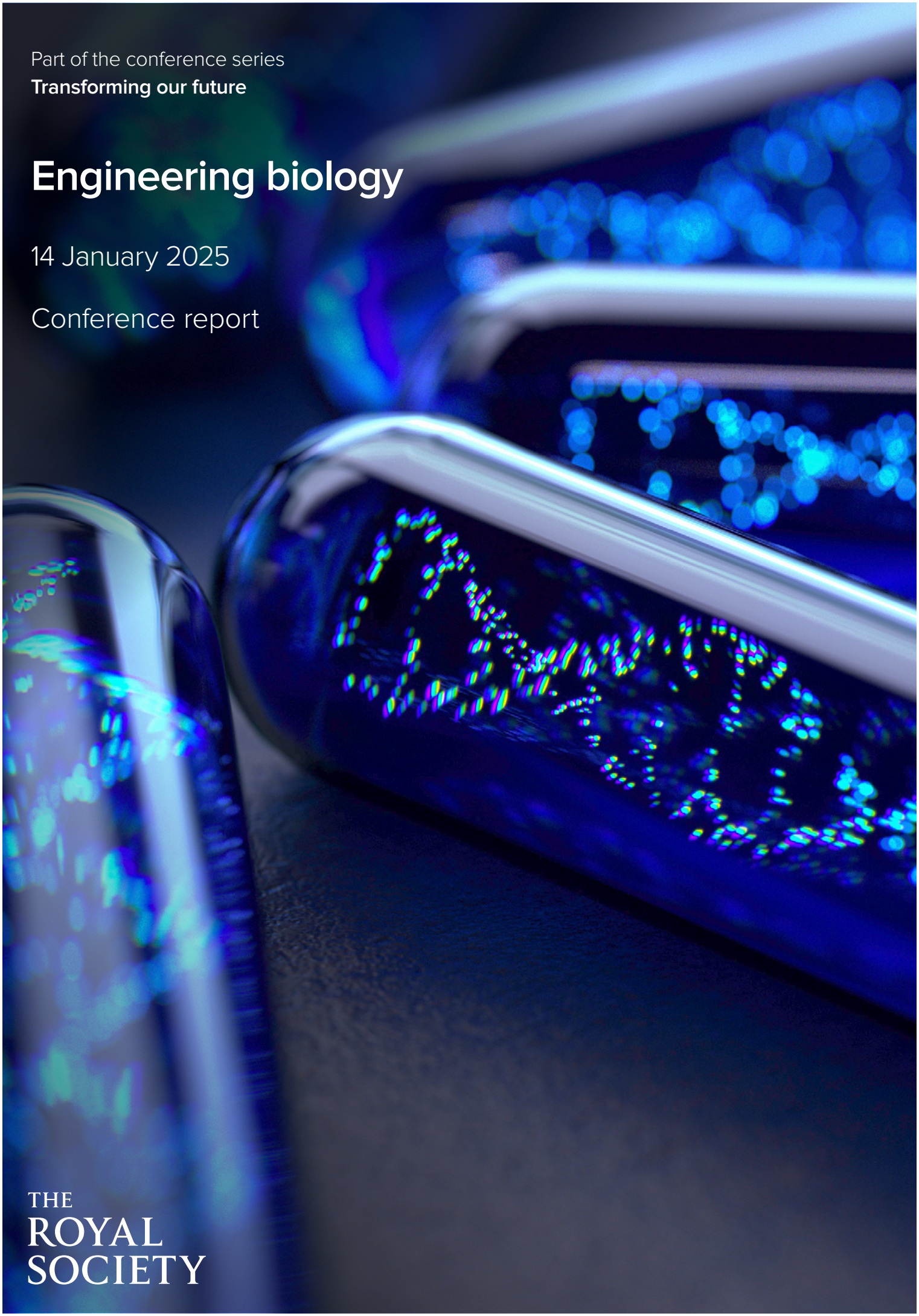
Part of the conference series
Transforming our future

Engineering biology

14 January 2025

Conference report



THE ROYAL SOCIETY

***Transforming our future* conference series**
This unique series brings together leading stakeholders from industry, academia, government, funding bodies, charities, and the wider scientific community to address the major scientific and technological challenges of the next decade. Through talks and panel discussions, each conference features cutting-edge science on one topic or in one industry sector.

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This document is not a verbatim record, but a summary of the discussions that took place during the event and the key points raised. Comments and recommendations reflect the views and opinions of the speakers and not necessarily those of the Royal Society.

Contents

Introduction

On 14 January 2025, the Royal Society hosted a hybrid conference on engineering biology.

This event was delivered as part of the Royal Society's *Transforming our future* conference series. Meetings in this series bring together experts from industry, academia, funding bodies, the wider scientific community and government to explore and address key scientific and technical challenges of the coming decade. These conferences are organised with the support of the Royal Society's Science, Industry and Translation Committee.

For more details and to view other conferences in the series, visit **royalsociety.org/transforming-our-future**

A summary of key discussion points along with abstracts of the talks and an overview of the panel session are presented in this report.

This document is not a verbatim record, but a summary of the discussions that took place during the event and the key points raised. Comments and recommendations reflect the views and opinions of the speakers and not necessarily those of the Royal Society.

Recordings of the presentations are available on Youtube. Visit **youtube.com/playlist?list=PLg7f-TkW11iXBCuKm9E_gDYoeltlBrCWW&feature=shared**

"As highlighted in the House of Lords Science and Technology Committee's *Don't fail to scale* report, understanding and engaging with the public will be critical for the next phase of the engineering biology mission."

Professor Anne Osbourn OBE FRS, John Innes Centre, conference organiser.

Executive summary

Engineering biology is one of five critical technologies identified by the Department for Science, Innovation and Technology (DSIT) as areas where the UK is in an excellent position to lead the world. However, as this field continues to rapidly advance, the themes of effective translation, responsible innovation and availability and accessibility of infrastructure are becoming increasingly important.

The *Engineering biology* conference held on 14 January 2025 brought together speakers from industry, academia and government to discuss how the UK can maintain and enhance its position as a global leader in this sector.

The day opened with a keynote presentation from Professor Jason Chin FMedSci FRS, Medical Research Council Laboratory of Molecular Biology. He shared the progress his research group have recently made towards the encoded synthesis of non-canonical biopolymers. He described the cutting-edge scientific work being done to create new ribosomes, new aminoacyl-tRNA synthetase / tRNA pairs, and organisms with entirely synthetic genomes.

Additional talks and panel sessions aligned with the following themes:

- From lab to market: the translation journey
- Trustworthy innovation
- UK infrastructure: what is needed?
- Funding innovation

> "In terms of infrastructure in the UK, we need more assets, but we are also not making full use of the infrastructure we have."
>
> Dr Damian Kelly, Croda, conference organiser.

> "We are excellent at innovation in engineering biology, but we are far from excellent at translating that innovation to the marketplace."
>
> Dr David Tew, GSK, conference organiser.

KEYNOTE

Reprogramming the genetic code

Watch the keynote at: youtube.com/watch?v=GNOuu5UMF0U

Professor Jason Chin FMedSci FRS, Medical Research Council Laboratory of Molecular Biology, described his pioneering work on the encoded synthesis of non-canonical biopolymers.

In terrestrial life, DNA is copied to messenger RNA, and the 64 triplet codons in messenger RNAs are decoded – in the process of translation – to synthesise proteins. Cellular protein translation provides the ultimate paradigm for the synthesis of long polymers of defined sequence and composition, but is commonly limited to polymerising the 20 canonical amino acids. Professor Chin described recent progress towards the encoded synthesis of non-canonical biopolymers. These advances may form a basis for new classes of genetically encoded polymeric materials and medicines. To realise these goals, Professor Chin's research group is re-imagining some of the most conserved features of the cell; they have created new ribosomes, new aminoacyl-tRNA synthetase / tRNA pairs, and organisms with entirely synthetic genomes in which they have re-written the genetic code.

> "In a commercial context, we've been working on using these approaches to build therapeutic proteins and develop a whole range of applications."
>
> Professor Jason Chin FMedSci FRS, Medical Research Council Laboratory of Molecular Biology.

Image: Professor Jason Chin FMedSci FRS, Medical Research Council Laboratory of Molecular Biology.

SESSION ONE

From lab to market

Chair: Dr David Tew, GSK
Watch all session 1 talks at: youtube.com/watch?v=GNOuu5UMF0U

TALK ONE

Recoding regulation: towards predictable engineering of quantitative traits

Dr Nicola J Patron, University of Cambridge, discussed scientific approaches that can be used to better understand the complex regulatory networks in plants and the implications for crop enhancement.

Genetic technologies can be used to enhance crops and promote sustainable agriculture. However, the manipulation of traits governed by multiple genes can be challenging. Plant responses to the environment, including to biotic and abiotic stressors, are often controlled by multiple genes, coordinated by complex regulatory networks. Recent advances in genomics and computational modelling allow dynamic responses to environmental perturbations to be measured and the underlying networks inferred. Although these networks identify candidate regulators associated with traits, the effects of genetic manipulation, particularly given network topologies such as feedforward and feedback loops, are non-intuitive and difficult to predict. Dr Patron's team combines systems biology and computational modelling to predict the impacts of network perturbations / re-wiring. They test their impact using gene editing and synthetic genetic controllers, with the aim of providing strategies for the predictable engineering of agricultural traits.

Image: Dr Nicola J Patron, University of Cambridge.

"Some crop traits are relatively easy to engineer as they are controlled by just one or two genes. However, more complex traits, such as the use of nutrients, or tolerance to stresses like drought, are governed by large networks of genes. Engineering biology approaches are helping us to understand these traits and predict how to improve them."

Dr Nicola J Patron, University of Cambridge.

TALK TWO

From lab to scale: insights from the Colorifix journey

Christopher Hunter, Colorifix Ltd, described the scientific and operational approaches that are enabling this engineering biology spin-out company to scale.

Colorifix is a UK-based synthetic biology company that has developed a biological process to produce, deposit and fix colorants onto materials. Compared to incumbent dyeing solutions, Colorifix's patented technology leads to significant reductions in energy and water usage, as well as the avoidance of harmful chemicals. It began as a University of Cambridge spin-out and has since raised over £40m in investor funding. The company has several active customers across Europe and has been primarily focused on serving manufacturers working with leading fashion brands, followed by more recent partnerships in cosmetics and homewares. Colorifix has a semi-distributed scaling model. The team engineers colour-producing micro-organisms, but then rather than fermenting them in centralised production facilities, proprietary bioreactors are installed on customer sites and Colorifix provides training to run the fermentation process in the dye house. This approach aims to maximise environmental savings and accelerate the path to cost parity.

> "Dyeing is a two-part problem. A lot of people are focused on making eco-friendly colourants but are still using harsh chemistry to apply those products to textiles. We are trying to address both issues."
>
> Christopher Hunter, Colorifix Ltd.

Image: Christopher Hunter, Colorifix Ltd.

TALK THREE

The role of IP in real-world impact

Dr Sara Holland, Potter Clarkson, shared highlights from a recent examination of the engineering biology patent landscape in Europe.

Academics, investors, policy makers and regulators all need to know - what are the emerging opportunities? Where to invest? What to fund? What regulations will we need?

Although patent protection is just one form of intellectual property, it is crucial for innovative engineering biology companies to bring their products to market, and analysing the patent landscape gives a lot of information as to who is doing what, and where.

> "We have seen a steep increase in the number of patents filed in Europe associated with sustainable packaging, alternative proteins and genetically modified organisms."
>
> Dr Sara Holland, Potter Clarkson.

Potter Clarkson is launching results of an in-depth, bespoke study with Inevus Advanced Analytics Ltd, exploring patents in engineering biology published at the European Patent Office from 2004 to 2023, using advanced analytics, including natural language processing and topic modelling.

Patenting in the engineering biology space is experiencing rapid growth, powered by diverse applications including therapeutics, biomanufacturing, biofuels and much more, with the UK ranked 5th in the world by relative specialisation index.

Image: Dr Sara Holland, Potter Clarkson.

SESSION TWO

Trustworthy innovation

Chair: Professor Anne Osbourn OBE FRS, John Innes Centre
Watch all session 2 talks at: youtube.com/watch?v=28iCXqG9YYQ

TALK ONE

Creating a meeting place for science and society

Dr Jenni Rant, SAW Trust and John Innes Centre, highlighted the importance of engagement with non-scientists to promote trust in and understanding of new technologies.

Scientific discovery and innovation offer enormous opportunities to improve people's lives and look after our planet. However, for societies to realise the benefits of any advances, people need to be accepting of new technologies and so there needs to be trust. Scientists are the general public and represent diverse cross-sections of society, so who better to engage with communities to improve understanding of scientific processes and goals. The SAW Trust provides training for scientists to develop skills to explore research topics with non-scientists and creates opportunities for people to reflect and respond to science through poetry and visual arts.

> "Scientists ARE part of society and should all participate in conversations with non-scientists to help people understand advances in science and technology that could benefit us all."
>
> Dr Jenni Rant, SAW Trust and John Innes Centre.

Image: Dr Jenni Rant, SAW Trust and John Innes Centre.

TALK TWO

Delivering pro-innovation regulation for engineering biology

Professor Joyce Tait CBE, Innogen Institute, University of Edinburgh, discussed the changing regulatory landscape and its impact on the engineering biology sector.

The UK Pro-Innovation Regulation of Technologies Review on Life Sciences, led by Dame Angela McLean, published in 2023, included a section on engineering biology that pointed to the difficulties faced by novel technologies in fitting into current legislative boundaries. Following from that, as part of the DSIT 'Sector Vision', the Regulatory Horizons Council was commissioned to review the regulation of engineering biology sectors and the report, published in December 2024, considers what pro-innovation regulation would mean for engineering biology sectors and how it could be delivered. This talk summarised the conclusions and recommendations of the RHC report and will speculate on future developments in the governance / regulation of engineering biology.

"The governance game is changing. Thinking of it as a chess game, the pieces will need to learn new moves. Knights will no longer ride on horseback. Governance must be brought into the twenty-first century."

Professor Joyce Tait CBE, Innogen Institute, University of Edinburgh.

Image: Professor Joyce Tait CBE, Innogen Institute, University of Edinburgh.

TALK THREE

Developing ethically sensitive governance for trustworthy and inclusive innovation

Professor Sarah Cunningham-Burley, Nuffield Council on Bioethics and the University of Edinburgh, discussed how consideration of ethical concerns could be embedded in engineering biology governance and regulation.

Engineering biology brings new and old ethical questions into focus, and exploring these requires considered, rigorous and persistent ethical analyses at all stages of innovation. Professor Cunningham-Burley outlined some of the pressing ethical concerns, from big picture issues relating to desirable futures, to the pragmatics of research practice. She also discussed how deliberation, involving publics and a range of stakeholders, is essential to ensuring trustworthy governance that is inclusive, proportionate and agile. In this way, ethical challenges can be addressed and embedded in regulatory frameworks.

"Both public engagement and agile regulation are key to trustworthy innovation. Consideration of ethics should be at the heart of all engineering biology innovation."

Professor Sarah Cunningham-Burley, Nuffield Council on Bioethics and the University of Edinburgh.

Image: Professor Sarah Cunningham-Burley, Nuffield Council on Bioethics and the University of Edinburgh.

SESSION THREE

UK infrastructure – what is needed?

Chair: Dr Damian Kelly, Croda
Watch all session 3 talks at: youtube.com/watch?v=9nzZ-1kiirw

TALK ONE

Addressing the challenges of bio-manufacturing: a path to sustainable and cost-effective production of industrial chemicals and fuels

Professor Nigel S Scrutton FRS, C3 Biotechnologies Ltd and University of Manchester, highlighted several challenges to scaling engineering biology technologies in the UK. He described the development of a novel biomanufacturing platform that may help overcome some of these barriers.

The need for disruptive technologies to overcome the high capital and operational costs in large-scale bio-manufacturing of industrial chemicals and fuels, while enhancing process resilience, remains a critical challenge. Engineering biology has shown considerable promise, but it has yet to deliver production platforms that are cost-competitive with traditional manufacturing methods at scale. In response, C3 Biotech is pioneering a novel platform that enables on-site production of 'programmable fuels' and industrial chemicals from waste biomass / CO_2. This platform eliminates the need for sterilisation of equipment and feedstocks, providing a more energy-efficient and sustainable manufacturing solution.

"For bio-manufactured chemicals and fuels to compete with petrochemicals, we need a radical rethink. This isn't about tweaking existing fermentation methodologies. We need to reinvent the process entirely."

Professor Nigel S Scrutton FRS, C3 Biotechnologies Ltd and University of Manchester.

Continuous, non-sterile production has been demonstrated. Modular, industrial-scale systems are now being developed for scalability and transportability with substantial reductions in capital / operational expenditure. This will position bio-manufacturing of chemicals as a near-term commercial reality to secure UK supply chains for critical chemicals / fuels and support the nation's net-zero goals for chemicals / fuels production.

Image: Professor Nigel S Scrutton FRS, C3 Biotechnologies Ltd and University of Manchester.

TALK TWO

Engineering biology's future: The startup perspective on growth and challenges

Zoe Woods, Change Bio, shared her thoughts on the support engineering biology startups need to successfully scale.

Startups are essential to unlocking the full potential of engineering biology in the UK, driving innovation, growth, and solutions to critical challenges in sustainability. But what's holding them back? In this talk, Zoe Woods explored how startups can accelerate the translation of groundbreaking research into impactful, commercially viable solutions.

Drawing on success stories and lessons from the field, she highlighted the role of startups in advancing innovation and delivering global impact—and the infrastructure, support, and funding needed to help them thrive. She shared one startup's reflections on what's needed to build a stronger ecosystem and cement the UK's leadership in engineering biology.

> "A lack of physical infrastructure isn't what is holding our start-ups back. Getting the right access, at the right time, so you can get fast customer feedback? This is the bigger issue."
>
> Zoe Woods, Change Bio.

Image: Zoe Woods, Change Bio.

TALK THREE

Industrialising synthetic biology: lessons from pharma

Ted Chapman, recently retired from GSK, discussed how engineering biology approaches are currently being used in the pharmaceutical sector, and what changes are needed to expand their applications.

Large molecule pharmaceuticals are discovered and manufactured using engineering biology and account for 80% of the world's top selling pharmaceuticals and vaccines. Most small molecule pharmaceuticals are either existing natural products or are constructed using medicinal chemistry. Engineering biology is used to make bespoke enzyme catalysts to simplify and improve the sustainability of chemical processes. There are few examples of synthetic biology being used in small molecule manufacture beyond metabolic engineering of the natural hosts or making common natural molecules in new hosts.

The key challenge is creation of a pipeline of new products discovered using engineering biology as opposed to changing processes in development. For a change process to be viable the principle obstacle to target is the time taken converting a hit into a viable process.

"Facilities available through centres like CPI and BioBase Europe are absolutely important, but there are limitations in terms of, for example, scheduling and molecule fit. Sharing of flexible, plug-and-play hardware and software would address these issues and enable companies and institutions to undertake much of the work themselves."

Ted Chapman, recently retired from GSK.

Image: Ted Chapman, recently retired from GSK.

TALK FOUR

A perspective from the agriculture industry

Dr Robert Harris, Syngenta, discussed the infrastructure requirements for scaling engineering biology approaches in an agricultural context.

Syngenta is a leading global agricultural life sciences company, providing technologies to farmers around the world to enable them to grow food productively and sustainably. An increasing demand for sustainable crop protection and nutrition, driven by regulatory, society and value chain pressures are providing exciting opportunities for biological based innovation (eg microbes, extracts, proteins, natural products etc). Differing significantly from conventional chemical products, these technologies require engineering biology tools to manipulate and edit microbes for rapid optimisation and the development of bioprocesses. They believe that to successfully scale and bring biological crop protection technologies to global markets will require key engineering biology platforms, infrastructure and skills to be drawn together around this thematic area.

Image: Dr Robert Harris, Syngenta.

> "Engineering biology technologies are scattered, and the ecosystem in the UK is dynamic and complex. Some form of intervention is needed to effectively bring this network together and cement the UK's place as a leader in the field."
>
> Dr Robert Harris, Syngenta.

PANEL DISCUSSION

Funding innovation

Watch both the panel discussion and reflections from Professor Dame Angela McLean at: youtube.com/watch?v=6hRbBW2_0NU

Dr Christopher Kaminker, BlackRock, chaired a panel discussion focused on the current and potential future funding landscape for innovations in engineering biology.

Engineering biology technologies are used in many economically important industries and are thus of substantial interest to both public and private funders. To close the meeting, five panelists were invited to the stage to share their reflections on the conference and discuss their thoughts on the financial support available to the engineering biology sector.

> "Engineering biology is an approach used across many industries and will be used across many more in the future. It is an area that is investable today in private and public markets, as many of the largest companies in the world are already using these techniques to improve productivity and create new products."
>
> Dr Christopher Kaminker, BlackRock.

Image: (left to right) Dr Mark Renshaw, DSIT; Dr Rowan McKibbin, BBSRC-UKRI; Professor Paul Freemont, Imperial College London; Dr Fabrizio Ticchiarelli-Marjot, ARIA; Dr Jason Mellad, Start Codon; and Dr Christopher Kaminker, BlackRock (Panel Chair).

Professor Paul Freemont (Imperial College London), Dr Rowan McKibbin (BBSRC-UKRI), Dr Jason Mellad (Start Codon), Dr Mark Renshaw (DSIT) and Dr Fabrizio Ticchiarelli-Marjot (ARIA) spoke about a range of topics, including:

- What makes an idea worth investing in?
  - The UK government is interested in innovations that can address one or more of the following key priorities: promoting economic growth; facilitating the UK's drive towards net zero emissions targets; supporting UK biosecurity; and enhancing UK economic security.
  - For funding agencies, investable ideas must involve novel, cutting-edge science. They must also meet the criteria for a specific funding call or initiative.
  - For all types of funding, having the right team to deliver the work is crucial. Most innovative ideas fail, and most start-ups inevitably must pivot. A skilled, experienced team is more likely to adapt and perform well under challenging circumstances.
- What emerging areas are underfunded but likely to be critical for the future?
  - Engineering biology approaches can be used to address gaps in our foundational understanding of biological systems. Progress towards the creation of synthetic genomics and synthetic, self-replicating cells is advancing rapidly.
  - Innovations that capitalise on the convergence of engineering biology techniques with AI and / or quantum technologies are of interest to both public and private funders.
  - Other areas in need of investment include (but are not limited to):
    - Building up a skills base in the UK
    - Supporting local, accessible infrastructure
    - Financing research tools (eg methods, reagents, etc) that can change the way science is performed.
- What are some of the biggest challenges in terms of funding and commercialising innovation?
  - Amongst investors, the appetite for risk is typically lower in the UK than in the US. There is considerable funding available for early-stage companies, however in order to scale beyond Series A many UK companies wind up seeking investment abroad.
  - Innovation can wind up locked in universities. Universities are typically highly protective of any intellectual property generated at their institution. Many (but not all) take high equity shares in their spin-outs, which can make it difficult to find other investors.
  - Most public funding for R&D is highly specific and short-term. Grants are typically provided for projects lasting five years or less, and there is no guarantee of follow-on funding. This makes it difficult to maintain work programmes, and researchers may wind up 'chasing the money' and pursuing many different, smaller research directions.

Reflections

Dame Angela McLean DBE FRS, Government Chief Scientific Adviser, shared her thoughts on the importance of engineering biology and the need for scientific expertise within government.

Each year, the Government Chief Scientific Adviser, Dame Angela McLean, focuses on a different emerging technology. Since the start of her year, April 2024, she has been working to raise awareness, particularly within the Civil Service, of the transformative potential of engineering biology across numerous industrial sectors.

As part of these efforts, five essays have been commissioned to explore a diverse range of possible applications for engineering biology technologies[1]. Written by experts in the field, these aspirations for the future are optimistic, grounded in scientific truths and will demonstrate the breadth of engineering biology's potential to solve real-world problems.

However, there is still work to do to harness the opportunities that these technologies offer. The UK engineering biology sector is at a tipping point in terms of scale-up and commercialisation. There are lessons to be learned from the UK National Quantum Technologies Programme. Over the last decade, this initiative has brought together quantum researchers with companies and entrepreneurs via long-term government support and has established the UK as a leader in quantum innovation. Providing a similar blueprint for the engineering biology community could be game-changing for this sector and for the UK economy.

Watch both the panel discussion and reflections from Dame Angela McLean at:
youtube.com/watch?v=6hRbBW2_0NU

Image: Dame Angela McLean DBE FRS, Government Chief Scientific Advisor.

"The potential applications of engineering biology are breathtaking, but this prize is not yet in our hands. The UK has significant strengths in this field but there is still work to do to ensure that we harness the opportunities that this transformative technology can offer."

Dame Angela McLean DBE FRS, Government Chief Scientific Adviser

1. Government Office for Science. 2025. Engineering Biology Aspirations. Available from https://www.gov.uk/government/publications/engineering-biology-aspirations-report/engineering-biology-aspirations (accessed 11 August 2025).

Acknowledgements

The Royal Society is grateful to the organising committee for their guidance in shaping the agenda and for leading the conference.

Organisers
Dr Damian Kelly, Croda
Professor Anne Osbourn OBE FRS, John Innes Centre
Dr David Tew, GSK

The Royal Society is a self-governing Fellowship of many of the world's most distinguished scientists drawn from all areas of science, engineering, and medicine. The Society's fundamental purpose, as it has been since its foundation in 1660, is to recognise, promote, and support excellence in science and to encourage the development and use of science for the benefit of humanity.

The Society's strategic priorities emphasise its commitment to the highest quality science, to curiosity-driven research, and to the development and use of science for the benefit of society. These priorities are:

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