Biology's Brave New World

The Promise and Perils of the Synbio Revolution

Excerpts from an essay published in *Foreign Affairs*, pp 28-46 of the issue of November/December 2013 by Laurie Garret, who is Senior Fellow for Global Health at the Council on Foreign Relations.

Introduction

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Coding Life

Shortly after Venter's game-changing experiment was announced, the National Academy of Sciences' Institute of Medicine convened a special panel aimed at examining the brave new biology world's ethical, scientific, and national security dimensions. Andrew Ellington and Jared Ellefson of the University of Texas at Austin argued that a new breed of biologists was taking over the frontiers of science --- a breed that views life forms and DNA much the way the technology wizards who spawned IBM, Cisco, and Apple once looked at basic electronics, transistors, and circuits. These two fields, each with spectacular private-sector and academic engagement, are colliding, merging, and transforming one another, as computer scientists speak of "DNA-based computation" and synthetic biologists talk of "life circuit boards." The biologist has become an engineer, coding new life form as desired.

Gerald Joyce of the Scripps Research Institute in La Jolla, California, frets that as the boundaries blur, biologists are now going to be directing evolution and that we are witnessing "the end of Darwinism." "Life on Earth, " Joyce has noted, "has demonstrated extraordinary resiliency and inventiveness in adapting to highly disparate niches. Perhaps the most significant invention of life is a generic system that has an extensible capacity for inventiveness, something that likely will not be achieved soon for synthetic biological systems. However, once informational macromolecules are given the opportunity to inherit profitable variation through self-sustained Darwinian evolution, they just may take on a life of their own."

This is not hyperbole. All the key barriers to the artificial synthesis of viruses and bacteria have been overcome, at least on a proof-of-principle basis. In 2002, researchers at SUNY Stony Brook made a living polio virus, constructed from its genetic code. Three years later, scientists worried about pandemic influenza decided to re-create the devastating 1918 Spanish flu virus for research purposes, identifying key elements of the viral genes that gave that virus the ability to kill at least 50 million people in less than two years. What all this means is that the dual-use dilemma that first hit chemistry a century ago, and then hit physics a generation later, is now emerging with special force in contemporary biology.

Between 1894 and 1911, the German chemist Fritz Haber figured out how to mass-produce ammonia. This work revolutionized agriculture by generating the modern fertilizer industry. But the same research helped create chemical weapons for German use during World War I --- and Harber was crucial to both the positive and the negative efforts. Three years after Harber won the Noble Prize in Chemistry, his compatriot Albert Einstein won a Noble Prize for his contributions to physics. Einstein's revolutionary theories of relativity, gravity, mass, and energy helped unravel the secrets of the cosmos and paved the way for the harnessing of nuclear energy. They also led to the atomic bomb.

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A Global Remedy

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I Believe the Children Are Our Future

Advocates for open, fast-paced synthetic biological research, such as Drew Endy of Stanford University and Todd Kuiken of the Wilson Center, the latter one of the leaders of a growing do-it-yourself international biology movement, insist that attention should be paid not just to the dangers of synthetic biology but also to its promise. Endy reckons that two percent of the U.S. economy is already derived from genetic engineering and synthetic biology and that the sector is growing by 12 percent annually. His bioengineering department at Stanford operates on a budget of half a billion dollars a year, and Endy predicts that synthetic biology will in the near future lead to an economic and technological boom like that of Internet and social media technologies during the earlier part of this century.

Many biology students these days see the genetic engineering of existing life forms and the creation of new ones as the cutting edge of the field. Whether they are competing in science fairs or carrying out experiments, they have little time for debates surrounding dual-use research; they are simply plowing ahead. **------ Omit -------**

The most difficult part of the process now is putting the DNA components in a sensible sequence, but that is unlikely to be true for long. The world of biosynthesis is hooking up with 3-D printing, so scientists can now load nucleotides into a 3-D “bio-printer” that generates genomes. And they can collaborate across the globe, with scientists in one city designing a genetic sequence on a computer and sending the code to a printer somewhere else --- anywhere else connected to the Internet. The code might be information that turns the tiny phi X174 virus that Venter worked on a decade ago into something that kills human cells, or makes nasty bacteria resistant to antibiotics, or creates some entirely new viral strain.

Information, Please

What stymies the very few national security and law enforcement experts closely following this biological revolution is the realization that the key component is simply information. While virtually all current laws in this field, both local and global, restrict and track organisms of concern (such as, say, the Ebola virus), tracking information is all but impossible. Code can be buried anywhere --- al Qaeda operatives have hidden attack instructions inside porn videos, and a seemingly innocent tweet could direct readers to an obscure Internet location containing genomic code ready to be downloaded to a 3-D printer. Suddenly, what started as a biology problem has become a matter of information security.

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From WHO to HAJ

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What Now

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The controversies and concerns surrounding dual-use research in synthetic biology have arisen in less than four years, starting from the moment in 2010 when Venter announced his team’s creation of a new life form described as “the first self-replicating species on the planet whose parent is a computer." Before Venter's group raced down such a god-like path, it went to the OBAMA White House, briefing officials on a range of policy and ethical issues the project raised. For a while, the administration considered classifying the effort, worrying that it might spawn grave dangers. Instead, much to Venter's delight, the White House opted for full transparency and publication. "Perhaps it's a giant philosophical change in how we view life," Venter said with a shrug at a Washington press conference. He wasn't sure. But he did feel confident that what he called "a very powerful set of tools" would lead to flu vaccines manufactured overnight, possibly a vaccine for the AIDS virus, and maybe microbes that consume carbon dioxide and emit a safe energy alternative to fossil fuels. Now that synthetic biology is here to stay, the challenger is how to ensure that future generations see its emergence as more boon than bane.

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