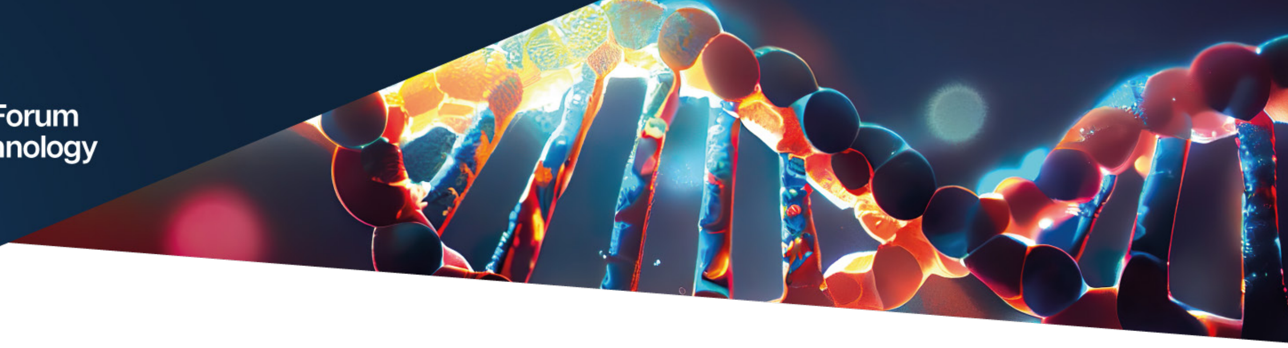
OECD
Global Forum
on Technology



Technology deep dives
Synthetic biology

Key messages

- **Harnessing life:** Synthetic biology involves the engineering of living systems at multiple scales, from molecules to organisms, to enable research and product development.
- **A range of applications:** Potential synthetic biology applications include alternative protein sources such as plant-based meats (a solution for food security), gene editing of insects (to eradicate Malaria), scaled production of microorganisms (for carbon dioxide removal) and rapid vaccine development (such as RNA vaccines).
- **mRNA vaccines demonstrating success:** the COVID-19 pandemic has shown how synthetic biology can deliver life-saving solutions to health security challenges and support economic prosperity, leading more and more countries to invest in and grow their biotechnology enterprises.
- **Contributing to sustainable development:** Synthetic biology could help tackle a range of grand societal challenges, from climate change to biodiversity regeneration, from sustainable manufacturing to improved food and health systems.
- **Equity and bridging technology divides:** Open science and low cost of many relevant tools is enabling global access to the benefits of synthetic biology.
- **Governance:** Synthetic biology is not without real and perceived risks for health, environment, biosecurity and biosafety, making a credible and trusted system of governance and forward-looking technology assessment particularly important.

What is synthetic biology?

The last two decades of biotechnology have witnessed the development of the first synthetic cell, a million-fold drop in the cost of sequencing DNA, a thousand-fold drop in the cost of synthesising DNA, and the development of CRISPR genome editing. Building on these advances, synthetic biology is a multidisciplinary area of biotechnology that seeks to harness living systems in research and product development. The field is already providing breakthrough innovations, e.g. COVID vaccines, and promises others in the areas of health, food security, and the green transition.

Synthetic biology products are arriving on the market

Many products using engineering biology are already on the market. One recent success of biomanufacturing powered by synthetic biology (see figure 1) is the rapid development of COVID-19 vaccines, speeding up the vaccine development process in a time of global crisis. Other products include a yeast engineered to produce meaty flavours to aid taste in plant- based burgers (promising 90% reductions in land use and green-house gases), thin films for electronics from molecules produced from engineered organisms, and engineered bacteria for nitrogen fixing in soils to reduce chemical fertilizers and to improve soil health.

Potential applications

Synthetic biology is a field that may provide benefits in different areas of the current and future global challenges, including treating or eradicating infectious and genetic diseases, preventing food shortages, enabling sustainable manufacturing, and mitigating the impacts of climate change, among many others. Potential synthetic biology applications include alternative protein sources such as plant-based and other synthetic meats (a solution for food security), gene editing of insects (to eradicate Malaria), scaled production of microorganisms (for carbon dioxide removal) and rapid vaccine development (such as RNA vaccines).

An open research community including citizen innovators

Synthetic biology has a visible do-it-yourself biology (DIYbio) community which operates as a cultural movement. This community focuses on making it easier to harness biology through sharing knowledge, protocols and co-locating instrumentation into community labs. These activities are parallel to, and sometimes overlapping with, the FabLab movement which mobilises 3D printers and other tools and techniques. Community DIYbio labs offer a suite of tools and techniques along with courses and training to enable any citizen to engage in biology research and development.

DIYbio communities overlap with traditional higher education and research institutes, as well as the private sector. One location is the International Genetically Engineered Machines Competition (iGEM). Initiated in MIT in 2003, this competition challenges high-school students, undergraduates, DIYbio communities and start-ups to construct genetically engineered systems using the standardised biological building blocks, called BioBricks, available on an online open registry. To date, 60,000 students have participated in the annual competition, and many students from this community have gone on to found successful synthetic biology companies.

Governance

Questions have been raised regarding the sufficiency of current governance approaches to synthetic biology with its rapid development in diverse sectors, the potential risks posed by nefarious uses, and its variety of non-traditional innovation communities. In many countries, dedicated biotechnology regulations already exist. Some argue that these are already fit-for- purpose, and that additional regulatory oversight might stifle innovation and reduce national competitiveness. Critics say that the current regulatory frameworks are insufficient to cope with the complexities of engineering biology innovations and also do not take into consideration building and maintaining trust in the regulation of engineered organisms.

The mix of traditional and non-traditional innovation communities could be taken as a governance opportunity, through the identification of key loci for creating standards, codes, principles and frameworks that can enable societally beneficial and environmentally safe synthetic organisms whilst safeguarding against negative consequences. Agile regulation, for instance the use of regulatory sandboxes, is one approach that could be developed. Another is the use of standards. Standards (norms or codes) ranging from technical specifications to high-level principles or frameworks, can complement regulation in a broader technology governance approach. Potential standards for synthetic biology include technical specifications for the description of biological components, processes of their assembly into larger systems and quality control process. Examples of potential higher-level principles and frameworks could include principles of safe-by-design and sustainability criteria.

Questions for discussion

- Which directions of development are the most promising and how fast are they emerging?
- What are the greatest barriers for realising the potential of synthetic biology in terms of maximising benefits whilst mitigating risks?
- What action could be taken to overcome these barriers and what could the possible role of OECD be?

The Global Forum on Technology inaugural event will take place on 6 June 2023 under the theme "Shaping our future at the tech frontier".

Learn more at **http://oe.cd/gftech**

Figure 1. Design and scale up of synthetic biology products and biomanufacturing

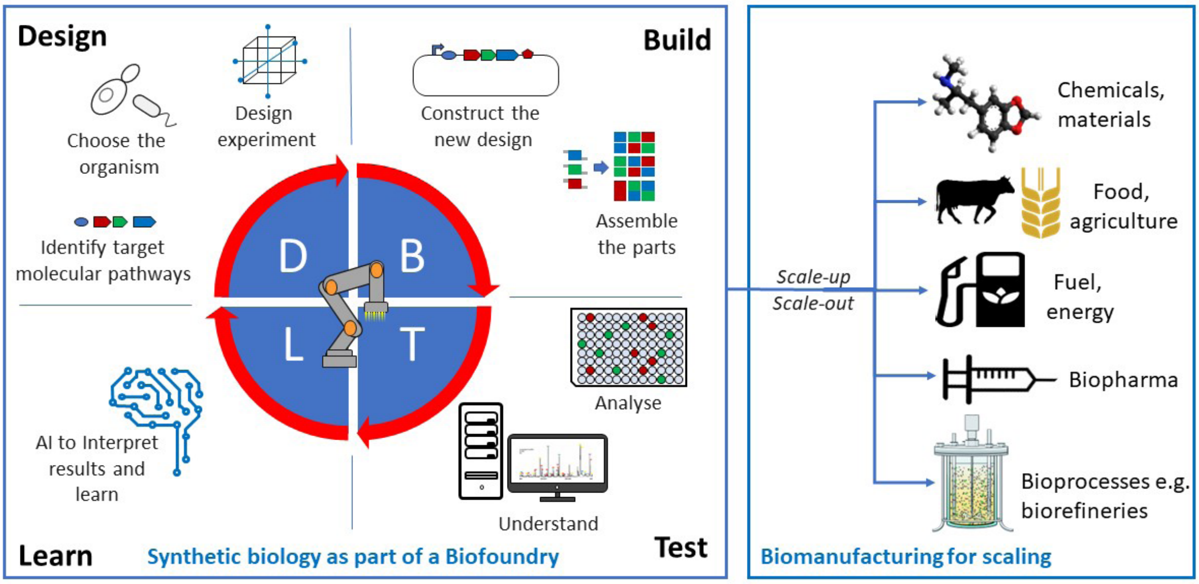


Figure: Synthetic biology, integrated into new factories for genetic products called biofoundries (left), allows for Design, Building, Testing, and Learning of living systems. This can be combined with biomanufacturing to enable products to scale (right), an example being the recent RNA vaccines for COVID-19. Adapted from OECD (2021), OECD Science, Technology and Innovation Outlook 2021: Times of Crisis and Opportunity, OECD Publishing, Paris, https://doi.org/10.1787/75f79015-en.