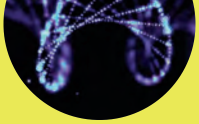
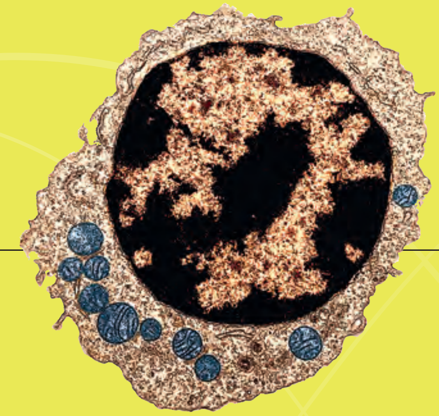




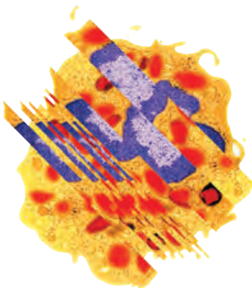
BIOLOGY, REIMAGINED:

NORTHWESTERN'S CENTER FOR SYNTHETIC BIOLOGY AT 10

TEN YEARS OF DISCOVERY—AND THE BREAKTHROUGHS STILL AHEAD.

"HERE IN CHICAGO AND EVANSTON, WE ARE THE THIRD COAST OF BIOTECH. THE CENTER IS AT THE FOREFRONT OF DEVELOPING TECHNOLOGIES THAT CAN SOLVE KEY PROBLEMS IN SUSTAINABLE AND RESPONSIBLE WAYS. IT WILL HOPEFULLY TRANSFORM THE WORLD."

Julius Lucks
Center for Synthetic Biology Codirector, Margery Claire Carlson Professor of Chemical and Biological Engineering



NOW THAT WE CAN DO ANYTHING, WHAT SHOULD WE DO?

In the world of synthetic biology—where scientists and engineers can rewire biological systems to perform remarkable new tasks, like sensing chemicals or delivering therapies—that question could hardly feel more urgent.

Even a mere 10 years ago, when Northwestern Engineering doubled down on its commitment to the field by establishing the Center for Synthetic Biology, researchers required expensive equipment, intricate algorithms, and lengthy experimentation to design and test new ideas.

Now empowered with the center's automated Foundry lab, team members can use AI tools like AlphaFold to design proteins and use powerful, high-throughput experimental equipment to create and test thousands of designs a day.

"That would have been science fiction five years ago," says Danielle Tullman-Ercek, James N. and Nancy J. Farley Professor in Manufacturing and Entrepreneurship, professor of chemical and biological engineering, and codirector of the center.

As the field accelerates and the center celebrates its 10th anniversary, faculty point to successes created by the team—new kinds of diagnostics and sensors, more effective therapies—while also looking to the future of the field.

"Here in Chicago and Evanston, we are the third coast of biotech," says Julius Lucks, Margery Claire Carlson Professor of Chemical and Biological Engineering and codirector of the center. "The center is at the forefront of developing technologies that can solve key problems in sustainable and responsible ways. It will hopefully transform the world."

"WHEN WE'RE CONSIDERING HOW TO SOLVE A PROBLEM, WE HAVE TO THINK ABOUT WHETHER IT IS ACCEPTABLE TO PURSUE AND HOW IT WILL AFFECT SOCIETY. WE WANT NORTHWESTERN TO BE THE PLACE WHERE THESE QUESTIONS ARE ASKED AND WHERE STUDENTS LEARN TO ASK THOSE QUESTIONS THROUGHOUT THEIR LIVES."

Danielle Tullman-Ercek
Center for Synthetic Biology Codirector, James N. and Nancy J. Farley Professor in Manufacturing and Entrepreneurship, Professor of Chemical and Biological Engineering

BUILDING SUCCESS THROUGH MULTIDISCIPLINARITY

Northwestern's reputation as a powerhouse in synthetic biology stems from its multidisciplinary, collaborative team, which represents some of the best minds in engineering, medicine, chemistry, law, policy, and anthropology.

"All of these perspectives are needed when technologies are developed," Lucks says. "We have one of the largest concentrations of synthetic biology researchers in the country, if not the world. When you're doing pioneering work, a collaborative team of experts is needed to go after important societal challenges."

One of those challenges is access to clean water. Over the past several years, Lucks and his collaborators have developed new synthetic biology biosensors that can detect lead and cadmium in water within minutes. The multidisciplinary project benefitted from field testing in Costa Rica, Kenya, and Chicago and involved faculty from anthropology, the Pritzker School of Law, and the Buffett Institute for Global Affairs.

Such technology-driven initiatives have also benefited from Northwestern's strengths in cell-free systems—harnessing the power of biology without being constrained by keeping the "machinery" inside the cell.

Researchers like Neha Kamat, associate professor of biomedical engineering, are taking that idea one step further and creating artificial cells. She and her team build membranes and put cellular machinery inside to perform useful functions, like synthesizing proteins. The goal is to create biosensors that can detect environmental contaminants or early biomarkers for diseases.

"With artificial cells, you can access the biological function that you get from a real cell, but in a very customizable way by building it up from scratch," she says. "And while regular cells are designed to grow and evolve, artificial cells will not do that. That makes them more controllable and safer."

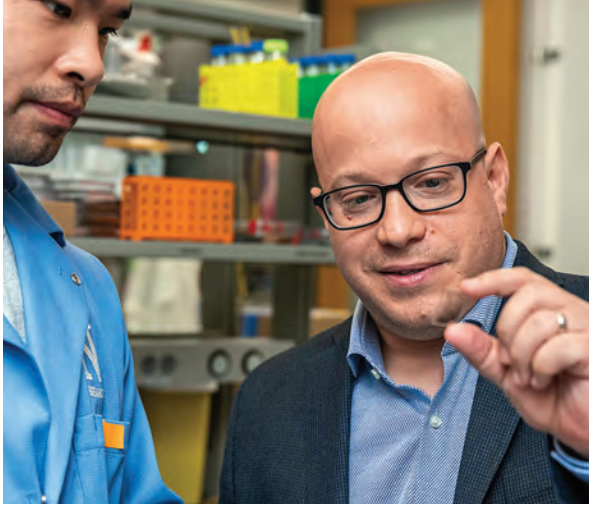
MODELING THE COMPLEXITY OF BIOLOGY

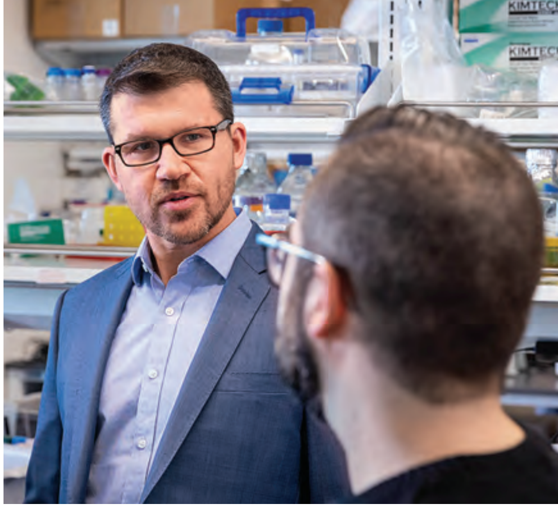
Northwestern synthetic biology researchers have made major breakthroughs in areas ranging from drug delivery to biofuels. For example:

DANIELLE TULLMAN-ERCEK, an expert in highly organized self-assembling proteins, has developed a biomanufacturing platform for proteins that could be used to create biofuels and meat alternatives.

JOSH LEONARD, professor of chemical and biological engineering, developed a platform that uses extracellular vesicles—particles released by cells—to deliver cell and gene therapy medicines.

JONATHAN RIVNAY, Jerome B. Cohen Professor of Biomedical Engineering and Materials Science and Engineering, is developing a "living pharmacy," an implantable electronic device that uses engineered cells to synthesize and release therapies.





left Danielle Tullman-Ercek and Julius Lucks, *top center* Jonathan Rivnay (photos by Heather Eidson), *bottom center* Niall Mangan, *top right* Josh Leonard, *bottom right* Neha Kamat (photos by Northwestern University)

Because biology is so complex, reengineering it to perform new tasks requires not only experimental innovation but mathematical models that describe which of the thousands of parameters that affect a cell's function are necessary for a certain task. That's where Niall Mangan, assistant professor of engineering sciences and applied mathematics, comes in.

"The art of mathematical modeling is understanding how you pick what's important," Mangan says. "We try to blend a combination of intuition with our collaborator's knowledge and the flexibility of learning new things from the data."

In one project, she worked with Tullman-Ercek to create a mathematical model of how metabolism is organized in space and time within bacteria—essential background knowledge needed to engineer bacteria to perform new tasks, like creating biofuels or pharmaceuticals.

And as in every research field, AI plays an increasingly large role. Mangan is developing AI-inspired methods, with the goal of automatically building new models for new experiments based on data from previous experiments.

With the automated equipment at the Foundry, "we could close the loop," she says. "Combining automated experiments with automatic models could help us look at the results and direct the next experiment."

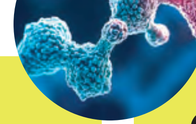
EDUCATING STUDENTS TO ASK THE BIG QUESTIONS

Of course, no one is looking to take humans completely out of the loop. That's why education is such a large part of the center, which has developed a research experience for undergraduates and the first graduate training program in synthetic biology in the United States—both funded by the US National Science Foundation.

The team is even writing a textbook to serve as a foundational tool for teaching synthetic biology. As AI and automated equipment accelerate what the field can do—empowering center members to tackle new challenges, such as using synthetic biology to create fertilizers to help feed the planet—understanding the underlying concepts and their implications is critically important.

"We want to educate students to think about the big questions when dealing with synthetic biology," Tullman-Ercek says. "When we're considering how to solve a problem, we have to think about whether it is acceptable to pursue and how it will affect society. We want Northwestern to be the place where these questions are asked and where students learn to ask those questions throughout their lives."

EMILY AYSHFORD



>$53 MILLION

IN RESEARCH FUNDING

300+

UNDERGRADUATE AND GRADUATE STUDENTS AND POSTDOC TRAINEES

24

FACULTY ACROSS THE McCORMICK SCHOOL OF ENGINEERING, WEINBERG COLLEGE OF ARTS AND SCIENCES, AND FEINBERG SCHOOL OF MEDICINE

RESEARCH STRENGTHS ACROSS SCALES

Center for Synthetic Biology faculty develop solutions from molecular to societal scales to drive innovation and impact in science, technology, and ethics. Areas of strength include:

CELL-FREE BIOMANUFACTURING

A departure from traditional processes that turn cells into tiny reactors to create new products, cell-free biomanufacturing uses the power of biological machinery outside of the constraints of actual cells. This versatile approach requires less time to develop new platforms that can provide on-demand manufacturing at scale.

SYNTHETIC BIOLOGICAL MATERIALS

Faculty are creating new functional materials that could transform medicine and biotechnology. They use AI, computational modeling, and experimental data to develop tailored biomaterials that use intricate biological components, including bacterial microcompartments and artificial cells.

SYNTHETIC IMMUNOLOGY

From engineering immune cells that target specific pathogens to developing synthetic vaccines that offer rapid response to emerging diseases, synthetic immunology has the potential to reshape healthcare.

MODEL-INFORMED DESIGN

By leveraging sophisticated mathematical and computational models to simulate and predict the behavior of complex biological systems, researchers can navigate the intricate landscape of genetic circuits, cellular processes, and biomolecular interactions to gain invaluable insights into the design and optimization of synthetic biology projects.

SUSTAINABLE BIOCHEMICAL PRODUCTION

As the need for low-cost bio-products like fuels and medicine increases, synthetic biology offers a new way to engineer biological systems to produce these chemicals and materials via efficient, environmentally sustainable systems.

BIOSENSORS AND DIAGNOSTICS

Biosensors that detect chemicals in water or biomarkers in blood are breakthrough synthetic biology technologies. At the core of these platforms are genetically encoded factors that bind to chemical markers and trigger changes in reporter gene expression to generate a visible output.

HUMAN THERAPEUTICS

Harnessing the power of genetic engineering and synthetic biology techniques, researchers are pioneering novel, tailored treatments—including gene therapies, vaccines, and protein-based drugs—for a wide range of human diseases.

HIGH-THROUGHPUT DISCOVERY

With automated technology, scientists can evaluate thousands of genetic variations, cellular responses, or biomolecular interactions simultaneously, unlocking the potential to discover novel solutions and optimize biological systems at an unprecedented pace.

EDUCATIONAL TOOLS

Educating students about the science and ethics underpinning synthetic biology technologies is critical to empowering them to make informed decisions. Faculty have adapted synthetic biology lab activities into two portable, low-cost, user-friendly educational kits: BioBits Bright and BioBits Explorer.

WHERE SYNTHETIC BIOLOGY ACCELERATES

In synthetic biology, progress can often be hindered by the sheer complexity of biological systems. The more efficiently researchers can design, build, and test these new systems, the faster they can make medicines, produce sustainable chemicals, capture carbon, and pioneer other remarkable new tasks while taking into account any ethical considerations.

Opened in 2025, the SynBio Foundry at the Center for Synthetic Biology offers robotics, automation, and advanced data analysis to streamline engineering biology.

There, scientists use automated platforms to assemble DNA, construct engineered microbes, and run large numbers of experiments simultaneously. Automated workflows can shorten experimental cycles from months to weeks, enabling researchers to test far more designs.

The facility supports the core workflow of synthetic biology: the "design–build–test–learn" cycle. Researchers begin by using computational tools to design biological components for their technologies. The Foundry then builds those designs by assembling DNA and introducing it into cell or cell-free systems. Automated platforms test how the engineered systems perform, generating large datasets that researchers analyze to improve the next round of designs.

At the technical level, the Foundry integrates liquid-handling robots, automated DNA assembly platforms, high-throughput microbial culturing and cell-free gene expression systems, and advanced analytical instruments. Robotic systems can precisely transfer microscopic volumes of liquids, allowing thousands of biological reactions to be prepared in parallel. High-throughput screening platforms then use plate readers, fluorescence detection, or automated imaging to monitor how engineered cells grow or cell-free systems operate, produce chemicals, or respond to environmental signals.

These instruments are run by specialized software that manages experimental design, tracks samples, and captures data from each step of the workflow. The result is a highly standardized and traceable process that makes experiments easier to reproduce and allows researchers to compare results across large numbers of genetic designs.

BRIAN SANDALOW

FROM LAB TO STARTUP

Synthetic biology researchers have launched several startups to translate their innovations:

MOONLIGHT BIO

Founded by adjunct professor Jaehyuk Choi, this startup aims to harness evolutionary forces that reveal unparalleled advances in T cell potency to create therapies that achieve unrivaled outcomes for cancer patients.

SAMDI TECH

SAMDI Tech was founded by Professor Milan Mrksich in 2011 to help researchers benefit from SAMDI (Self-Assembled Monolayer Desorption Ionization) technology for diverse drug discovery applications.

DESIGN PHARMACEUTICALS

Founded by adjunct professor Michael Jewett, Design Pharmaceuticals applies robust ultra-high throughput bioscience technologies in a novel approach to accelerate drug discovery and outpace current industry capabilities.

PEARL BIO

Cofounded by Michael Jewett, Pearl Bio's proprietary technology couples genome and ribosome engineering to produce novel biologics with diverse chemistries previously inaccessible.

SWIFTSCALE BIOLOGICS

Cofounded by Michael Jewett, this company's technology eliminates the constraints of using living cells in the drug manufacturing process, resulting in faster production times, less variability across batches, and greater scalability with hard-to-produce proteins. In 2021, the company was acquired by Resilience.

SYENEX

Syenex, cofounded by Professor Josh Leonard, is developing a synthetic biology discovery platform to harness the therapeutic potential of extracellular vesicles to accelerate the development of cell and gene therapy medicines.

OPERA BIOSCIENCE

Founded by Professor Danielle Tullman-Ercek, Opera offers a platform that allows scientists to source the proteins, growth factors, and reagents they need quickly and inexpensively.