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Don't fail to scale: seizing the opportunity of engineering biology

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SUMMARY

Engineering biology is a fast-developing field of science with exciting potential applications across many sectors. These range from medicine and manufacturing to materials and food, and from growing more resilient crops to cleaning up waste in the environment. Biotechnologies could allow us to replace fossil fuels as the basic feedstock for much of industrial production—this would be a significant step towards achieving net zero and a sustainable economy.

Engineering biology involves the design and construction of new or modified organisms or molecules, based on those we find in nature. Recent technological developments, such as gene editing, as well as data analysis through machine learning, allow us to harness and even enhance biological processes. Developments in AI increasingly enable us to rewrite the "software" of our world. However, essential products often require "hardware", too—new ways to shape the world around us. Engineering biology has the potential to provide this, moving atoms as well as bits. As the Government Chief Scientific Adviser, Dame Angela McLean, told us, its beneficial uses "are not science fiction"—they are here now.

The UK was a world-leader in engineering biology, following far-sighted investments over a decade ago. However, the UK's position at the forefront of this field has slipped as other countries invest more and adopt more strategic, holistic policies. The UK continues to have long-standing strengths in the life sciences, a significant academic base, and a growing start-up scene. The previous Government identified engineering biology as a critical technology. It launched the National Vision for Engineering Biology, for which the current Government has expressed support. But unless we act quickly, the UK is at a severe risk, once again, of seeing the economic and industrial benefits of science and technology developed here exploited overseas.

The UK still has a strong research base. However, this cannot be taken for granted. It needs consistent funding, skilled researchers and technical experts trained here or attracted to the UK, and well-funded research infrastructure to stay at the cutting edge. Each of these areas require coordinated government action to secure the future of engineering biology R&D in the UK.

For engineering biology to contribute to UK sustainability and economic growth requires, above all, that companies can scale up beyond the start-up and spin-out phase and become globally competitive. All too often we hear that when companies reach a certain size, they move abroad for better investment and development prospects, taking most of the economic benefit with them. Our inquiry found that engineering biology was often an illustrative case study of wider issues across the UK economy. This failure to scale in the UK is a long-standing issue across many sectors of technology which requires an urgent, concerted, cross-government approach to fix.

Like many other technologies such as AI, engineering biology also has the potential to be misused by hostile actors. It can raise biosecurity risks which the Government must carefully manage through informed regulation.

For the public to make informed choices about this technology and its development, active public engagement is required. The technology must be

understood, and public concerns addressed to avoid a possible repeat of past experiences with GMOs.

There are several policy areas the UK must get right to support a flourishing sector. Our inquiry highlights seven key areas: **strategy, skills, regulation, infrastructure, investment, adoption and governance:**

- **Strategy**: The Government needs a plan for engineering biology as part of its Industrial Strategy. It should, as a minimum, recommit to the previous Government's £2 billion funding target over ten years to maintain the UK's R&D sector. The plan will require concrete outcomes and targets, regular progress updates against these metrics, and coordinated work across Government. It should identify how novel cross-sectoral technologies like engineering biology can be supported to deliver the wider goals of the industrial strategy such as sustainability and economic growth. It must consider factors such as the availability of feedstocks and where the UK can be a leading player, in the context of global markets and supply chains.

- **Skills**: The UK needs an expanded training offer and more effective visa policies to attract top talent from abroad. UKRI should fund more doctoral training programmes for engineering biology, incorporating a year in industry, including start-ups and spinouts, and there is a gap for Masters' level graduate conversion courses. Skills England should work with industry to expand routes into engineering biology, with a focus on apprenticeships and training for technical roles. High upfront visa costs and limited selection criteria limit the Global Talent visa, which should be expanded in scientific and technical areas.

- **Regulation**: The UK needs a swift and clear regulatory landscape to help drive responsible innovation. At present it is too difficult for companies to understand which regulators will oversee them and what the route to market is in this cross-disciplinary sector. The creation of the Regulatory Innovation Office is a good step. It is vital that regulators operate at the leading edge of the technology, sufficiently resourced, and independent. They should have experts from a wide range of disciplines and industries on hand, to clarify the landscape and ensure that any risks are identified and managed. Standards are important for any industry to grow, and are particularly lacking in engineering biology: the UK can use its research expertise to play a leading role in setting these internationally.

- **Infrastructure**: Infrastructure is key at various stages of development, from early-stage research infrastructure which allows companies to acquire the data needed for patents, to scale-up infrastructure to demonstrate that a new process can work on an industrial scale. The UK has some useful infrastructure, especially at the early stages, but its use is limited by lack of awareness, and prohibitive access costs. A map of available research infrastructure and funding support for researchers and businesses to use it is needed. Core, stable funding for laboratories would prevent them from charging high prices for access or relying on inconsistent grant funding. A flexible policy for scale-up infrastructure is required to respond to a rapidly developing sector and provide support to build facilities when the need is identified.

- **Investment:** Both public and private investment are needed. The UK's public investment offer suffers from a pipeline problem—Innovate UK and research councils can provide early-stage funding, but it is unclear where to go for scale-up funding. Initiatives like the National Wealth Fund and British Business Bank may help address this, but their roles need clarity, their mandates need to be expanded. They need to be able to move at speed and take risks, necessitating teams of specialist investors for large-scale technological investments. In the private sector, there is a significant lack of scale-up funding coupled with a long-term decline in the UK's capital markets, preventing the growth of companies. Widespread and significant financial reforms, including those announced in the Chancellor's 2024 Mansion House speech, which aim to address the limited availability of scale-up funding in the UK must be rapidly progressed, or we will continue to see an exodus of capital, companies and pioneering technology to the United States.

- **Adoption: public procurement and incentives.** The Government can lead the way in adopting engineering biology through the power of public procurement, as we have seen in the US with its BioPreferred model, but this requires adopting a healthy appetite for risk and making a clear statement that procurement budgets are to be used in part to support UK-based innovative companies and products. Many larger companies have biotechnology initiatives, but without incentives they will not shift production away from cheaper, but unsustainable fossil-fuel based processes. Faster adoption of bio-based processes is needed to deliver cost reduction through learning and scale. Sector-specific Government incentives or mandates are required to support the adoption of bio-based processes and help with market creation.

- **Governance**: The potential societal and economic benefits of engineering biology could be severely undermined by safety and acceptability concerns. There is need for renewed public engagement to ensure the benefits of these technologies are understood and concerns addressed. The UK must build on the Biological Security Strategy, and work with international partners, to ensure that malicious uses of engineering biology are prevented, and to ensure that the nation is protected against biological threats, whether engineered or natural.

A national sector champion for engineering biology should be appointed to coordinate this activity across government.

We believe, as Lord Vallance of Balham told our Committee, that there is a real opportunity for engineering biology to provide immense benefits to the UK. It can help us to address the challenges we face in health, sustainability, and in addressing climate change. There are major opportunities to grow the economy by applying this technology. We have many of the ingredients to make this a success. But this reaction requires a catalyst.

Without urgent action in the areas this report outlines, we are in danger of losing out as other countries catch up and overtake the UK's level of investment and R&D. Lord Vallance indicated that we have a small—and closing—window of opportunity to realise these benefits in the UK. We cannot afford to miss it.

Don't fail to scale: seizing the opportunity of engineering biology

CHAPTER 1: INTRODUCTION

1. Engineering biology is the design, scaling and commercialisation of biology-derived products and services, which can transform sectors or produce existing products more sustainably.[1] Recent developments in synthetic biology have enabled much faster reading, writing, and editing of genetic code. Engineering biology uses the tools of synthetic biology, including but not limited to gene editing, and involves its application and commercialisation across sectors. These engineered biological systems can be used to manipulate information, assemble materials, process chemicals, produce energy, provide food, and help maintain or enhance human health and the environment.

2. The previous Government's Science and Technology Framework, published in February 2023, identified engineering biology as one of the "five critical technologies" on which the UK should focus.[2] In December 2023, the Department for Science, Innovation and Technology (DSIT) published its National Vision for Engineering Biology, setting out its approach to engineering biology policy and committing to invest £2 billion over the subsequent 10 years.[3] In March 2024, DSIT and UK Research and Innovation (UKRI) announced funding for two new Doctoral Training Centres in the field of engineering biology.[4]

3. In our inquiry, we have sought to understand which technologies fall under the umbrella of engineering biology, and what its potential is, particularly for delivering UK economic growth through commercialisation of research, and for improvements to public services. We sought to evaluate existing government policy, to explore what the key applications for engineering biology might be; which areas of engineering biology the UK excels at and which it is well-placed to exploit; and what more needs to happen to ensure that the science developed in the UK benefits its public services and the UK economy. Our inquiry also considered the ethical, regulatory and safety implications of the rapid developments in engineering biology.

4. For the purposes of this inquiry, we sought out evidence from many academics and companies concerned with the non-medical applications of engineering biology. However, many of our conclusions and recommendations are common to all areas of applied synthetic biology, and we recognise that there are many exciting applications in healthcare and the life sciences.

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1 Department for Science, Innovation and Technology, *National vision for engineering biology* (December 2023): https://assets.publishing.service.gov.uk/media/656de8030f12ef07a53e01ac/national_vision_for_engineering_biology.pdf [accessed 5 October 2024]

2 Department for Science, Innovation and Technology, *Science and Technology Framework - taking a systems approach to UK science and technology* (March 2023): https://assets.publishing.service.gov.uk/media/6405955ed3bf7f25f5948f99/uk-science-technology-framework.pdf [accessed 5 October 2024]

3 Department for Science, Innovation and Technology, *National vision for engineering biology* (December 2023): https://assets.publishing.service.gov.uk/media/656de8030f12ef07a53e01ac/national_vision_for_engineering_biology.pdf [accessed 5 October 2024]

4 UKRI, '£1 billion doctoral training investment announced' (12 March 2024): https://www.ukri.org/news/1-billion-doctoral-training-investment-announced/ [accessed 5 October 2024]

5. Chapter 2 sets out some of the background, definition and examples of engineering biology, and explains why it has seen renewed focus in government policy in recent years. Chapter 3 assesses the existing government strategies towards engineering biology, including DSIT's National Vision for Engineering Biology. Chapter 4 looks at what needs to be done to enable a healthy engineering biology sector and makes recommendations on the industrial strategy and the roles of regulation, infrastructure, and skills training. Chapter 5 considers the economic dimension of engineering biology and how best to maximise its potential for growth, examining the roles of public and private investment methods of driving adoption across the economy, and the importance of scaling-up engineering biology companies in the UK. Chapter 6 examines operational challenges for engineering biology, including public acceptability and biosecurity concerns.

6. We began our inquiry in April 2024 and issued our call for evidence on 2 April 2024.[5] Upon the Dissolution of Parliament on 30 May 2024 ahead of the general election on 4 July, in common with all Parliamentary committees, the Committee formally ceased to exist and our work on this inquiry was paused. The Committee was reappointed on 29 July 2024 and agreed to resume this inquiry. Due to the change of Government, the report will sometimes refer to policy documents published under the previous Government; however, we have sought clarification from the Department for Science, Innovation, and Technology and Ministers on whether any major policy changes can be expected, and we have adjusted our conclusions and recommendations to reflect the priorities and positions of the new Government.

7. We are grateful to all those who provided their views in oral or written evidence over the course of the inquiry; a full list of all those who contributed is contained in Appendix 2.

5 House of Lords, Science and Technology Committee, 'Call for Evidence': https://committees.parliament.uk/call-for-evidence/3399

CHAPTER 2: ENGINEERING BIOLOGY: WHAT AND WHY?

8. This chapter sets out definitions for engineering biology, examples of its applications, and the motivation for renewed focus on this technology in recent years.

9. As defined by the Government, engineering biology involves applying synthetic biology to solve practical problems. For example, engineering biology can be used to develop new vaccines, therapies, or materials with different properties. Some examples are included in Box 1.

Box 1: Example applications of engineering biology

Outside of the health and life sciences, where engineering biology is already extensively applied, for example in cell and gene therapy, many engineering biology applications focus on using engineered biological systems to replace existing processes. This can enable the manufacture of useful products in different ways—for example, without the use of fossil fuels, or by converting waste into less harmful or even useful substances. It can also enable the creation of materials that would be more difficult or energy-intensive to create through other methods.

Examples include:

Sustainable dyes: With support from Innovate UK, Norwich-based Colorifix has developed the first entirely biological process to produce, deposit and fix dyes onto textiles. They identify pigments produced in nature, and use DNA sequencing to identify the exact genes and enzymes that produce the pigment. These genes are then transferred into a microbe that can produce, transfer, and fix dyes onto textiles with reduced environmental impact compared to synthetic dye methods.

Fuel from waste: C3 Biotechnologies, a spin-out company from the University of Manchester, focuses on making fuel from waste. It can make fuel precursors and bioethanol from waste gases. Bioengineered bacteria use fermentation and photocatalysis to combine waste biomass with carbon dioxide captured from industrial processes, or even directly from the atmosphere, to generate butyrate and other related fuel precursors which can then be converted to propane and butane.

Cultivated meat: Cultivated meat is meat produced directly from cells, rather than being raised from animals. This does not require producing food from genetically modified animals, but instead growing cells in laboratory conditions. Extracellular, a Bristol-based start-up company, is a contract development and manufacturing organisation (CDMO) which provides equipment and cells for companies developing cultivated meat and seafood. They provide bioreactors, standard cell lines and cultures, and other services for companies looking to develop their bio-based processes. The UK recently approved the use of cultivated meat in pet food, becoming the first European country to do so.

Recovering and recycling rare earth minerals: In other areas of resource management, one of the recent Engineering Biology Mission Hub grants administered through UK Research and Innovation was awarded to a group aiming to use biology to recover and recycle rare earth minerals, led by principal investigator Professor Martin Warren of the Quadram Institute and the University of Kent.[6] Genetically engineered microorganisms could be used to extract metals, for example from waste (bioleaching) or break down contaminants in polluted water and land (bioremediation.)

Bio-engineered plants: Efforts are underway to alter plants genetically in order to enhance resistance to diseases, reducing the need for pesticides and fungicides, or to fortify plants with additional vitamins to make them more nutritious. The Sainsbury Laboratory in Norwich is designing and developing molecular tools that engineer genomes, and use natural and synthetic biological components, to produce novel functions in plant cells.

Source: Q 17–Q 34 (Will Milligan); Written evidence from Norwich Research Park (ENB0046); CPI, 'What is engineering biology and how will it help create a more sustainable future?' (30 September 2024): https://www.uk-cpi.com/blog/what-is-engineering-biology-and-how-will-it-help-create-a-more-sustainable-future [accessed 15 November 2024]; BBC, 'Lab-grown meat set to be sold in UK pet food' (17 July 2024): https://www.bbc.co.uk/news/articles/c19k0ky9v4yo [accessed 15 November 2024]; UKRI, Engineering Biology (September 2021) : https://www.ukri.org/wp-content/uploads/2021/09/UKRI-160921-EngineeringBiology.pdf [accessed 10 October 2024]; Biotech, 'Ground-breaking solutions': https://c3biotech.com/products/ [accessed 10 October 2024]; Norwich Research Park, 'Science and Technology Secretary announces Engineering Biology investment' (13 February 2024): https://www.norwichresearchpark.com/science-and-technology-secretary-announces-engineering-biology-investment [accessed 10 October 2024]; University of Kent, '14m for Kent led project to advance recycling of rare materials' (9 February 2024): https://www.kent.ac.uk/news/sustainability-environment-and-natural-resources/34548/14m-for-kent-led-project-to-advance-recycling-of-rare-metals [accessed 10 October 2024]; The Sainsbury Laboratory (TSL), 'Synthetic Biology': https://www.tsl.ac.uk/our-work/support-groups/synthetic-biology [accessed 10 October 2024]; Extracellular, 'The first-choice manufacturing partner for the future bioeconomy': https://www.extracellular.com/ [accessed 10 October 2024].

10. Compared to traditional manufacturing, engineering biology has the potential to produce specific molecules, compounds, or materials that can be difficult to create with conventional methods. Engineering biology processes can use non-fossil-fuel based feedstocks that cannot be used in traditional manufacturing, such as chemical or plastic wastes which can be "revalorised" into useful materials. They can involve reactions at lower temperatures, which can be more sustainable and efficient. Engineering biology can be used to re-engineer biological systems to enhance favourable properties—for example, producing crops that are more resilient to disease, with higher yields, or using biological processes to produce novel foods such as lab-grown meat.

11. Recent years have seen rapid developments in synthetic biology and other key enabling technologies. For example, the costs of sequencing and synthesising DNA have declined significantly. The first human genome sequenced cost around $100 million in 2005; it can now be done for less than $1,000. DNA synthesis has declined from a cost of $1 per base pair (1993) to a few cents per base pair today[7] (see Figure 1). These technologies have also become more widely available; handheld DNA sequencing tools can be purchased,

6 UKRI, 'New £100m fund will unlock the potential of engineering biology': https://www.ukri.org/news/new-100m-fund-will-unlock-the-potential-of-engineering-biology/ [accessed 1 November 2024]

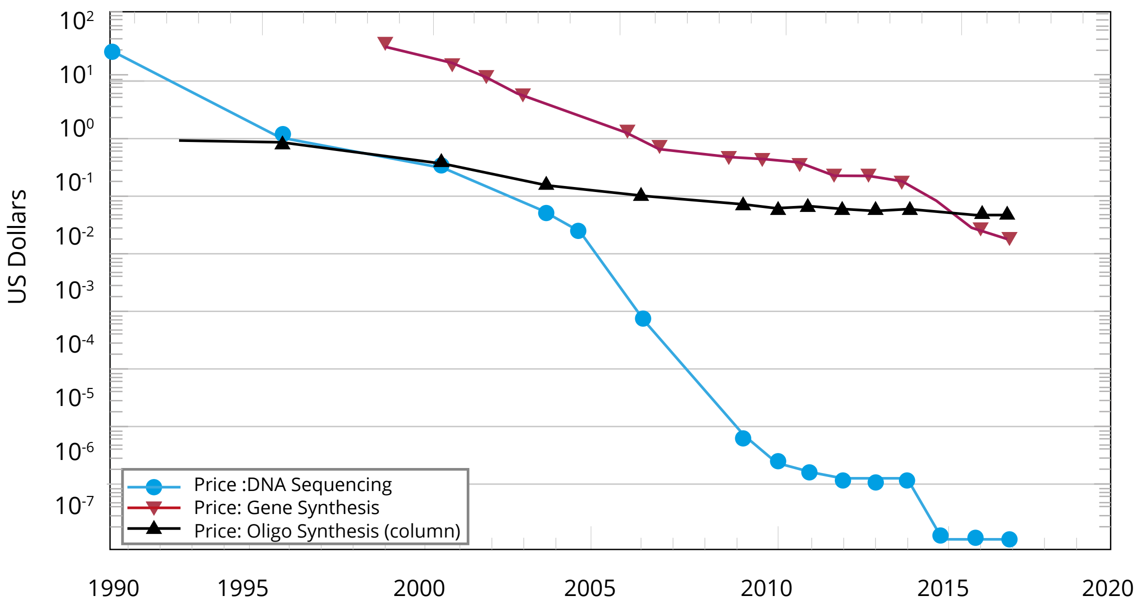
7 One base is the individual molecule of adenine, cytosine, thymine, or guanine, the four molecules which make up DNA [they make up the chemical base of the coding, but there is also the backbone]. These are always paired together to form the familiar "rungs" of the DNA ladder and encode genetic information. National Institute of Health, 'Base Pair' (updated 6 January 2025): https://www.genome.gov/genetics-glossary/Base-Pair [accessed 5 October 2024]

and commercial companies will synthesise DNA to order through the post.[8] This has helped to create large genetic and biological datasets, which are being analysed with the aid of machine learning and artificial intelligence. New frontiers are now opening due to these fundamental developments.

12. Since 2012, developments in synthetic biology have been further enabled by the use of CRISPR-Cas9.[9] CRISPR, short for Clustered Interspaced Short Palindromic Repeats, is an immune system used by microbes to recognize and eliminate viruses through recognising and "snipping" strands of DNA. This has been harnessed to provide gene-editing techniques which are much simpler and more cost-effective, making gene-editing more accessible.[10]

13. Note that gene-editing should not be confused with genetic modification (GM). Genetically modified organisms are those where DNA from a different species has been introduced into another. Gene edited organisms do not contain DNA from different species, but instead changes to genetics in one species that could be made more slowly using traditional breeding methods. Under the Genetic Technology (Precision Breeding) Act 2023, gene-edited plants and animals are under a different regulatory regime than genetically modified organisms (GMOs).[11]

Figure 1: Price declines for DNA sequencing and synthesis



Source: Bioeconomy Capital from synthesis, 'DNA Cost and Productivity Data, aka "Carlson Curves" (26 October 2022): https://www.synthesis.cc/synthesis/2022/10/dna-synthesis-cost-data [accessed 10 October 2024]
Note: The "Carlson Curve", analogous to Moore's Law, illustrates how the cost of sequencing the human genome has declined dramatically over recent decades (although it has started to plateau recently). Note the logarithmic scale on the y-axis. The price to synthesise DNA has also declined, although less dramatically. Oligo synthesis refers to oligonucleotide synthesis, which is a technique for making relatively short single strands of synthetic DNA or RNA with precise sequences

8 Written submission from Wellcome Sanger Institute (ENB0021)
9 This breakthrough was awarded the Nobel Prize in Chemistry in 2020. The Nobel Prize, Press release: *Genetic scissors: a tool for rewriting the code of life* on 5 October: https://www.nobelprize.org/prizes/chemistry/2020/press-release/ [accessed 5 October 2024]
10 Stanford Report, 'Stanford explainer: CRISPR, gene editing, and beyond' (10 June 2024): https://news.stanford.edu/stories/2024/06/stanford-explainer-crispr-gene-editing-and-beyond [accessed 5 October 2024]
11 House of Commons Library, Genetic Technology (Precision Breeding) Act 2023, Research Briefing, CBP 9557, March 2023

14. A significant motivation behind the pursuit of engineering biology solutions is finding alternative ways to produce and process crucial products such as fuels, foods, and medicines in a more sustainable way. Professor Paul Freemont, Co-Director of the Innovation and Knowledge Centre for Synthetic Biology (SynbiCITE), outlined this:

> "I think that everyone realises that we are facing a rather existential problem: we have a very dramatic shift in climate, and issues around population growth and food. These are global problems … a lot of countries are looking towards developing alternative solutions to address some of these issues, including moving away from a petrochemical-based economy to a more bio-based, circular, and sustainable economy." [12]

Professor Freemont elaborated that "engineering biology could address the production and biomanufacturing of commodity chemicals, specialised chemicals, sustainable aviation fuel, drugs and pharmaceuticals, and alternative food systems."[13]

15. The US Engineering Biology Research Council produced a roadmap that summarises the engineering biology field.[14] It is driven by developments in enabling technologies such as our ability to synthesise, edit and engineer DNA, but also biologically produced molecules and larger organisms up to the level of single or multi-cellular organisms. This is aided by growing capacities in data science and machine learning which allow for analysis and prediction. It has applications in areas including health and medicine, energy, agriculture, industrial and advanced manufacturing (industrial biotechnology), and environmental applications, for example in the remediation of waste. At the heart is a cycle of design, build, test, learn—designing novel biological systems or molecules, using synthetic biology to create them, testing their performance, and refining the design accordingly based on what is learned from tests.

16. The Government has historically recognised that engineering biology is a sector of potential strength in the UK, with a strong academic and a growing commercial base. For example, according to DSIT's own research, the UK has founded more biotechnology companies than any other nation in Europe, ranks third worldwide behind the US and China for total investment between 2017 and 2022, and ranks fifth for the number of academic papers produced in engineering biology between 2018 and 2022.[15]

17. The previous Government committed to support engineering biology. Its Science and Technology Framework, published in March 2023, recognised engineering biology as one of five critical technologies for the UK.[16] Following on from this, in December 2023, it published a white paper, the National

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12 Q 1 (Professor Paul Freemont)
13 *Ibid.*
14 EBRC, 'About Engineering Biology': https://roadmap.ebrc.org/2019-roadmap/overview/ [accessed 15 November 2024]
15 Written evidence from the Department for Science, Innovation and Technology (DSIT) (ENB0011). Their research suggests that, as of December 2023, there were 1,162 Engineering Biology firms in the UK, with 707 in applications, of which 576 were in the health and life sciences and 131 were in the non-health subsectors. There were also 726 firms involved in the supply chain, with 261 of these small-scale manufacturing and 160 producing biological materials and reagents. In the last decade, they recorded 50 "exits" from the UK private market, either via an acquisition or initial public offering.
16 Department for Science, Innovation and Technology, Policy paper, *The UK Science and Technology Framework* (9 February 2024): https://www.gov.uk/government/publications/uk-science-and-technology-framework/the-uk-science-and-technology-framework [accessed 5 October 2024]

Vision for Engineering Biology, setting out its policies towards engineering biology, including a high-level commitment to invest £2 billion over 10 years, and commitments in the areas of research and development (R&D), infrastructure, talent and skills, regulation and standards, engineering biology in the economy, and responsible and trustworthy innovation.[17]

18. DSIT has recognised the potential for engineering biology to contribute to growth, better public services, and a more sustainable economy. It told us, in written evidence submitted before the general election, that it "sees significant economic opportunities for the UK in health, agriculture and food, chemicals and materials and low carbon fuels" and that it has "the ambition of creating a thriving engineering biology ecosystem within the UK."[18] We heard oral evidence from Lord Vallance of Balham, the new Minister of State for Science, Research and Innovation, in October 2024. He told us that "we need to take engineering biology very seriously" and said that the National Vision was developed "following extensive consultation with industry and others. It seems like a very sensible thing to keep."[19]

19. Professor Dame Angela McLean, Government Chief Scientific Adviser, set out why engineering biology was "a great opportunity for us as a country" as an area of focus; it was "a platform technology … that sits underneath all sorts of different applications." She said that "we can use it to address some of the grand challenges like net zero, plastic pollution and health challenges—and there are fantastic growth opportunities". Furthermore, "we are good at it … we have good evidence about the ways in which we rank highly in engineering biology … by any international comparison."[20]

20. **Government witnesses told us that engineering biology has historically been an area of strength in UK research and development, and it is a potential driver of growth. The new Government has indicated that it still views it as a priority sector. However, as our report explores, other countries are beginning to overtake the UK and we are at severe risk of losing the prospective benefits of a world-leading engineering biology sector.**

17 Department for Science, Innovation and Technology, *National vision for engineering biology* (December 2023): https://assets.publishing.service.gov.uk/media/656de8030f12ef07a53e01ac/national_vision_for_engineering_biology.pdf [accessed 5 October 2024]
18 Written evidence from the Department for Science, Innovation and Technology (DSIT) (ENB0011)
19 Q 142 (Lord Vallance of Balham)
20 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 1 (Professor Dame Angela McLean)

CHAPTER 3: GOVERNMENT STRATEGY FOR ENGINEERING BIOLOGY

21. This chapter analyses the Government's existing strategy for engineering biology, and makes recommendations around the policy, industrial strategy cross-government capacity, research funding, and public procurement measures needed to make it a success.

Industrial strategy and DSIT's National Vision for Engineering Biology

Industrial Strategy

22. Witnesses supported the idea of engineering biology forming a part of the UK's industrial strategy. An industrial strategy brings together industry sectors with Government to develop a series of long-term Government policies and industry commitments intended to encourage the development or growth of part of the economy, particularly in manufacturing or areas of emerging technology. In early 2024, when most of our evidence was taken, the Government at the time did not have a formal industrial strategy, following a decision made in 2021 to end the previous one.[21] However, it did have white papers setting out strategies for research and technology development in individual sectors, such as the National Vision for Engineering Biology, and an overarching Science and Technology Framework for these critical sectors.[22] After the general election, the new Government has committed to publish an industrial strategy in Spring 2025 having published a Green Paper in October 2024.[23]

23. Graeme Cruickshank, Chief Technology & Innovation Officer, Centre for Process Innovation (CPI), said that: "Step one is to have an overt industrial strategy that we are proud of and declare. What industry needs is the surety that … we are on a course that we will maintain."[24] Dr Peter Williams, Group Technology Director, INEOS, emphasised the importance of long-term support, saying "it requires an industrial strategy", otherwise "we end up with one-liners, soundbites and so on, instead of a coherent thought process that leads to actions that last beyond one Parliament."[25]

24. There is a perception that the UK had a lead in this technology a decade ago, and had a coherent plan, but that this position is now in jeopardy. Professor Tom Ellis, Professor of Synthetic Genome Engineering, Imperial College London, told us:

21 Civil Service World (CSW), 'Industrial strategy to be scrapped, Sunak and Kwarteng confirm' (31 March 2021): https://www.civilserviceworld.com/professions/article/industrial-strategy-to-be-scrapped-sunak-and-kwarteng-confirm [accessed 1 November 2024]

22 Department for Science, Innovation and Technology, *Science and Technology Framework - taking a systems approach to UK science and technology* (March 2023): https://assets.publishing.service.gov.uk/media/6405955ed3bf7f25f5948f99/uk-science-technology-framework.pdf [accessed 5 October 2024]; Department for Science, Innovation and Technology, *National vision for engineering biology* (December 2023): https://assets.publishing.service.gov.uk/media/656de8030f12ef07a53e01ac/national_vision_for_engineering_biology.pdf [accessed 5 October 2024]

23 Department for Business and Trade, Closed consultation, *Invest 2035: the UK's modern industrial strategy* (updated 24 November 2024): https://www.gov.uk/government/consultations/invest-2035-the-uks-modern-industrial-strategy/invest-2035-the-uks-modern-industrial-strategy [accessed 1 November 2024]

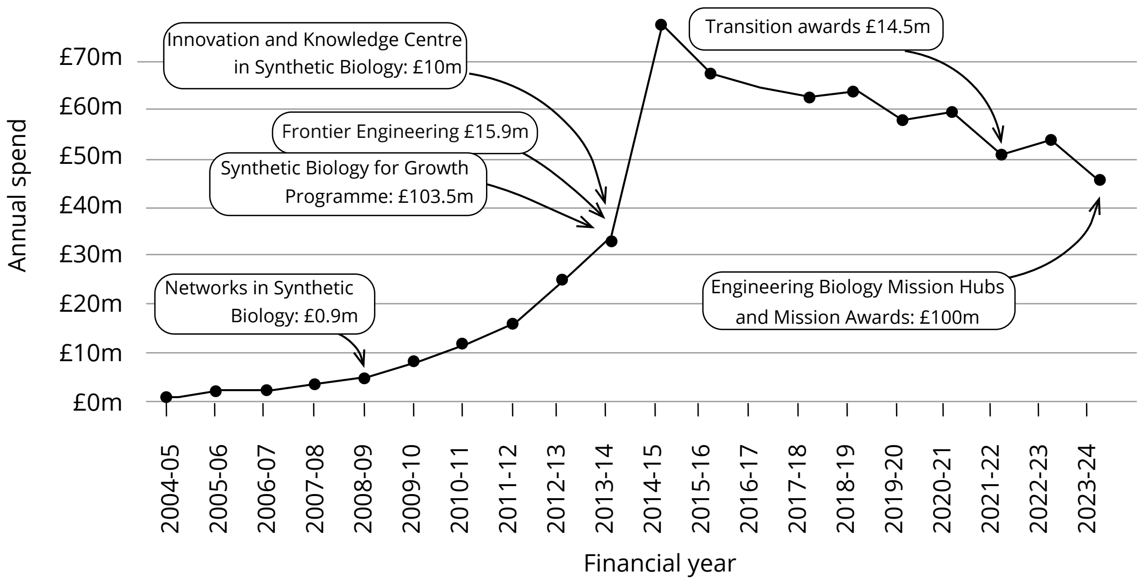
24 Q 96 (Graeme Cruickshank)

25 Q 108 (Dr Peter Williams)

> "In the UK we were the first country to have a national plan for—at the time—synthetic biology. That road map was 10 to 12 years ago … Since 2017 it has all become a bit fragmented … It was a lot more short-term and there was a lack of that initial plan being followed on. It would be great to be able to revisit that now and go back to that longer vision and longer funding for the next stage of investment in engineering biology."[26]

25. Professor Susan Rosser, Co-Director, Edinburgh Genome Foundry, agreed, saying: "We were ahead of the game, but we have lost that leadership", citing substantial investments in the US and Korea.[27] She stated that "We were given the last tranche of money for six centres of excellence. At the end of that term, we lost a lot of staff because the funding dropped off a cliff … we lost a lot of the people we had already trained to overseas." This inconsistency in funding delivered via UKRI can be seen in Figure 2.

Figure 2: UKRI's Engineering Biology Annual Spend, 2004–2023



Source: UKRI's written evidence (ENB0053). Note that this figure does not include the £170m announced alongside the National Vision for Engineering Biology which will be spent over the next few years, so illustrates the historical spending pattern up to 2023.

26. UKRI wrote that "Consistent feedback from industry suggests that certainty around long-term funding opportunities would allow businesses to begin planning activities."[28] More broadly, short-term fiscal decisions were criticised. Dr Charles Hall, Head of Research, Peel Hunt, said the five-year cycle for the OBR created "a whole load of tax rules that are purely based on that five-year cycle, rather than the 10 or 20 years that we will need for a lot of these projects to come to fruition." He added that projects that needed to be "put in place for a decade or more" required "a certain planning and regulatory environment."[29]

27. Witnesses said it was important that any strategy focused on specific outcomes. Professor Rosser framed the issue as needing to decide: "This is the problem we want to address using engineering biology. How are we going

26 Q 15 (Professor Tom Ellis)
27 Q 4 (Professor Susan Rosser)
28 Written evidence from UKRI (ENB0053)
29 Q 113 (Dr Charles Hall)

to do it?"[30] Professor Freemont criticised the "non-strategic" nature of past investments, saying that "we need much more focus … That is no way to deal with this technology."[31] The Carbon Technology Research Foundation argued for a "mission orientated investment model which targets end goals rather than specific niches."[32] Dr Peter Williams summarised the need for more strategic focus simply: "We need to decide what the UK wants to be."[33]

28. An industrial strategy that supports new technologies and industries, rather than existing sectors, must take their nature and needs into account. Dr Martin Turner, Associate Director, UK BioIndustry Association, argued that traditional subsidy rules—for example, historical rules that prevented Innovate UK from giving grants to loss-making companies—were "designed for non-innovative, more traditional industries, which can be really problematic for R&D-intensive, venture capital-backed, innovative industries."[34] This was echoed by the Minister, Lord Vallance of Balham, who said: "there is a risk with an industrial strategy that you simply support the current incumbents. One of our roles is to make sure that the emerging areas are properly understood and taken account of, because they may be the very high-growth areas of the future".[35]

29. Witnesses generally welcomed the National Vision for Engineering Biology. The UK Bioindustry Association said it was "received well by industry … it provides a strong signal of intent from government, showing the sector that it is a priority," although it called on the Government to "expand and uphold" its funding commitment and "deliver swiftly" on "regulation, innovation and finance" in the first five years of the vision.[36] Other witnesses described it as a "good starting point", "welcome" and "excellent."[37] However, some witnesses expressed reservations about a lack of targets and actions: Greg Archer, Director of European Policy, LanzaTech UK, thought that the vision was "very broad and rather ill defined. It lacks smart targets and many actions." He was sceptical of its ability to change anything.[38]

30. In October 2024, the Government published the first green paper for its industrial strategy.[39] While it did not explicitly mention engineering biology, Dr Isabel Webb, Deputy Director for Technology Strategy and Security, Department for Science, Innovation and Technology, told us it was "quite heartening to read that list of eight sectors in the industrial strategy. The majority of them … have really exciting applications" for engineering biology.[40] Lord Vallance argued that the industrial strategy gave a "clear line of sight in sectors".[41]

30 Q 7 (Professor Susan Rosser)
31 Q 7 (Professor Paul Freemont)
32 Written evidence from Carbon Technology Research Foundation (ENB0031)
33 Q 114 (Dr Peter Williams)
34 Q 35 (Dr Martin Turner)
35 Q 126 (Lord Vallance of Balham)
36 Written evidence from the UK Bioindustry Association (ENB0013)
37 Q 79 (Lord Willetts); Written evidence from Bristol BioDesign Institute, University of Bristol Supplementary written evidence (ENB0043) and Bit.bio (ENB0022),
38 Q 114 (Greg Archer)
39 UK Government, *Invest 2035: UK's modern industrial strategy* (October 2024): https://assets.publishing.service.gov.uk/media/6711176c386bf0964853d747/industrial-strategy-green-paper.pdf [accessed 20 October 2024]
40 Q 142 (Dr Isabel Webb)
41 Q 149 (Lord Vallance of Balham)

31. **We welcome the idea of an industrial strategy to provide long-term certainty and a plan for investment and policy instruments to achieve specific goals. Such a strategy needs to support innovative, emerging and cross-cutting sectors like engineering biology, not just established industries. Clear decisions must be made about the areas where the UK has significant strengths and potential for industrial and economic development and where it can realistically secure global advantage. Short-term policies, particularly fiscal decisions relating to investment, but also on priorities, have created uncertainty that makes it difficult for businesses to invest.**

32. **There is a perception in the sector that the UK was a leader in engineering biology ten years ago, but that inconsistent Government investment has allowed other countries to overtake the UK. A long-term strategy with clear commitment to engineering biology is key. The National Vision for Engineering Biology was broadly welcomed by the sector and covers many of the key areas that our inquiry identified as requiring policy action. However, the Vision is lacking in terms of specific outcomes.**

33. ***The Government's industrial strategy should set out a clear plan for developing engineering biology and other key technologies that can underpin industrial development across sectors. It should recommit to, and build on, the work from the Science and Technology Framework and National Vision for Engineering Biology, and set out how foundational technologies like engineering biology will be supported and pulled through into application across sectors.***

34. ***This will require coordinated action across a range of policy areas covered in this report, including:***

- ***public investment, including R&D, the roles of UKRI and the National Wealth Fund***
- ***public policy, including procurement***
- ***private investment to support scale-up***
- ***skills and visas***
- ***regulation and standards***
- ***infrastructure***
- ***incentives and mandates.***

35. ***The strategy should set out a clear direction of travel in these policy areas, identifying areas where the UK has a potential to excel, with more specific metrics and outcomes, and the Government should provide regular updates on progress towards these targets.***

National Vision for Engineering Biology: research funding

36. Recent years have seen significant global investment in engineering biology. One prominent example was an executive order from the Biden administration in the United States, which allocated funding and set out

the administration's priorities for engineering biology.[42] Stressing the need for urgent action, Professor Paul Freemont told us: "It is a race. It is very competitive. Since the Biden executive order and the Chinese five-year plan … plus, last week … the European Union announced a big initiative on biomanufacturing and biotechnology—it is a race."[43] Dr Mary Maxon, Executive Director, BioFutures, Schmidt Sciences, explained that in the US, alongside the biomanufacturing executive order, "there was an announcement of $2 billion"[44] made immediately available to the sector. Engineering biology in the US will also get a share of the $280 billion provided by the CHIPS and Science Act, which authorised funding to boost domestic research and semiconductor manufacture in the US.[45] China was estimated to have invested $3.8 billion in biotechnology R&D between 2008 and 2020.[46]

37. The headline funding commitment from the National Vision for Engineering Biology, issued under the previous Government, was to invest £2 billion of public funds in the sector over the next ten years.[47] Witnesses welcomed this commitment, but expressed some concerns about how firm and novel this commitment was, and what the money would be spent on. For example, Dr Martin Turner said:

> "We do not quite know how the £2 billion was arrived at, and it would be interesting if the Government could explain which departments they envisage allocating this money to and what they consider to be engineering biology. I would guess that £2 billion would not involve health engineering biology, because it would be a much bigger figure if it did." [48]

38. He argued that this compared unfavourably to spending in other priority areas: "quantum is getting £2.5 billion. AI does not have a 10-year funding programme as yet but has £500 million over the next two years, on top of an existing £300 million. We would like to see a more ambitious target for investment."[49]

39. There were also concerns around whether the commitment represented new funding, or just a continuation of historical levels of spending. The National Vision included an initial announcement of £73 million for Engineering Biology Missions Hubs and Awards but limited details about the £2 billion

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42 The White House, *Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy* (12 September 2022): https://www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-advancing-biotechnology-and-biomanufacturing-innovation-for-a-sustainable-safe-and-secure-american-bioeconomy/ [accessed 10 October 2024]
43 Q 3 (Professor Paul Freemont)
44 Q 115 (Dr Mary Maxon)
45 H.R.4346 - CHIPS and Science Act; American Society for Microbiology, 'How the CHIPS and Science Act Benefits Microbiology' (10 August 2022): https://asm.org/articles/policy/2022/aug2022/how-the-chips-and-science-act-benefits-microbiolog [accessed 5 October 2024]
46 The Chemical Engineer, 'UK government lays out national vision for engineering biology industry' (7 December 2023): https://www.thechemicalengineer.com/news/uk-government-lays-out-national-vision-for-engineering-biology-industry/ [accessed 5 October 2024]
47 Department for Science, Innovation and Technology, *National vision for engineering biology* (December 2023): https://assets.publishing.service.gov.uk/media/656de8030f12ef07a53e01ac/national_vision_for_engineering_biology.pdf [accessed 5 October 2024]
48 Q 40 (Dr Martin Turner)
49 *Ibid.*

headline figure.[50] Professor Rosser said: "If it is new money, that is fabulous. If it is rebadged money … we are back to square one."[51] DSIT told us (before the general election) that "The £2 billion commitment will be deployed by partners across government" and will "adapt spend over the decade".[52]

40. Before the general election, the Labour Party manifesto pledged to set 10-year R&D budgets for key institutions, with these institutions to be selected as part of its industrial strategy.[53] Witnesses set out many possible uses for longer-term, targeted funding. Dr Carolina Grandellis, Earlham Biofoundry Manager, Earlham Institute, thought "longer timescales" would allow her organisation to "retain talent and plan activities accordingly—a three- or four-year project" and that this would be an improvement over "irregular and short-term" funding calls.[54] The Autumn Budget 2024 set out record funding for research and development, but details on the allocations for DSIT, UKRI, and for ten-year R&D budgets for key institutions await the Spending Review.[55]

41. Professor Nick Talbot, Executive Director and Group Leader, The Sainsbury Laboratory, stressed the importance of "longer-term funding" for innovative areas like engineering biology which require "patient capital".[56] He told us:

> "Giving out the same amount of money in longer-term grants of five to eight years would be better than what is done currently, which is funding one to three years. Do a fund and filter model, where you fund but then stage gate against performance milestones. However, peer review and short-term funding are so deeply culturally embedded—not just in politics but in science, too—that it is quite difficult to move from one stage to another."[57]

42. Professor Rosser set out several possible areas of funding:

> "If we have new money, we need to do the doctoral training centres. We need the new infrastructure for start-ups and the scale-up stuff. We need new schemes. There used to be a scheme called the industrial biotechnology catalyst, which was a fantastic scheme. It was an Innovate UK scheme. It had different investments at different [Technology

50 Department for Science, Innovation and Technology, Press release: *Government publishes £2 billion vision for engineering biology to revolutionise medicine, food and environmental protection* on 5 December 2023: https://www.gov.uk/government/news/government-publishes-2-billion-vision-for-engineering-biology-to-revolutionise-medicine-food-and-environmental-protection [accessed 9 January 2025]

51 Q 5 (Professor Susan Rosser); Written evidence from the University of Edinburgh (ENB0037); See also Ian Shott's comments here, The Chemical Engineer, 'UK government lays out national vision for engineering biology industry': https://www.thechemicalengineer.com/news/uk-government-lays-out-national-vision-for-engineering-biology-industry/ [accessed 9 January 2025]

52 Written evidence from Department for Science and Technology (DSIT) (ENB0011)

53 Campaign for Science and Engineering (CaSE), 'Analysis of the 2024 Labour Party manifesto' (13 June 2024): https://www.sciencecampaign.org.uk/analysis-and-publications/detail/analysis-of-the-2024-labour-party-manifesto/ [accessed 5 October]; 'Labour pledge to 'relight fire of regions' with 10-year R&D budgets', *Independent* (20 June 2024) : https://www.independent.co.uk/news/uk/politics/angela-rayner-wiltshire-britain-conservatives-tories-b2566268.html [accessed 5 October 2024]

54 Q 5 (Dr Carolina Grandellis)

55 Campaign for Science and Engineering (CaSE), 'Analysis of the 2024 Labour Party manifesto' (13 June 2024): https://www.sciencecampaign.org.uk/analysis-and-publications/detail/analysis-of-the-2024-labour-party-manifesto/; Campaign for Science and Engineering (CaSE), 'CaSE responds to the 2024 Autumn Budget' (31 October 2024): https://www.sciencecampaign.org.uk/analysis-and-publications/detail/case-responds-to-the-2024-autumn-budget/ [all accessed 1 November 2024]

56 Q 88,Q 91 (Professor Nick Talbot)

57 Q 91 (Professor Nick Talbot)

Readiness Levels].[58] You could have a five-year project that was just academic. Then you could have a project with industry at the next level and the levels beyond that. That was enormously popular with industry and academia. If we had something like that catalyst programme for engineering biology, that would be a really good start."[59]

43. **The National Vision for Engineering Biology, issued under the previous Government, committed to £2 billion in public funding over the next ten years. At least this level of investment will be needed to compete with the scale of funding set out by rival nations and to maintain the UK's engineering biology R&D sector. However, it is uncertain whether the new Government is committed to this level of spending. There is also some uncertainty over whether this represents new money, or just a continuation of historic levels of investment from UKRI in engineering biology, and few concrete funding announcements have been made since the initial £2 billion commitment was made. The five-year funding cycle has proved detrimental for long-term research in this area.**

44. ***The Government should, as a matter of urgency, recommit to the target set out in the National Vision for at least £2 billion of funding over the next decade. It should set out more details of how it intends to allocate this funding between R&D, skills, and infrastructure, as well as which areas of engineering biology the UK has potential to excel at and desirable outcomes it wishes to achieve from the funding. Longer-term certainty around funding could form part of the new Government's commitment to provide ten-year R&D budgets to key research institutions.***

Skilled staffing for Government and DSIT

45. The Science and Technology Framework and the National Vision for Engineering Biology, shortly followed the creation of a standalone Department for Science, Innovation and Technology.[60]

46. Discussing experiences with the Civil Service based on his time with the vaccine taskforce, Dr Clive Dix, Executive Chair, C4X Discovery, said: "There are very few people from the STEM background there … we need people who almost mirror what is going on in the commercial world, who act on behalf of the Government but understand it too." He continued: "My recommendation for the next Government is to reinvent the Civil Service around business and have many more people with industrial experience and science experience … thought leaders in themselves, even though they are civil servants."[61]

47. Lord Willetts, Co-founder, SynBioVen, made a similar point, arguing that:

58 Technology Readiness Levels are a type of measurement system used to assess how mature and ready for deployment a particular technology is, from initial basic principles to full-scale operations. Nuclear Decommissioning Authority, News story, *Guidance on Technology Readiness Levels* (23 December 2014): https://www.gov.uk/government/news/guidance-on-technology-readiness-levels [accessed 1 November 2024]

59 Q 5 (Professor Susan Rosser)

60 Department for Science, Innovation and Technology, News story, *Science, innovation and technology takes top seat at Cabinet table* (10 February 2023): https://www.gov.uk/government/news/science-innovation-and-technology-takes-top-seat-at-cabinet-table [accessed 5 October 2024]

61 Q 79 (Dr Clive Dix)

> "There is increasingly a Civil Service career model where you move around: you do three years on one subject, then you move to a different department and do something completely different for three years. Process expertise is the only thing you then show."

He described the civil service as "wary of those decisions" requiring technical expertise. He thought that "sometimes the challenge is paying people sufficiently to keep them as experts."[62]

48. The Government acknowledged the importance of science expertise in the civil service, with Lord Vallance describing it as "essential". He said that "We are never going to compete with the private sector on salaries. Let us not pretend that we can. We can do better in some places than we are currently doing … we can, however, compete on purpose … There is a strong desire to do things that make a difference to society" while also noting that "the speed of recruitment" was crucial.[63] Dr Isabel Webb noted that "the engineering biology team has a third bioscience PhDs in it."[64]

49. **There is a need to embed individuals who understand the potential of this technology throughout the system—including regulators and procurement officials. The Department for Science, Innovation and Technology has a unique and important role to play in coordinating the development of key technological sectors such as AI and engineering biology. This will require specific scientific and industry expertise in the department and other relevant government bodies.**

50. ***DSIT, and the Government more widely, must be able to hire individuals with appropriate technical and industrial expertise, being flexible about pay scales and seconding from industry where necessary.***

Coordinating role of DSIT

51. Witnesses were clear that DSIT had a coordinating role to play across departments. The February 2024 Science and Technology Framework update emphasises this by assigning each of its different strands to different lead departments in Government, while the overall strategy is run by DSIT.[65]

52. Graeme Cruickshank told us about the importance of a team unifying responsibilities within the different departments of the Department for the Environment, Food, and Rural Affairs (Defra), the Department for Energy Security and Net Zero (DESNZ) and DSIT. He was "not entirely sure who to engage with, where and when."[66] On regulations, Professor Robin May, Chief Scientific Adviser, Food Standards Agency, thought that "we are increasingly seeing these things fall between different departments."[67]

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62 Q 83 (Lord Willetts)
63 Q 126 (Lord Vallance of Balham)
64 Q 126 (Dr Isabel Webb)
65 For example, the 'Talent and Skills' strand lists the Department for Education as its lead department, while 'Financing innovative science and technology companies' lists HM Treasury and 'Procurement' the Cabinet Office. Department for Science, Innovation and Technology, *Science and Technology Framework: update on progress* (February 2024)': https://assets.publishing.service.gov.uk/media/65c9f67714b83c000ea7169c/uk-science-technology-framework-update-on-progress.pdf [accessed 5 October 2024].
66 Q 97 (Graeme Cruickshank)
67 Q 69 (Professor Robin May)

53. Describing the efforts to deploy engineering biology solutions to reduce emissions, Greg Archer said there was not "joined-up government between DESNZ, the Department for Transport, and the Department for Business and Trade."[68] The Centre for Process Innovation told us in written evidence that a "cross-departmental initiative, including DESNZ, DSIT, DBT, Defra, MHCLG, GO-Science and HM Treasury, would maximise opportunities and minimise any 'unintended consequences' of individual policy actions that might adversely impact markets and technologies."[69] The UK Bioindustry Association told us that they welcomed "DSIT, DBT, GO-Science and DHSC who actively engage in the engineering biology agenda" but that they would "welcome more engagement from Defra and DESNZ, as the impact of engineering biology in their sectors could be significant."[70]

54. Lord Vallance told us that an aim in setting up the Science and Technology Framework was to achieve an "all-of-government approach". He pointed to the Procurement Act 2023 which gives the Cabinet Office and departments more procurement freedoms. He also discussed the establishment of the Government's Missions, as well as the Regulatory Innovation Office and the Cabinet Committee on Science and Technology as means of achieving that joined-up approach across departments.[71] For example, the Government's Growth Mission aims to secure the highest sustained growth in the G7, and policies including the industrial strategy have been linked to this mission.[72]

55. **DSIT cannot act alone to support engineering biology and must be supported by other departments with significant operational and procurement budgets in the areas that stand to be affected by engineering biology, or those that sponsor regulators. A renewed commitment and shared sense of ownership is needed across the whole of Government to implement the UK's science and technology policy, in line with the Growth Mission. We were pleased that the Minister acknowledged this and that the Government appears to be taking steps to embed a joined-up approach. This should be led by a national sector champion.**

56. ***The other departments implicated in the Science and Technology Framework, including departments with significant procurement budgets and the Treasury, should support engineering biology and the objectives of the Science and Technology Framework. Formal coordinating mechanisms, such as regular meetings at ministerial and senior staff level should be put in place.***

57. ***Cross-governmental working efforts should include the appointment of a national sector champion for engineering biology. This should be a recognised, high-profile figure from industry or academia who can exercise convening power and lead on delivering the sectoral strategy for engineering biology.***

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68 Q 113 (Greg Archer)

69 Written evidence from the CPI (ENB0027)

70 Written evidence from the UK Bioindustry Association (ENB0013)

71 Q 125 (Lord Vallance of Balham); the five Missions were originally set out in the Labour Party's Manifesto - Labour, 'Mission-driven government': https://labour.org.uk/change/mission-driven-government/ [accessed 1 November 2024]

72 Labour, 'Mission-driven government': https://labour.org.uk/change/mission-driven-government/ [accessed 1 November 2024] ; Department for Business and Trade, Closed consultation, *Invest 2035: the UK's modern industrial strategy* (last updated 24 November 2024): https://www.gov.uk/government/consultations/invest-2035-the-uks-modern-industrial-strategy [accessed 9 January 2025]

Public procurement policy

58. Public procurement has long been seen as a possible lever to support the development of innovative technologies.[73] Talking about the Government's National Vision for Engineering Biology, the Royal Academy of Engineering said that the objective most in need of development was the 'adoption in the wider economy' objective. They said "we would have liked to see greater attention paid to the role of government procurement", noting it accounted for a third of all public expenditure at £292 billion a year.[74]

59. Mark Bustard told us of public procurement schemes in the US:

> "the US Department of Agriculture … has something called the BioPreferred scheme, a procurement scheme that the US Government run for products that are predominantly bio-based; they preferentially procure … it gives companies an opportunity to invest in the production at scale because there is a better chance that it will be procured, and they will sell their goods." [75]

60. Dr Jim Ajioka alluded to the success of US defence procurement being linked to innovative technology agencies such as the US Defense Advanced Research Projects Agency (DARPA). He told us "You need DARPA. You need deep pockets where the money is coming from something where you can make a contract rather than just a straight-up grant … DARPA comes from the US Department of Defense, which has huge, huge cash reserves."[76]

61. Fiona Mischel told us that a government procurement of engineering biology products "would stabilise the supply, increase the demand and bring in economies of scale. It would also support further investment from venture capital". At present: "there is a lack of awareness and a lack of a pathway."[77] Lord Willetts told us that procurement opportunities existed in a range of departments: "Synthetic biology has so many applications. You can imagine DESNZ having some innovative contracts with synbio companies that will replace conventional carbon-producing energy sources even before they are fully operational."[78]

62. Both the previous and current Governments have acknowledged these opportunities. Public procurement to support innovation was one of the strands of action in the Science and Technology Framework.[79] Written evidence from DSIT (submitted before the general election) said that "Government sector teams will raise awareness of engineering biology across their sectors to ensure the pull through of products and services."[80] Lord Vallance told us that there were "too many examples of companies that have

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73 The previous Government's approach was discussed in Science and Technology Committee, *"Science and technology superpower": more than a slogan?* (1st Report, Session 2022–23, HL Paper 47), pp 42–43.

74 Written evidence from the Royal Academy of Engineering (ENB0047); Royal Academy of Engineering, *Green Paper: Transforming public procurement* (10 March 2021): https://raeng.org.uk/media/j5xfbl3o/raeng-procurement-consultation-response.pdf [accessed 20 October 2024]

75 Q 36 (Mark Bustard)

76 Q 30 (Dr Jim Ajioka)

77 Q 120 (Fiona Mischel)

78 Q 80 (Lord Willetts)

79 Department for Science, Innovation and Technology & Prime Minister's Office 10 Downing Street, Policy paper, *The UK Science and Technology Framework - taking a systems approach to UK science and technology* (March 2023): https://www.gov.uk/government/publications/uk-science-and-technology-framework/the-uk-science-and-technology-framework [accessed 10 October 2024]

80 Written evidence from the Department for Science, Innovation and Technology (DSIT) (ENB0011)

had a good start with an Innovate grant, have a little bit of venture funds from somewhere, get some sort of product or close to some sort of product, and then there is absolutely no procurement pull."[81] However, he said that "there has been progress on many of those areas. The Procurement Act due to come in next year will help. I have met with Minister Gould, the Minister for Procurement in the Cabinet Office, to try to make sure that that is fully tied into what we are trying to do."[82]

63. Lord Willetts noted that companies sometimes found it easier to sell their products to overseas governments rather than the UK Government because of UK procurement rules, which require products to be ready before being purchased. He told us that "We had some new legislation go through the House, but UK procurement rules still make it virtually impossible to pay for something in advance, for example."[83] This was in contrast to the US, where he said that companies might say "I've already sold my first 20,000 widgets to the DOD. I haven't made them yet, but I have a prototype and they like it". He said "That is pretty much contrary to UK procurement rules."[84]

64. Dr Mary Maxon told us that "the training of [government] procurement officers would need to focus on the procurement officers' ability to understand and access the products."[85] The Science and Technology Framework talked about the need for "a culture within policy and operational teams to … [support] innovation and critical technologies. This includes improved technical expertise … increased appetite for appropriate risk-taking and improved adoption of innovation."[86] It said the Cabinet Office was working on a "cross-government action plan with departments that have a significant procurement spend."

65. Professor Dame Angela McLean gave an example of procurement helping to develop technologies in the UK, saying that when she was Chief Scientific Adviser for the Ministry of Defence:

> "we bought a quantum computer … we bought a UK one, and a byproduct of that purchase was that it was an important sale for the quite small company that was making them".

She added that "a purchase is worth 10 times a grant."[87]

66. The Wellcome Sanger Institute explained that the world's largest DNA synthesis companies were predominantly based in the US or China, but that companies developing "next-generation synthesis methods are UK-based."[88] Dame Angela told us that "there are bits of the supply chain for engineering biology where we are very exposed to supplies from other countries. That ought to be addressed if we want to have a sovereign capability."[89]

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81 Q 150 (Lord Vallance of Balham)
82 Q 125 (Lord Vallance of Balham)
83 Q 80 (Lord Willetts)
84 *Ibid.*
85 Q 120 (Dr Mary Maxon)
86 Department for Science, Innovation and Technology, *The UK Science and Technology Framework: update on progress* (February 2024): https://assets.publishing.service.gov.uk/media/65c9f67714b83c000ea7169c/uk-science-technology-framework-update-on-progress.pdf [accessed 10 October 2024]
87 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 12 (Professor Dame Angela McLean)
88 Written evidence from Wellcome Sanger (ENB0021)
89 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 13 (Professor Dame Angela McLean)

67. Lord Willetts explained that risk tolerance was important: "If it ends up that companies cannot then deliver some of the contracts, that is not a political scandal; it is the risk you need to bear if you fund innovation."[90] Lord Vallance agreed, using the Vaccine Taskforce, set up to procure a coronavirus vaccine during the pandemic, as an example:

> "there was no need for a single change in regulatory rules or procurement rules in order to create a system whereby both regulation and procurement were pro-innovation but it required clear and unambiguous ministerial oversight … if the Vaccine Taskforce had failed, which was the most likely outcome at the beginning, it would have been slated as a waste of public money and a terrible thing for somebody to have done. That is the thing that drives conservative behaviours of not taking risks on the approach we take to investment and procurement."[91]

68. When pressed on how to overcome risk aversion, Lord Vallance said that "it is a matter of ministerial clarity on the risk profile that is acceptable, the Civil Service believing that, and the National Audit Office (NAO) and the Public Accounts Committee understanding that innovation inevitably comes with risk." He said that the NAO was open to using different processes, but acknowledged that "it is a massive behavioural change that is not easy to get right".[92]

69. **The Government's Science and Technology Framework set out ambitions to use public procurement to 'pull through' key technologies. This can be a very powerful tool—the example of the Department of Defense and DARPA in the US illustrates this. Public procurement could help bridge the scale-up funding gap by providing companies with contracts to produce novel or innovative products or services which then attract private investment. It can also help address the problems faced by departments in innovative ways and achieve the Government's wider aims in the public sector.**

70. **There are a range of different procurement opportunities involving engineering biology across Government. This could include supplying sustainable fuels, supporting waste valorisation, or novel methods for DNA synthesis. However, this is hindered by a culture of risk aversion, as well as procurement rules that prevent advanced purchase of technologies. Using public procurement to support innovative technologies will not succeed if departments do not view this as part of their remit. Ministers must provide the clear political support needed for a higher risk tolerance to empower officials to make these decisions.**

71. ***The Government should seek to support engineering biology in the UK through its public procurement. It should learn from the example of the US's BioPreferred programme. The Government should consider setting aside a mandatory percentage of procurement budgets which will be used to support innovative, UK-based SMEs and new technologies. These budgets could be subject to broader considerations for value-for-money than are currently used and subjected to alternative targets for auditing. This will encourage the***

90 Q 80 (Lord Willetts)
91 Q 150 (Lord Vallance of Balham)
92 Q 151 (Lord Vallance of Balham)

development of a healthier risk appetite: civil servants who work on procurement who are well-versed in the technologies that the Government wants to support and are empowered to authorise a range of potentially riskier but more rewarding contracts.

72. ***Departments should work with UK agencies like the Advanced Research and Invention Agency and Innovate UK to identify opportunities for procurement to support novel technologies and achieve the Government's wider policy aims, such as on sustainability. This should be done in line with the UK's broader industrial strategy. The Government should set out how the Cabinet Office's cross-government plan mentioned in the Science and Technology Framework will support innovative procurement practice across departments.***

CHAPTER 4: POLICY TO SUPPORT ENGINEERING BIOLOGY

73. This chapter sets out recommendations for areas of government policy including skills and visa policy, regulation, standards and R&D infrastructure that need to be addressed to lay the foundations for a successful engineering biology sector.

Skills for engineering biology

Training the next generation of researchers

74. In the UK, the main policy and funding lever for training new researchers in a particular area of science is via Doctoral Training Programmes. These are typically four-year funded PhD places in universities with the topic of research focused on a particular area identified by the funding body as strategically important.

75. Witnesses emphasised the importance of funding doctoral training places. Professor Susan Rosser said:

> "One of my key priorities would be to invest in doctoral training centres for the next generation of people … In the AI area, there has been investment in 12 doctoral training centres for PhD students. There has been one for engineering biology. We are losing trained people overseas. People from Edinburgh have moved to Singapore, the States, Germany and Austria … If this is genuinely going to be a key part of our economy, we need the skill set trained, and as soon as possible."[93]

76. According to UKRI's website, there are two Centres for Doctoral Training for engineering biology and biotechnology, compared to 12 new CDTs for AI announced in 2023, which will train 900 students over 8 years.[94] The earlier Synthetic Biology for Growth programme, which ran from 2014 to 2022, funded two centres for doctoral training in this area which trained around 140 postgraduate students. [95]

77. Other witnesses stressed the importance of PhD research including exposure to industry. Dr Lucia Marucci, Associate Professor in Systems and Synthetic Biology, University of Bristol, who is leading one of the new Doctoral Training Partnerships, said:

> "There is a shortage, and this is something industry told us as well … We have 26 industrial partners. They have a shortage of people who are trained in engineering biology—people who can write DNA, read DNA and understand what DNA does. They have a shortage of people who can design experiments, run experiments and analyse their data. To do that you need cross-disciplinary training. On the other hand, they

93 Q 5 (Professor Susan Rosser) A second engineering biology CDT was subsequently announced.

94 UKRI, 'Centres for Doctoral Training - EPSRC' (26 September 2024): https://www.ukri.org/what-we-do/developing-people-and-skills/epsrc/studentships/centres-for-doctoral-training/ [accessed 5 October 2024]; UKRI, 'How we work in artificial intelligence' (18 March 2024): https://www.ukri.org/who-we-are/our-vision-and-strategy/tomorrows-technologies/how-we-work-in-ai/ [accessed 5 October 2024].

95 UKRI, 'Synthetic Biology for Growth' (1 December 2023): https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/synthetic-biology-for-growth/ [accessed 5 October 2024]; UK Research and Innovation (UKRI), 'Independent report - Synthetic Biology for Growth programme economic impact evaluation' (3 October 2024): https://www.ukri.org/publications/synthetic-biology-for-growth-programme-economic-impact-evaluation/ [accessed 1 November 2024]

> also need people who can understand and write code to run a machine learning algorithm and know how to interpret what they get out of this.”[96]

78. Some witnesses told us that translating research into products and companies required academics to engage with commercial realities at an earlier stage. For example, Dr Marucci told us:

> “Lots of colleagues do not know much about what they should do if they want to translate something they do in their lab … into a product. They do not know much about regulations and [intellectual property]. Most importantly, it is about training early-career researchers, because in most cases they are the ones who have the time and the will to spin out something that they did during their studies.”[97]

79. Dr Sara Holland, Patent Attorney and Partner, Potter Clarkson, said there was “a shift in that people in academia are starting to think more about commercialising, but you can tell that they really do not understand anything”.[98] Although content with the fundamentals of the intellectual property (IP) legal framework, Dr Holland said that there was a problem of awareness amongst academics making the transition to the commercial sector: there was “a massive learning curve coming straight from a life of pipetting to learning about IP.”[99] Given the range of issues a founder would need to be informed about, “there is a role for somebody to do a lot more and consolidate” the information sources.[100]

80. Lord Willetts emphasised his view that doctoral training should include an industrial component:

> “it does not follow that the only career option if you get a doctorate is becoming an academic. Indeed, looking at the shape of the career pyramid, there is no way that people going through centres for doctoral training will all become academics … increasingly, the centres for doctoral training involve … business training … to prepare people not for going on to be a post-doc in academia but for going on to a job in business.”[101]

81. Dr Marucci said that the “translational aspects” of engineering biology were important: “If a student can think from day one about the possibility of translating his or her PhD project into a product, there is a greater chance that that will happen.”[102]

82. Other witnesses emphasised the importance of interdisciplinary training. Dr Marucci stressed that “it is key to allow that type of interdisciplinary training … it would also generate more basic science”[103]. Professor Ellis said that “Training is definitely the area where we really need to do the most work in the UK” but that this was hampered “at a structural UKRI level … engineering biology crosses exactly two research councils [EPSRC and BBSRC], and therefore who decides to make that big investment is very

96 Q 16 (Dr Lucia Marucci)
97 Q 12 (Dr Lucia Marucci)
98 *Ibid.*
99 Q 74 (Dr Sara Holland)
100 *Ibid.*
101 Q 75 (Lord Willetts)
102 Q 16 (Dr Lucia Marucci)
103 *Ibid.*

undecided."[104] Several witnesses mentioned the importance of people who knew about machine learning and biology who could apply their skills to engineering biology projects; for example, Rosemary Sinclair Dokos, SVP of Product and Programme Management, Oxford Nanopore Technologies, told us that "Mechanical engineering, algorithm development, machine learning, AI—all those skill sets are needed."[105]

83. **Maintaining the UK's academic and industrial position in engineering biology will require training the next generation of doctoral students. So far, only two Centres for Doctoral Training have been announced for engineering biology compared to many more for AI. The UK risks falling behind the training offered by other countries. There is also a need to encourage more research in interdisciplinary areas of science and technology, as well as at the interface between academia and industry. Doctoral training that includes a component of working in industry is crucial to strengthening the links between universities, start-up companies and larger companies as well as preparing researchers to commercialise UK engineering biology applications.**

84. ***The Government, through UKRI, should urgently commit to fund more doctoral training centres for engineering biology. Links between these programmes and industry must be strengthened: the majority of these places should provide a funded year in industry as part of the programme to give students either experience of working at cutting-edge engineering biology start-up companies or SMEs, or the opportunity to transfer their skills, knowledge, and ways of working into larger companies.***

Training for technicians and technical skills

85. Witnesses were clear that there was a need for a wider range of training options below PhD level. Professor Freemont told us that "we also need to focus more on the BTEC skills. If we are going to develop biomanufacturing as an industrial process, we will need trained people to run these machines. Those will not necessarily be at PhD level."[106]

86. Professor Ellis stressed the importance of training offers for engineering biology at an earlier stage of university: "better co-ordinated training before PhD because, although it is still a complex science to do engineering biology work at these start-up companies, they would like to employ people more at undergraduate and master's level to do a lot of that work."[107] Mark Bustard, Chief Executive Officer, Industrial Biotechnology Innovation Centre (IBioIC), told us of the success that IBioIC had in supporting "a master's degree with an industrial placement".[108]

87. He argued:

> "we really need to ramp up on the skills across the piece. With manufacturing, I am thinking about more technical and hands-on skills. We have seen a massive shortage in fermentation, bioprocessing and purification—very process-focused skills … we have trained over 260

104 Q 16 (Professor Tom Ellis)
105 Q 27 (Rosemary Sinclair Dokos)
106 Q 6 (Professor Paul Freemont)
107 Q 16 (Professor Tom Ellis)
108 Q 39 (Mark Bustard)

> people on fermentation and purification of bio-based processes. They all get hoovered up, and companies are still lacking access to the skills."[109]

88. Graeme Cruickshank told us of the CPI's role in providing training of these practical skills with its "Researchers in Residence programme … a significant cohort of early-stage researchers who come and embed with us for a period of time"; however, this initiative was constrained by a lack of funding.[110]

89. Witnesses emphasised the importance of apprenticeships as a route into engineering biology. Anecdotally, Professor Rosser told us:

> "At our foundry, we took on a modern apprentice. He had worked in Kentucky Fried Chicken. He came to work in our foundry. He did part-time training at a college and became an expert in running and fixing our robots. He saved us tens of thousands of pounds. He left us, sadly, because the robotic manufacturing company took him on to work full-time. We were devastated to lose him, but it is an amazing trajectory, from Kentucky Fried Chicken to a really highly skilled automation biologist. We want more of that."[111]

90. The Engineering Biology Interdisciplinary Research Centre at Cambridge told us that "many of the workflows we use … would be well suited to T-level, apprenticeships, or degree apprenticeships."[112]

91. Lord Willetts told us that "the other scale-up problem is technicians—people to operate the kit. It is wonderful that two CDTs are being funded in the latest round of announcements, but we need technical people who can operate the kit, with a City & Guilds recognised qualification in operating the equipment."[113] The UK Institute for Technical Skills and Strategy noted that "an aging workforce means that large numbers of skilled technicians are retiring", adding to the need for technical skills training. Employment insecurity, lack of pathways into the career, incorporating technicians into research grant budgeting, knowledge and skills retention, and concerns around career development were all raised in the Institute's written evidence as issues affecting technicians.[114]

92. Some of these issues have been acknowledged by the Government. Skills England is due to be fully established in 2025, and in its initial report noted the importance of the life sciences more broadly, as well as the difficulty in attracting talent for laboratory technicians.[115] DSIT's written evidence to us in April 2024 stated that "DSIT is working with the Department for Education (DfE) to support developing the pipeline of individuals studying

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109 *Ibid.*
110 Q 88 (Graeme Cruickshank)
111 Q 6 (Professor Susan Rosser)
112 Written evidence from Engineering Biology Interdisciplinary Research Centre, University of Cambridge (ENB0034)
113 Q 71 (Lord Willetts)
114 Written evidence from UK Institute for Technical Skills and Strategy (ENB0038), the role of technicians was also highlighted by Norwich Research Park (ENB0046), the University of Edinburgh (ENB0037) and the Carbon Technology Research Foundation (ENB0031).
115 Department for Education, *Skills England: Driving growth and widening opportunities* (September 2024) p 56: https://assets.publishing.service.gov.uk/media/66ffd4fce84ae1fd8592ee37/Skills_England_Report.pdf [accessed 2 November 2024]; Department for Education, Collection, *Skills England* (24 September 2024): https://www.gov.uk/government/collections/skills-england [accessed 2 November 2024]

and working in priority sectors, including those taking up apprenticeships", but did not provide any specifics.[116]

93. **There are significant gaps in training for gaining practical, industrial engineering biology skills that do not require a full PhD—for example, fermentation techniques in industrial biotechnology. Technical and technician skills are in short supply and industry witnesses told us that skilled individuals who acquire them are hard to retain. There is also a relative lack of individuals with industrial-scale fermentation skills and many of those that do have these skills are attracted into medical engineering biology fields where the profit margins can be greater and the industry is more mature.**

94. ***There is a need to expand the number of routes into the engineering biology sector, especially when it comes to developing technical and industrial experience. Skills England should work with industry, PSREs and universities to provide flexible funding for apprenticeships, including degree apprenticeships. This would provide more routes into the engineering biology sector and enable the training of the next generation of technicians. UKRI should support a Masters' level conversion course suitable for undergraduates to learn some of the practical, lab-based and industrial skills required for engineering biology and related techniques.***

Visa policy issues

95. Many witnesses raised concerns about whether the visa system for skilled immigration was fit for purpose. Dr Carolina Grandellis told us that "[people] in the specific skills and disciplines that we need, such as AI, machine learning and bioengineering [are] in very short supply" and recruiting people was described as "hard" and "already globally competitive". When she gave evidence in April 2024, she noted concerning policy trends at the time:

> "the Government intend to increase restrictions on legal skilled migration. That will have a cost for our field because … biofoundries require trained and experienced technicians. By adding these visa fees and immigration surcharging, we are adding an extra burden on people who want to come to the UK … some colleagues are not willing even to look into important opportunities in the UK because they consider it a hostile environment for immigration of international researchers."[117]

96. Professor Nick Talbot agreed, saying "it is now much harder to recruit leading scientists than it was five or ten years ago. You will be aware of the reasons … the visa regime and so on … but believe me, they are serious structural impediments".[118]

97. Rosemary Sinclair Dokos told us of a gap in the existing visa system for flexible work:

> "If we are missing skills, we may find those skills in Europe, for instance, and in roles that can be done remotely; people who could be consultants for us whilst happily living in their countries. Under current Brexit rules, they are allowed to come to the UK for only eight, maybe 12, working

116 Written evidence from Department of Science, Innovation and Technology (ENB0011)
117 Q 4 (Dr Carolina Grandellis)
118 Q 97 (Professor Nick Talbot)

days a year. We are fine for people who want to relocate and move here, but for people who want to do hybrid working it is a bit difficult."[119]

98. This sentiment was echoed by witnesses from industry. Dr Jim Ajioka, Chief Scientific Officer, Colorifix, said "We face similar employment issues because we work in India and Portugal and we have visa issues all the time, which slows us down. Trying to get people from one place to another is not always easy."[120] Industry witnesses Dr Ajioka, Will Milligan, Chief Executive Officer, Extracellular, and Rosemary Sinclair Dokos were asked for suggestions to improve skilled person immigration to the UK, and they respectively told us: "Speed up visas"; "Lowering the salary threshold for people coming to the [UK]"; and "hybrid working rules".[121]

99. Fiona Mischel, Director of International Outreach, SynBioBeta, told us that "the paths for talent to remain in the United Kingdom are narrowing dramatically." She said that this was about "retaining talent we have trained … if we do not retain that talent, the United States … will pay a lot of money for it." She further told us that "Singapore is another really good example: it has visas for folks to come in for industry … right now, a lot of our visas in this sector are academic-focused."[122] From the US perspective, Dr Mary Maxon told us: "There have long been conversations in the United States around whether we should perhaps staple a green card to every PhD that is granted in the US."[123] The Engineering Biology Interdisciplinary Research Centre, University of Cambridge, told us that "Recruitment in this area of science is already globally competitive and the UK offers non-competitive salaries for academics."[124]

100. In written evidence, bit.bio commented on proposed changes to Skilled Worker Visas, which the Government implemented in March 2024.[125] Bit.bio said that these changes would include raising the salary threshold "from £26,200 to £38,700, making it near impossible for organisations such as bit.bio to hire for certain key roles."[126] This threshold would be above the 76th percentile for salaries in the UK in 2021/22, and excludes a greater fraction of workers outside London; it also exceeds the salary for many postdoctoral researchers.[127] Evidence from Norwich Research Park and the Wellcome Sanger Institute raised the upfront nature of the Immigration Health Surcharge (a cost which immigrants must pay for UK healthcare), as well as high visa fees, as a barrier.[128]

101. This Committee wrote to a previous Home Secretary in 2023 asking for the number of sponsors for routes like the Global Talent visa to be increased, and questioning the principle whereby the "user pays" for the immigration

119 Q 22 (Rosemary Sinclair Dokos)
120 Q 22 (Dr Jim Ajioka)
121 Q 28 (Dr Jim Ajioka, Will Milligan, Rosemary Sinclair Dokos)
122 Q 118 (Fiona Mischel)
123 Q 118 (Dr Mary Maxon)
124 Written evidence from Engineering Biology Interdisciplinary Research Centre, University of Cambridge (ENB0034)
125 House of Commons Library, Changes to legal migration rules for family and work visas in 2024,Research Briefing CBP 9920, May 2024
126 Written evidence from bit.bio (ENB0022); Gov.uk, 'Skilled Worker visa': https://www.gov.uk/skilled-worker-visa/your-job [accessed 15 November 2024]
127 Indeed, 'Q&A: How much does a postdoc make and what do they do?' (16 August 2024): https://uk.indeed.com/career-advice/pay-salary/how-much-does-postdoc-make [accessed 5 October 2024]
128 Written submission from Wellcome Sanger Institute (ENB0021) and the Norwich Research Park (ENB0046)

and borders system in the context of a global race for talent.[129] Witnesses in our "people and skills" inquiry raised concerns around the high upfront cost of visas in 2022, even before recent changes.[130] Our letter asked whether it would be possible, if the Immigration Health Surcharge is retained, for it to be paid in instalments, but were told this would represent an unacceptable administrative burden.[131]

102. Lord Vallance told us that some visa costs can now be met "on Horizon and UKRI grants" and that the Global Talent visa numbers increased from "7,000 in 2023 to 8,000 in 2024." He said that he had "been very clear that this is an important thing to get right" in discussions with the Home Office and Migration Advisory Committee."[132]

103. **In engineering biology, as in many other areas of science, the UK is in a global competition for talent. However, restrictive visa policies, high visa fees, upfront Immigration Health Surcharge costs, and a perceived hostile attitude to immigration, are jeopardising the UK's ability to attract and retain the best talent. The UK already suffers due to lower salaries and higher cost of living than many competitor nations, such as the US and in Europe. The UK still has universities with world-leading research that attract skilled individuals, but it must do more to retain them. There are deep concerns that recent immigration reforms will deter talent and harm growing industries such as engineering biology.**

104. ***The UK must rethink its attitude to immigration for skilled workers in scientific and technical sectors, as we are falling behind in the global race for talent. The Global Talent Visa should be expanded from a few thousand issued a year, with more routes for organisations to sponsor this visa beyond the relatively small number of primarily academic organisations who are currently listed as sponsors. Specifically, it should support applicants with entrepreneurial, manufacturing and industrial skills as well as scientific ones. Additional visa routes that allow for flexible hybrid working should be considered, as other countries have put in place.***

105. ***More must be done to reduce up front visa costs and resettlement costs for top talent in competitive scientific and technical fields. If the Immigration Health Surcharge is retained, the burden of payment must be reduced by allowing individuals to pay on an annual basis***

129 Letter from Baroness Brown of Cambridge, Chair of House of Lords Science and Technology Committee to Rt Hon Suella Braverman KC MP, then Secretary of State for the Home Office: https://committees.parliament.uk/publications/40341/documents/196983/default/. At present, only a limited number of organisations such as the National Academies or Tech Nation can provide an endorsement for a Global Talent visa. The number of people supported to arrive via Tech Nation, assessed as having skills in business or AI/machine learning for example, was just over 5,000 over ten years. Tech Nation, 'Tech Nation Global Talent Visa Report 2024: 10 Years of Global Talent in UK Tech' (6 February 2024): https://technation.io/global-talent-visa-report-2024/ [accessed 10 October 2024]

130 Science and Technology Committee, 'People and skills in UK science, technology, engineering and mathematics': https://committees.parliament.uk/work/6838/people-and-skills-in-uk-science-technology-engineering-and-mathematics/

131 Letter from Rt Hon Suella Braverman KC MP, Home Secretary, Home Office to Baroness Brown of Cambridge, Chair of House of Lords Science and Technology Committee, ref visa policy for STEM talent https:// committees.parliament.uk/publications/41353/documents/203230/default/

132 Q 147 (Lord Vallance of Balham); UKRI sets out its approach to covering some visa costs here. UKRI, 'Other costs' (12 February 2024): https://www.ukri.org/councils/stfc/guidance-for-applicants/costs-we-fund/other-costs/ [accessed 10 October 2024]

or a monthly basis by deduction from salary, rather than paying the full cost up-front. The Government should benchmark postdoctoral salaries against comparative salaries in Europe. Action must be taken urgently to ensure the UK remains an attractive destination for increasingly mobile global talent.

Regulation and standards

Engineering Biology Regulators' Network and Regulatory Innovation Office

106. When asked what the Government could do to stop engineering biology companies leaving the UK, Will Milligan said "it is line of sight in getting these products approved and on the market. The Food Standards Agency (FSA) is the main regulator they would have to interact with. It is underfunded and has quite a high backlog post Brexit that it has to process." He compared this unfavourably to other countries: "Singapore, on the other hand, has a very clear framework for the approval process in bringing products to market, and the recommended timelines are about half what they are in the UK."[133] He compared the UK's approach "in the innovative food space" unfavourably to the "two leading markets" of the US and Singapore which had a more "streamlined and efficient" regulatory process with a "better line of sight", drawing investment and custom.[134]

107. The Government set up the Engineering Biology Regulators' Network after the Pro-innovation Regulation of Technologies Review for the Life Sciences undertaken by Professor Dame Angela McLean. In her report, published in May 2023, she said that the landscape for engineering biology regulators was complicated and companies needed help to navigate it. She recommended that:

> "The government should commission and resource the creation of an Engineering Biology Regulatory Network (EBRN), utilising the expertise within existing regulators. The EBRN should enable collaboration and sharing of capacity between regulators and should provide clarity and support to the companies who navigate the existing regulatory landscape … We recommend the EBRN creates a coherent taxonomy to classify which products fall under which regulator's remit and a roadmap to outline the relevant regulatory pathways, with clear starting points and timelines."[135]

108. The previous Government accepted these recommendations in its response, saying that: "Stakeholders inform us that a lack of join-up between regulators creates uncertainty for innovators, consumers and investors."[136] It further committed in the Science and Technology Framework update to implement these recommendations "over the next 12 months", and to develop "a regulatory support service specifically designed to help science

133 Q 23 (Will Milligan)
134 *Ibid.*
135 HM Government, *Pro-innovation Regulation of Technologies Review:- Life Sciences* (May 2023) : https://assets.publishing.service.gov.uk/media/64706d21c38c55000c342bd5/Life_sciences_report_-_Pro-innovation_Regulation_of_Technologies.pdf [accessed 5 October 2024]
136 HM Government, *HM Government Response to Professor Dame Angela McClean's Pro-Innovation Regulation of Technologies Review - Life Sciences* (May 2023): https://assets.publishing.service.gov.uk/media/64706d2e4a892b0013746bbd/HMG_response_to_McLean_life_sciences_review.pdf [accessed 5 October 2024]

and technology companies navigate rules and regulations."[137] The Network was set up prior to the publication of the Vision in December 2023.

109. Dr Martin Turner told us that the network was "really welcome", but noted "we do not know which regulators they are, but the initiative is welcome; we just need a bit more information and transparency about it."[138]

110. Professor Robin May told us:

> "The Engineering Biology Regulators' Network is very new. It has met four times … Thus far, that network has been very good in terms of people sharing early information and their approach. What we do not quite have yet from them is a single unifying document that sets out the different regulatory landscape for the UK. In the fullness of time, it would be really good if the department were able to create something that clearly demonstrated where these different responsibilities fall."[139]

111. On 8 October 2024, the Government announced the creation of the Regulatory Innovation Office (RIO), which it said would "support regulators to update regulation, speeding up approvals, and ensuring different regulatory bodies work together smoothly."[140] It was announced that engineering biology would be one of four key initial areas of focus for the Office. Lord Vallance told us: "The Regulatory Innovation Office is designed to … ask, with a sharp focus, what things are preventing this emerging area from progressing, which regulators we need to bring on board, upskill, link with others, and enable with sandboxes, and how we can make sure that they have the appropriate ability to attract the rights skills into them."[141]

112. Professor Dame Angela McLean said that the "RIO is there to improve the existing regulatory ecosystems … it has asked the Regulatory Horizons Council to give it suggestions."[142] She also described the approach of trialling some light-touch regulation programmes where businesses can test out new ideas in coordination with a regulator ('regulatory sandboxes') and discussed the recent establishment of a sandbox with the Food Standards Agency which will start in February 2025.[143] On the Engineering Biology Regulators' Network, she said that "there will be an announcement of who [the regulators] are" but that "even I do not know." Dame Angela was unsure whether the EBRN would publish the taxonomy or roadmap to regulation that she had recommended in her pro-innovation review of the life sciences,[144]

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137 Department for Science, Innovation and Technology, *Science and Technology Framework: Update on progress* (9 February 2024)', p 59–64. Regulation and standards: https://assets.publishing.service.gov.uk/media/65c9f67714b83c000ea7169c/uk-science-technology-framework-update-on-progress.pdf [accessed 5 October 2024]

138 Q 38 (Dr Martin Turner)

139 Q 62 (Professor Robin May)

140 Department for Science, Innovation and Technology, Press release: *Game-changing tech to reach the public faster as dedicated new unit launched to curb tape* on 8 October 2024: https://www.gov.uk/government/news/game-changing-tech-to-reach-the-public-faster-as-dedicated-new-unit-launched-to-curb-red-tape [accessed 10 October 2024]

141 Q 145 (Lord Vallance of Balham)

142 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 7 (Professor Dame Angela McLean)

143 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 8 (Professor Dame Angela McLean)

144 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 9 (Professor Dame Angela McLean)

but expressed confidence that engineering biology would continue to be a priority.[145]

113. **We welcome the establishment of the Engineering Biology Regulators' Network (EBRN) and the Regulatory Innovation Office (RIO), which are good first steps in creating a coherent, pragmatic, pro-innovation regulatory regime for engineering biology. However, regulatory pathways for new engineering biology products and technologies remain unclear. In such a fast-moving sector, early coordination between industry and regulators is crucial, but those we spoke to in the industry did not know which regulators were included in the EBRN initiative. The EBRN has not yet fulfilled the goals that were set in Dame Angela McLean's recommendations and has no public-facing offer to companies yet. With the creation of the RIO, the ongoing status of the EBRN is now unclear.**

114. ***The EBRN and RIO should be sufficiently resourced to have a public-facing offer that maps out which categories of engineering biology products map onto which regulators and sets out a streamlined regulatory pathway. The "coherent taxonomy" and roadmap to regulatory approval recommended by Dame Angela McLean should be published, and the Government should set out a clear timeline for this in its response. There should be a single resource or point of contact published by these bodies for companies in the sector seeking to understand the regulatory implications of any products or services they might develop. The "regulatory support service" for small science and technology companies mentioned in DSIT's Science and Technology Framework should be pursued and could provide this interface.***

115. ***The membership and activity of the Engineering Biology Regulators' Network should be made public as a necessary first step. There should be clear individuals or teams responsible for coordinating with the network within each regulator.***

Resourcing and expertise for regulators

116. Engineering biology will sometimes require regulators to approve entirely new classes of product. Will Milligan told us that "many regulators around the world are strapped for resources and capabilities, and some are looking at harmonisation more quickly … looking at approved products in other geographies and adopting them, or adopting the approval process of other regulators, to streamline their approval processes."[146] He further commented that for novel foods, regulation:

> "is a rigorous scientific process, as it should be, but sufficient resources are needed in order to be able to review these products as they come through approval, to engage with the companies for any additional questions … in a timely manner and, ultimately, to progress these to approval."[147]

145 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 10 (Professor Dame Angela McLean)

146 Q 25 (Will Milligan)

147 *Ibid.*

117. Dr Martin Turner told us that "the regulators need resourcing, money, and upskilling … it is very difficult to stay ahead of the game in these areas." [148]

118. Professor Robin May set out some of the challenges facing regulators in engineering biology: "access to scientifically skilled experts is absolutely critical", but "many organisations, including our own, need a steady supply" of experts, "as does industry". Consequently, "competing in the market" for experts was described as "a real challenge."[149] He also said that there is "a challenge around international collaboration … it is really important to be visible in that international community, but that is quite tricky if you are in a regulatory area where some things are confidential." Professor May also described the FSA as struggling with handling the volume of complex data produced by the industry. He thought that for "a really good data analyst, that is a very exciting project, but there are also lots of exciting projects in industry where … you can earn a lot more than you can in government."[150]

119. She told us "I do not know if the regulators are fully aware of what engineering biology can and will be able to do."[151] The UK Bioindustry Association told us that regulators need to "have a pro-innovation mindset and to be resourced appropriately, both in terms of funding and knowledge, to be able to horizon scan and deliver effective regulation."[152]

120. Dr Charles Hall described the importance of embedding expertise in regulators: "We see the best regulation when practitioners are brought in from industry who have real-life experience … If there was one thing I would change, it would be to make every regulator bring experts on secondment so that they understood how running a business worked." He noted that otherwise "you have to educate yourself in the industry you are trying to regulate before you even regulate, which is partly why [regulation] took so long."[153]

121. Professor Dame Angela McLean explained that "regulation that can be clear, proportionate, and as speedy as possible but not hasty is a driver for innovation and, in fact, can bring people to our shores … we have the intellectual hinterland in our fantastic science and technology to [be] the world-leading place to come and get your first approvals". However, she noted that because "much more of our very high-tech is happening in tiny companies", they find it harder to engage with standards bodies, which is important in learning good practice and shaping international regulations.[154]

122. **If the UK is to become a leading nation in engineering biology, it needs world-leading regulators that can anticipate areas where regulatory clarity is needed, and set out a very clear regulatory path to market for new technologies with swift timelines for assessment and approval. Engineering biology is a rapidly moving scientific field with implications for a range of different regulators, which will need to be capable of understanding and managing emerging risks. They will require the necessary scientific skills and industrial experience**

148 Q 38 (Dr Martin Turner)
149 Q 66 (Professor Robin May)
150 *Ibid.*
151 Q 77 (Dr Sara Holland)
152 Written evidence from the UK Bioindustry Association (ENB0013)
153 Q 111 (Dr Charles Hall)
154 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 11 (Professor Dame Angela McLean)

to craft regulatory frameworks that achieve the goals in the National Vision for Engineering Biology and enable the field to move forward at pace in the UK.

123. ***The UK needs to develop a world-class regulatory approach for engineering biology, characterised by being swift, effective, and involving leading experts. Regulators need to be appropriately resourced to work with businesses to assess new technologies early and mitigate any unintended consequences from their use. They must be able to bring in the relevant expertise to regulate the sector appropriately, proactively, and swiftly, with timelines that are competitive with other nations.***

Genetic Technology (Precision Breeding) Act 2023

124. The Genetic Technology (Precision Breeding) Act 2023 was intended to regulate (and therefore permit) precision breeding technologies, in which techniques such as gene editing can produce beneficial traits in crops and animals, in a proportionate way.[155] Witnesses expressed concern though that regulations which could be made under the Act had been slow to emerge. Dr Carolina Grandellis, manager at the Earlham Biofoundry, welcomed the Act due to its potential to allow the development of sustainable agricultural solutions but was concerned over delays to the secondary legislation. Speaking before the general election, she warned that, if the legislation was not in place before the election, "it will block industrial investment in agritech solutions and food production innovations that are using our engineering biology."[156]

125. **Some of the secondary legislation which was expected to be made under the Genetic Technology (Precision Breeding) Act 2023 was not made in the last Parliament but was seen as necessary to help create regulations that would allow for experimentation in plant breeding to take place in the UK.**

126. ***The secondary legislation for the Genetic Technology (Precision Breeding) Act 2023 should be passed urgently to establish a regulatory framework that provides certainty, in accordance with the Act's provisions.***

Standards for engineering biology

127. Professor Paul Freemont stressed the importance of standards. He said:

> "Standards and regulations are both interlinked … You would be horrified to know that in biotechnology, a multibillion-dollar industry, we have 36 ISO standards. That is slightly problematic, given that, if you are in the aviation industry or any other industry, there are thousands of standards. We have some significant work to do in looking into that."[157]

128. Dr Lucia Marucci thought that standardisation was important for data analysis and sharing, saying that:

155 Department for Environment Food and Rural Affairs, *Genetic Technology (Precision Breeding) Bill* (May 2022): https://publications.parliament.uk/pa/bills/cbill/58-03/0011/FactsheetGenetic.pdf [accessed 2 November 2024]
156 Q 2 (Dr Carolina Grandellis)
157 Q 7 (Professor Paul Freemont)

> "In synthetic and engineering biology, there is still a barrier to getting high-throughput data that is collected following standards, as in any other engineering discipline … I think it is important to lower the barrier to make data acquisition easier, faster and cheaper … it is important to make platforms for data acquisition, data analysis, integration and automation more accessible to wider communities. That is really important for speeding up progress, and it allows this transition from synthetic bio into an engineering discipline."[158]

129. Dr Michael Adeogun, Head of Strategy (Life Sciences and Health), National Physical Laboratory (NPL), explained the role that the NPL played in developing standards:

> "NPL is an asset base of facilities, skills and knowledge that provides the means to ensure that measurements and standards are internationally comparable and consistent across all market sectors … measurements and standards are the invisible currency that underpin trade and regulatory systems, but also help accelerate innovation and adoption of new technologies such as engineering biology."[159]

130. He set out different types of standards, and agreed that an overall lack of standards was a "challenge",[160] explaining that:

> "biological systems, in themselves, are inherently complex … all these factors make it difficult to reproduce activities at a larger scale … We are looking to create new multimodal, multiscale, interoperable measurement techniques and, therefore, the standards alongside them to look at the whole of the system, but it is still, in some respects, early days as we move forward … If you cannot reproduce something, that is problematic." [161]

131. Lord Vallance told us that the Biotechnology and Biological Sciences Research Council (BBSRC) has "funded standards and metrology" but accepted that this is "quite a difficult area" because "defining the product" is difficult in engineering biology compared to traditional chemical industries.[162] The National Physical Laboratory published some recommendations from a workshop it held in December 2024 as part of its work on standards for engineering biology.[163]

132. **A set of coherent standards are necessary for any industry to scale-up. They can allow for more interoperable and less disjointed processes between companies, as well as to promote consumer and industrial confidence. A lack of a coherent set of standards in engineering biology is holding back the emerging sector, where the inherent variability of biological processes makes standards particularly important. There is an opportunity for the UK to be a leader in standard-setting and ensure that the standards are compatible with the UK's strengths.**

158 Q 10 (Dr Lucia Marucci)
159 Q 60 (Dr Michael Adeogun)
160 Q 63 (Dr Michael Adeogun)
161 Q 64 (Dr Michael Adeogun)
162 Q 144, Q 146 (Lord Vallance of Balham)
163 National Physical Laboratory (NPL), *Standards and metrics for Engineering Biology in the UK: Driving, growth, investment and Engineering powered solutions for UK companies* (December 2024): https://www.npl.co.uk/getattachment/research/biometrology/metrology-for-engineering-biology/resources/Standard-and-metrics-for-Engineering-Biology-in-the-UK.pdf.aspx?lang=en-GB [accessed 3 December 2024]

133. ***The Government should work with the National Physical Laboratory, the British Standards Institution, industry partners, national laboratories like the Centre for Process Innovation and ISO organisations to assist in the development of standards across the engineering biology industry. Data-sharing should be encouraged between different companies to enable standardisation of processes and products. Schemes that encourage and support start-up companies and SMEs to access national laboratories could assist in this data-sharing.***

134. **Many countries are currently seeking to regulate engineering biology and international standards and regulations will be important for trade. Sending high-level delegations to ISO meetings is important to maintain the UK's influence.**

135. ***The UK should engage at the most senior, expert level with EU and international standards—through organisations like the International Organization for Standardization (ISO)—to ensure that the UK can influence these and are not disadvantaged by international standards and regulations.***

Pilot-scale infrastructure

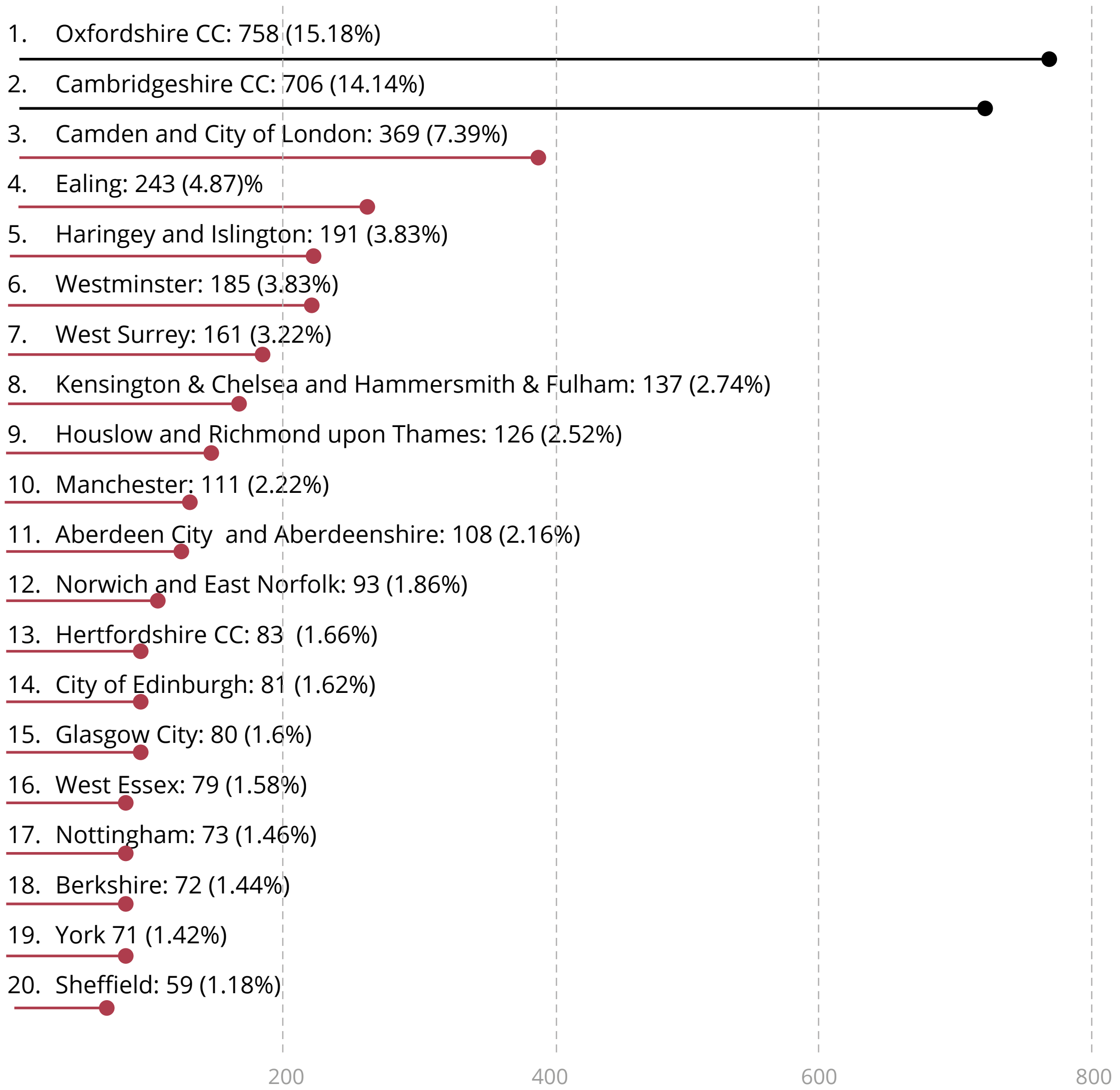
Access to facilities for generating data; intellectual property

136. Engineering biology organisations need capital-intensive specialist facilities in which to carry out their work. Will Milligan, CEO of Extracellular, argued that, particularly for early-stage start-up companies, government facilities were useful. Such start-ups needed "a huge amount of capex[164] and quite simply do not have the time or resources to be able to build them. First-of-a-kind facilities are exactly where government resources should be. Where they span multiple products is where they would be most cost effective."[165] Paul Freemont agreed that early-stage pilot-scale facilities were important areas for Government to fund, saying "I do not think that venture capitalists will fund large capex investments in the pilot-scale infrastructure that we need."[166]

137. Related to this, Dr Sara Holland, patent attorney and Partner at Potter Clarkson, told us that intellectual property (IP) law was also a central consideration for commercial engineering biology ventures: "it is the core of their business … if people are going to buy [a start-up] it will be for [its] patents, [its] trade secrets and [its] IP."[167] Asked whether IP law and the relevant regulators were able to keep up with developments in the engineering biology sector, Dr Holland was confident that IP law could keep pace, as "patent officers see what people are filing."[168]

164 'Capex' refers to capital expenditure
165 Q 26 (Will Milligan)
166 Q 4 (Professor Paul Freemont); Written evidence from Good Food Institute Europe (ENB0005) stated that for the sector "Dependence on venture capital raises significant questions, as it is not a suitable instrument for making long-term capital investments in commercial-scale equipment and infrastructure."
167 Q 76 (Dr Sara Holland)
168 Q 77 (Dr Sara Holland)

Figure 3: Patent applications in engineering biology by region of the UK (Top 20 ITL3 regions (2004–2023))



Source: Supplementary written evidence from Dr Sara Holland (ENB0055).

138. However, obtaining this intellectual property requires access to facilities. Dr Holland explained to us that:

> "a key challenge in biotech and life sciences more generally is that you need data to get a patent. In engineering, if you come up with a new widget you can just draw a picture of it … You do not need to spend lots of money renting out lab space. Biotech is very different because biology is unpredictable. Patent examiners want to see the data. The first hurdle for a lot of the companies I work with is getting that proof-of-concept data. There is this awful chicken-and-egg … you need the data to get a patent, but you need the money to get the data, and you cannot get the money because investors are increasingly pushing to get a patent … A lot of the companies I work with are doing quite well on Innovate [UK] funding … that is how they are getting this proof of concept. It

takes ages. It would be great if they could just pop into a lab and do their work."[169]

139. **Biological processes are inherently more variable than chemical or industrial processes. It is therefore crucial to be able to test these processes and demonstrate that they can be replicated reliably at scale. This need to obtain large amounts of data on a process is a key barrier to defining and protecting intellectual property, and hence to securing investment. Start-up companies face a 'chicken and egg' problem whereby they need data to obtain patents to get access to funding, but they need the funding to access the labs in order to generate the data. A few companies have been able to invest and build laboratories and infrastructure themselves, but this type of development is difficult to fund from venture capital and other private sector investors. There is a clear need to ensure existing facilities are easier to access.**

140. **We heard no evidence that suggested UK intellectual property law was not fit for purpose, but that barriers to obtaining patents in practice needed to be addressed.**

141. ***The Government should work with public sector research establishments and universities to make national and university laboratories accessible for the purpose of assembling the data required for start-up and spin-out companies to file patents. Innovate UK should consider providing additional funding to help small and early stage companies obtain the data needed for patents which can unlock additional private sector funding. National laboratories, public sector research establishments and related research infrastructure should add the number of patent applications they have supported to their key performance indicators.***

Funding and mapping existing infrastructure

142. To turn an engineering biology product or process from an idea to a commercial reality requires several stages of research infrastructure. Initially, university and research laboratories allow scientists to develop new processes. Pilot-scale infrastructure allows them to demonstrate that this process can be repeatable and viable at a certain scale and apply for funding and patents. Scale-up infrastructure allows the researchers to demonstrate that the process or product can be produced at a commercial scale and characterise commercial-scale production. Ultimately, manufacturing infrastructure will either be constructed specifically for the new product or process, or it may use existing manufacturing capacity such as in contract development and manufacturing organisations (CDMOs).

Biofoundries

143. Biofoundries are facilities that allow for access to automation and analytics infrastructure for engineering biological systems. They can provide researchers who have access to them with the ability to synthesise, edit, and

169 Q 76 (Dr Sara Holland)

analyse DNA, as part of the "Design-Build-Test-Learn" cycle. The UK has initially funded five biofoundries.[170]

144. Government investment in biofoundries was initially received in 2014 as part of the Synthetic Biology for Growth programme, but we heard from Professor Rosser that they did not receive sustained funding to operate. UK biofoundries were said to be:

> "enormously grateful to the research councils for funding the equipment for our biofoundries. What they did not fund was the staff to run the equipment. They are very expensive and complex pieces of equipment, so the issue is that we, the foundries—in my case a university—have to fund the staff. That makes us quite expensive to use because we have to run a cost recovery model. … One of the biggest challenges for us is that we are expensive to use because of the funding model."[171]

145. In written evidence, the University of Edinburgh explained that "the funding model imposed on [the biofoundries] makes them too expensive to be competitive and to be used by start-ups, SMEs and academics … we would strongly suggest that when there is capital spend on large complex pieces of equipment there is associated funding for staff to run the equipment for reasonable duration."[172]

146. Some witnesses raised the disparity in funding between biofoundries at home and overseas. Professor Freemont told us that, internationally, "the scale of investment in biofoundries is enormous … in Korea, it just announced $100m for a K-Biofoundry … in Shenzhen in China, about $750m … has gone into a building in which each floor [studies] an organism "[173] By comparison, the London Biofoundry "had £7m of public investment in infrastructure … and we have had no funding for staff … we are constantly scrabbling for cash."[174] Professor Nick Talbot described this as a "batteries not included model" of funding.[175]

Pilot-scale and scale-up facilities

147. Biofoundries are useful for the early stages of engineering biology—designing, building, and testing new genetic constructs—but as processes and products are developed as a result, scale-up facilities are also needed. Lord Willetts explained: "there is an enormous gap between what you can do in the lab and the volumes you need to be commercial."[176] In the UK, these are provided by facilities like the IBioIC, the High Value Manufacturing Catapult and the Centre for Process Innovation (CPI). Graeme Cruickshank told us that CPI was focused on "process design, the scale-up … [and] the industrial knowledge that says, "Here's how you make money out of that."[177] Mark Bustard explained the role of IBioIC:

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170 These are: the Edinburgh Genome Foundry, University of Edinburgh; Earlham Institute, Norwich Research Park; London DNA Foundry, Imperial College London; SYNBIOCHEM, University of Manchester; GeneMill University of Liverpool.
171 Q 2 (Professor Susan Rosser)
172 Written evidence from University of Edinburgh (ENB0037)
173 Q 2 (Professor Paul Freemont)
174 *Ibid.*
175 Q 92 (Professor Nick Talbot)
176 Q 71 (Lord Willetts)
177 Q 92 (Graeme Cruickshank)

> "there was a very clear market failure in companies accessing equipment and the bioprocess knowledge in non-healthcare spaces to enable them to run … proof of process. It then gives them robust data to go to their boards with, say, 'This is what our process looks like', and ask for more investment."[178]

148. Graeme Cruickshank explained the difficulties involved with scaling up processes from the lab towards commercialisation. Discussing the CPI, he said:

> "Transferring across the valley of death means that the exam question is no longer 'Is this possible?' but 'Is this viable?' In fact, technoeconomic analysis and industrial realities must be brought to bear. We tend to find that some early interactions can be painful on both sides … What needs to happen are multiple interactions with the academics … that allows us to learn each other's languages and needs."[179]

149. He discussed the CPI's Researchers in Residence programme as an example of this. However, programmes like this are "constrained" by funding rules: "even when we find the academics to support and we can support them, the amount of grant available for us … is constrained to somewhere between 30% and 50%".[180] He argued that "slightly more liquid funding … would be a step change in the UK's innovation potential."[181]

150. The Institution of Chemical Engineers told us that "there are significant barriers to accessing the scale-up facilities at CPI due to the requirement for projects to be financially self-sufficient. As a result, many companies are forced to seek more cost-effective alternatives abroad."[182] We heard that the Bio Base Europe Pilot Plant offered "direct access to vouchers for up to €60,000" which incentivised start-ups to go there.[183] Graeme Cruickshank told us that "I would love for the UK to celebrate the assets and provide more fuel to the engine; by "fuel", I mean funding for SMEs, academics or other colleagues to come and use the assets that exist."[184]

Mapping existing infrastructure

151. One reason behind possible under-utilisation of UK research infrastructure is the lack of a map of capabilities. Graeme Cruickshank told us "we already have an exceptional asset base, from biofoundries through to scale-up facilities, university facilities and RTOs [Research and Technology Organisations] facilities. However, we do not have them easily mapped and we have a habit of confusing each other, through our names, on quite what we do."

152. He thought it would be helpful create an innovation asset map, with clearer descriptions of the capabilities that each facility has.[185] Dr Sara Holland emphasised the importance of this from the industrial side: "we have a lot of really good infrastructure in our universities. It would be useful for early stage companies to access what is in a university on an ad hoc, quite quick

178 Q 36 (Mark Bustard)
179 Q 88 (Graeme Cruickshank)
180 *Ibid.*
181 Q 90 (Graeme Cruickshank)
182 Written evidence from the Institution of Chemical Engineers (ENB0052)
183 Q 92 (Graeme Cruickshank)
184 *Ibid.*
185 Q 97 (Graeme Cruickshank)

basis, without getting stuck in years of discussing IP terms, which is what happens."[186]

153. Lord Willetts told us: "it is one of the responsibilities of government to help with that kind of shared infrastructure. It is what our network of Catapults has done. The Cell and Gene Therapy Catapult is one of the reasons why we are very lively in that sector."[187] Professor Freemont set out how the UK could benefit through more interconnected facilities: "The one thing that the UK has got is that it is a very small place. We need a very integrated network of pilot-scale facilities and biofoundries, all interoperable and using the whole capacity of the country. We have not really done that properly yet."[188]

154. Other witnesses also raised the importance of ensuring that engineering biology researchers can access other relevant research infrastructure. For example, the Wellcome Sanger Institute said that:

> "computational labs developing and applying AI models should be brought together with experimental labs designing assays and generating data … a national engineering biology institute could be co-located with computer science research institutes … to facilitate cross-discipline collaboration."[189]

155. The Science and Technology Framework said that the DSIT would set out a "long-term national plan for research and innovation infrastructure."[190] Alexandra Jones from DSIT told us, in our 5 November 2024 one-off session with Rt Hon Peter Kyle MP, the Secretary of State for DSIT, that they were looking at investment in research infrastructure for "stage two" of the spending review: "for phase two, we will need some long-term plans around infrastructure."[191] A mapping effort could build on work done by GO-Science and the Innovation and Research Caucus.[192]

156. **The UK already has some significant infrastructure that supports the growth of the engineering biology sector, such as the biofoundries and the Centre for Process Innovation. However, they are not always used to their maximum potential, in part because they are expensive for start-up companies and researchers to use owing to their cost recovery models. The UK risks losing valuable research infrastructure because too often funding is allocated to setting up new research institutes and laboratories without considering a sustainable, long-term funding model for existing labs. Funding for research infrastructure in the UK is falling behind comparable countries. There is a need for start-ups and spin-outs to use these scale-up facilities to engage with the**

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186 Q 73 (Dr Sara Holland)
187 Q 73 (Lord Willetts)
188 Q 4 (Professor Paul Freemont)
189 Written evidence from Wellcome Sanger (ENB0021)
190 Department for Science, Innovation and Technology, *The UK Science and Technology Framework—taking a systems approach to UK science and technology* (March 2023): https://assets.publishing.service.gov.uk/media/6405955ed3bf7f25f5948f99/uk-science-technology-framework.pdf [accessed 5 October 2024]
191 Q 7 (Alexandra Jones)
192 Innovation and Research Caucus, *Mapping the innovation and commercialisation infrastructure for non-health applications of Engineering Biology in the UK* (February 2024): https://innovation-research-caucus-uploads.s3.amazonaws.com/production/uploads/2024/02/Engineering-Biology-Report-27.2.24-final4.pdf [accessed 10 November 2024]

practical problems of scaling up their products and processes at an earlier stage.

157. ***The stop-start funding of research infrastructure must end. The Government should set a timeline for producing its long-term national plan for research infrastructure. In the Spending Review, it should use some of the new flexibility for infrastructure spending to fund R&D infrastructure.***

158. ***The Government should provide more funding to enable greater use of existing engineering biology research infrastructure, such as the biofoundries and the CPI. This could be in the form of block grants for those institutions to maintain their operations and reduce the cost recovery that they must charge users, or grants for using these facilities, as the EU offers for the Bio Base Europe Pilot Plant. The scale-up facilities should have an enhanced educational role to play with preparing researchers and start-ups to engage with the practicalities of scaling up their processes at an earlier stage.***

159. **One reason that facilities are under-utilised is that researchers and SMEs have a lack of awareness of the equipment, specialisms and capabilities that are available in universities and public sector research establishments, and the terms of use of different facilities are not always transparent.**

160. ***As part of its long-term national plan for research infrastructure, DSIT should map out the existing capabilities of innovation infrastructure in its key technology areas (including engineering biology) and the terms for using them. It should identify and address any barriers to accessing existing facilities in this area, such as the biofoundries, and Catapults, including the CPI. Interconnectivity of existing infrastructure should be encouraged to ensure that there are clearer pathways for scaling-up processes and production. AI and compute infrastructure should be made accessible for applications of machine learning, such as those in engineering biology.***

New lab space and scale-up infrastructure

161. As well as needing to make better use of existing infrastructure, particularly at the early-stages of development, some witnesses felt there was a need for further, targeted scale-up infrastructure. Lord Willetts told us:

> "We now have stories of companies that have started up in the UK doing the scale-up elsewhere, where there is greater access to the facilities they need for fermentation on a larger scale. Even the excellent vision that was published just at the end of last year asks questions; it says, 'We need to consult on what kind of investment in further infrastructure might be necessary'. It is blindingly obvious: we need more biofoundries, we need more fermentation capacity that is not quite fully commercial, and we need to get on with it. That is the first problem."[193]

162. Professor Tom Ellis told us that:

> "a lot of what is needed for early-stage companies to get to the next level of scale is access to fermentation facilities to scale up their stuff. To

193 Q 79 (Lord Willetts)

> build the infrastructure to do that is incredibly expensive. People are not going to fund that unless this is a really long-term, big amount of funding."[194]

163. He thought there could be a role for supporting private sector facilities that have this capacity: "That is where CMOs—contract manufacturing organisations—come in, and there are not that many of them in the UK. Maybe there needs to be more effort to have CMOs in the UK that can ferment at scale some of this stuff."[195]

164. Mark Bustard of IBioIC told us of a "leaky pipeline" due to a lack of facilities beyond pilot-scale stage in the UK: "unfortunately, when [companies] go beyond our scale, they tend to go to European facilities in the first instance [such as] BBE (Bio Base Europe) … we lose them and they tend not to come back for manufacturing."[196] He explained that "before Brexit, they were going there because they could tap into Horizon funding … then Brexit arrived, it all stopped, and there were no significant facilities in the UK where companies could go, apart from CPI."[197]

165. Some witnesses raised significant concerns over lab space. Professor Gino Martini, Chief Executive Officer, PHTA Ltd, wrote that "lack of land [for bioengineered crops] and dedicated lab space is undoubtedly inhibiting the sector in the UK."[198] Bit.bio told us that "the need for lab space is a salient issue in the Oxford-Cambridge Arc … we welcome recent measures … to reform planning rules to help scientists." The University of Edinburgh told us that "there is a serious lack of lab space for companies to move into once out of the universities" in Scotland, which was described as "extremely damaging" and forcing many companies to move to the Greater South East.[199] The Bristol Bio-Design Institute described this as a "market failure in laboratory space" leading to "geographically unbalanced access to infrastructure."[200]

166. Dr Webb, Deputy Director for Technology Strategy and Security at DSIT, explained that infrastructure needs for engineering biology can be complex:

> "It is not simply a case of building a fermenter and that is what people need. They need different fermenters and other bioprocessing facilities of different sizes. In fact, downstream processing, once you have grown up your bacteria, fungi or whatever other organism, is as critical and so variable, depending on whether you are going for medical grade, food grade or chemical grade."

167. She said that the Government Office for Science had undertaken work alongside DSIT to assess the right approach for government efforts to support new infrastructure.[201] Professor Dame Angela McLean told us that "there is a gap in the scale-up of the non-pharmaceutical end" and that DSIT was "in the process of consulting with those companies on what exactly they need."[202]

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194 Q 13 (Professor Tom Ellis)
195 *Ibid.*
196 Q 36 (Mark Bustard)
197 *Ibid.*
198 Written evidence from Professor Gino Martini (ENB0002)
199 Written evidence from University of Edinburgh (ENB0037)
200 Supplementary written evidence from Bristol BioDesign Institute (ENB0043)
201 Q 154 (Dr Isabel Webb)
202 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 3 (Professor Dame Angela McLean)

168. On infrastructure, Lord Vallance told us:

> "we will almost certainly need to do more. I am being a little hesitant about what more looks like, because we know from examples in other countries that creating a big infrastructure of stainless steel fermenters and so on, which sit there and do not do anything, is not a helpful way to do this. We need really to think about how to leverage private sector investment in the right places and what government money can do to make that happen, rather than assume that we know exactly what infrastructure we need as this really exciting area emerges."[203]

169. **There is a need for more scale-up infrastructure, in particular large-scale fermentation facilities, which would allow for the scale-up of processes that have been demonstrated in the lab. As the sector develops, there will be an increasing need for more specialist facilities that relate to specific applications. Much of this will be developed by the private sector, but the Government still has a role in supporting private and public-private investment for manufacturing infrastructure.**

170. ***The Government should ensure that the UK has a competitive answer to the scale-up infrastructure provided by facilities like the Bio Base Europe Pilot Plant, responding to the work done by GO-Science and DSIT in this area. In particular, existing fermentation facilities and facilities like the CPI which focus on non-life sciences applications of engineering biology should be supported. The Government's proposed reforms to the planning system should encourage the development of laboratory space around existing clusters for the life sciences.***

203 Q 226 (Lord Vallance of Balham)

CHAPTER 5: ENGINEERING BIOLOGY FOR GROWTH

171. This chapter sets out recommendations for better-coordinated public and private investment to encourage the growth and scale-up of engineering biology companies, as well as policies on incentives for existing companies to adopt engineering biology processes and ensuring the UK fits into global supply chains for feedstocks.

Scaling up companies: economic issues

172. Witnesses talking about engineering biology spoke about the difficulty in scaling up companies, a familiar problem in other science sectors which we have discussed in previous reports.[204] Professor Paul Freemont said:

> "When it comes to funding, angel, start-up and seed investment is absolutely fine. … The big problem, as always, is the valley of death and scale-up. How do they get these products on to the market? … This is our biggest challenge. We have a fantastic, exciting ecosystem of very young people who want to change the world. We have great companies. We have investors supporting them. Then, when they want to scale and get products to market, we have issues with regulatory structures, scale, fermentation capacity and pilot-scale facilities, so it all just falls apart. My strong view is that we need to build and allow these companies to scale. We have to scale. It is really important."[205]

173. This was echoed by many other witnesses. Lord Willetts told us: "For synthetic biology, the scale-up challenge is a vivid example of the wider British problem". He described problems around "substantial funding" on the scale of tens of millions of pounds, "infrastructure and facilities", and the availability of technicians as three challenges for scale-up.[206] Dr Charles Hall told us that: "Typically, we have quite good seed money but very poor scale-up money. The reality is that when you get to a certain size, floating in the US or selling out to an overseas company becomes more and more attractive."[207]

174. Witnesses such as Dr Clive Dix described the "real pull to America" for companies. Lord Willetts said that the UK should, as a "fallback", ensure that "when the Americans inevitably turn up and buy a company, by then it should be sufficiently well-established and have sufficiently deep roots in a British ecosystem that it is a rational decision for an American investor to leave a large part of the operation here" so that not all of the economic benefit of UK research and development and start-up companies accrued to the US, a situation he described as the UK providing "corporate veal: the Americans turn it into beef."[208]

175. These issues are not new: this Committee, in 2022, published a report entitled "*Science and Technology Superpower": more than a slogan?*[209] which made recommendations in areas including scale-up funding, pension fund

204 Science and Technology Committee, *"Science and technology superpower": more than a slogan?* (1st Report, Session 2022–23, HL Paper 47)
205 Q 4 (Professor Paul Freemont)
206 Q 71 (Lord Willetts)
207 Q 104 (Dr Charles Hall)
208 Q 72 (Dr Clive Dix and Lord Willetts)
209 Science and Technology Committee, *"Science and technology superpower": more than a slogan?* (1st Report, Session 2022–23, HL Paper 47)

reforms, public procurement, and the Government's role as an investor, and acknowledged the significant history of efforts to address this problem and some of the initiatives pursued by the previous Government.

176. **There is a long-standing and severe problem in the UK with the ability of science and technology companies to scale up. We heard many times that the UK is quite competitive when it comes to start-up and spin-out companies, but that such companies struggle to grow and often move abroad, especially to the US, for funding or to float on stock exchanges when they reach a certain size. This limits the economic benefits captured by the UK. A lack of sovereign large companies in the UK also limits opportunities for investment and acquisition of new companies and processes here. What we heard from engineering biology companies provides an example of a much more general, and long-standing problem.**

177. ***There are many factors behind this failure to scale and the Government needs to initiate coordinated policy initiatives on multiple fronts to turn it around, including the areas of public and private investment (such as the Mansion House reforms), infrastructure, skills, regulation, adoption by larger companies, and public procurement we address in this report.***

Public investment

178. Witnesses stressed that there was a key role for state investment, particularly in infrastructure in which the private sector is less likely to invest.[210] This can be done in coordination with public procurement policy, as discussed in Chapter 4, to ensure that there is funding or contracts available for public companies to scale up. Professor Susan Rosser said:

> "There needs to be investment at the level that allows these companies to grow to the next level … you need to have the public-private investment. If you want to build something that will be a big manufacturing site, a [venture capital] investor will not put in those many millions in the UK at this time. They are more liable to do that over in the US."[211]

179. Rosemary Sinclair Dokos set out the difficulties in obtaining innovation funding through existing channels, saying:

> "We needed to build a factory to get things to a decent scale. As a loss-making company, it was incredibly difficult to get Innovate UK funding. We spent ages going through all the applications, and then, three or four months after that process started, someone said, "Oh, there's a clause at the back here that says you're a loss-making company, so you don't qualify for this."[212]

180. She further explained that for medium-sized companies it "is often really unclear how you can get that support, be it from the Office for Life Sciences or Innovate UK. I do not know how much attention gets paid to companies at the 200 or 300 people size that are trying to make it big, and that is one of the most challenging parts of the business." This issue remains, as she noted: "That will continue to be a challenge the next time we want to duplicate

210 Q 4 (Professor Paul Freemont)
211 Q 4 (Professor Susan Rosser)
212 Q 19 (Rosemary Sinclair Dokos)

the footprint of our factory … What funding cycles will be available for companies that really want to make it in the UK?" [213] Dr Jim Ajioka told us about the difficulties Colorifix had encountered: "we had to make our own machines … for an engineering biology company [that] is not normal. That was a major challenge, and we had to do it on the sly so that our investors did not really know we were doing it."[214] Other witnesses, such as Mark Bustard, said that "Innovate UK funding is exceptionally good for companies in growth" but that "some companies … are able to secure capital at probably between £20m and £60m [valuation]. There is nothing beyond that, so they tend to go overseas then."[215] He argued that:

> "The UK has not been so successful in securing major capital investment and investors who are willing to put steel in the ground and support the construction of facilities … We are not asking the UK Government to invest themselves but for more public/private and de-risking activity."[216]

181. The Institution of Chemical Engineers set out that "acquiring sufficient funds is … the critical factor in technology successfully passing through the 'Valley of Death'", the phrase used to describe the "gap that exists between research-related funding for novel projects and the commercial resources available for more mature technologies."[217]

182. Dr Martin Turner told us of the value of specialist investment teams within public investment bodies that exist: "British Patient Capital, the equity investment arm of the British Business Bank, is really valuable; it has worked well in life sciences. It could … look at engineering biology applied outside healthcare. Currently, it has a life sciences investment team and a tech investment team, and a lot of these industries fall between the two."[218]

183. The non-medical applications of engineering biology do not always receive the same capital support as is available in the life sciences. It is not always clear where companies should go if they want larger-scale capital investments to fund large-scale manufacturing infrastructure. Dr Turner expressed the view that:

> "there is very little incentive within the Government's fiscal policy for companies to make manufacturing investments. R&D tax reliefs do not encourage capital investment; outside of medicines manufacturing, very few capital grants are available to companies to invest in this kit."[219]

184. The Government re-announced with its Autumn Budget the Life Sciences Innovative Manufacturing Fund, which provides up to £520m of capital grants for investments in the manufacture of human medicines, medical diagnostics, and MedTech products. However, this does not seem to include the non-medical applications of engineering biology.[220]

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213 Q 20 (Rosemary Sinclair Dokos)
214 Q 19 (Dr Jim Ajioka)
215 Q 35 (Mark Bustard)
216 *Ibid.*
217 Written evidence from the Institution of Chemical Engineers (ENB0052)
218 Q 36 (Dr Martin Turner)
219 Q 37 (Dr Martin Turner)
220 Department for Science, Innovation and Technology, Notice, *Life Sciences Innovative Manufacturing Fund (LSIMF): Expression of Interest* (2 March 2022) : https://www.gov.uk/government/publications/life-sciences-innovative-manufacturing-fund-lsimf [accessed 2 November 2024]

185. Suggesting alternative investment vehicles, Dr Charles Hall said "a sovereign wealth fund would make a big difference to the UK. We should have done this decades ago. It is never too late to start".[221]

186. Since our evidence sessions, the Government has also introduced a National Wealth Fund, as a reformed version of the UK Infrastructure Bank which will now operate alongside the British Business Bank. The Government has said that the National Wealth Fund will support the goals of its industrial strategy, which include technologies and life sciences. It has announced an initial "additional £5.8 billion" in funding, resulting in a total capitalisation of £27.8 billion, and that "at least £5.8 billion" would focus on priority areas in cleantech.[222] However, it is unclear whether any of this investment is intended to be in engineering biology. Lord Vallance told us that "the national wealth fund exists to try to help with some of that co-investment", as does the "British Business Bank growth fund".[223]

187. **We have heard that there is a significant role for public investment, especially to support research infrastructure and also to de-risk larger investments on the scale of tens of millions of pounds which are lacking in the UK. The UK must fill the gap at this level of investment, through a combination of public and private efforts, to prevent promising companies from going overseas. We have also heard that a sovereign wealth fund could support the goals of an industrial strategy. However, as currently constituted, it is not clear that the new National Wealth Fund has a remit that would allow it to invest in engineering biology in this way.**

188. ***The Government should urgently expand the scope and scale of its National Wealth Fund to ensure it can include investments in technologies such as engineering biology that support the aims of its industrial strategy. A specialist investment team for engineering biology as a part of the National Wealth Fund should be established to enable it to identify and make these investments.***

189. **It is not always clear that the Government has a consistent sense of the role it wants to play as an investor, or that businesses know who to approach for large-scale investment. The respective roles that Innovate UK, the National Wealth Fund and the British Business Bank should play in supporting scale-up companies and the deal sizes that they seek to undertake have not been fully set out. There is also a relative lack of capital grants in engineering biology compared to other areas of the life sciences, although engineering biology offers the UK an opportunity to translate its success in the life sciences into other sectors of the economy.**

190. ***There is a need for a clear, joined-up pipeline of funding to support companies to make the transition over the 'valley of death' from research, through pilot-scale and scale-up, to funding for larger***

221 Q 113 (Dr Charles Hall)

222 HM Treasury, *National Wealth Fund* (October 2024): https://assets.publishing.service.gov.uk/media/6710cf42080bdf716392f558/NWF_IIS_Publication.pdf [accessed 2 November 2024]; UK Government, *Invest 2035: the UK's modern industrial strategy* (October 2024): https://assets.publishing.service.gov.uk/media/670d394f3b919067bb48310c/invest-2035-the-uks-modern_industrial-strategy.pdf [accessed 15 November 2024] - Priority areas announced included green hydrogen, carbon capture, ports, gigafactories, and green steel.

223 Q 149 (Lord Vallance of Balham)

companies with a commercial product. This will require coordination between bodies like the National Wealth Fund and British Patient Capital, which could focus on de-risking larger-scale infrastructure investments and providing late-stage equity funding, and agencies like Innovate UK and research councils, which should focus on expanding existing programmes to support research and pilot-scale investments. It will also require coordination with the Government's public procurement policy to pull through innovative technologies, discussed earlier. The Government should also consider a capital grant scheme to support non-medical engineering biology in the same way as the Life Sciences Innovative Manufacturing Fund currently supports the medical applications.

Private investment

191. There are several factors currently limiting private sector investments in engineering biology. Dr Martin Turner explained that for scale-up funding, "there are not many investors in the UK with those deep pockets."[224] Professor Paul Freemont told us that in the UK, "investors are looking for revenue streams very early on in companies' development", which is inappropriate for highly innovative technology companies.[225] Dr Clive Dix agreed, saying that the "most important thing is sophisticated investors who understand what they are investing in and that they are there for the long term."[226]

192. Lord Willetts described some cultural differences between investors in the US and the UK:

> "if you are going to raise money for a tech company in the UK you take your CFO and if you are going to raise money in the US you take your CTO. The Americans are interested in the technology story. Because of the financialisation of our investment model in Britain, scientists and technologists find themselves constructing fantastical accounts of cash flow … but the Americans want an explanation why there is something special about your technology … the US conversations are at a completely different level: they are sophisticated people who want to get their heads around the technology, rather than people with financial training who want to know exactly what your EBITDA forecasts are."[227]

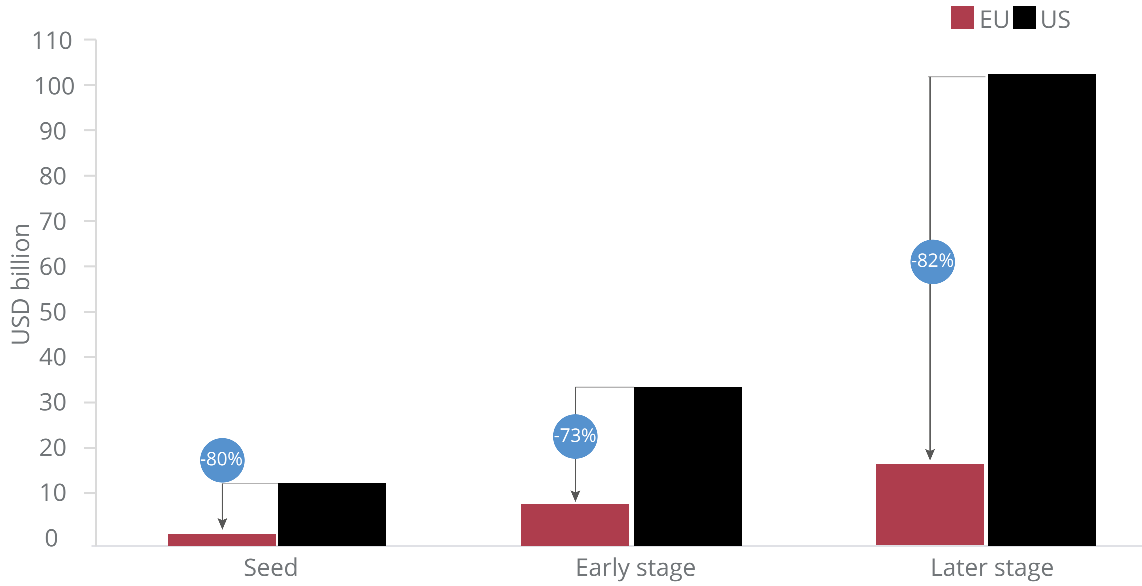
193. Dr Dix agreed, noting that:

> "Ten years ago there were funds—pension funds mainly—that had sophisticated healthcare teams that invested. They had healthcare analysts, so when you went to speak to them they were far more interested in what you were going to do than the money. Now when you go to these same funds they have turned their back a little bit on high-risk biotech and life sciences, but if you do get in the door they scrutinise your financials."[228]

224 Q 35 (Dr Martin Turner)
225 Q 4 (Professor Paul Freemont)
226 Q 71 (Dr Clive Dix)
227 Q 73 (Lord Willetts)
228 Q 73 (Dr Clive Dix)

194. Another major cultural difference was that "we have an incredibly risk-averse society … so much of our attitude towards investment is that we have to avoid risk."[229]

Figure 4: EU-US venture capital investment by development stage



Source: The Future of European Competitiveness: European Commission, The future of European competitiveness - Part A: A competitiveness strategy for Europe (September 2024): https://commission.europa.eu/document/download/97e481fd-2dc3-412d-be4c-f152a8232961_en *[accessed 15 November 2024]*

195. Dr Dix stressed the importance of "sophisticated investors who understand what they are investing in and that they are there for the long term."[230]

196. Dr Hall put some of this loss of investor expertise and focus down to much larger macroeconomic trends:

> "More than 40% of our stock market was owned by pensions only 25 years ago. That is now down to 4%. We have globalised and diversified and moved into passive investments, and that really matters because it is active fund managers that invest in technology and projects."[231]

197. He said that:

> "Pensions are going global, wealth managers are going global, and retail investors are increasingly going global … as an individual … that is no problem at all, but for a country it is a disaster, because we are not retaining capital in the UK … Just in the last ten years, [the] overall proportion of [equity capital markets in the] UK compared to the global indices has halved."[232]

198. He explained that as the equity market is reduced "the ecosystem" of asset managers with expertise "goes with that … we absolutely need to encourage greater expertise in the UK. You cannot do that overnight, but you can have a number of UK champions and then the expertise builds around it."[233]

229 Q 106 (Dr Charles Hall)
230 Q 71 (Dr Clive Dix)
231 Q 103 (Dr Charles Hall)
232 *Ibid.*
233 Q 106 (Dr Charles Hall)

199. Witnesses suggested some financial reforms for the UK that could support innovation. For example, pension funds could be reformed to encourage large-scale investments into UK equities.[234] Dr Hall said:

> "We can learn from other countries. Australia was in a similar position to us 25 years ago and now it has one of the best pension markets in the world. Its people are putting enough money into their pensions, unlike us … But they also invest significantly in Australia. The Australian Superfund … invests 23% of the Australian contributors into Australia. Compare similar UK funds to that and it is more like 5%."

200. The Government has already committed to some reforms to address these areas. DSIT told us in its written evidence:

> "The Mansion House reforms announced this year committed the largest UK defined contribution pension funds to ambitious goals for their investments in unlisted equities. In addition, the Long-Term Investment for Technology and Science (LIFTS) aims to mobilise institutional investment into the UK's science and technology companies, while a new fellowship scheme will build on the pool of talented UK VCs to create a pipeline of world-leading investors in science and technology."[235]

201. Commenting on existing Government attempts to reform the pension markets, Dr Hall said "we are starting to move on that" with "the Mansion House compact—but we need to move faster and further … Why have we underperformed for the last 25 years? A huge amount of it can be put down to pensions alone."[236] Lord Willetts agreed that efforts to "aggregate pension fund pots and get some bigger funds" that can make large-scale investments in high-risk, high-reward ventures "is the right thing to do. It needs to carry on and go further and faster."[237] Lord Vallance told us that the Mansion House reforms were "an important step in the right direction" and "a great start".[238] In a speech at Mansion House in November 2024, the Chancellor of the Exchequer, Rt Hon Rachel Reeves MP, set out the interim report of the Pensions Investment Review, and a commitment to legislate in 2025 to achieve a significant consolidation of pension funds.[239] Dr Hall suggested some further reforms to UK equity markets to encourage growth:

> "We need to encourage our equity market. Over the last few years, all the reasons for investing in the UK have become worse because of our dividend tax, capital gains tax, stamp duty. Effectively, everyone is being encouraged to invest overseas, because we have the second highest stamp duty tax in the world. It is no wonder that people are investing in the States rather than in the UK … if you do not create the ecosystem in the UK, it is no surprise".[240]

234 Peel Hunt, *Thematic Research: Reinvigorating the UK equity market* (1 August 2023): https://www.peelhunt.com/media/pheh1pii/uk-equities-final.pdf [accessed 5 October]
235 Written evidence from the Department for Science, Innovation and Technology (DSIT) (ENB0011)
236 Q 103 (Dr Charles Hall)
237 Q 80 (Lord Willetts)
238 Q 144 Lord Vallance of Balham
239 The Rt Hon Rachel Reeves MP speech at Mansion House, 14 November 2024: https://www.gov.uk/government/speeches/mansion-house-2024-speech [accessed 2 November 2024] This will include consolidating the 86 Local Government Pension Schemes into 8 pools.
240 Q 104 (Dr Charles Hall)

202. **Witnesses raised concerns about the ability and willingness of private investors to invest in UK engineering biology companies. Some told us that institutional investors are reluctant to invest in UK companies due to a lack of sophisticated research or excessive focus on the financials of companies, rather than the technology’s potential. In some cases the economics of these firms can be marginal, especially to begin with as they develop their products. In addition, equity capital markets in the UK are shrinking on a relative basis, and the rise of passive investment has resulted in globalised, diversified pension funds which invest to a lesser degree in UK companies. This can result in a ‘doom loop’ whereby pension funds invest less in UK equities, which in turn makes them less profitable. We welcome that the Government has acknowledged this and committed to pension reform. However, new, consolidated pension funds will still need expertise and incentives to identify and invest in innovative UK companies. The UK needs more capital, but also more focus on the specific areas that it can excel in.**

203. ***The UK should pursue reforms to the financial sector that encourage investment in UK companies, including the Mansion House reforms in the pension sector, which need to be more ambitious and faster. Maintaining a sophisticated investment ecosystem requires some large UK investors in the sector, and reform is needed to slow the decline of active investment. Pension reforms should consider ways of supporting consolidated pension funds to invest in small, innovative UK tech companies and provide scale-up capital for them, as part of their diversified portfolios, including by supporting the development of tech expertise among investors.***

Driving adoption across the economy

Adoption by larger companies

204. One route for innovative technologies to scale up is to partner with larger companies. Rosemary Sinclair Dokos set this out:

> “In order to take a company from an interesting technical innovation to a global powerhouse, you need people with high experience in manufacturing, but not manufacturing in small stages, which is what we have a lot of in the UK. The UK is an interesting place: we have a lot of small, mid-sized biotech companies, and we have enormous pharma companies. You do not have this lovely thing in the middle”.[241]

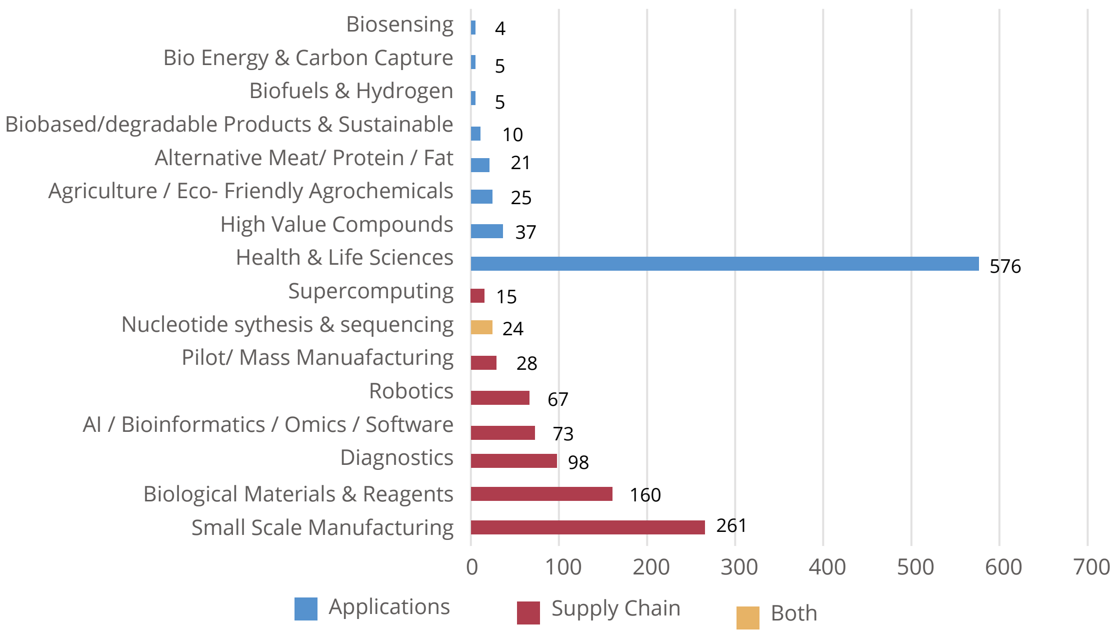
205. The decline of the manufacturing base was highlighted by Dr Peter Williams: “Manufacturing in the UK as a contribution to UK GDP has fallen from 16% or 17% to 8% or 9%. It has halved over the last couple of decades. With that halving goes the ecosystem that you need in the manufacturing base.”[242]

206. Graeme Cruickshank said that: “We absolutely struggle for sovereign companies. We have footprints from many companies but decision-making power typically resides outside the UK.”[243] However, he noted that “we have strong design capability in the UK” due to our R&D and science strengths,

241 Q 22 (Rosemary Sinclair Dokos)
242 Q 105 (Dr Peter Williams)
243 Q 94 (Graeme Cruickshank)

even among companies that "do not necessarily manufacture here."[244] Dr Martin Turner told us that in healthcare "it is certainly a well-trodden path for SMEs to interact with large pharmaceutical companies. At the moment we see it less in other industries … I do not think there is a significant pull from the large companies."[245]

Figure 5: Engineering biology firms in the UK by category



Source : Department for Science, Innovation & Technology, Policy paper, National vision for engineering biology (5 December 2023): https://www.gov.uk/government/publications/national-vision-for-engineering-biology/national-vision-for-engineering-biology [accessed 9 January 2025]

207. Several factors were said to be holding back the UK's manufacturing sector. Greg Archer told us that for manufacturing, "the costs of energy are truly prohibitive, compared to many other markets in which we could be developing facilities. Much of the cost of that energy is not in the costs of the electrons but in the costs of the infrastructure, the connections to the grid and so on."[246] Graeme Cruickshank agreed saying we need "cheap, green electrons … ready access to significant quantities of affordable, green electricity; that is what underpins all chemical and biochemical processes [and] changes the game economically."[247]

208. Mr Cruickshank suggested that some of the Government's engagement was not designed for drawing in big companies, saying a barrier was "Too many small, bitty programmes which are too much trouble. It is more trouble than it is worth for these large corporates to engage in small CR&D programmes or even what we think of as multi-million-pound programmes."[248]

209. Some witnesses suggested that a lack of awareness was an issue. Dr Sara Holland said: "engineering biology covers every sector: electronics,

244 *Ibid.*
245 Q 34 (Dr Martin Turner)
246 Q 113 (Greg Archer)
247 Q 94 (Graeme Cruickshank)
248 *Ibid.*

engineering, materials. We do have companies, but maybe they do not know about engineering biology."[249]

210. Dr Peter Williams said that the important thing to decide was: "what does the UK want to be? Does it want to manufacture its goods? Does it want to be self-sufficient in energy? What are the strategic requirements for the UK? In one or two sectors, that is very clear. In the sector that we deal with, it is not."[250] Figure 5 sets out the engineering biology firms that exist in the UK by subsector, according to DSIT analysis, which suggests areas where the UK may have particular strengths.

211. **One of the major barriers for engineering biology in the UK is the lack of large Tier 1 manufacturers at the 'top of the ecosystem' outside the life sciences. These large companies can play a crucial role in successful innovation ecosystems by buying out smaller companies, co-funding additional research, and converting science into products and services.**

212. ***The UK needs a clearer direction of travel when it comes to which parts of the biomanufacturing supply chain it intends to have domestically. Any sectoral strategy must carefully consider which existing companies might ultimately invest in biomanufacturing in the UK. These should be linked to the priority areas and outcomes for engineering biology that the Government should identify and support. Broader infrastructure issues, such as ready access to cheap electricity, are holding the manufacturing sector back and should be addressed by the industrial strategy.***

Incentives and mandates to create a market for engineering biology

213. One of the drivers of engineering biology research is finding alternative, more sustainable methods of production for goods. However, there is a lack of incentives to invest in innovative alternatives to goods that have historically been derived from fossil fuels. Dr Turner thought that the desire to do so existed but companies were not willing to invest in building capabilities or to support small companies to bring products to market: "There is perhaps not enough incentive for companies to pursue more sustainable technologies at this time, although there is significant public pressure to do it. Economics often still win out and, unfortunately, it can be cheaper to have the more environmentally unfriendly, less sustainable processes in place."[251] This was compared unfavourably to other countries by Dr Peter Williams, who cited "the Inflation Reduction Act" which had "channelled a lot of investment thinking to the US." He added that: "For our sort of industry, those incentives do not really exist in the UK", and that while some schemes supported biofuels, "there are no incentives for materials and chemicals".[252]

214. Professor Paul Freemont said: "All the big guys have biotechnology initiatives. They are all just sitting there, waiting to see how they will drop into their existing value chain. They are not going to create the new transition. They will just wait and see. If more pressure is put on them through carbon taxation … they will start reacting."[253] The University of Edinburgh also told us that:

249 Q 74 (Dr Sara Holland)
250 Q 113 Dr Peter Williams
251 Q 34 (Dr Martin Turner)
252 Q 105 (Dr Peter Williams)
253 Q 4 (Professor Paul Freemont)

"For many of these processes to become economically viable there would need to be the application of some form of carbon tax to motivate industry to move away from fossil-fuel based processes which are currently cheaper."[254]

215. Mark Bustard cited a particular example:

> "Italy changed its policy around waste sorting and waste utilisation to generate other products [which] created an enormous opportunity for those companies making biodegradable biopolymers … Italy grew a whole industry on the back of that and had a policy shift to enforce it as the way forward."[255]

216. Greg Archer argued that a major challenge was:

> "to have markets for our products. We are beginning to see mandates coming in for sustainable aviation fuels … but there is no requirement on the chemicals industry, for example, to begin to phase out the use of virgin fossil fuels as a feedstock for their chemical processes. We have targets for the car industry to phase out and shift to electric vehicles … but at the moment there is no responsibility on the chemical industry to switch."[256]

217. Dr Hendrik Waegeman, Head of Business Operations, Bio Base Europe Pilot Plant, argued that this applied particularly to waste valorisation: "Hoping that the technology itself will be applied without any kind of support is a bit of daydreaming. If the UK or any other Government want to put more focus on the efficient use of waste, there should be some incentives in place to make that feasible."[257]

218. **Among the larger manufacturing companies that do exist, there is a reluctance to adopt engineering biology solutions. We were concerned that we had limited engagement from larger companies during this inquiry. While bio-based technologies can be more sustainable, they are also more expensive to adopt initially. Without significant incentives or mandates to act as a 'pull factor' for supporting these technologies, these companies are unlikely to move away from current practice on their own. There is an urgent need to create a market for engineering biology products and technologies that can displace fossil fuels in order to incentivise pull-through of technologies such as engineering biology. As with the example of the sustainable aviation fuel mandate, there is a need for the Government to create the market to incentivise switching production.**

219. ***The Government should introduce incentives which encourage manufacturing companies, for example in the chemicals and fossil fuel industries, to fund research, development and production in biomanufacturing and engineering biology. For example:***

- ***carbon taxes or other taxes on pollutants or raw material waste,***
- ***mandates for processes that currently use fossil-fuel feedstocks, but where a viable alternative could be scaled-up.***

254 Written evidence from the University of Edinburgh (ENB0037)
255 Q 36 (Mark Bustard)
256 Q 99 (Greg Archer)
257 Q 121 (Dr Hendrik Waegeman)

220. ***The Government should initially mandate that a certain small percentage of the production was done using bio-based processes, with a view to increasing this percentage over time.***

Feedstocks and supply chain implications

221. Our inquiry considered feedstocks—the inputs to many engineering biology processes. These issues are not new; we explored some of them in our 2014 report *Waste or resource? Stimulating a bioeconomy.*[258] This is an area in which the Government has a track record for strategies with little follow-on action. In 2018, the UK's Bioeconomy Strategy had a vision to "enable rapid development and deployment of new technologies, including regulation and industry guidance on waste; the impact of bio-based procurement and standards for biomaterials." This strategy was intended to run until 2030, but was withdrawn in 2021, only a few years after it was published.[259]

222. In 2021, the UK's Innovation Strategy stated that "engineering biology will help lessen our dependence on fossil fuels and simplify global supply chains, shifting us from an oil-based economy towards a bio-based economy … where fossil-derived fuels or plastics are required, biomanufacturing will deliver biobased and waste-derived alternatives in 80% of cases by 2035."[260]

223. By moving away from traditional petrochemical feedstock, engineering biology has the potential to reshape manufacturing and play a role in the development of a circular economy. As Professor Paul Freemont told us:

> "apart from natural products, pretty much everything is based on a petrochemical feedstock, which comes from commodity and specialised chemicals. Ultimately, we will have to transition away from using those chemical feedstocks into bio-based, more circular and more sustainable feedstocks, and one technology will be engineering biology."[261]

224. Countries vary in terms of what feedstocks they have available. Fiona Mischel told us that this has implications for the processes that can be developed:

> "The US has an unbelievable amount of corn, mainland Europe has quite a lot of sugar beets and Thailand has a lot of sugar cane … the UK does not really have much of that. We have limited arable land, and we need to use that, obviously, for growing food for the human population as well as for biodiversity protection."[262]

225. For the UK, this means that waste valorisation will be "critical"; as Professor Susan Rosser put it; "it is about using the waste streams to produce things with value and using biology to take that kind of approach."[263] She noted that:

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258 Science and Technology Committee, *Waste or resource? Stimulating a bioeconomy* (3rd Report, Session 2013–14, HL Paper 141)

259 HM Government, *Bioeconomy strategy: 2018 to 2030* (December 2018): https://assets.publishing.service.gov.uk/media/61a60c91d3bf7f055b2934cf/181205_BEIS_Growing_the_Bioeconomy__Web_SP_.pdf [accessed 5 October 2024]

260 Department for Business, Energy and Industrial Strategy, *UK Innovation Strategy: leading the future by creating it* (July 2021): https://assets.publishing.service.gov.uk/media/61110f2fd3bf7f04402446a8/uk-innovation-strategy.pdf [accessed 5 October 2024]

261 Q 1 (Professor Paul Freemont)

262 Q 121 (Fiona Mischel)

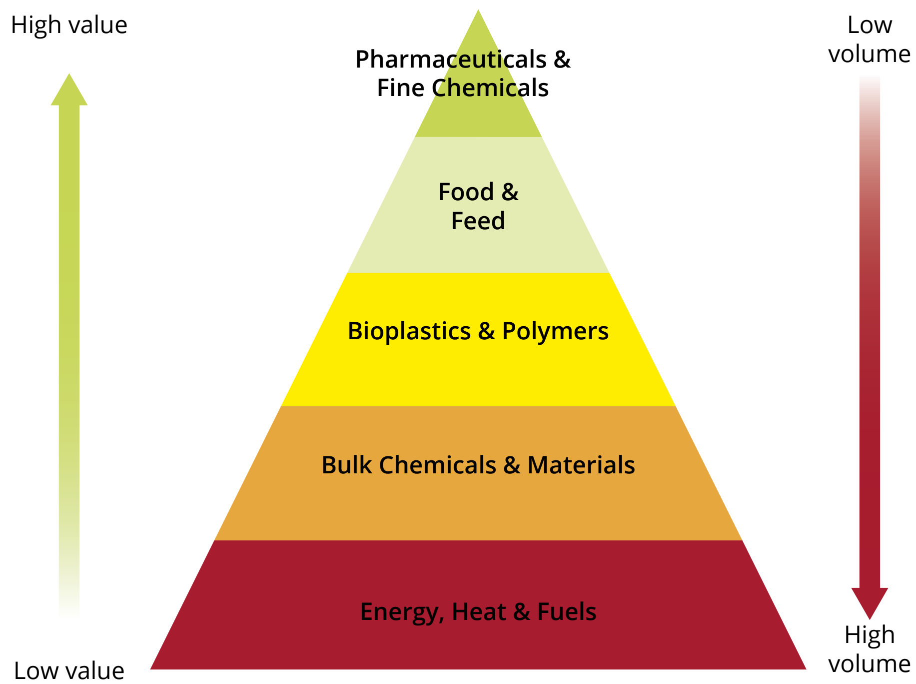
263 Q 1 (Professor Susan Rosser)

"companies are very aware that there might be some sort of carbon levy coming in … Where there are limited resources, such as metals, … you want to get all those metals back again. You do not necessarily have to have a big feedstock in the UK to be able to use biology to reduce the carbon footprint and waste, and make good commercial sense out of what we can do with that waste."[264]

226. She noted that potential inputs included such things as the waste products from the whisky and brewing industry to produce fish feed for the salmon industry, or from so-called fatbergs to produce products for the perfumery industry.[265] These feedstocks can be processed by engineering biology-enabled processes to produce useful products. Figure 6 illustrates the different types of products that can be produced from bio-based feedstocks with a "utilisation hierarchy"; some products are high-value and produced in low volumes, while others are low-value but require large-scale production. This might help to prioritise how limited feedstocks should be used, or suggest different feedstocks might be appropriate for different applications.

227. Professor Freemont told us that in the UK, C1 gas (methane) is "one of the obvious waste streams"; "those are the gas waste streams that come out of some of our industrial processes … There are organisms that will grow on C1 gas and produce products." He said that "there is a lot of R&D that needs to be done to look at organic waste streams, agricultural waste streams and gas waste streams."[266]

Figure 6: Biomass utilisation hierarchy



Source: Adapted from written evidence from the Bio-based and Biodegradable Industries Association (BBIA) (ENB0007).

264 Q 3 (Professor Susan Rosser)
265 Q 5 (Professor Susan Rosser)
266 Q 5 (Professor Paul Freemont)

228. However, as witnesses told us, securing these feedstocks is a challenge. Dr Peter Williams, Group Technology Director, INEOS said that whilst INEOS made "modest quantities of bioproducts today", "the single most important problem for us in trying to commercialise, to scale the approach is the availability of feedstock—bio feedstocks are in pretty short supply".[267] This was echoed by Greg Archer, Director of European Policy, LanzaTech UK. He said that in the immediate short-term, LanzaTech uses industrial waste gases, but that: "In the long term, we can take CO2 from the air through direct air capture and we can recycle that, but that is a very expensive process at present and one that requires enormous amounts of renewable electricity, both for the direct air capture and for the hydrogen."[268]

229. Mr Archer did note that with respect to waste valorisation, the shortage of feedstock is:

> "largely because we are wasting a lot of the waste that is available. We are still incinerating large amounts of our municipal and other wastes. We are producing very high carbon-intensity electricity in some cases, but in some cases without any energy recovery at all. These are valuable resources. Instead of incinerating these waste products, we could be gasifying, capturing the carbon and reusing it to make new chemical products."[269]

230. Professor Dame Angela McLean told us that this was "one of the big questions for … the engineering revolution: what are the feedstocks going to be? … as we move away from using oil and coal … we have to address the issue of what we will use instead."[270] She suggested that "the dream" would be to use waste plastics: "I have a fantasy that plastic is so valuable that you cannot find it anymore; it has all been scavenged up and sold to be made into useful, valuable products."[271] She told us that "as feedstock becomes rare and valuable, many things we currently put in the bin will become valuable too" as part of the "circular economy."[272]

231. However, Dr Hendrik Waegeman sounded a note of caution about the efficiency of waste valorisation, telling us that "when you are using sugar beet or sugar cane, you are … extracting the sugar out of that crop, but when you are using the remainder of the plant, you have to put in a lot of energy to get the remaining sugars out. As a result, that feedstock will be more expensive than using virgin material."[273]

232. The need to map the availability of feedstocks for bio-based industries was also highlighted by the National Physical Laboratory's December 2024 report into engineering biology (recommendations 7 and 8).[274]

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267 Q 98 (Dr Peter Williams)
268 Q 99 (Greg Archer)
269 Q 109 (Greg Archer)
270 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 2 (Professor Dame Angela McLean)
271 *Ibid.*
272 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 16 (Professor Dame Angela McLean)
273 Q 121 (Dr Hendrik Waegeman)
274 National Physical Laboratory (NPL), *Standards and metrics for Engineering Biology in the UK: Driving growth, investment and Engineering Biology powered solutions for UK companies* (December 2024): https://www.npl.co.uk/getattachment/research/biometrology/metrology-for-engineering-biology/resources/Standard-and-metrics-for-Engineering-Biology-in-the-UK.pdf.aspx?lang=en-GB [accessed 3 December 2024]

233. **A major motivation behind the development of engineering biology is to move production away from petrochemical-based initial feedstocks towards more sustainable alternatives, such as bio-based alternatives or valorised (recycled) waste, including waste carbon dioxide. Engineering biology offers a means of waste valorisation for some complex waste resources that are unsuitable for chemical processes. However, as with petrochemicals, each of these feedstocks has a global supply chain that must be considered, and some may not be suitable for the UK. We have seen with earlier biofuels efforts that there can be unintended consequences for the environment, land use, and sustainability if the feedstocks are not carefully considered.**

234. ***Any engineering biology strategy for the UK must consider carefully which feedstocks are available domestically and which might have to be imported, as well as the supply chain implications. DSIT should categorise, map and quantify relevant feedstocks, in particular for waste resources, and make this information publicly available. This could be used by industry, and should inform the technologies that are prioritised and supported through interventions such as public procurement.***

235. ***The UK needs a coherent strategy for waste valorisation, with clear financial incentives in place for companies that can find ways to turn waste back into useful products. Projects that have multiple benefits—for example, converting captured carbon dioxide and domestically-produced hydrogen into sustainable aviation fuels, which supports three industries and makes use of waste—should be prioritised.***

CHAPTER 6: OPERATIONAL CHALLENGES FOR ENGINEERING BIOLOGY

236. This chapter makes recommendations around public acceptability and engagement, as well as biosecurity issues, which should be addressed in order to ensure this technology is deployed responsibly and in a manner acceptable to the public.

Public acceptability

237. Public acceptability for the technology is also a long-standing concern with engineering biology. Dr Alexandra Freeman (now Baroness Freeman of Steventon)[275] set out some of the reasons why in written evidence, noting that for synthetic biology:

> "there are a lot of unknowns, it feels 'unnatural', 'inequitable'… and people are concerned that they are not able to control their exposure to it … This means that the potential benefits, costs, and the regulation need to be clear and agreed to by society."[276]

She highlighted the 2010 public dialogue run by the Biotechnology and Biological Sciences Research Council and the Engineering and Physical Sciences Research Council as an example of good engagement.[277]

238. Professor Paul Freemont said: "We have taken our eye off the ball a little bit in engaging with … our publics. I think we need to re-engage with that. When we started this whole field many years ago, we really did go out there and ended up with various dialogues and reports." As engineering biology moves into "the public domain", the sector needs to ensure "that the general consumer and citizen can begin to understand what this technology is and what it can do. We need to reactivate that … This will not work if customers, consumers or people do not accept it, or do not buy the products."[278] The British Science Association told us that "recent evidence on public attitudes to engineering biology in the UK is relatively scarce" and has declined since the early 2010s.[279]

239. Dr Freeman noted that "people considered synthetic biology both exciting and scary, with strong views that it should not be stopped, but that there were major risks involved [requiring] regulation and monitoring." She also noted that there was a need to "consider different applications of the technology (e.g. medical, agricultural, energy, environmental) separately, as they have different risk and benefit profiles."[280] Various witnesses raised historical controversies around genetically modified organisms as an example of how a lack of public engagement can hold technologies back.[281]

275 Baroness Freeman's evidence was submitted before she became a member of the House of Lords. We have therefore used the name under which the evidence was submitted for consistency.
276 Written evidence from Dr Alexandra Freeman (ENB0001)
277 UK Research and Innovation (UKRI), 'Corporate report - Synthetic biology: Public dialogue' (7 February 2010): https://www.ukri.org/publications/synthetic-biology-public-dialogue/ [accessed 10 October 2024]
278 Q 7 (Professor Paul Freemont)
279 Written evidence from the British Science Association (ENB0012)
280 Written evidence from Dr Alexandra Freeman (ENB0001)
281 Supplementary written evidence from Innovation and Knowledge Centre for Synthetic Biology (SynbiCITE) (ENB0006), American University of Sovereign Nations (ENB0010), British Science Association (ENB0012) and Dr Rodrigo Ledesma-Amaro (ENB0026)

240. Some witnesses emphasised the importance of a broader approach to responsible research and innovation. Researchers from the University of Edinburgh told us that it was "crucial not to confuse responsible innovation with mitigating biosecurity and biosafety risks. Responsible innovation goes beyond these concerns to ask, 'what kind of future do we want science and innovation to bring into the world?'"[282]

241. Professor Robin May told us:

> "the FSA has a critical responsibility in terms of consumer awareness … terms such as 'engineering biology' are not ones that most consumers are familiar with. There is a huge amount of mystique around lab-grown meat … our key role is … not about persuading people to eat more—or less—lab grown meat. It is just about explaining what it is, how the safety risks have been appraised, and, if it is on the market, why it is safe".[283]

242. On 29 November 2024, DSIT published the results of an online survey into engineering biology and public trust.[284] It showed that awareness of engineering biology was generally low, a widely held belief that it will have a positive impact on science, desire for regulation, transparency, and information to be made available to the public.

243. **Public acceptability of engineering biology is an important consideration and the approach will need to vary according to the application. Failure to understand and engage with the public could jeopardise some applications of engineering biology, as exemplified by historical controversies over genetically modified organisms, but at present public awareness is limited. There is a renewed need to build on early public engagement exercises, and to explain clearly what the new technologies are, what they can do, and how they are used, as products come to market. There is equally a need to understand what specific objections and concerns the public may have and how they can be addressed: this should build on existing work such as the initial opinion survey. The public also need to be able to make informed decisions about products and services they use.**

244. ***The Government should support a public engagement programme for engineering biology, focusing on consumer-facing products that have the potential to be available in the medium term. As part of their remit, regulators in these areas should explain the new technologies they are regulating and why, and they should be fully resourced to do this engagement work. UKRI should continue to fund research into public attitudes and dialogues around the ethical implications of engineering biology technologies as they come to market.***

282 Written evidence from Professor Jane Calvert (University of Edinburgh). Professor Sarah Hartley (University of Exeter), Dr Reuben Message (University of Edinburgh), Dr Rob Smith (University of Edinburgh), Dr Sophie Stone (University of Edinburgh) (ENB0024)

283 Q 62 (Professor Robin May)

284 Department for Science, Innovation and Technology, Research and analysis, *Engineering biology public trust survey findings* (29 November 2024): https://www.gov.uk/government/publications/engineering-biology-public-trust-survey-findings [accessed 9 January 2025]

Biosecurity and risk management

245. Much of the evidence we heard focused on the benefits of engineering biology. However, witnesses also discussed potential harms. Engineering biology is a dual-use technology: it has both civilian and military uses. Professor Dame Angela McLean told us that "there are risks associated with any emerging technology … a large part of government work is to make wise balancing decisions between the risks and the opportunities."[285] The British Science Association told us that "manipulating biological matter could … lead to the loss of biodiversity, human health problems, and opportunities for bioterrorism."[286] Dr Freeman told us that the British public had historically expressed "Concerns over security (biosecurity), particularly if there is global and unrestricted access to building-blocks."[287]

246. This risk has grown in part because the speed of production has increased whilst cost has decreased. Piers Millett, Executive Director at the International Biosecurity and Biosafety Initiative for Science, said that "developments in AI, machine learning and automated science are only making it quicker, faster, cheaper and easier to make things with biology, regardless of whether that is something to do good or something to do harm."[288] Written evidence from researchers at UCL told us that "the potential to … intend harm by creating new constructs … cannot be underestimated."[289] For example, scientists have recently warned about, and urged a moratorium on, the creation of "mirror life".[290] While the ability to do this is likely over a decade away and would require significant investment and technological advances, the possible severe negative consequences of its creation provide an example of the importance of forward-thinking regulation when a field is rapidly developing.

247. Sophie Rose, Senior Biosecurity Policy Adviser at the Centre for Long-Term Resilience set out a distinction between measures that might "prevent deliberate misuse or accidental" release, and the need for a robust public health system to respond to any kind of biosecurity event:

> "No matter whether we are talking about a natural pandemic, the result of an accident or the deliberate misuse of biology, once we get to that stage we are playing a very similar game where we are relying on our ability to keep people healthy and safe, irrespective of the origin … bolstering those elements covers all your possible pathways to harm."[291]

248. Ms Rose said that the COVID-19 pandemic "revealed that planning … had not considered a broad enough range of possibilities and therefore what actions might need to be taken", and "also emphasised that cuts in the public health space can be detrimental to our ability to respond" to public health events.[292]

285 Oral evidence taken before the Science and Technology Committee on 22 October 2024 (Session 2024–25), Q 5 (Professor Dame Angela McLean)
286 Written evidence from the British Science Association (ENB0012)
287 Written evidence from Dr Alexandra Freeman (ENB0001)
288 Q 41 (Piers Millett)
289 Written evidence from Chris Barnes, Paul Dalby, Emily Kostas, Gary Lye (ENB0036)
290 Katarzyna P. Adamala, 'Confronting risks of mirror life' *Science*, vol 386, Issue 6728, pp 1351–1353: https://www.science.org/doi/10.1126/science.ads9158 [accessed 9 January 2025]
291 Q 51 (Sophie Rose)
292 *Ibid.*

249. The June 2023 UK Biological Security Strategy outlines the previous Government's vision to make the UK "resilient to a spectrum of biological threats". It includes fifteen outcomes to support this vision, including:

- a real-time integrated Biothreats Radar,
- a national biosurveillance network,
- enhanced capability to rapidly roll out diagnostics for population use in response to new or existing biological threats,
- regular domestic and international exercises for biological threats, and
- the capability to scale up discovery and development of therapeutics and vaccines within 100 days, underpinned by targeted research and development programmes.[293]

250. Both Ms Rose and Mr Millett praised the ambition in the Biological Security Strategy. Ms Rose highlighted three elements in particular:

> "Updates to the Government's existing biosecurity governance structure include formalising central leadership and providing more opportunities for those people to come together and report on progress … They made some excellent commitments to leading internationally on responsible innovation … The strategy made a commitment to investing in the UK's capabilities with respect to bio surveillance."[294]

251. Both also said that explicit milestones and deadlines associated with the strategy would be useful. Mr Millett offered an example from the US of what form these might take, where an "executive order on AI included 180-day limits on coming up with national frameworks and for the national standards body to start consultations with relevant actors on what these standards internationally, or specifically domestically in the US, could look like."[295]

252. A number of public authorities are involved in implementing the UK Biological Security Strategy. Mr Millett said that the Strategy "highlight[s] how many different agencies are involved and who has the lead in different parts of the national strategy … it is an impressive example of an attempt at joined-up thinking in this space." Ms Rose noted that her "team is currently working on trying to assess each of the 15 priority outcomes and the three strategic enablers that accompanied those. We are trying to assess the progress on each of those."[296] Lord Vallance explained that "the biosecurity strategy lays out who has responsibility for each bit of this system" and that overall responsibility for that lay with the Cabinet Office.[297]

253. **Engineering biology is a dual-use technology—it poses risks to society as well as providing potential benefits. It is plausible that bad actors could utilise these technologies to produce or enhance novel pathogens, especially if the technology becomes more widely available and inexpensive.**

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293 HM Government, *UK Biological Security Strategy*, CP858 (July 2023): https://assets.publishing.service.gov.uk/media/64c0ded51e10bf000e17ceba/UK_Biological_Security_Strategy.pdf [accessed 10 October 2024]. These are Outcomes 1, 9, 10, 14.

294 Q 42 (Sophie Rose)

295 *Ibid.*

296 Q 52 (Sophie Rose)

297 Q 140 (Lord Vallance of Balham)

254. ***The new Government should explicitly commit to the key measures in the UK Biological Security Strategy around biosurveillance and population-level testing, empowering public health authorities such as UK Health Security Agency to learn and implement the lessons from the pandemic. The Government should publish an update on the implementation of the Biological Security Strategy by its second anniversary in June 2025 and set out actions that have been taken towards each of the outcomes.***

Biosurveillance, testing, vaccine, and therapeutics infrastructure

255. Ms Rose told us that prevention was key: "In relation to some of the commitments made in [the UK Biological Security Strategy] … that means that spending at that point feels like an insurance policy for preventing the later on-the-spot spending."[298] One aspect of this prevention is monitoring. Mr Millett told us that to assess what may represent a risk, it is necessary to know what is present in normal circumstances: "If we do not know what normal is, we do not know what unusual is".[299] Ms Rose also told us that it was "essential not only that we maintain a robust basic level of surveillance, but that our surveillance continues to develop to be able to deal with new threats and challenges."[300]

256. Professor Isabel Oliver, Director General of Science and Research and Chief Scientific Officer at the UK Health Security Agency (UKHSA), told us of a pilot scheme led by UKHSA, working with Defra and other government departments, which aims "to bring together surveillance data from humans, animals and the environment to allow us to detect and understand threats to health more rapidly and effectively than we are able to do otherwise … we are exploring the benefits of this, with the aim of informing future surveillance developments in the UK."[301] The Government set out some plans to form a new 'real-time surveillance system' for future pandemics in November 2024, as part of a partnership with Oxford Nanopore, Genomics England, UK Biobank, and NHS England.[302] On 5 December 2024, we published a letter into vaccine resilience in the UK which included recommendations for the Government in implementation for the Biological Security Strategy.[303]

257. **Many of the biosecurity measures the UK needs to take to protect against engineered pathogens are similar to those that should be taken against naturally occurring pathogens. There are many lessons to be learned from the pandemic which have not yet been reflected in changes to public policy. The recently announced 'early warning system' for pandemics is welcome and should be given long-term support.**

258. ***Key measures in the UK Biological Security Strategy, such as creating a robust system for biosurveillance and population-level testing***

298 Q 51 (Sophie Rose)
299 Q 52 (Piers Millett)
300 Q 65 (Professor Isabel Oliver)
301 Q 67 (Professor Isabel Oliver)
302 Department of Health and Social Care, Press release: *UK to create world-first 'early warning system' for pandemics* on 5 November 2024: https://www.gov.uk/government/news/uk-to-create-world-first-early-warning-system-for-pandemics [accessed 10 October 2024]
303 Letter from Baroness Brown of Cambridge, Chair of the Science and Technology Committee to Rt Hon Pat McFadden MP, Chancellor of the Duchy of Lancaster, Cabinet Office (5 December 2024): https://committees.parliament.uk/publications/45865/documents/227678/default/

to identify any new concerning pathogens, must be implemented without delay. The UK should have testing, vaccine and therapeutics infrastructure capable of being scaled up if a new pathogen emerges. Public health authorities such as UKHSA must be sufficiently resourced to undertake their responsibilities under the Biological Security Strategy, including more comprehensive biosurveillance and population testing measures.

259. **Ensuring any risks from engineering biology are well-managed will require a co-ordinated international approach.**

260. ***The UK must engage with, and where appropriate lead, global efforts to ensure that any risks from engineering biology are well-regulated internationally.***

DNA sequence screening

261. Ms Rose told us that international co-operation was key to mitigating the risks associated with engineering biology. This was particularly true given that the UK relies heavily on overseas companies in the US and China for DNA synthesis, although some novel methods of DNA synthesis were being developed in the UK.[304] Ms Rose said that there would be an advantage to the UK establishing a safety framework "to be able to set the standard for what best practice looks like".[305]

262. She told us that there were examples of success in this area, including "the US-UK strategic dialogue on biological security" which included "commitments on joint investment in R&D and working together on some of the issues of responsible innovation … and other areas of investment relating to biosecurity."[306]

263. Ms Rose added that she "would encourage the UK to complement that with additional engagement at the G7 and G20 level."[307] However, Mr Millett argued that:

> "When we move into multilateral global forums, the broader geopolitics are making progress very difficult. To get substantive work on this into the Biological Weapons Convention will be very challenging in the short to medium term, simply because there are states in the world that do not want to see outcomes from multilateral processes, regardless of the subject matter."[308]

264. Ms Rose also noted that nucleic acids screening, which would highlight whether engineered DNA posed a risk, was currently voluntary. She said that some companies "are signed up to the International Gene Synthesis Consortium … that commit to following a set of principles relating to this screening, but not all companies have to be part of that." These companies do some sequence screening, "looking at what their customers are ordering, and deciding whether they think that is appropriate."[309]

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304 Written evidence from the Wellcome Sanger Institute (ENB0021)
305 Q 42 (Sophie Rose)
306 Q 55 (Sophie Rose)
307 *Ibid.*
308 Q 56 (Piers Millett)
309 Q 56 (Sophie Rose)

265. Ms Rose told us that companies which the Centre for Long-Term Resilience had spoken to "indicated that it would be helpful for them for [screening] to be mandatory" for two reasons. First, because of the potential expense involved in resolving queries regarding a sequence of concern (SOC), mandatory screening "levels the playing field, by making sure it is not a competitive advantage for a company not to screen." Second, it makes it easier to justify requests for information from customers when they identify a SOC.[310] Regarding the SOCs, she told us: "there is no existing gold standard … when it comes to checking whether your customer is legitimate … That can make screening really difficult for companies."[311]

266. Ms Rose recommended that:

> "the UK Government should take a stepwise approach to building a more robust nucleic acid synthesis landscape. That could start with things like developing public-facing guidance on what best practice in the sequence screening and customer screening elements of those things would look like. What does it look like to do those things well?"[312]

267. On 8 October 2024, the Government published the 'UK screening guidance on synthetic nucleic acids for users and providers'.[313] This set out best practice guidelines as to how synthetic DNA orders should be screened for sequences of concern, and DSIT is supporting the adoption of its recommendations and encouraging other countries to adopt best practice.[314] This includes a requirement to maintain records of orders for sequences of concern for at least three years. However, the guidance remains voluntary. Mr Millett told us that a supplementary ISO standard would be valuable: "It would … become a de facto industry standard in many cases. With larger companies, once there is an ISO standard it is very difficult for compliance officers not to implement it."[315]

268. **One of the major points of intervention is in genetic sequencing and screening for 'sequences of concern' when DNA is synthesised, which can help to ensure that the creation of potentially harmful DNA sequences is carefully controlled. The recently announced Government guidance on screening synthetic nucleic acids was a good first step towards this. However, such screening currently takes place on a voluntary basis.**

269. ***The UK should work with international partners towards standardising the screening of sequences of concern, with a view to making DNA synthesis screening a mandatory requirement for anyone synthesising or ordering synthesised DNA in the UK. It should pursue export controls and international treaties to ensure that this takes place on a global basis.***

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310 Q 45 (Sophie Rose)
311 Q 44 (Sophie Rose)
312 Q 58 (Sophie Rose)
313 Department for Science, Innovation and Technology (DSIT), Guidance, *UK screening guidance on synthetic nucleic acids for users and providers* (8 October 2024): https://www.gov.uk/government/publications/uk-screening-guidance-on-synthetic-nucleic-acids/uk-screening-guidance-on-synthetic-nucleic-acids-for-users-and-providers [accessed 10 October 2024]
314 BIA, 'Safely unlocking the huge potential of synthetic nucleic acid in the UK' (14 October 2024): https://www.bioindustry.org/resource/safely-unlocking-the-huge-potential-of-synthetic-nucleic-acid-in-the-uk.html [accessed 10 October 2024]
315 Q 58 (Piers Millett)

Managing risks of bio-error or accidental release

270. As well as the deliberate use of engineering biology for adverse purposes, witnesses discussed the possibility of the accidental release of pathogens. This is the responsibility of the Health and Safety Executive (HSE). Ms Rose told us that whilst the HSE evaluates laboratories of a particular standard—with the frequency and depth of the evaluation depending on the level of security—"there would probably be immense benefit in facilitating more transparent reporting on accidents, near misses and safety incidents that take place at all of those facilities."[316]

271. **Bio-error or accidental release is also a clear risk, which should be mitigated as much as possible.**

272. ***The Health and Safety Executive needs to demonstrate that it has sufficient expertise and powers to monitor and prevent accidental release from the most secure facilities. It should be transparent about lab accidents that do occur so that lessons can be learned.***

Managing risks to biodiversity

273. Some witnesses raised concerns around the possible impact of genetic modification on biodiversity. For example, the UK Agri-Tech Centre told us that "there is potential for engineered organisms to outcompete native organisms … which could lead to changes in community structure [or] reduced biodiversity." They advised that "tools need to be in place to model potential environmental risks and to responsibly monitor engineered organisms post-release."[317]

274. Professor Talbot told us that he could see "many advantages" for Natural England being involved as a regulator for engineered plants, but that "the same should be true of any new plant variety entered into agriculture in terms of its effect on ecosystems … it is about the outcomes rather than the technology that was used to create the variety." He expressed concerns around the "massive monocultures" in UK agriculture helping to cause a "crash in biodiversity" and suggested that the environmental impact of any new agricultural product should be "part of the overall regulatory framework."[318]

275. **There is a potential for negative impacts on biodiversity if genetically engineered plants or animals outcompete native organisms.**

276. ***Regulators such as Natural England should be part of the regulatory framework for engineered plants and animals. This should include impact assessments on any possible risks to biodiversity from releasing engineered organisms into ecosystems or using them in agriculture.***

316 Q 42 (Sophie Rose)
317 Written evidence from the UK Agri-tech Centre (ENB0040)
318 Q 87 (Professor Nick Talbot)

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Chapter 2: Engineering biology: what and why?

1. Government witnesses told us that engineering biology has historically been an area of strength in UK research and development, and it is a potential driver of growth. The new Government has indicated that it still views it as a priority sector. However, as our report explores, other countries are beginning to overtake the UK and we are at severe risk of losing the prospective benefits of a world-leading engineering biology sector. (Paragraph 20)

Chapter 3: Government strategy for engineering biology

2. We welcome the idea of an industrial strategy to provide long-term certainty and a plan for investment and policy instruments to achieve specific goals. Such a strategy needs to support innovative, emerging and cross-cutting sectors like engineering biology, not just established industries. Clear decisions must be made about the areas where the UK has significant strengths and potential for industrial and economic development and where it can realistically secure global advantage. Short-term policies, particularly fiscal decisions relating to investment, but also on priorities, have created uncertainty that makes it difficult for businesses to invest. (Paragraph 31)

3. There is a perception in the sector that the UK was a leader in engineering biology ten years ago, but that inconsistent Government investment has allowed other countries to overtake the UK. A long-term strategy with clear commitment to engineering biology is key. The National Vision for Engineering Biology was broadly welcomed by the sector and covers many of the key areas that our inquiry identified as requiring policy action. However, the Vision is lacking in terms of specific outcomes. (Paragraph 32)

4. *The Government's industrial strategy should set out a clear plan for developing engineering biology and other key technologies that can underpin industrial development across sectors. It should recommit to, and build on, the work from the Science and Technology Framework and National Vision for Engineering Biology, and set out how foundational technologies like engineering biology will be supported and pulled through into application across sectors.* (Paragraph 33)

5. *This will require coordinated action across a range of policy areas covered in this report, including:*

   - *public investment, including R&D, the roles of UKRI and the National Wealth Fund*
   - *public policy, including procurement*
   - *private investment to support scale-up*
   - *skills and visas*
   - *regulation and standards*
   - *infrastructure*
   - *incentives and mandates.* (Paragraph 34)

6. *The strategy should set out a clear direction of travel in these policy areas, identifying areas where the UK has a potential to excel, with more specific metrics and outcomes,*

and the Government should provide regular updates on progress towards these targets. (Paragraph 35)

7. The National Vision for Engineering Biology, issued under the previous Government, committed to £2 billion in public funding over the next ten years. At least this level of investment will be needed to compete with the scale of funding set out by rival nations and to maintain the UK's engineering biology R&D sector. However, it is uncertain whether the new Government is committed to this level of spending. There is also some uncertainty over whether this represents new money, or just a continuation of historic levels of investment from UKRI in engineering biology, and few concrete funding announcements have been made since the initial £2 billion commitment was made. The five-year funding cycle has proved detrimental for long-term research in this area. (Paragraph 43)

8. *The Government should, as a matter of urgency, recommit to the target set out in the National Vision for at least £2 billion of funding over the next decade. It should set out more details of how it intends to allocate this funding between R&D, skills, and infrastructure, as well as which areas of engineering biology the UK has potential to excel at and desirable outcomes it wishes to achieve from the funding. Longer-term certainty around funding could form part of the new Government's commitment to provide ten-year R&D budgets to key research institutions.* (Paragraph 44)

9. There is a need to embed individuals who understand the potential of this technology throughout the system—including regulators and procurement officials. The Department for Science, Innovation and Technology has a unique and important role to play in coordinating the development of key technological sectors such as AI and engineering biology. This will require specific scientific and industry expertise in the department and other relevant government bodies. (Paragraph 49)

10. *DSIT, and the Government more widely, must be able to hire individuals with appropriate technical and industrial expertise, being flexible about pay scales and seconding from industry where necessary.* (Paragraph 50)

11. DSIT cannot act alone to support engineering biology and must be supported by other departments with significant operational and procurement budgets in the areas that stand to be affected by engineering biology, or those that sponsor regulators. A renewed commitment and shared sense of ownership is needed across the whole of Government to implement the UK's science and technology policy, in line with the Growth Mission. We were pleased that the Minister acknowledged this and that the Government appears to be taking steps to embed a joined-up approach. This should be led by a national sector champion. (Paragraph 55)

12. *The other departments implicated in the Science and Technology Framework, including departments with significant procurement budgets and the Treasury, should support engineering biology and the objectives of the Science and Technology Framework. Formal coordinating mechanisms, such as regular meetings at ministerial and senior staff level should be put in place.* (Paragraph 56)

13. *Cross-governmental working efforts should include the appointment of a national sector champion for engineering biology. This should be a recognised, high-profile figure from industry or academia who can exercise convening power and lead on delivering the sectoral strategy for engineering biology.* (Paragraph 57)

14. The Government's Science and Technology Framework set out ambitions to use public procurement to 'pull through' key technologies. This can be a very powerful tool—the example of the Department of Defense and DARPA in the US illustrates this. Public procurement could help bridge the scale-up funding gap by providing companies with contracts to produce novel or innovative products or services which then attract private investment. It can also help address the problems faced by departments in innovative ways and achieve the Government's wider aims in the public sector. (Paragraph 69)

15. There are a range of different procurement opportunities involving engineering biology across Government. This could include supplying sustainable fuels, supporting waste valorisation, or novel methods for DNA synthesis. However, this is hindered by a culture of risk aversion, as well as procurement rules that prevent advanced purchase of technologies. Using public procurement to support innovative technologies will not succeed if departments do not view this as part of their remit. Ministers must provide the clear political support needed for a higher risk tolerance to empower officials to make these decisions. (Paragraph 70)

16. *The Government should seek to support engineering biology in the UK through its public procurement. It should learn from the example of the US's BioPreferred programme. The Government should consider setting aside a mandatory percentage of procurement budgets which will be used to support innovative, UK-based SMEs and new technologies. These budgets could be subject to broader considerations for value-for-money than are currently used and subjected to alternative targets for auditing. This will encourage the development of a healthier risk appetite: civil servants who work on procurement who are well-versed in the technologies that the Government wants to support and are empowered to authorise a range of potentially riskier but more rewarding contracts.* (Paragraph 71)

17. *Departments should work with UK agencies like the Advanced Research and Invention Agency and Innovate UK to identify opportunities for procurement to support novel technologies and achieve the Government's wider policy aims, such as on sustainability. This should be done in line with the UK's broader industrial strategy. The Government should set out how the Cabinet Office's cross-government plan mentioned in the Science and Technology Framework will support innovative procurement practice across departments.* (Paragraph 72)

Chapter 4: Policy to support engineering biology

18. Maintaining the UK's academic and industrial position in engineering biology will require training the next generation of doctoral students. So far, only two Centres for Doctoral Training have been announced for engineering biology compared to many more for AI. The UK risks falling behind the training offered by other countries. There is also a need to encourage more research in interdisciplinary areas of science and technology, as well as at the interface between academia and industry. Doctoral training that includes a component of working in industry is crucial to strengthening the links between universities, start-up companies and larger companies as well as preparing researchers to commercialise UK engineering biology applications. (Paragraph 83)

19. *The Government, through UKRI, should urgently commit to fund more doctoral training centres for engineering biology. Links between these programmes and industry must be strengthened: the majority of these places should provide a funded year in industry as part of the programme to give students either experience of*

working at cutting-edge engineering biology start-up companies or SMEs, or the opportunity to transfer their skills, knowledge, and ways of working into larger companies. (Paragraph 84)

20. There are significant gaps in training for gaining practical, industrial engineering biology skills that do not require a full PhD—for example, fermentation techniques in industrial biotechnology. Technical and technician skills are in short supply and industry witnesses told us that skilled individuals who acquire them are hard to retain. There is also a relative lack of individuals with industrial-scale fermentation skills and many of those that do have these skills are attracted into medical engineering biology fields where the profit margins can be greater and the industry is more mature. (Paragraph 93)

21. *There is a need to expand the number of routes into the engineering biology sector, especially when it comes to developing technical and industrial experience. Skills England should work with industry, PSREs and universities to provide flexible funding for apprenticeships, including degree apprenticeships. This would provide more routes into the engineering biology sector and enable the training of the next generation of technicians. UKRI should support a Masters' level conversion course suitable for undergraduates to learn some of the practical, lab-based and industrial skills required for engineering biology and related techniques.* (Paragraph 94)

22. In engineering biology, as in many other areas of science, the UK is in a global competition for talent. However, restrictive visa policies, high visa fees, upfront Immigration Health Surcharge costs, and a perceived hostile attitude to immigration, are jeopardising the UK's ability to attract and retain the best talent. The UK already suffers due to lower salaries and higher cost of living than many competitor nations, such as the US and in Europe. The UK still has universities with world-leading research that attract skilled individuals, but it must do more to retain them. There are deep concerns that recent immigration reforms will deter talent and harm growing industries such as engineering biology. (Paragraph 103)

23. *The UK must rethink its attitude to immigration for skilled workers in scientific and technical sectors, as we are falling behind in the global race for talent. The Global Talent Visa should be expanded from a few thousand issued a year, with more routes for organisations to sponsor this visa beyond the relatively small number of primarily academic organisations who are currently listed as sponsors. Specifically, it should support applicants with entrepreneurial, manufacturing and industrial skills as well as scientific ones. Additional visa routes that allow for flexible hybrid working should be considered, as other countries have put in place.* (Paragraph 104)

24. *More must be done to reduce up front visa costs and resettlement costs for top talent in competitive scientific and technical fields. If the Immigration Health Surcharge is retained, the burden of payment must be reduced by allowing individuals to pay on an annual basis or a monthly basis by deduction from salary, rather than paying the full cost up-front. The Government should benchmark postdoctoral salaries against comparative salaries in Europe. Action must be taken urgently to ensure the UK remains an attractive destination for increasingly mobile global talent.* (Paragraph 105)

25. We welcome the establishment of the Engineering Biology Regulators' Network (EBRN) and the Regulatory Innovation Office (RIO), which are good first steps in creating a coherent, pragmatic, pro-innovation regulatory regime for engineering biology. However, regulatory pathways for new

engineering biology products and technologies remain unclear. In such a fast-moving sector, early coordination between industry and regulators is crucial, but those we spoke to in the industry did not know which regulators were included in the EBRN initiative. The EBRN has not yet fulfilled the goals that were set in Dame Angela McLean's recommendations and has no public-facing offer to companies yet. With the creation of the RIO, the ongoing status of the EBRN is now unclear. (Paragraph 113)

26. *The EBRN and RIO should be sufficiently resourced to have a public-facing offer that maps out which categories of engineering biology products map onto which regulators and sets out a streamlined regulatory pathway. The "coherent taxonomy" and roadmap to regulatory approval recommended by Dame Angela McLean should be published, and the Government should set out a clear timeline for this in its response. There should be a single resource or point of contact published by these bodies for companies in the sector seeking to understand the regulatory implications of any products or services they might develop. The "regulatory support service" for small science and technology companies mentioned in DSIT's Science and Technology Framework should be pursued and could provide this interface.* (Paragraph 114)

27. *The membership and activity of the Engineering Biology Regulators' Network should be made public as a necessary first step. There should be clear individuals or teams responsible for coordinating with the network within each regulator.* (Paragraph 115)

28. If the UK is to become a leading nation in engineering biology, it needs world-leading regulators that can anticipate areas where regulatory clarity is needed, and set out a very clear regulatory path to market for new technologies with swift timelines for assessment and approval. Engineering biology is a rapidly moving scientific field with implications for a range of different regulators, which will need to be capable of understanding and managing emerging risks. They will require the necessary scientific skills and industrial experience to craft regulatory frameworks that achieve the goals in the National Vision for Engineering Biology and enable the field to move forward at pace in the UK. (Paragraph 122)

29. *The UK needs to develop a world-class regulatory approach for engineering biology, characterised by being swift, effective, and involving leading experts. Regulators need to be appropriately resourced to work with businesses to assess new technologies early and mitigate any unintended consequences from their use. They must be able to bring in the relevant expertise to regulate the sector appropriately, proactively, and swiftly, with timelines that are competitive with other nations.* (Paragraph 123)

30. Some of the secondary legislation which was expected to be made under the Genetic Technology (Precision Breeding) Act 2023 was not made in the last Parliament but was seen as necessary to help create regulations that would allow for experimentation in plant breeding to take place in the UK. (Paragraph 125)

31. *The secondary legislation for the Genetic Technology (Precision Breeding) Act 2023 should be passed urgently to establish a regulatory framework that provides certainty, in accordance with the Act's provisions.* (Paragraph 126)

32. A set of coherent standards are necessary for any industry to scale-up. They can allow for more interoperable and less disjointed processes between companies, as well as to promote consumer and industrial confidence. A

lack of a coherent set of standards in engineering biology is holding back the emerging sector, where the inherent variability of biological processes makes standards particularly important. There is an opportunity for the UK to be a leader in standard-setting and ensure that the standards are compatible with the UK's strengths. (Paragraph 132)

33. *The Government should work with the National Physical Laboratory, the British Standards Institution, industry partners, national laboratories like the Centre for Process Innovation and ISO organisations to assist in the development of standards across the engineering biology industry. Data-sharing should be encouraged between different companies to enable standardisation of processes and products. Schemes that encourage and support start-up companies and SMEs to access national laboratories could assist in this data-sharing.* (Paragraph 133)

34. Many countries are currently seeking to regulate engineering biology and international standards and regulations will be important for trade. Sending high-level delegations to ISO meetings is important to maintain the UK's influence. (Paragraph 134)

35. *The UK should engage at the most senior, expert level with EU and international standards—through organisations like the International Organization for Standardization (ISO)—to ensure that the UK can influence these and are not disadvantaged by international standards and regulations.* (Paragraph 135)

36. Biological processes are inherently more variable than chemical or industrial processes. It is therefore crucial to be able to test these processes and demonstrate that they can be replicated reliably at scale. This need to obtain large amounts of data on a process is a key barrier to defining and protecting intellectual property, and hence to securing investment. Start-up companies face a 'chicken and egg' problem whereby they need data to obtain patents to get access to funding, but they need the funding to access the labs in order to generate the data. A few companies have been able to invest and build laboratories and infrastructure themselves, but this type of development is difficult to fund from venture capital and other private sector investors. There is a clear need to ensure existing facilities are easier to access. (Paragraph 139)

37. We heard no evidence that suggested UK intellectual property law was not fit for purpose, but that barriers to obtaining patents in practice needed to be addressed. (Paragraph 140)

38. *The Government should work with public sector research establishments and universities to make national and university laboratories accessible for the purpose of assembling the data required for start-up and spin-out companies to file patents. Innovate UK should consider providing additional funding to help small and early stage companies obtain the data needed for patents which can unlock additional private sector funding. National laboratories, public sector research establishments and related research infrastructure should add the number of patent applications they have supported to their key performance indicators.* (Paragraph 141)

39. The UK already has some significant infrastructure that supports the growth of the engineering biology sector, such as the biofoundries and the Centre for Process Innovation. However, they are not always used to their maximum potential, in part because they are expensive for start-up companies and researchers to use owing to their cost recovery models. The UK risks losing valuable research infrastructure because too often funding is allocated to

setting up new research institutes and laboratories without considering a sustainable, long-term funding model for existing labs. Funding for research infrastructure in the UK is falling behind comparable countries. There is a need for start-ups and spin-outs to use these scale-up facilities to engage with the practical problems of scaling up their products and processes at an earlier stage. (Paragraph 156)

40. *The stop-start funding of research infrastructure must end. The Government should set a timeline for producing its long-term national plan for research infrastructure. In the Spending Review, it should use some of the new flexibility for infrastructure spending to fund R&D infrastructure.* (Paragraph 157)

41. *The Government should provide more funding to enable greater use of existing engineering biology research infrastructure, such as the biofoundries and the CPI. This could be in the form of block grants for those institutions to maintain their operations and reduce the cost recovery that they must charge users, or grants for using these facilities, as the EU offers for the Bio Base Europe Pilot Plant. The scale-up facilities should have an enhanced educational role to play with preparing researchers and start-ups to engage with the practicalities of scaling up their processes at an earlier stage.* (Paragraph 158)

42. One reason that facilities are under-utilised is that researchers and SMEs have a lack of awareness of the equipment, specialisms and capabilities that are available in universities and public sector research establishments, and the terms of use of different facilities are not always transparent. (Paragraph 159)

43. *As part of its long-term national plan for research infrastructure, DSIT should map out the existing capabilities of innovation infrastructure in its key technology areas (including engineering biology) and the terms for using them. It should identify and address any barriers to accessing existing facilities in this area, such as the biofoundries, and Catapults, including the CPI. Interconnectivity of existing infrastructure should be encouraged to ensure that there are clearer pathways for scaling-up processes and production. AI and compute infrastructure should be made accessible for applications of machine learning, such as those in engineering biology.* (Paragraph 160)

44. There is a need for more scale-up infrastructure, in particular large-scale fermentation facilities, which would allow for the scale-up of processes that have been demonstrated in the lab. As the sector develops, there will be an increasing need for more specialist facilities that relate to specific applications. Much of this will be developed by the private sector, but the Government still has a role in supporting private and public-private investment for manufacturing infrastructure. (Paragraph 169)

45. *The Government should ensure that the UK has a competitive answer to the scale-up infrastructure provided by facilities like the Bio Base Europe Pilot Plant, responding to the work done by GO-Science and DSIT in this area. In particular, existing fermentation facilities and facilities like the CPI which focus on non-life sciences applications of engineering biology should be supported. The Government's proposed reforms to the planning system should encourage the development of laboratory space around existing clusters for the life sciences.* (Paragraph 170)

Chapter 5: Engineering biology for growth

46. There is a long-standing and severe problem in the UK with the ability of science and technology companies to scale up. We heard many times that the

UK is quite competitive when it comes to start-up and spin-out companies, but that such companies struggle to grow and often move abroad, especially to the US, for funding or to float on stock exchanges when they reach a certain size. This limits the economic benefits captured by the UK. A lack of sovereign large companies in the UK also limits opportunities for investment and acquisition of new companies and processes here. What we heard from engineering biology companies provides an example of a much more general, and long-standing problem. (Paragraph 176)

47. *There are many factors behind this failure to scale and the Government needs to initiate coordinated policy initiatives on multiple fronts to turn it around, including the areas of public and private investment (such as the Mansion House reforms), infrastructure, skills, regulation, adoption by larger companies, and public procurement we address in this report.* (Paragraph 177)

48. We have heard that there is a significant role for public investment, especially to support research infrastructure and also to de-risk larger investments on the scale of tens of millions of pounds which are lacking in the UK. The UK must fill the gap at this level of investment, through a combination of public and private efforts, to prevent promising companies from going overseas. We have also heard that a sovereign wealth fund could support the goals of an industrial strategy. However, as currently constituted, it is not clear that the new National Wealth Fund has a remit that would allow it to invest in engineering biology in this way. (Paragraph 187)

49. *The Government should urgently expand the scope and scale of its National Wealth Fund to ensure it can include investments in technologies such as engineering biology that support the aims of its industrial strategy. A specialist investment team for engineering biology as a part of the National Wealth Fund should be established to enable it to identify and make these investments.* (Paragraph 188)

50. It is not always clear that the Government has a consistent sense of the role it wants to play as an investor, or that businesses know who to approach for large-scale investment. The respective roles that Innovate UK, the National Wealth Fund and the British Business Bank should play in supporting scale-up companies and the deal sizes that they seek to undertake have not been fully set out. There is also a relative lack of capital grants in engineering biology compared to other areas of the life sciences, although engineering biology offers the UK an opportunity to translate its success in the life sciences into other sectors of the economy. (Paragraph 189)

51. *There is a need for a clear, joined-up pipeline of funding to support companies to make the transition over the 'valley of death' from research, through pilot-scale and scale-up, to funding for larger companies with a commercial product. This will require coordination between bodies like the National Wealth Fund and British Patient Capital, which could focus on de-risking larger-scale infrastructure investments and providing late-stage equity funding, and agencies like Innovate UK and research councils, which should focus on expanding existing programmes to support research and pilot-scale investments. It will also require coordination with the Government's public procurement policy to pull through innovative technologies, discussed earlier. The Government should also consider a capital grant scheme to support non-medical engineering biology in the same way as the Life Sciences Innovative Manufacturing Fund currently supports the medical applications.* (Paragraph 190)

52. Witnesses raised concerns about the ability and willingness of private investors to invest in UK engineering biology companies. Some told us that

institutional investors are reluctant to invest in UK companies due to a lack of sophisticated research or excessive focus on the financials of companies, rather than the technology's potential. In some cases the economics of these firms can be marginal, especially to begin with as they develop their products. In addition, equity capital markets in the UK are shrinking on a relative basis, and the rise of passive investment has resulted in globalised, diversified pension funds which invest to a lesser degree in UK companies. This can result in a 'doom loop' whereby pension funds invest less in UK equities, which in turn makes them less profitable. We welcome that the Government has acknowledged this and committed to pension reform. However, new, consolidated pension funds will still need expertise and incentives to identify and invest in innovative UK companies. The UK needs more capital, but also more focus on the specific areas that it can excel in. (Paragraph 202)

53. *The UK should pursue reforms to the financial sector that encourage investment in UK companies, including the Mansion House reforms in the pension sector, which need to be more ambitious and faster. Maintaining a sophisticated investment ecosystem requires some large UK investors in the sector, and reform is needed to slow the decline of active investment. Pension reforms should consider ways of supporting consolidated pension funds to invest in small, innovative UK tech companies and provide scale-up capital for them, as part of their diversified portfolios, including by supporting the development of tech expertise among investors.* (Paragraph 203)

54. One of the major barriers for engineering biology in the UK is the lack of large Tier 1 manufacturers at the 'top of the ecosystem' outside the life sciences. These large companies can play a crucial role in successful innovation ecosystems by buying out smaller companies, co-funding additional research, and converting science into products and services. (Paragraph 211)

55. *The UK needs a clearer direction of travel when it comes to which parts of the biomanufacturing supply chain it intends to have domestically. Any sectoral strategy must carefully consider which existing companies might ultimately invest in biomanufacturing in the UK. These should be linked to the priority areas and outcomes for engineering biology that the Government should identify and support. Broader infrastructure issues, such as ready access to cheap electricity, are holding the manufacturing sector back and should be addressed by the industrial strategy.* (Paragraph 212)

56. Among the larger manufacturing companies that do exist, there is a reluctance to adopt engineering biology solutions. We were concerned that we had limited engagement from larger companies during this inquiry. While bio-based technologies can be more sustainable, they are also more expensive to adopt initially. Without significant incentives or mandates to act as a 'pull factor' for supporting these technologies, these companies are unlikely to move away from current practice on their own. There is an urgent need to create a market for engineering biology products and technologies that can displace fossil fuels in order to incentivise pull-through of technologies such as engineering biology. As with the example of the sustainable aviation fuel mandate, there is a need for the Government to create the market to incentivise switching production. (Paragraph 218)

57. *The Government should introduce incentives which encourage manufacturing companies, for example in the chemicals and fossil fuel industries, to fund research, development and production in biomanufacturing and engineering biology. For example:*

- *carbon taxes or other taxes on pollutants or raw material waste,*
- *mandates for processes that currently use fossil-fuel feedstocks, but where a viable alternative could be scaled-up.* (Paragraph 219)

58. *The Government should initially mandate that a certain small percentage of the production was done using bio-based processes, with a view to increasing this percentage over time.* (Paragraph 220)

59. A major motivation behind the development of engineering biology is to move production away from petrochemical-based initial feedstocks towards more sustainable alternatives, such as bio-based alternatives or valorised (recycled) waste, including waste carbon dioxide. Engineering biology offers a means of waste valorisation for some complex waste resources that are unsuitable for chemical processes. However, as with petrochemicals, each of these feedstocks has a global supply chain that must be considered, and some may not be suitable for the UK. We have seen with earlier biofuels efforts that there can be unintended consequences for the environment, land use, and sustainability if the feedstocks are not carefully considered. (Paragraph 233)

60. *Any engineering biology strategy for the UK must consider carefully which feedstocks are available domestically and which might have to be imported, as well as the supply chain implications. DSIT should categorise, map and quantify relevant feedstocks, in particular for waste resources, and make this information publicly available. This could be used by industry, and should inform the technologies that are prioritised and supported through interventions such as public procurement.* (Paragraph 234)

61. *The UK needs a coherent strategy for waste valorisation, with clear financial incentives in place for companies that can find ways to turn waste back into useful products. Projects that have multiple benefits—for example, converting captured carbon dioxide and domestically-produced hydrogen into sustainable aviation fuels, which supports three industries and makes use of waste—should be prioritised.* (Paragraph 235)

Chapter 6: Operational challenges for engineering biology

62. Public acceptability of engineering biology is an important consideration and the approach will need to vary according to the application. Failure to understand and engage with the public could jeopardise some applications of engineering biology, as exemplified by historical controversies over genetically modified organisms, but at present public awareness is limited. There is a renewed need to build on early public engagement exercises, and to explain clearly what the new technologies are, what they can do, and how they are used, as products come to market. There is equally a need to understand what specific objections and concerns the public may have and how they can be addressed: this should build on existing work such as the initial opinion survey. The public also need to be able to make informed decisions about products and services they use. (Paragraph 243)

63. *The Government should support a public engagement programme for engineering biology, focusing on consumer-facing products that have the potential to be available in the medium term. As part of their remit, regulators in these areas should explain the new technologies they are regulating and why, and they should be fully resourced to do this engagement work. UKRI should continue to fund research into public*

attitudes and dialogues around the ethical implications of engineering biology technologies as they come to market. (Paragraph 244)

64. Engineering biology is a dual-use technology—it poses risks to society as well as providing potential benefits. It is plausible that bad actors could utilise these technologies to produce or enhance novel pathogens, especially if the technology becomes more widely available and inexpensive. (Paragraph 253)

65. *The new Government should explicitly commit to the key measures in the UK Biological Security Strategy around biosurveillance and population-level testing, empowering public health authorities such as UK Health Security Agency to learn and implement the lessons from the pandemic. The Government should publish an update on the implementation of the Biological Security Strategy by its second anniversary in June 2025 and set out actions that have been taken towards each of the outcomes.* (Paragraph 254)

66. Many of the biosecurity measures the UK needs to take to protect against engineered pathogens are similar to those that should be taken against naturally occurring pathogens. There are many lessons to be learned from the pandemic which have not yet been reflected in changes to public policy. The recently announced 'early warning system' for pandemics is welcome and should be given long-term support. (Paragraph 257)

67. *Key measures in the UK Biological Security Strategy, such as creating a robust system for biosurveillance and population-level testing to identify any new concerning pathogens, must be implemented without delay. The UK should have testing, vaccine and therapeutics infrastructure capable of being scaled up if a new pathogen emerges. Public health authorities such as UKHSA must be sufficiently resourced to undertake their responsibilities under the Biological Security Strategy, including more comprehensive biosurveillance and population testing measures.* (Paragraph 258)

68. Ensuring any risks from engineering biology are well-managed will require a co-ordinated international approach. (Paragraph 259)

69. *The UK must engage with, and where appropriate lead, global efforts to ensure that any risks from engineering biology are well-regulated internationally.* (Paragraph 260)

70. One of the major points of intervention is in genetic sequencing and screening for 'sequences of concern' when DNA is synthesised, which can help to ensure that the creation of potentially harmful DNA sequences is carefully controlled. The recently announced Government guidance on screening synthetic nucleic acids was a good first step towards this. However, such screening currently takes place on a voluntary basis. (Paragraph 268)

71. *The UK should work with international partners towards standardising the screening of sequences of concern, with a view to making DNA synthesis screening a mandatory requirement for anyone synthesising or ordering synthesised DNA in the UK. It should pursue export controls and international treaties to ensure that this takes place on a global basis.* (Paragraph 269)

72. Bio-error or accidental release is also a clear risk, which should be mitigated as much as possible. (Paragraph 271)

73. *The Health and Safety Executive needs to demonstrate that it has sufficient expertise and powers to monitor and prevent accidental release from the most secure facilities.*

It should be transparent about lab accidents that do occur so that lessons can be learned. (Paragraph 272)

74. There is a potential for negative impacts on biodiversity if genetically engineered plants or animals outcompete native organisms. (Paragraph 275)

75. *Regulators such as Natural England should be part of the regulatory framework for engineered plants and animals. This should include impact assessments on any possible risks to biodiversity from releasing engineered organisms into ecosystems or using them in agriculture.* (Paragraph 276)

APPENDIX 1: LIST OF MEMBERS AND DECLARATIONS OF INTEREST

Members

Lord Berkeley
Lord Borwick
Baroness Brown of Cambridge (Chair)
Lord Drayson
Lord Lucas
Baroness Neuberger
Baroness Neville-Jones
Baroness Northover
Lord Rees of Ludlow
Viscount Stansgate
Lord Strasburger
Lord Wei
Baroness Willis of Summertown
Baroness Young of Old Scone

Declarations of interest

Lord Berkeley

No relevant interests

Lord Borwick

No relevant interests

Baroness Brown of Cambridge (Chair)

Chair of Frontier IP

Chancellor of Cranfield University

Lord Drayson

I am a shareholder of Arcturis Data Limited (formerly Sensyne Health plc) (healthcare technology company).

I am a shareholder and a director and Chairman of Appella AI Limited (technology company developing AI conversational tools)

I am a director of Isovia Health Limited (health technology company)

I am an Industry Adviser, Advent International Corporation (private equity firm)

I am an Honorary Supernumerary Fellow, St John's College, Oxford

Lord Lucas

No relevant interests

Baroness Neuberger

Chair, University College London Hospitals NHS Foundation Trust

Chair, Whittington Health NHS Trust

Baroness Neville-Jones

No relevant interests

Baroness Northover

Member of Council, London School of Hygiene and Tropical Medicine - unpaid position

Visiting Honorary Professor, Institute of Global Health Innovation, Imperial College London - unpaid position

Trustee, MedAccess Trust (seeking to promote the advancement of health in poorly served populations of ODA eligible countries) - unpaid position

Lord Rees of Ludlow

No relevant interests

Viscount Stansgate

No relevant interests

Lord Strasburger

No relevant interests

Lord Wei

No relevant interests

Baroness Willis of Summertown

Professor of Biodiversity in the Department of Biology and Principal of St Edmund Hall, University of Oxford

Non-Executive director of NatCap Research

Baroness Young of Old Scone

Commissioner, Food, Farming and the Countryside Commission

Chair, Royal Veterinary College

A full list of Members' interests can be found in the Register of Lords' Interests: https://www.parliament.uk/mps-lords-and-offices/standards-and-interests/register-of-lords-interests/

APPENDIX 2: LIST OF WITNESSES

Evidence is published online at https://committees.parliament.uk/committee/193/science-and-technology-committee/publications/written-evidence/ .and available for inspection at the Parliamentary Archives (020 7219 3074).

Evidence received by the Committee is listed below in chronological order of oral evidence session and in alphabetical order. Those witnesses marked with ** gave both oral and written evidence. Those marked with * gave oral evidence and did not submit any written evidence. All other witnesses submitted written evidence only.

Oral evidence in chronological order

**	Professor Paul Freemont, Co-Director, Innovation and Knowledge Centre for Synthetic Biology (SynbiCITE)	QQ 1–7
*	Dr Carolina Grandellis, Earlham Biofoundry Manager, Earlham Institute	QQ 1–7
*	Professor Susan Rosser, Co-Director, Edinburgh Genome Foundry	QQ 1–7
*	Professor Tom Ellis, Professor of Synthetic Genome Engineering, Imperial College London	QQ 8–16
*	Dr Lucia Marucci, Associate Professor in Systems and Synthetic Biology, University of Bristol	QQ 8–16
*	Will Milligan, Chief Executive Officer, Extracellular	QQ 17–34
**	Dr Jim Ajioka, Chief Scientific Officer, Colorifix	QQ 17–34
*	Rosemary Sinclair Dokos, SVP of Product and Programme Management, Oxford Nanopore Technologies	QQ 17–34
**	Dr Martin Turner, Associate Director, UK BioIndustry Association.	QQ 35-40
*	Mark Bustard, Chief Executive Officer, Industrial Biotechnology Innovation Centre	QQ 35-40
*	Piers Millett, Executive Director, International Biosecurity and Biosafety Initiative for Science	QQ 41–59
*	Sophie Rose, Senior Biosecurity Policy Adviser, Centre for Long-Term Resilience	QQ 41–59
**	Dr Michael Adeogun, Head of Strategy (Life Sciences and Health), National Physical Laboratory	QQ 60–70
**	Professor Robin May, Chief Scientific Adviser, Food Standards Agency	QQ 60–70
*	Professor Isabel Oliver, Director General of Science and Research and Chief Scientific Officer, UK Health Security Agency (UKHSA)	QQ 60–70
*	Dr Clive Dix, Executive Chair, C4X Discovery	QQ 71–85
*	The Rt Hon Lord Willetts, Co-founder, SynBioVen	QQ 71–85

**	Dr Sara Holland, Patent Attorney, Potter Clarkson	QQ 71–85
*	Graeme Cruickshank, Chief Technology & Innovation Officer, Centre for Process Innovation	QQ 86–97
*	Professor Nick Talbot, Executive Director and Group Leader, The Sainsbury Laboratory	QQ 86–97
*	Dr Peter Williams, Group Technology Director, INEOS	QQ 98–114
*	Greg Archer, Director of European Policy, LanzaTech UK	QQ 98–114
**	Dr Charles Hall, Head of Research, Peel Hunt	QQ 98–114
*	Fiona Mischel, Director of International Outreach, SynBioBeta	QQ 115–122
*	Dr Mary Maxon, Executive Director, BioFutures, Schmidt Sciences	QQ 115–122
*	Dr Hendrik Waegeman, Head of Business Operations, Bio Base Europe Pilot Plant	QQ 115–122
*	Lord Vallance of Balham, Minister of State, Department for Science, Innovation and Technology	QQ 123–155
*	Dr Isabel Webb, Deputy Director for Technology Strategy and Security, Department for Science, Innovation and Technology	QQ 123–155
*	Alexandra Jones, Director-General for Science, Innovation and Growth, Department for Science, Innovation and Technology	QQ 123–155

Alphabetical list of witnesses

	Agricultural Biotechnology Council (abc)	ENB0025
**	Dr Jim Ajioka, Chief Scientific Officer, Colorifix (QQ 17–34)	ENB0051
	Alternative Proteins Association	ENB0003
	American University of Sovereign Nations	ENB0010
*	Greg Archer, Director of European Policy, LanzaTech UK (QQ 98–114)	
	AstraZeneca	ENB0044
	Dr Joshua Biggs O'May, Visiting Scientist, Francis Crick Institute	ENB0032
	Bio-Based and Biodegradable Industries Association	ENB0007
	bit.bio	ENB0022
	Biomass Biorefinery Network, Supergen Bioenergy Hub	ENB0041
	Bristol BioDesign Institute, University of Bristol	ENB0043
	British Science Association	ENB0012
*	Mark Bustard, Chief Executive Officer, Industrial Biotechnology Innovation Centre (QQ 34–40)	

	Professor Jane Calvert, Professor of Science and Technology Studies, University of Edinburgh, Dr Rob Smith, Lecturer, Responsible Research & Innovation, University of Edinburgh, Dr Sophie Stone, Postdoctoral Research Fellow in Science & Technology Studies (STS), University of Edinburgh, Dr Reuben Message, Research Fellow (Responsible Research and Innovation), University of Edinburgh, and Professor Sarah Hartley, Professor , University of Exeter	ENB0024
	Carbon Technology Research Foundation	ENB0031
★	Graeme Cruickshank, Chief Technology & Innovation Officer, Centre for Process Innovation (QQ 86–97)	
	Constructive Bio	ENB0054
★	Prof Frederic Coulon, Director, Environmental Biotechnology Innovation Centre, Cranfield University, and Prof Louise Horsfall, Chair of Sustainable Biotechnology, University of Edinburgh	ENB0035
	CPI (Centre for Process Innovation)	ENB0027
	Paul Dalby, Professor in Biochemical Engineering and Biotechnology, University College London (UCL), Gary Lye, Professor of Biochemical Engineering, Director of EPSRC Centre for Doctoral Training in Bioprocess Engineering Leadership, and Director UCL East Manufacturing Futures Lab, University College London (UCL), Emily Kostas, UKRI Future Leaders Fellow, University College London (UCL), and Chris Barnes, Professor of Systems and Synthetic Biology, University College London (UCL)	ENB0036
	Department of Biology, University of York	ENB0028
	Department for Science, Innovation and Technology	ENB0011
★	Dr Clive Dix, Executive Chair, C4X Discovery (QQ 71–85)	
★	Rosemary Sinclair Dokos, SVP of Product and Programme Management, Oxford Nanopore Technologies (QQ 17–34)	
★	Professor Tom Ellis, Professor of Synthetic Genome Engineering, Imperial College Centre for Synthetic Biology, Professor Geoff Baldwin, Professor of Synthetic and Molecular Biology, Imperial College Centre for Synthetic Biology, and Professor Karen Polizzi, Professor of Biotechnology, Imperial College Centre for Synthetic Biology	ENB0030
★	Professor Tom Ellis, Professor of Synthetic Genome Engineering, Imperial College London (QQ 8–16)	
	Engineering Biology Interdisciplinary Research Centre, University of Cambridge	ENB0034

**	Food Standards Agency (QQ 60–70)	ENB0015
	Dr Stefanie Frank (UCL), Rita Morais (UCL), Dr Brenda Parker (UCL), Anca Tacu (UCL), Professor Brendan Wren (LSHTM)	ENB0029
	Dr Alexandra Freeman (Baroness Freeman of Steventon)	ENB0001
*	Professor Paul Freemont, Co-Director, Innovation and Knowledge Centre for Synthetic Biology (SynbiCITE) (QQ 1–7)	ENB0050
*	Good Food Institute Europe	ENB0005
	Dr Carolina Grandellis, Earlham Biofoundry Manager, Earlham Institute (QQ 1–7)	
*	Charles Hall, Head of Research, Peel Hunt (QQ 98–114)	
	Health and Safety Executive (HSE)	ENB0048
**	Dr Sara Holland, Patent Attorney, Potter Clarkson (QQ 71–85)	ENB0055
	Prof. Yan Yan Shery Huang, Professor of Bioengineering, University of Cambridge	ENB0049
*	Innovation and Knowledge Centre for Synthetic Biology (SynbiCITE) (QQ 1–7)	ENB0006
	Institution of Chemical Engineers (IChemE)	ENB0052
*	Alexandra Jones, Director-General for Science, Innovation and Growth, Department for Science, Innovation and Technology (QQ 123–155)	
	Kidney Research UK	ENB0020
	Dr Rodrigo Ledesma-Amaro, Reader in Synthetic Biology, Imperial	ENB0026
	Manchester Institute of Biotechnology	ENB0019
	Professor Gino Martini, Chief Executive Officer, PHTA Ltd	ENB0002
*	Dr Lucia Marucci, Associate Professor in Systems and Synthetic Biology, University of Bristol (QQ 8–16)	
*	Dr Mary Maxon, Executive Director, BioFutures, Schmidt Sciences (QQ 114–122)	
*	Piers Millett, Executive Director, International Biosecurity and Biosafety Initiative for Science (QQ 41–59)	
*	Will Milligan, Chief Executive Officer, Extracellular (QQ 17–34)	
*	Fiona Mischel, Director of International Outreach, SynBioBeta (QQ 114–122)	
	National Biofilms Innovation Centre	ENB0033
	National Measurement Laboratory (NML)	ENB0017

**	National Physical Laboratory (QQ 60–70)	ENB0039
	Norwich Research Park	ENB0046
	Nuffield Council on Bioethics	ENB0004
	Professor Roisin Owens, Professor of Bioelectronics, University of Cambridge	ENB0009
*	Sophie Rose, Senior Biosecurity Policy Adviser, Centre for Long-Term Resilience (QQ 41–59)	
*	Professor Susan Rosser, Co-Director, Edinburgh Genome Foundry (QQ 1–7)	
	The Rosalind Franklin Institute	ENB0042
	Royal Academy of Engineering	ENB0047
*	Professor Nick Talbot, Executive Director and Group Leader, The Sainsbury Laboratory (QQ 86–97)	
	Professor Harrison Steel, Associate Professor of Engineering Science, University of Oxford, Mr Kirill Sechkar, PhD Student, University of Oxford, Mr Vicente Trelles Fernandez, PhD Student, University of Oxford, Mr Ting Lee, PhD Student, University of Oxford, Ms Jessica James, PhD Student, University of Oxford, Mr Marco Corrao, PhD Student, University of Oxford, Ms Lisa Zillig, PhD Student, University of Oxford, and Mr Scott Stacey, PhD Student, University of Oxford	ENB0018
**	Dr Martin Turner, Associate Director, UK BioIndustry Association (QQ 34–40)	ENB0045
	UK Agri-Tech Centre	ENB0040
**	UK BioIndustry Association (QQ 34–40)	ENB0013
*	Professor Isabel Oliver, Director General of Science and Research and Chief Scientific Officer, UK Health Security Agency (UKHSA) (QQ 60–70)	
*	UK Institute for Technical Skills and Strategy	ENB0038
	UK Research and Innovation (UKRI)	ENB005
	University of Edinburgh	ENB0037
*	Lord Vallance of Balham, Minister of State, Department for Science, Innovation and Technology (QQ 123–155)	
*	Dr Hendrik Waegeman, Head of Business Operations, Bio Base Europe Pilot Plant (QQ 114–122)	
*	Dr Isabel Webb, Deputy Director for Technology Strategy and Security, Department for Science, Innovation and Technology (QQ 123–155)	
	Wellcome	ENB0016
	Wellcome Sanger Institute	ENB0021

- The Rt Hon Lord Willetts, Co-founder, SynBioVen (QQ 71–85)
- Dr Peter Williams, Group Technology Director, INEOS (QQ 98–114)

APPENDIX 3: CALL FOR EVIDENCE

Background

The Government defines engineering biology as the design, scaling and commercialisation of biology-derived products and services that can transform sectors or produce existing products more sustainably.[319] It can use the tools of synthetic biology, including but not limited to gene editing, and involves its application and commercialisation across sectors. These engineered biological systems can be used to manipulate information, assemble materials, process chemicals, produce energy, provide food, and help maintain or enhance human health and the environment.

Engineering Biology has also been defined by the Council on Science and Technology as the application of rigorous engineering principles to biology, enabling the construction of new or redesigned biological systems, such as cells or proteins, with applications across numerous sectors, including food, materials, and health.

In the Science and Technology Framework, published in February 2023, Engineering Biology was identified as one of the "five critical technologies" that the UK should focus on.[320] In December 2023, the Department for Science, Innovation and Technology (DSIT) published its National Vision for Engineering Biology, setting out its approach to engineering biology policy and committing to invest £2 billion over the next 10 years.[321] In March 2024, DSIT and UKRI announced funding for two new Doctoral Training Centres in the field of Engineering Biology.[322]

Purpose of the inquiry

The Committee seeks to understand which technologies fall under the umbrella of engineering biology, and what its potential is, particularly in delivering UK economic growth through commercialisation and for improvements to public services. It wishes to explore what the key applications for engineering biology might be; how realistic some of the claims made are; which developments are already underway, which areas of engineering biology the UK excels at and which it is well placed to exploit; and what more needs to happen to ensure that the science developed in the UK benefits our public services and the UK economy. The Committee is also interested in the ethical, regulatory and safety implications of the rapid developments in engineering biology. The Committee's findings will inform a report which makes conclusions and policy recommendations to the Government and other key organisations.

319 Department for Science, Innovation& Technology, National vision for engineering biology (5 December 2023): https://www.gov.uk/government/publications/national-vision-for-engineering-biology/national-vision-for-engineering-biology [accessed 2 April 2024]

320 Department for Science, Innovation& Technology, The UK Science and Technology Framework (Updated 9 February 2024): https://www.gov.uk/government/publications/uk-science-and-technology-framework/the-uk-science-and-technology-framework [accessed 2 April 2024]

321 Department for Science, Innovation& Technology, National vision for engineering biology (5 December 2023): https://www.gov.uk/government/publications/national-vision-for-engineering-biology/national-vision-for-engineering-biology [accessed 2 April 2024]

322 UK Research and Innovation, £1 billion doctoral training investment announced – UKRI (12 March 2024): https://www.ukri.org/news/1-billion-doctoral-training-investment-announced/ [accessed 2 April 2024]

Questions

There is no requirement to answer all questions in your submission; sub-questions provide further detail on the areas of evidence and lines of inquiry we would be interested in, but do not need to be answered individually. We would prefer submissions that answered 2–3 questions in the specific area of your expertise well rather than attempting to answer all in detail. The Committee is seeking evidence on the following questions:

(1) What are the UK's key strengths in the area of engineering biology

- Are there any notable research institutes or groups or key projects?Are there innovative companies, start-ups, or spin-outs that you think are of particular promise or significance using engineering biology in the UK today?
- What is the current economic impact of engineering biology on the UK and what might its potential economic impact be?

(2) What are the key applications for engineering biology?

- Can you give examples of particularly exciting or interesting applications? In particular, applications which could be taken forward or are being worked on in the UK?
- On what timescales might the different applications for engineering biology be realised? Which applications are emerging now, and what is on the horizon in the next 5–10 years or further ahead?
- Are there areas of application for engineering biology where the hype exceeds the reality, or where significant barriers remain?
- Where does engineering biology have the potential to add value over processes that are currently used? What is the nature of this added value (e.g. throughput, sustainability, range of processes that are possible)? Which industries are most likely to be affected?
- How does the UK compare to other countries, such as Germany, the US, or China, in terms of investment and policy activity, as well as areas of specialism?
- Which applications for waste biorefining and the circular economy merit particular attention?

(3) How can Government policy support the development of engineering biology?

- Does the Government's "National Vision for Engineering Biology" set out the right priorities for government to develop the engineering biology field in the UK? Was there anything missing from the strategy that should have been included? Does it build appropriately on earlier approaches to synthetic biology and life sciences?
- The Government has committed to spend £2 billion over the next 10 years on engineering biology. Is this scale of subsidy sufficient to be competitive? Where should this funding be focused to best support engineering biology in the UK? Is it more important to support facilities, skills, or flagship research projects? Which specific skills or facilities are most needed?

- What should the role of UKRI be in supporting engineering biology? Which research councils are most involved in funding it? Are there areas where more could be done to support interdisciplinary research? What would the best mechanisms be for achieving this?
- Which Government departments, and non-departmental public bodies, are engaged or should be engaged with engineering biology?
- Which are the key enabling technologies that have developed in recent years that have enabled wider applications for engineering biology?
- Is the UK getting the best value out of its existing facilities, such as the biofoundaries? If not, why not?

(4) How can the UK maximise the economic potential of developments in engineering biology?

- Who is investing in engineering biology in the UK, and what is the scale of the investment activity right now? Where are the areas with significant economic and start-up activity?
- How should the Government best support engineering biology startups to scale-up in the UK? Are there specific facilities that it would be helpful to invest in? Are the financial support mechanisms for start-ups and scale-ups appropriate and sufficient, or could they be reformed?
- How well are Innovate UK, British Business Bank and British Infrastructure Bank supporting the commercialisation of engineering biology in the UK?
- Are there any elements of UK taxation policy which could support engineering biology? How does it fit into efforts to increase investment in UK technology companies, such as the Mansion House reforms?
- Are there opportunities for engineering biology to be used to improve public services, or opportunities for public procurement to support engineering biology, which the Government should consider?
- Where could engineering biology improve productivity (GDP/capita) or provide value-added in the UK?
- Does the UK need large companies in the field to help form the ecosystem in which spinouts and start-ups can thrive? If so, does it have the right ingredients for a healthy engineering biology ecosystem? Are major industrial players investing in engineering biology?
- Given that the applications of engineering biology can include applications such as bulk materials or chemical production, are the right support mechanisms in place to support this type of investment in the UK? Or should the UK focus on high-value-add but relatively low through-put applications?
- What can the Government do to encourage investors to invest in engineering biology and is there a need for investors with more scientific expertise?
- How does the UK's approach to engineering biology, commercialisation and translation compare to other nations, such as Germany, China and the US? Are there specific areas the UK should look to focus on in order to gain or maintain a competitive advantage?

- Is there a danger that engineering biology advances developed in the UK are exploited overseas?

(5) What are the risks posed to society by engineering biology?

- There are regulatory, ethical, and safety concerns that go along with any dual-use technology, particularly in the case of gene-editing. What are the major areas of concern?
- Does engineering biology pose national security risks and if so, what are they? Is the Government's 2023 Biosecurity Strategy sufficient to address these risks and, if not, what more does the Government need to do to?
- What early warning systems are in place, both nationally and internationally, to monitor whether engineering biology is being misused? Are these sufficient, or is further regulation needed, for example setting out what DNA synthesis technology can be used for?

(6) How should engineering biology be regulated?

- Who regulates engineering biology in the UK and internationally?
- Is the current regulatory framework adequate? Does it strike the right balance between encouraging innovation and ensuring safety? Where should any reforms be enacted?
- How are the ethical, safety, and national security concerns raised in Q5 addressed under current regulations? Are regulators sufficiently independent from Government and from industry?
- What implications would rapid progress in engineering biology have for existing regulatory structures, for example around intellectual property?
- Has regulation in this area evolved quickly enough? Are regulators sufficiently resourced, in terms of expertise and budgets, to keep up with the pace of change of science? How does scientific evidence feed into regulation of engineering biology? What should the Government do to ensure the regulatory environment is able to keep up?
- Is there a tension between the desire to support open-access science – for example in genome sequencing, genetic datasets, engineering biology platforms and techniques – and a risk that IP developed in the UK is exploited elsewhere?

(7) What are the possible barriers and limitations to good and effective use of engineering biology?

- What is already known about the likely limitations of engineering biology due to limits in our scientific understanding? Are there areas that would benefit from more fundamental research before those limitations might be understood? Are some suggested applications implausible?
- What more can the Government do to foster public understanding of engineering biology? Is public acceptability of these technologies a barrier to deployment in the UK?
- Does the UK have a sufficient skills base to harness the potential of engineering biology?

- What barriers are there to incumbent manufacturers making use of engineering biology techniques? Is there anything the Government can do to address these?
- What are some of the key feedstocks and enabling technologies for engineering biology? Do these pose any risks to the supply chain for a bioeconomy that should be considered and addressed? Are there applications which are less viable in the UK due to a lack of feedstocks?
- Does lack of land (e.g. for biofuels or growing GM crops) or dedicated lab space inhibit the growth of engineering biology? If so, what should the Government do to address this?

You may follow the progress of the inquiry at https://committees.parliament.uk/work/8377/engineering-biology/

APPENDIX 4: GLOSSARY

Technical term	Definition
Biofoundry	Biofoundries are facilities that use automation and synthetic biology to design and test biological systems. They include equipment, materials, and data analytics that allow scientists to prototype their ideas in a laboratory.
BBSRC	The Biotechnology and Biological Sciences Research Council. The UK's research council funding biotechnology and biological sciences. Part of UKRI
Capex	Spending on assets like buildings, equipment or infrastructure, as opposed to operational expenditure on salaries, utilities, or maintenance.
Carlson Curve	A trend that describes the decrease in the cost of DNA sequencing and synthesis over time, similar to Moore's Law in computing. The curve refers to plots of this graph.
CRISPR	A gene-editing technology based on bacterial self-defence systems which allows precise modifications to DNA sequences.
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization, a measure of a company's financial performance.
Engineering biology	Engineering biology involves applying the tools of synthetic biology and engineering principles to design, build, and optimise biological systems. The applications can include areas such as health, agriculture, industry and advanced manufacturing.
EPSRC	The Engineering and Physical Sciences Research Council. Part of UKRI, the UK's research council funding research in the engineering and physical science disciplines.
Feedstocks	Raw materials used as inputs in an industrial process to produce useful products. Engineering biology can seek to use alternative feedstocks to traditional fossil-fuel based chemical processes.
Moore's Law	An observation of the rate of development of computing power, which historically showed that the number of transistors that could be put on a microchip doubled every two years, illustrating the declining relative cost of computing power.
Photocatalysis	A process that uses a catalyst to accelerate chemical reactions that occur due to exposure to light.
Precision breeding	Advanced techniques, such as gene editing, when used to develop plants or animals with desirable traits, accelerating the methods of traditional breeding.

Technical term	Definition
Regulatory sandbox	A controlled environment, possibly under the supervision of a regulator, where companies can test innovative products or services under relaxed regulatory conditions.
Synthetic biology	The design and construction of novel, artificial biological organisms or pathways, or the redesign and altering of natural biological systems.