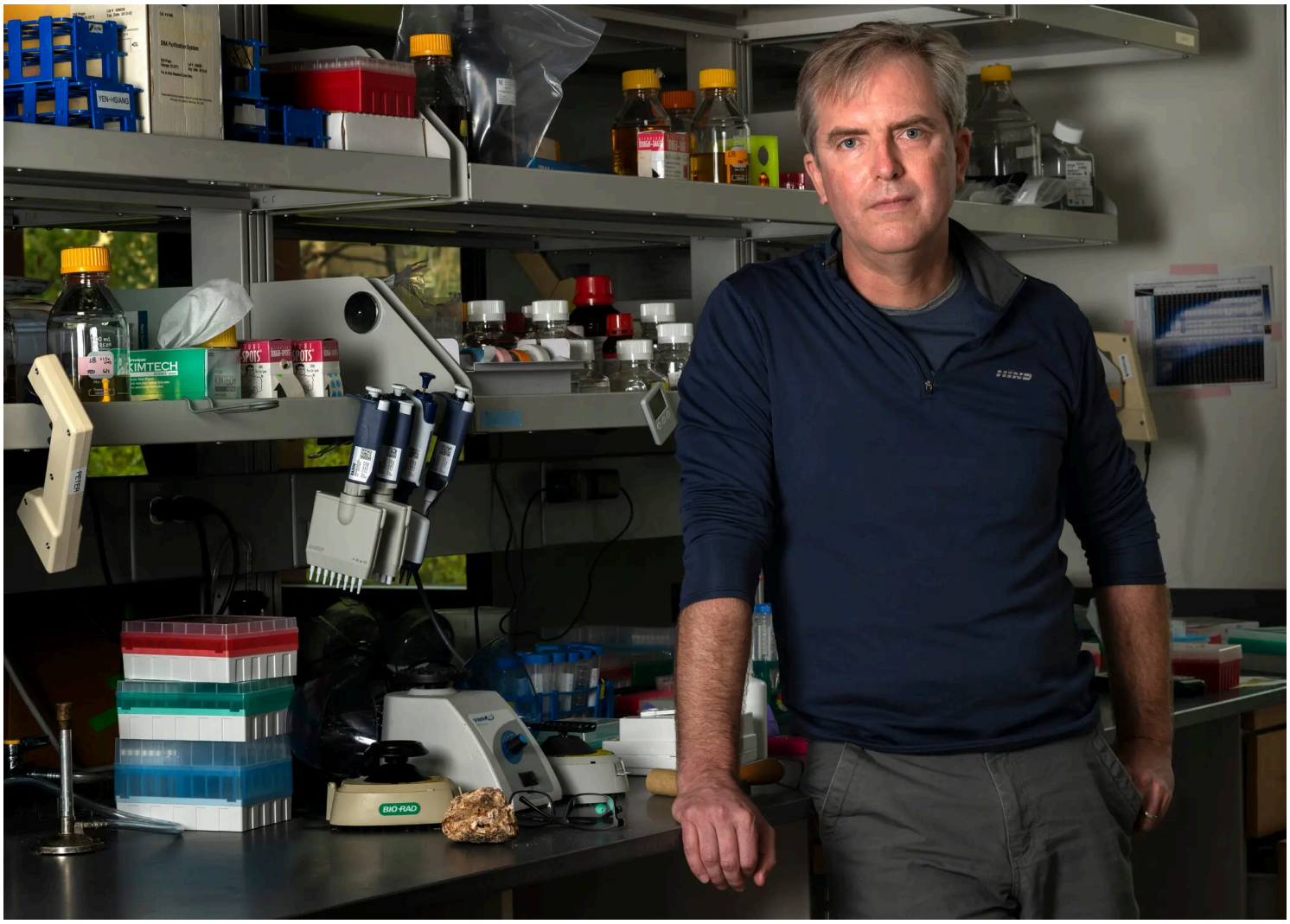
The money flowing in is still the clearest sign of commercial optimism. Synthetic biology companies raised $9 billion from venture capitalists and initial public offerings worldwide in the first half of this year, more than the amount raised all last year, according to SynBioBeta, an industry newsletter. In 2015, the total raised was $1 billion.

The industry, broadly, is divided into tools makers and product developers. The tool makers include well-established suppliers to synthetic biology companies and others, like the gene sequencers Illumina and Pacific Biosciences, as well as DNA synthesizers, which are younger companies like Twist Bioscience and Codex DNA.

Ginkgo Bioworks, which recently went public, has an all-in-one biofoundry that others can use to make synthetic biology products — much as Amazon supplies cloud computing services to many companies.

The product developers, which include organizations from tiny start-ups to pharma giants, are developing products and new manufacturing processes with synthetic biology across the spectrum of industry. Synthetic biology, for example, was employed to accelerate the production of Covid-19 vaccines.

Not every application aims to save lives or the planet. Cronos, a Canadian company, is using synthetic biology to develop cannabis edibles. Zbiotics, a San Francisco start-up, has a hangover killer.



Mr. Endy is a star in the emerging field of synthetic biology. “Biology and engineering are coming together in profound ways,” he said. Deanne Fitzmaurice for The New York Times

But there are elements of the potential Mr. Endy sees for transformation of major industries. Bayer, whose agricultural interests include the DEKALB seed business, is creating nitrogen-fixing microbes to apply to seeds, potentially reducing the use of chemical fertilizer.

Lululemon, the athleisure wear maker, is working with a start-up, Genomatica, to shift from petrochemical-based nylon to bio-built fabrics. Impossible Foods uses synthetic biology to create its plant-based burgers. Bridgestone is exploring the use of bio-based alternatives for chemical polymers used in producing tires. And Amyris, an early synthetic biology company, has become a thriving supplier of ingredients for the cosmetics and fragrance industry.

Mr. Endy's technical achievements include work in amplifying genetic logic, rewritable DNA data storage, genome refactoring and developing reusable biological parts. But perhaps his greatest skills are as a communicator and a social engineer.

This sometimes manifests in the form of seemingly outlandish, calculated exaggerations and clever turns of phrase — all part of his verbal arsenal.

He'll hold up a smartphone and say that in not so many years it can be made with synthetic biology. Who knows if it could be done or, if so, it would ever make economic sense. But his point is the vast potential of synthetic biology to produce new materials.

The annual garden clippings of the small city of Menlo Park, Calif., carted away into compost, Mr. Endy said, weigh more than the global production of microchips. Well, maybe, but they are hardly comparable.

"Yes, it's a provocation," Mr. Endy replied. "But it points to first principles. Biology is literally a surplus manufacturing capacity. It happens so much we don't think about it. Biology is making this stuff for free."

Another Endy one-liner: "All atoms are local." So synthetic biology lashed to the internet will enable a "design anywhere, grow everywhere" paradigm that could, he said, lead to a "massive upgrading of local manufacturing" and an economic "rebalancing in favor of deglobalization."

Synthetic biology, according to Mr. Endy, could also prompt a rethinking of humanity's relationship to nature. "It's an expression of human intention in partnership with nature," he said. "We're speaking with life."

The technology can also be used to increase biodiversity and protect endangered species. Ocean warming, for example, is destroying coral reefs. But corals in the Red Sea have remarkable heat tolerance. Altering coral genes to mimic the Red Sea varieties could halt the decline and possibly revive coral reefs worldwide.

Some of these theoretical applications may sound far-fetched, but Mr. Endy's intent is to stretch minds and inspire — and he is often successful.

"When I talk to him, I feel as if my I.Q. has dropped," said Emily Leproust, an organic chemist and chief executive of Twist Bioscience, one of the DNA synthesis specialists. "He's thinking on a different plane, offering a larger vision of what we are doing."

Jason Kelly recalled being a senior at the Massachusetts Institute of Technology in the fall of 2002 when Mr. Endy gave a guest lecture in a biology class. Until then, Mr. Kelly found biology filled with tedious lab work, and he was questioning whether to continue. But he was captivated by Mr. Endy, who spoke of the future and potential.

"I literally chased him down in the hall," recalled Mr. Kelly, who went on to earn a Ph.D. in biological engineering at M.I.T. (Mr. Endy was his thesis adviser) and to become a founder and chief executive of Ginkgo Bioworks.

"Drew Endy is first and foremost a great community builder," Mr. Kelly said. "His message is, Here's a vision of the future. Let's get together and try to make it happen."

In an attempt to build that community, Mr. Endy was a founder and continues to be a board member in two major nonprofit organizations designed to enlarge the synthetic biology community.

BioBricks Foundation organizes scientists and engineers to develop standardized DNA parts — biological building blocks for use in synthetic biology. Contributors agree to let others freely use the biobricks — much as open-source software projects operate.

The International Genetically Engineered Machine Foundation, or iGEM, runs annual contests for teams of students making synthetic biology projects, from kits of biobricks. An estimated 60,000 students from teams worldwide have participated in the competitions since 2004.

“That’s been transformational for the field, getting young people involved and opening their eyes to the potential to build life instead of just observing it,” said David Haussler, a professor of biomolecular engineering at the University of California, Santa Cruz. “Drew Endy has been a mentor to a whole new generation.”

Synthetic biology holds great promise, but there is a dark side as well. Hacking biology and democratizing the tools to do so raises the specter of an angry loner or terrorist group creating a build-your-own pandemic genetically targeted at their enemies, among other potential horrors.

Mr. Endy, though synthetic biology’s champion, has been cleareyed about the risks since the outset. He was the lead author of a report for the Pentagon’s advanced research agency in 2003 that laid out a framework for developing synthetic biology and managing its risks. In the report, he assessed the spectrum of dangers and imagined the bad-actor threat as “Bin Laden Genetics.”

Today, risk management, Mr. Endy said, should start with the assumption that in the not too distant future “anyone, anywhere can make any virus from scratch.”

One line of protection is synthetic biology itself. For example, Mr. Endy points to the possibility of advanced technologies like engineered chromosomes that would give humans a built-in defense system, say, against the world’s top 20 pathogens.

But countermeasures are also dependent on social cohesion and institutional effectiveness of the kind that have proved challenging during the Covid-19 pandemic — like resistance to getting vaccinated and wearing masks, and gaps in the public health system.

The risks, Mr. Endy acknowledges, are worrisome, and they contribute to qualms about the entire synthetic biology endeavor. It can easily be cast as an unnerving, if not unholy, tampering with nature.

His big-tent community building seeks to create enthusiasm, even affection, for next-generation biotechnology, much as he felt toward his personal computer — a Franklin Ace, produced by a long-gone Apple clone maker — as a 12-year-old.

Like the personal computer, synthetic biology, he suggests, is a powerful technology, more good than bad, and one that can even inspire an emotional connection. “Why did I run out of the house with the computer? Because I loved it,” he said. “Can a society fall in love with biotechnology? That’s my bet.”

Steve Lohr has covered technology, business and economics for The Times for more than 20 years. In 2013, he was part of the team awarded the Pulitzer Prize for Explanatory Reporting. He is the author of “Data-ism” and “Go To.” More about Steve Lohr