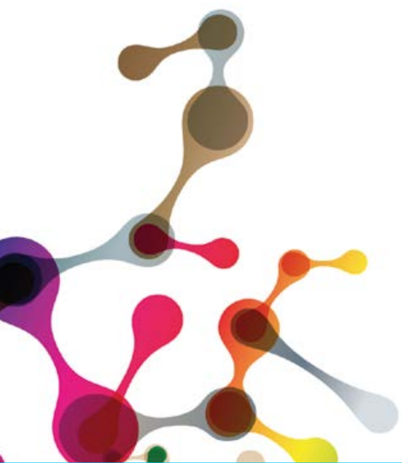
Synthetic biology in the real world – automating the creation of new lifeforms

Synthetic biology is, quite literally, the creation of new genetic constructs and novel micro-organisms with innovative functions. Together with systems biology, it provides a platform for translating advances in genomics, proteomics and molecular biology into real-world applications.

Automating DNA synthesis

Recent advances in robotics and liquid handling technologies are enabling synthetic and systems biologists to fully automate the design and production of the basic components of life. This ability to define and control the various steps involved in synthesizing genes, promoters and other genomic control regions with increasingly high precision is making it possible for scientists to reprogram the activities and capabilities of bacterial, yeast and mammalian cells.

Automated instruments and computer-controlled robotic systems have propelled synthetic biology from the research and development laboratory to commercial-scale, real-world industrial applications. This approach allows many of the time-consuming and labor-intensive tasks intrinsic to synthetic biology workflows – such as colony picking and liquid dispensing – to be performed more quickly and efficiently, with uncompromised accuracy. The various applications and collaborative ventures described below give a taste of the scope and commercial implications of the field at present, as well as the directions in which it could develop.



An assembly line for life

One need look no further than the Massachusetts Institute of Technology's Synthetic Biology Center to get a sense of the breadth of applications being investigated. Researchers at MIT are developing genetic circuits capable of regulating numerous cellular functions,[1] with potential uses in areas as diverse as biofuel development and drug discovery. By automating specific protocols and processes within their workflow, the MIT team has been able to fabricate plasmid constructs encoding these novel biological circuits on a much larger scale. "Scaling up this process on a robotic system gives us higher throughput and repeatability, without the variability inherent in manual procedures," said researcher Dr Jonathan Babb.

Similarly, scientists at the University of Montreal's Institute for Research in Immunology and Cancer have used automation to streamline the cloning and DNA assembly workflow they use to design artificial cell signaling circuits and sensors.[2] "Automation has given us a dramatically higher throughput," commented Almer van der Sloot, a Senior Research Associate in the Institute's Systems Biology and Synthetic Biology Research Unit. "We can now routinely perform 48 or even 96 DNA assembly reactions from start to finish in the time it used to take us to do about 12 manually. Importantly, automation has also improved accuracy and reproducibility."

Producing drugs, chemicals, biofuels and more

Synthetic biology approaches are also being widely explored for biomanufacturing processes. For example, Elanco Animal Health, a division of Eli Lilly, is using Enbiotix's engineered phage technology to develop bacteriophage-based antimicrobial therapies targeting specific infectious veterinary diseases. This type of 'phage therapy' represents a complementary antibacterial strategy to help reduce the use of antibiotics.

Another example of synthetic biology-based production is Amyris' use of microbial engineering to develop plant-derived ingredients for cosmetics and lubricants. The company uses its µPharm™ discovery and production platform to create stable libraries of analogs of natural compounds. This technology offers rapid design and scale-up of fermentation processes for the production of target molecules in engineered yeast strains.

Global energy company Repsol is also applying synthetic biology technology to bioproduction, in this case for the development of micro-organisms capable of generating advanced biofuels via novel metabolic routes.[3] Jose Miguel Seoane, a researcher in the biotechnology department at Repsol's Madrid Technology Center, explained: "The investigation of new biological applications involves screening large numbers of mutants of different micro-organisms, enabling the best performing candidates to be selected for further studies. As we test thousands of different mutations, automated high throughput screening is the key to our success."

Building in flexibility

Computer-controlled robotic systems can be used to automate virtually all aspects of the synthetic biology workflow, including next generation sequencing, DNA extraction, PCR set-up and clean-up, cell transformation and transfection, colony picking, biochemical and cell-based assays, and protein purification and expression screening. The flexibility and open architecture of the Freedom EVO® workstation make it ideal for these applications, offering a complete solution for accelerating workflows and improving productivity for virtually any laboratory.

1) Reprogramming nature.
Tecan Journal 3 2012, 22-23.

2) Designer proteins.
Tecan Journal 3 2015, 20-21.

3) Developing the fuels of the future.
Tecan Journal 2 2015, 20-21.

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