Making living matter programmable

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Jay Keasling (left), director of SynBERC, and moderator Corey Powell of Discover listen as Monsanto scientist Virginia Ursin explains the company's interest in synthetic biology. Christine Fu photo.

Thirty years ago, the future lay in programming computers. Today, it's programming cells.

That was the message of panelists at an afternoon session yesterday (March 25) in Stanley Hall auditorium titled "Programming Life: the revolutionary potential of synthetic biology." Co-presented by UC Berkeley's Synthetic Biology Engineering Research Center (SynBERC) and Discover magazine, the panels brought together a dozen of synthetic biology's pioneers from academia and industry, in addition to ethicists focused on the societal impact of the technology.

Keynote speaker Juan Enriquez, a self-described "curiosity expert" and co-founder of the company Synthetic Genomics, compared the digital revolution spawned by thinking of information as a string of ones and zeros to the coming synthetic biology revolution, premised on thinking about life as a mix of interchangeable parts – genes and gene networks – that can be learned and manipulated like any language.

At the moment, this genetic manipulation, a natural outgrowth of genetic engineering, focuses on altering bacteria and yeast to produce products they wouldn't normally make, such as fuels or drugs. "To do with biology what you would do if you were designing a piece of software," according to moderator Corey Powell, editor at large of Discover, which plans to publish a story about the conference and post the video online.

UC Berkeley chemical engineer Jay Keasling has been a key player in developing the field of synthetic biology over the last decade. Enriquez introduced Keasling as someone "who in his spare time goes out and tries to build stuff that will cure malaria, and biofuels and the next generation of clean tech, all while mentoring students at this university and at the national labs and creating whole new fields of science."

Keasling, director of SynBERC, a UC Berkeley-led multi-institution collaboration that is laying the foundations for the field, expressed excitement about the newest development: the release next month by the pharmaceutical company sanofi aventis of a synthetic version of artemsinin, "the world's best antimalarial drug," he said. Sparked by discoveries in Keasling's lab more than a decade ago, the drug is produced by engineered yeast and will be the first product from synthetic biology to reach the market.

"There are roughly 300 to 500 million cases of malaria each year," he said. "Sanofi will initially produce about 100 million treatments, which will cover one-third to one-quarter of the need."

Biofuels from yeast

As CEO of the Joint BioEnergy Institute, Keasling is now focused on engineering microbes to turn "a billion tons of biomass that go unutilized in the U.S. on an annual basis … into fuel, producing roughly a third of the need in the U.S."

But other advances are on the horizon, he said, such as engineering new materials and engineering "green" replacements for all the products now made from petroleum. "Some of these have the potential to significantly reduce our carbon footprint, by say, 80 percent," he said.

Virginia Ursin, Technology Prospecting Lead and Science Fellow at Monsanto Corp., noted that industry sees synthetic biology's triumphs as being 10-20 years down the road, but anticipated, for example, producing enzymes used in manufacturing or even engineering microbes that live on plants to improve plant growth.

"Engineering (microbes) to increase their impact on (plant) health or protection against disease is probably going to be one of the nearer term impacts of synthetic biology on agriculture," she said. Ultimately, she said, the field could have a revolutionary impact on agriculture similar to the green revolution sparked by the development of chemical fertilizers.

But the implications of being able to engineer cells go deeper, according to Enriquez.

"This isn't just about economic growth, this is also about where we are going as a human species," he said. Humans will no longer merely adapt to or adopt the environment, but "begin to understand how life is written, how life is coded, how life is copied, and how you can rewrite life."

Scientists' moral choices

Directly guiding "the evolution of microbes, bacteria, plants, animals and even ourselves," as Enriquez put it, sounds like science fiction. George Church, a biologist at Harvard Medical School, suggested that we might want to bring back extinct animals, such as the mammoth to help restore Arctic permafrost disintegrating under the impact of global warming.

In response, ethicist Laurie Zoloth of Northwestern University urged caution in exploiting the technology of synthetic biology.

"You could change the world, and you have a powerful technology," she said. "I am more interested in what this technology makes of the women and men doing it. What sorts of interior moral choices they need to be making and how you create scientists who aren't only good at all these technical skills but very good at asking and thinking seriously about ethical and moral questions and coming to terms with the implications of their work."

Given the current crises of climate change and ecological change, she added, "frankly, without this work, I don't think we have such great answers for (them)."

Church acknowledged that "we have an obligation to do it right. But because our environment, our world is changing, the decision to do nothing is a gigantic risk. The decision to do a particular new thing is a risk. We have to get better at risk assessment and safety engineering."

Drew Endy, a bioengineering professor at Stanford, summed up his hopes for synthetic biology. "What I would like to imagine as a longer-term encompassing vision is that humanity figured out how to reinvent the manufacturing of the things we need so that we can do it in partnership with nature; not to replace nature, but to dance better with it

in sustaining what it means to be a flourishing human civilization."

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