SYNTHETIC BIOLOGY: THE UK'S OPPORTUNITY TO LEAD IN THE NEXT INDUSTRIAL REVOLUTION

Fiona Mischel Director, Human Health Content and Innovation. SynBioBeta

Synthetic biology is the biggest industry you have never heard of. If scaled successfully, it has the power to transform planetary and human health across the world.

I have cystic fibrosis, a life-threatening genetic condition, so I speak from personal experience when I say that synthetic biology is both an opportunity and a necessity.

I have been taking the life-saving medication, Kaftrio, since 2019 (known as Trikafta in the US). This medication has changed my life to the point where it is almost normal—I no longer live as a chronically ill person, just an occasionally sick one. Kaftrio has kept me out of the hospital for over three years, allowed me to gain full-time employment, and enabled me to emigrate from the US to the UK, the country where I feel most at home. I also believe this drug played a major role in saving my life and many others with CF during the height of the pandemic. To be clear, this drug is not a cure but it is certainly the next best thing.

Kaftrio is not a bioengineered therapeutic but a triple-action small molecule, that is, a synthetic chemical compound. However, only 80% of CF patients are genetically eligible to receive this life-changing drug. The remaining 20% of patients have genetic mutations that are too extreme for today's solutions. Thousands of patients still bear the burden of this disease and there are millions more with conditions far more genetically complex than CF who have gone untreated for decades.

Why do I write all this? Because I believe that I am one of the last of a generation of patients that will be significantly impacted by small-molecule drugs. We need innovations like synthetic biology to bring new solutions to patients, families, and our planet.

WHAT IS SYNTHETIC BIOLOGY?

Synthetic biology (synbio) is a field of science that applies

A range of products all made from synthetic biology including cultured meat, food colouring, textiles, bio-concrete, aviation fuel, and COVID-19 mRNA vaccines

engineering principles to biological systems to create new functions and materials. Simply put, synbio reprogrammes biology.

Synbio has the potential to impact every industrial sector from foods to fuels, materials, chemicals, and, of course, medicine. Today, our economies are underpinned by petrochemicals. By changing our systems of production to leverage biology, we can localise manufacturing, secure our supply chains, dramatically reduce greenhouse gas emissions, and create safe, high-paying jobs.

One of the best ways to understand the fundamentals of synbio is through fermentation. Just as we ferment yeast to make beer, we can also reprogram and brew single-cell organisms to make critical products like ethanol, polyurethane, surfactants, and fertilisers. We can also reprogramme animal cells for food or human cells to fight disease.

SYNBIO FOR HUMAN HEALTH

The COVID-19 pandemic clearly showed us what synbio can do for human health. mRNA technology (programmed mRNA molecules) was an overnight success over two decades in the making. But mRNA COVID vaccines are one only application of one therapeutic modality in the synbio family.

Synbio has been saving lives in the UK since 2018 through cell and gene therapies. Many cancer patients with fatal prognoses who were treated with CAR-T cell therapy are now considered cured. Meanwhile, the first gene therapy for a fatal childhood disease, metachromatic leukodystrophy (MLD), was just given to a 19-month-old baby. However, these powerful therapies are currently only available to a few hundred patients as a last resort.

Today, very few genetically programmed therapies are approved. They are also currently difficult to manufacture, meaning cell and gene therapies are some of the most expensive drugs in the world — one (curative) dose for MLD has a list price of £2.8 million.

Because these therapies were developed using synbio, we can also use synbio to scale production, reduce costs, and improve access until these therapies can become front-line treatments. Ideally, this will involve increased financial and tax-credit support for emerging companies in this space, regulatory review, and increased GMP-grade biomanufacturing capacity.

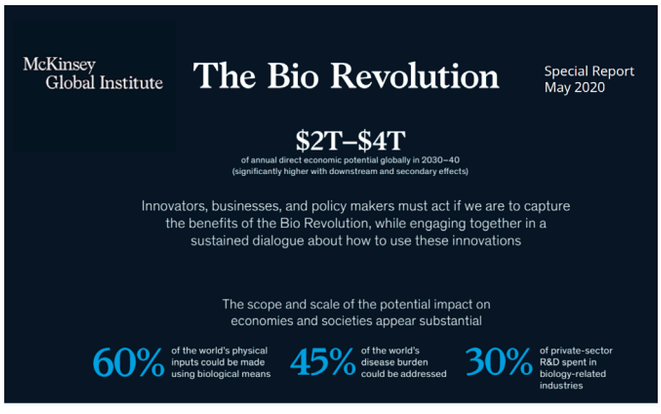
Human health isn't the UK's only opportunity to lead in life sciences. We also have the chance to leverage synbio to meet our Net Zero targets.

SYNBIO'S ROLE IN THE UK'S NET ZERO ROADMAP

The UK is already a leading nation in synbio research and entrepreneurship. In February of this year, 3D Bio-Tissues, a company in Newcastle, revealed the world's first pork steak made entirely of cultured porcine cells. The implications of this are tremendous. Cultured meat is often hailed as a solution to the growing demand for animal-based foods and products. Rather than farm whole animals to harvest only certain parts, cultured meat can grow specific meat cuts or animal-derived products directly. The technology involves taking a small biopsy from a living animal and growing those cells in a bioreactor. The result is the same chicken or pork you buy in stores today but without the carbon footprint, animal welfare implications, antibiotics, or human exposure to zoonotic disease.

The UK is also leveraging synbio to decarbonise heavy industry. The Government awarded leading synbio company LanzaTech a £25 million grant to build a sustainable aviation fuel plant (SAF) in Port Talbot, Wales. The factory will use genetically reprogrammed microbes to transform greenhouse gas emissions from the local steel mill into ethanol, a key ingredient in SAF.

These kinds of scientific and industrial breakthroughs could be repeated in every household product we buy, in every building we make, and in every meal on our plate. While this is a bold claim, it's hardly far-fetched when taken in the context of the global support behind synbio.



THE GLOBAL COMPETITIVE LANDSCAPE FOR SYNBIO

At SynBioBeta, we track global private investment in synthetic biology. We have seen tremendous investor appetite across all industrial sectors, especially in human health and food and agriculture. In 2021, private investment topped $18 billion, a record for the industry. We expect that figure to decline for 2022 (as of this writing in March 2023, we are still finalising our 2022 data). Our early projections show that synbio investment declined significantly in line with all other venture-capital-backed sectors. However, the current macroeconomic environment should not distract from the tremendous opportunity of synbio for the UK.

In 2020, McKinsey released a special report detailing the potential economic impact of synbio between 2030-2040. The report estimates that the annual economic value of synbio is between $2-4 trillion USD. At scale, the synbio industry could provide 60% of all material inputs and address 45% of the world's disease burden.

Many regions, especially the United States, have mustered significant financial, political, and regulatory might to support synbio. The Biden administration made headlines late last year with the Executive Order on Advancing Biotechnology and Biomanufacturing. This order directed major US government agencies to submit reports on how they will use synbio to achieve their health and sustainability goals and improve their services for taxpayers. Then, just weeks ago, the Biden Administration released their initial biotechnology goals following the Executive Order. Over the next 20 years, these bold goals aim to produce at least 30% of the U.S. chemical demand via biomanufacturing

pathways, produce 90% of plastics from bio-based polymers, and decrease the manufacturing cost of cell-based therapies 10-fold. These policies, coupled with new biotech hubs emerging across the US, are pushing the US bioeconomy forward in an unprecedented way. [1]

Meanwhile, Singapore has taken a different approach to promoting its bioeconomy and securing its future resources. As an island nation, Singapore imports most of its essential goods including food. But in 2020, Singapore became the first country to approve cultured meat, taking significant steps in securing the country's food supply, supply chain resilience, and human health.

ACHIEVING OUR GOALS AS A LIFE SCIENCE SUPERPOWER

The UK is perfectly positioned to take advantage of synbio's rising tide. The UK's academic strength alongside agencies such as UKRI, ARIA, and the new Department for Science, Innovation, and Technology, are powerful catalysts for promoting and scaling synbio. The NHS is also a global destination for clinical trials, especially for novel therapeutics like cell and gene therapies. These frameworks and know-how can play critical roles in achieving the UK's life science ambitions.

It's important to recognise that synbio is a more capital-intensive industry than other advanced industries such as FinTech, AI, and SasS platforms. There are two key reasons for this. First, synbio creates material goods, not just digital ones. Second, biology is far more complex than any computer and programming even the most basic single-celled organisms is non-trivial. When considering synbio's role as an industry of the future, it's important to balance the up-front costs against the long-term benefits.

Our societies are burdened by diseases and our planet is approaching a dangerous tipping point. There will never be a better moment to act for our future. Synbio looks to play a critical role in shaping our societies for generations to come. By harnessing and supporting synbio innovation, the UK can stake out its technological foothold and take a leading role in the global economy of the future.

UK Research and Innovation

NHS

Advanced Research + Invention Agency

ARIA

Department for Science, Innovation & Technology

Refence

1 (Source: Bold Goals for US Biotechnology and Biomanufacturing https://www.whitehouse.gov/wp-content/uploads/2023/03/Bold-Goals-for-U.S.-Biotechnology-and-Biomanufacturing-Harnessing-Research-and-Development-To-Further-Societal-Goals-FINAL.pdf) ■