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THE PROMISE AND PERILS OF DESIGNER GENES

Synthetic biology is expanding on an industrial scale, offering the hope of tailormade microbes—and the threat of global destruction, argues journalist Bryan Walsh

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In May of 2018, I visited the Boston offices of Ginkgo Bioworks, a company in the burgeoning field of synthetic biology—the science of designing and engineering biological entities. Ginkgo is the first startup in the field to achieve a private valuation of more than $1 billion. Its bioengineers design and build custom microbes.

Originally its microbes were mostly used to synthesize flavors or fragrances derived from plants. In one case Ginkgo partnered with a French perfume company to create a rose fragrance by extracting the genes from real roses, injecting them into yeast and then engineering the microbe's biosynthetic pathways to produce the smell of a rose—which, it turns out, smells just as sweet when emitted from a yeast. The company is also working on extracting DNA molecules from preserved plant specimens to synthesize the fragrances of flowers that have gone extinct, like a hibiscus from Maui that disappeared from the wild around 1911.

Fragrances are just the beginning. The facility I visited is less a lab than a biological factory, pumping out synthetic organisms the way a Ford plant pumps out F-150 pickups. Christina Agapakis, Ginkgo's creative director, showed me around the factory floor, as casually dressed biology PhDs busily pipetted and assayed. What struck me was how few of them there were. Much of the work at the Ginkgo factory—or "foundry," as they call it—is automated.

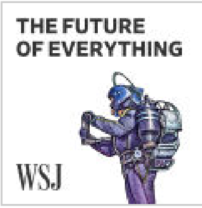
The synthetic biology revolution isn't just about what scientists can do, but how they can do it. The growing use of automation at a biotech company like Ginkgo is an example of a trend called "deskilling." With each passing year, the scientific expertise needed to pull off a specific experiment in synthetic biology falls. What might have recently required the hard work of a postdoctoral student can now be done by undergraduates, and might soon show up in an ambitious high school student's science fair project. Synthetic biology is getting easier, faster and cheaper, which means more and more people can do it. And as it does, the information hazard—the risk that comes from the dissemination of potentially dangerous knowledge—accumulates.

Deskilling has helped Ginkgo design and produce more than 10,000 genes per month, as synthetic biology shifts from an artisanal practice carried out in the laboratory by highly trained experts to a real industry. Everything is sped up, allowing researchers to design an organism, build it, test it, analyze the test and then start the whole cycle over and over again. "Things that would have made a great PhD thesis a few years back can now be done by people in two weeks here," Ms. Agapakis said.

The industrialization of synthetic biology is possible thanks to the same trend that has supercharged computing power. In recent years, the reading and writing of DNA has fallen in price and increased in speed. Synthetic biologists may never be able to program as seamlessly as their counterparts in tech—biology is made up of bits of life, however tiny, whereas computer code is just code—but they're getting better and faster all the time.

Many students today learn to write computer code. In the future, everyone might be an amateur synthetic biologist, programming the matter of life. If digital apps on our smartphones have transformed how we live and work, imagine what biological apps might do. It could be something as domestic as engineering a houseplant that rarely needed watering, or something as transformative as creating new forms of life.

That's the optimistic version.



But deskilling something as powerful as synthetic biology will inevitably amplify existential risk. The artificial-intelligence risk scholar Eliezer Yudkowsky calls it "Moore's law of mad science": "Every 18 months, the minimum IQ necessary to destroy the world drops by one point." It's not quite as precise as the original Moore's law—which predicted that computing power would double roughly every two years—but Mr. Yudkowsky is on to something. Consider computer programming. The relative ease of coding has created the multitrillion-dollar tech industry as we know it, but it has also empowered thousands of people to create malware for crime, for espionage and sometimes just for kicks.

Now imagine if it did become almost as easy to program biology as it is to program computers. Creativity would be unleashed, but so would our darker impulses. The first studies employing the gene-editing tool Crispr to cure a form of blindness have already begun, but those same tools could theoretically be used to make an existing virus more virulent. Far fewer people would likely use synthetic biology to program and release a killer virus into the world than the number who create malware for crime, in part because there are far more thieves among the population than there are murderers. But murderers do exist. And this technology could empower them in a way that threatens us all.

If everyone eventually gains the power to potentially end the world, and governments are largely helpless to stop them, then the continued existence of the world depends on the collective action of all of us—all 7.7 billion and counting—to actively choose not to destroy the world. The Stanford political scientist James Fearon developed a thought experiment he outlined in a 2003 talk, back when the global population was closer to five billion. He imagined a time when each

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person had the ability to destroy the world by pushing a button on their cellphone. "How long do you think the world would last if five billion individuals each had the capacity to blow the whole thing up?" he asked. "No one could plausibly defend an answer of anything more than a second."

Even the advanced biotechnology of the future will require more expertise than pushing a button on a cellphone—but perhaps not that much more, and certainly far less than is required to use current weapons of mass destruction. "What we now have [with biotechnology] is the mirror opposite of nuclear weapons, which require great infrastructure, access to controlled materials and knowledge that you can't simply go and look up online," said Gabriella Blum, a professor at Harvard Law School and the coauthor of the book "The Future of Violence: Robots and Germs, Hackers and Drones—Confronting a New Age of Threat." "So we ask ourselves: What's people's propensity to inflict harm, and in what ways?"

It doesn't even have to be deliberate harm. Because viruses and bacteria can self-replicate, even an accident could be as catastrophic as a deliberate attack. This is why biotechnology ultimately poses the single greatest existential risk humans will face in the years to come, as the science continues to mature. Biotechnology takes our ingenuity, our thirst for discovery—and turns it against us. It leaves us only as strong as our weakest, maddest link. It gives us promise and it gives us power, the most dangerous gifts of all.

Bryan Walsh is a journalist who worked as a foreign correspondent, reporter and editor for Time for over 15 years. This article is adapted from his book, "End Times: A Brief Guide to the End of the World," to be published Aug. 27 by Hachette Books.