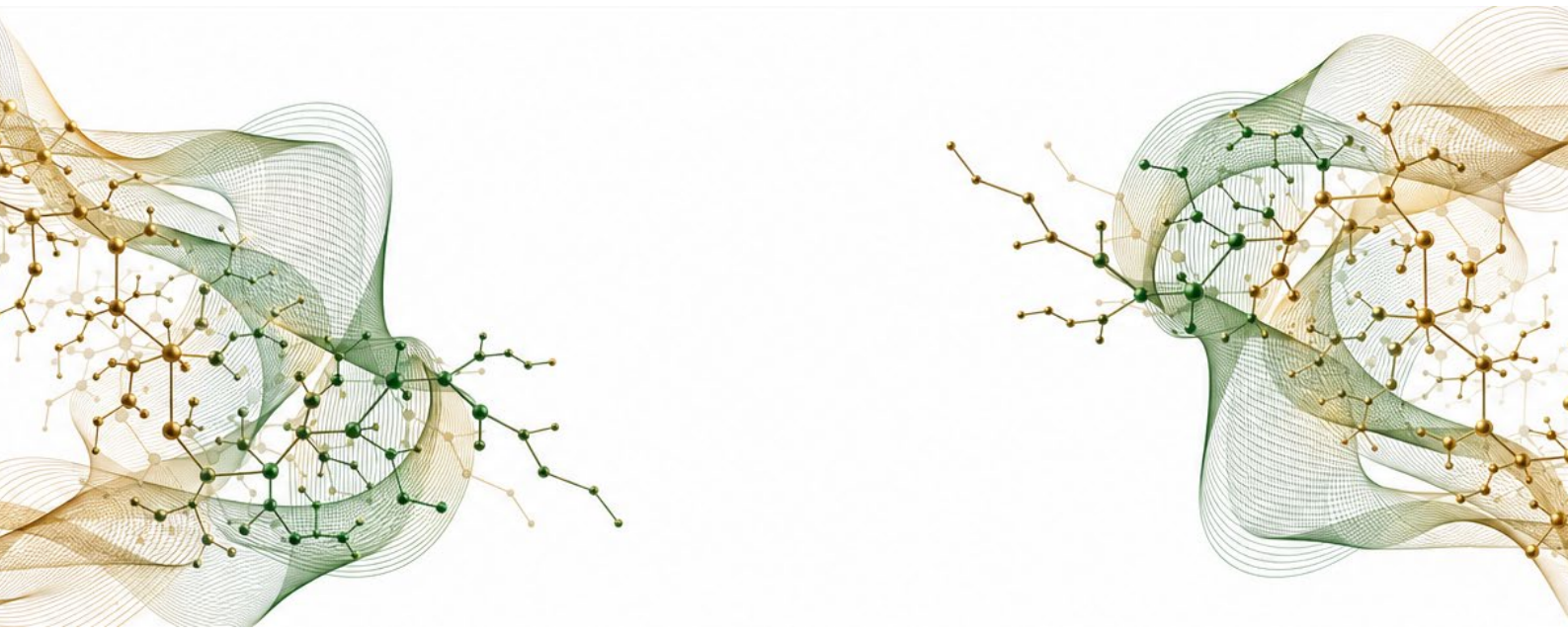
A public dialogue on the governance of engineering biology



November 2026

Department for Business, Innovation, Science and Trade

Human Voices Matter

sciencewise

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Ministerial foreword

Chris McDonald - Minister for Science, Innovation and Investment, Department for Business, Innovation, Science and Trade



Imagine being able to edit the biology of microorganisms so that they can ‘eat’ waste plastics, or produce fuels from biomass, or produce novel vaccines and therapeutics to prevent cancers and diseases. Engineering Biology is making this possible now and we’re only in the foothills of what can potentially be achieved.

The technology has incredible potential to transform every sector of the UK’s economy, create new jobs and pathways to work and drive good growth in every postcode. That’s why Engineering Biology is a frontier technology in the UK’s Industrial Strategy. The Strategy recognises the UK’s existing strengths in Engineering Biology and the technology’s potential to transform sectors such as health, chemicals and materials, low carbon fuels, agriculture and food, and waste and environment.

We recognise that alongside its enormous potential, Engineering Biology technologies bring risks, which is why the UK is committed to delivering responsible and trustworthy innovation in Engineering Biology. This commitment will ensure that unintended negative impacts of Engineering Biology are avoided and that the positive societal and economic benefits are felt by people across the UK.

Public engagement is a core part of our commitment to responsible innovation. It is vital that the Government engages with the UK public to understand their hopes and concerns for Engineering Biology. Choices on the future of Engineering Biology in the UK must be informed by people across the breadth of the UK. That is why the Government, in collaboration with Sciencewise, commissioned this public dialogue on the governance of Engineering Biology to highlight potential of Engineering Biology to help solve some of our biggest challenges, including the cost of living, health issues and climate change. Participants want long-term funding, flexible but strong governance and assurance that benefits will be felt in the UK and will shape our ambition. I welcome and underscore participants’ desire for the UK to be bold and ambitious on Engineering Biology.

The findings also make clear that the public have concerns for Engineering Biology. The Government will listen to and act on these concerns. Understanding and preventing unintended consequences will continue to be central to the Government’s approach to responsible and trustworthy innovation, and this will include learning from past failures in other areas. We will ensure that regulation in this space is coordinated, specific and proportionate to specific Engineering Biology application areas. We will be honest and transparent as we do this and ensure that the public plays a meaningful ongoing role in the governance of Engineering Biology.

I invite everyone across the Engineering Biology ecosystem to consider and act on these findings to help ensure that innovation aligns with the views and aspirations of the British public.

And I kindly thank the members of the public that participated in the dialogue and the specialists who have supported it. Your time, input and discussion is helping to ensure that Engineering Biology delivers for the UK.

Executive Summary

Context and purpose

Engineering biology (EB) is the design, scaling and commercialisation of biology-derived products and services. In its National Vision for Engineering Biology (December 2023), the UK government committed to responsible and trustworthy innovation in EB, including constructive two-way dialogue with the public. In December 2025 DSIT confirmed a £644m allocation for EB through the spending review. The findings of this public dialogue will, in part, inform the government's approach to EB policy, funding and regulation.

The dialogue was commissioned in early 2026 by DSIT's EB Team with UK Research and Innovation's (UKRI's) Sciencewise programme. In July 2026 the EB Team moved to the new Department for Business, Innovation, Science and Trade (BIST), which remains committed to public engagement on EB. HVM designed, delivered and reported on the dialogue, supported by an oversight group from academia, civil society, research funders and trade associations. It was independently evaluated by Navigator Consulting working with Graphic Science.

Participants explored four themes:

- Their hopes and concerns for EB, including the public's role in its governance;
- The principles that should guide that governance;
- What responsible innovation means in practice and how trust is built;
- Whether there should be red lines on EB innovation.

The dialogue did not seek consensus or to steer views. Its purpose was to understand what matters to people in the research and use of EB across five areas: health; food and agriculture; chemicals and materials; waste and the environment; and low-carbon fuels.

Method

The design drew on a 2024 DSIT public survey, a rapid HVM review of 41 evidence sources, seven stakeholder interviews and a design workshop where 14 stakeholders stress tested the approach.

56 participants, broadly reflective of the UK population, were recruited through random sampling. Some priority was given to younger people, people from minoritised ethnic backgrounds, people of faith, those in areas of higher deprivation and those experiencing financial vulnerability. Working in four regional cohorts of 14, they took part in 15 hours of deliberation over six weeks in May and June 2026. This included three online workshops, one in-person workshop in Bristol, Chester, Edinburgh or Norwich, and time in an online space (Recollective) exploring case studies and talking with friends and family. A sub-set of 15 participants then reviewed the early findings with stakeholders in a final workshop.

Key dialogue findings

Participants' vision for EB

Participants were excited about EB and its opportunities. They also pointed to past governance failures and earlier technologies that had appeared exciting but ultimately caused serious problems for society. Their support was conditional on four things:

1. Public benefit coming first;
2. A proactive and rigorous approach to risk;
3. Early and consistent public involvement;
4. Honesty and transparency.

They expressed a great deal of hope for EB if those conditions could be met, particularly for applications that improve health and combat climate change. They saw the EB as a way of tackling some of society's biggest challenges and wanted scientists, researchers and government to be ambitious and bold. Some hoped the UK could become a global leader, building on the strength of its universities.

Their greatest worries for EB were about unintended consequences, particularly the uncontrolled release of engineered organisms and long-term effects on health. Food and agriculture raised the most concern, especially for farmers and rural communities, food safety and people's choice over what they eat. Participants wanted reassurance that EB will not become another solution that creates its own problems, as they felt had already happened with plastics and pesticides.

Principles for governance

Participants identified seven principles that should guide the governance of EB.

1. The fundamental principle: public benefit

- EB should benefit people and the planet, and applications that improve quality of life in tangible ways should be prioritised;
- Governance should preserve what matters to people, including their histories, culture and natural environment, and must not destroy sectors such as farming or rural communities;
- Public money, shared knowledge and planetary resources should bring shared benefits back to UK society and the natural world;
- New forms of governance should help UK start-ups grow and develop in this country, so that talent, knowledge and tax revenue stay in the UK.

2. Responsive, flexible governance

- Governance should be agile enough to keep pace with EB, and be risk aware rather than risk averse, giving researchers, investors, and the public, confidence;
- Regulation should be smart and adapted to each application and its context;
- Well-planned exit strategies should allow developments to be stopped if they become too costly or if serious risks emerge.

3. Learning from the past to enable proactive governance

- UK medicines and food regulation are seen as particularly strong models to build on;

- EB governance must learn from successes and failures in the UK and abroad: examples include fossil fuels, single-use plastics and tobacco, which were woven into society before their harms were properly identified and acted on;
- The UK should lead in proactive governance, without making regulation so stringent that it leaves the UK behind.

4. A sustained, collaborative, independent regulatory body

- EB governance must sit apart from the electoral cycle, allowing long-term planning free of party-political interests;
- Independent oversight should rise above political, economic and professional interests and see "the bigger picture";
- The civil service, researchers, industry and the public should work together. They should be overseen by a body outside the world of EB that is not funded or run by those with a stake in it.

5. Honesty, transparency and accountability at all times

- The public should be told not only about successes, but also about what has gone wrong, why, and what was done about it;
- A culture change is needed in which mistakes are valued as learning opportunities, with clear plans for who resolves problems and who pays for that resolution;
- EB products should be clearly and honestly labelled, marketed and advertised so that consumers can make informed choices;
- High-stakes applications should be overseen in ways that can be acted on decisively, with penalties for those who deliberately or negligently cause harm;
- The public needs two-way communication and clear routes to raise safety concerns and seek recourse;
- Independent, well-resourced, statutory monitoring should track outcomes against stated goals.

6. International governance

- UK environmental standards must extend to international EB activity and supply chains, so that the UK neither exports pollution nor imports harm;
- EB that protects and repairs the climate and environment should be prioritised, with embedded consideration of fairness and social justice at home and abroad;
- International cooperation is needed to prevent or contain accidents and leaks, as well as helping improve, test and scale innovation.

7. Governance tailored to each application area

- Applications that act on the human body, or are eaten, need the most stringent and carefully paced regulation and protection from commercial interests, equally environmental applications that could affect water supplies or food growing need the same rigour;
- The pace of development should suit the context: speed may be right in some cases, as with the Covid-19 vaccine, with more caution applied to others;
- Applications that could affect the wider environment need long-term regulation with global reach, including secure, closed development for organisms such as algae or bacteria that can spread rapidly without containment;

- Genetic engineering that creates novel organisms needs more stringent governance and careful, honest public communication;
- New materials should break down naturally or be disposed of responsibly, avoiding a repeat of the forever chemicals crisis;
- Low-carbon fuels need stable policy, and climate technologies must not overpromise or distract from reducing emissions.

In-depth public involvement at every stage

There was strong consensus that the public should be involved in EB governance at every stage. At the start, some participants questioned whether their contribution would be useful. By the end, they saw public voices as essential. They wanted ordinary working people, affected communities and experts from beyond EB, such as ethicists and social and environmental scientists, to be involved. That involvement runs from early research funding decisions, through development and scaling, to communication.

Participants saw public involvement as central to building trust, strengthening accountability and making better decisions where outcomes are uncertain. They felt it could foster collective responsibility.

A call to action for a responsibly governed EB sector

Most participants began this dialogue having never heard of engineering biology. Six weeks later they were weighing up engineered bacteria, gene switches and cultivated meat as thoughtful contributors to how EB should be governed. Some became far more open, while for others learning more about EB sharpened their doubts. Despite variations in views participants applied very similar values to their deliberations.

Those values were about fairness as much as safety. Participants wanted everyone to benefit from EB whatever their means, and to keep the choice not to use it. They did not want poorer communities, in the UK or overseas, to carry the costs of others' innovations. Nor did they want future generations to inherit problems they had no say in, as they feel has happened with, for example, plastics and fossil fuels. They wanted a fair transition for anyone whose livelihood changes. They were clear, too, about how fragile trust is. One failure can outweigh many successes, people cannot trust what they do not understand, and silence leaves space for misinformation. For participants, trust is built on honesty about what is not yet known.

A key message from this dialogue is that people must be involved in every aspect of EB development. Given time, good information and respect, the public will engage seriously with complex science and reach considered views. As one participant put it,

> *"Technologies are nothing without the people they're applied to."* Workshop 4, Norwich

Government and everyone working in EB now has the chance to show that this dialogue was not a one-off, but the start of a lasting and fruitful partnership.

1. About the public dialogue

1.1 Background and context

The United Kingdom (UK) government is committed to fostering responsible and trustworthy innovation in engineering biology (EB). This includes supporting and maintaining a positive, transparent, and constructive two-way dialogue with the public. This was set out in the National Vision for Engineering Biology published in December 2023, and responsible innovation is also a commitment in the UK's Biological Security Strategy.

In August 2024, the Department for Science, Innovation and Technology (DSIT) surveyed 3,000 UK adults to understand public trust in EB. The survey results showed limited public awareness of EB, but that people are likely to be optimistic about using EB to solve societal challenges. This survey was the starting point. In December 2025 DSIT confirmed a £644m allocation for EB through the spending review. The UK government's approach to EB policy, funding and regulation will, in part, be informed by the findings of the public dialogue on the governance of EB and its applications being shared in this report.

Public dialogue objectives

Through a process of deliberative public dialogue in May and June 2026 participants were asked to explore and share their perspectives on the governance of EB. The process sought to understand:

- Public hopes and concerns for EB, including the role they think members of the public should play in the ongoing governance of EB;
- What people believe the overarching principles for the governance of EB should be;
- How members of the public define responsible innovation in EB in practice, and how it should be ensured to promote trust in EB products and processes;
- The extent to which the public think there should be red lines on EB innovation.

1.2 Commissioning, delivery and governance

Commissioning

In early 2026 in collaboration with UK Research and Innovation's Sciencewise programme, DSIT's EB Team commissioned a public dialogue on the governance of EB. In July 2026 the functions of DSIT were redistributed to align with government's core agenda and connect the UK's world-class science and technology base directly to the businesses, places and workers that will drive good growth across the country.

Some functions of DSIT, including the EB Team, became part of the new Department for Business, Innovation, Science and Trade (BIST). This move recognises that technology and innovation are not separate sectors of our economy: they are the foundation of all future industry, culture, and public service delivery.

A BIST priority is to increase the adoption of new technologies by businesses, improving the commercialisation and scaling of innovation, and accelerating technology-led economic growth.

The EB Team supports this priority by ensuring that EB is safely developed and deployed across the UK, with the benefits of those technologies more widely shared by the public. BIST remains committed to public engagement on EB.

Sciencewise is an internationally recognised public engagement programme which helps to ensure research and policy is informed by the views and aspirations of the public. The programme is led and funded by UK Research and Innovation (UKRI). Sciencewise supports policymakers and research funders to carry out public dialogues on issues with a scientific or technological component. This public dialogue was conducted in line with Sciencewise Guiding Principles, including its latest quality framework. The dialogue was supported by a Sciencewise advisor.

Governance and delivery

This UK-wide public dialogue was designed, delivered and reported on by HVM: Human Voices Matter (formerly Hopkins Van Mil). HVM is a specialist deliberative social research agency which for over twenty years has been engaging people across society in deliberative processes on complex, contentious and sensitive societal issues.

- HVM worked with Postcode Films who created a film of the public dialogue which illustrates the dialogue process. In the film participants speak about why the dialogue process was valuable in hearing the views of people across society on the issues that matter to them.

As with all Sciencewise projects, an oversight group (OG) was established involving multiple stakeholders from academia, civil society, research funders, and trade associations (Appendix A lists the OG members). The OG provided challenge, advice and guidance to the project. The project team met weekly in the scoping, design and fieldwork phases of the programme. The team comprised the commissioning bodies, the programme evaluators and the meetings were run by HVM.

An independent evaluation was commissioned at the beginning of the project, in this instance from Navigator Consulting working with Graphic Science. The evaluators provided formative evaluation by taking part in each element of the design process, including co-design meetings, OG meetings, and internal project meetings. The evaluators were also present for all workshops. A full evaluation of this study will be published in mid-2027 to assess the shorter-term impact of the project on research and policy agendas.

Those involved in the programme's governance played a significant role in designing the public dialogue, informing, shaping and making decisions on each element.

1.3 About this report

Public dialogue reports are qualitative in nature. As such the number of times something was said is not reported on. The focus is on the strength of feeling expressed during the dialogue.

In accordance with reporting on qualitative research processes, and in line with Sciencewise reporting on public dialogues, we use the following quantifiers in the report:

- “Participants”, “many” or “most” when it is clear that all or almost all participants shared a similar view;
- “Some” when a reasonable number of participants shared a similar view;
- “A few” when a small number of participants shared a similar view.

Bullet points are used to summarise key points made. These mostly reflect areas of agreement and where points were made by many participants across many groups. Public dialogue participants reflect together on the implications of a topic for society. For this reason, the analysis does not pull out differences in view according to demographics.

Anonymised quotations are used to highlight points of particular significance to participants and to underline points made by a range of people. Participants from each location worked together in workshops 1, 2 and 3. In workshop 4, held in person, participants met in specific location groups for their discussions. This is why the location is mentioned for workshop 4 quotations, but not for the other workshops.

Analysis of dialogue findings does not track how participants reacted to specific pieces of evidence, nor when they might have changed their mind on the topic or a specific aspect of it. Given the uncertainty in the evidence, and the range of perspectives presented to them on it, they might have changed their minds several times during one workshop, and over the whole project. For where participants changed their thinking or responded in a particular way to stimulus, see especially chapter 3.

2. Dialogue design and delivery

2.1 Dialogue method

Dialogue scope and key questions

The original brief for the public dialogue was to explore public perspectives on EB and its applications. During the design phase of the dialogue (see below) and in discussion with the OG, it was agreed that the scope should be refined to focus on the governance of EB. The five application areas remained a core part of the project, but participants were asked to consider them in the context of governance and responsible innovation.

A revised set of questions was developed which framed the dialogue process design. These were:

1. What are the public's hopes and concerns for EB?
2. What should the overarching principles be for the governance of EB?
3. How do members of the public define responsible innovation in EB in practice?
4. How do members of the public think that responsible innovation should be ensured to promote trust in EB products and processes? Do the public think there should be red lines on EB innovation?
5. How can government policy, regulation and investment support the responsible adoption of EB products and processes?
6. What do the public think the roles and responsibilities of organisations with a stake in the governance of EB should be?
7. What role do the public think they should play in the ongoing governance of EB?

What is public dialogue, and why this method was chosen

Public dialogue is a considered and intentional process for engaging people across society on questions and issues for which society does not as yet have clear answers. During the process members of the public interact with evidence from academics, scientists, stakeholders, civil society, policy and decision makers to consider issues relevant to future decisions.

The process enables and supports constructive conversations amongst diverse people, broadly reflective of the population, on topics which are often complex or controversial. Not only does it provide an in-depth insight into public opinion, but it also offers a window into understanding people's reasoning. HVM works within and promotes Sciencewise principles and quality framework[1]. The HVM team has extensive experience in designing and delivering public dialogue as well as reporting on the outcomes.

Public dialogue was chosen as the robust process for exploring the governance of EB with a broad public, to ensure that participants were given time and a level playing field to discuss the policy actions and issues that matter to individuals, to communities and to society. Public dialogue is:

- **Informed**: evidence is provided on the topic shared by experts in the field

[1] www.sciencewise.org

- **Two-way**: participants, policy makers and experts all give something to and take something away from the process
- **Facilitated**: the process is carefully structured to ensure that participants are supported in their discussions by a skilled and experienced facilitator so that throughout their discussions:
    - They receive the right level and detail of information
    - A diverse range of views are heard and taken into account
    - The discussion is not dominated by particular individuals or issues
    - And everyone's views are heard and respected.
- **Deliberative**: participants develop their views on an issue through conversation with other participants, policy makers and specialists, as well as with people from their families and communities.

The design process

The design process began with a rapid topic review conducted by HVM. This included 41 sources across academia, government/parliament, civil society and industry including published and grey literature. Sources were selected through suggestions from Project Team members, plus a wider search and snowball sampling. The review was conducted between 12th February and 5th March 2026. The review helped the team to:

- Gain an understanding of the key themes and range of perspectives that should be taken into account in the dialogue;
- Explore the scope of the field and identify options for how this could be presented to participants;
- Identify potential speakers and specialists to work with dialogue participants on this range of perspectives;
- Identify materials which could be used within the dialogue to shed light on the technologies, the current debates, and context;
- Identify gaps in evidence on public attitudes, where the dialogue could add value;
- Identify definitions/ language used in the field.

This was followed by seven stakeholder interviews and a design workshop led and designed by HVM. It was attended by 14 stakeholders from academia, research funding, civil society and trade associations. Those involved stress tested the draft design of the workshops and the overarching dialogue approach. They suggested case studies and refined the stimulus materials that were eventually shared with participants.

Definitions and terminology

Participants were told that EB is a topic with a wide scope and with no universally agreed definition. They were told that the Government's definition of EB would be used in the dialogue as the main way of describing the products and services related to EB. This was drawn from the National Vision for Engineering Biology as follows:

> *"The design, scaling and commercialisation of biology-derived products and services that can transform sectors or produce existing products more sustainably. It draws on the tools of synthetic biology to create the next wave of innovation in the bioeconomy."*

It was explained to participants synonyms are used to describe EB including the words “synthetic biology” and “biotechnology”. Given the focus of the dialogue, the terms “governance” (Figure 1) and “responsible innovation” (Figure 2) were also explained.

Governance

Governance is the system of **rules, processes, and people** that direct and control how an organisation, institution or country operates. It is used to make decisions, ensuring those decisions are fair, someone is responsible for what happens because of the decisions, and there are benefits for people in society.

Some examples:

Family: Parents setting house rules (bedtime, jobs to do, meals).
School: A school board of governors managing policies for teachers and students.
Company: A Board of Directors deciding how to spend budget and how to manage their staff.
Government: Laws determining how taxes are used to provide services, and how those services should work.



Figure 1: Explanation of governance used in the public dialogue

Responsible innovation

Is about creating new technologies, products, or services that are good for people and the planet, bringing benefits to society whilst minimising the risks.

It is about pausing to ask, "what if?" and "what now?" before developing a new programme or idea to ensure harms are considered and reduced.

Key Aspects:

Anticipation: Understanding and planning around potential risks or unintended negative consequences.
Inclusion: Involving people across society and diverse stakeholders in the design process.
Thinking through: Reflecting on the motives and assumptions behind the innovation.
Responsiveness: Adapting the design based on feedback and changing needs.



Figure 2: Explanation of responsible innovation used in the public dialogue

Participants were asked to focus their attention on five application areas and were provided with a wide range of case studies to help them do this. These are shared at Appendix E. The five application areas were:

- Health;
- Food and agriculture;
- Chemicals and materials;

- Waste and environment;
- Low carbon fuels.

Analysis

For this project we used grounded theory[2] (Glaser and Strauss, 1967), which meant that the analysis began in cycles as the fieldwork was being conducted. The team read and re-read the transcripts and other collated qualitative data many times. What was said was then collated into key themes, with thematic analysis used to draw out meaning from the discussions. HVM uses Quirkos, a qualitative research software package, to code the data against the agreed themes. This grounded theory, qualitative thematic analysis was chosen to ensure the findings were rooted in what participants told us, guided by the dialogue objectives and the research questions, rather than looking for confirmation of preconceived ideas.

Throughout the process the HVM coding, analysis and writing team maintained a rigorous approach, holding sense-checking sessions as a team to mitigate researcher bias. The purpose of the analysis was to meet the dialogue aims and objectives, accurately reflecting participants' views and sharing what they have found to be important in in-depth discussions on the governance of EB and its applications.

Process limitations

The amount of evidence and specialist input that the participants could consider was limited to what was reasonable in the six-week dialogue process. Nevertheless, over the 15 hours of deliberative time (in workshops and in participants' own time) this was substantial. The specialists who presented information to participants, or joined panel discussions on the topic, are listed in Appendix C and the stimulus materials are shared in Appendix E.

The dialogue engaged participants broadly reflective of the UK population in terms of demographic characteristics. Commonalities, patterns and differences were analysed across the complete data set, not by specific demographics. As such no conclusions can be drawn on what participants from particular groups or communities said.

The final workshop, to review early draft dialogue findings (see 2.3), was due to be held in person in Birmingham on Friday 26 June 2026. This fell during one of the hottest weeks of the 2026 heatwave, and the Met Office issued a red warning for extreme heat for the last three days of that week, including the day of the session. A red warning advises against travel and warns of risk to life. We therefore moved the workshop online at short notice. The risk was that, online, stakeholders and dialogue participants would find it harder to build the rapport needed to share their views openly on the draft findings. Despite this, the facilitation team worked hard to help everyone contribute, and useful findings emerged from the discussions.

2.2 Dialogue participants

A total of 56 participants were recruited to take part in the dialogue, with the group designed to reflect a broad cross-section of the UK population to ensure the inclusion of perspectives that are often underrepresented in discussions about

[2] Calman, L, *What is grounded theory?*, University of Manchester (2008)

science, technology and innovation. Participants were recruited by the recruitment agency Acumen Fieldwork using a detailed recruitment specification (Appendix B).

Participants were organised into four regional cohorts of 14 people, covering Scotland and Northern Ireland; South Wales and Southern England; Mid and North Wales and North West England; and North East and Eastern England. Recruitment processes drew participants from a mix of urban, suburban, rural and coastal communities.

Quotas were used to achieve diversity across a range of demographic and socio-economic characteristics, including gender, age, life stage, ethnicity, religion, employment status, social grade and household income. To ensure the views of people from a diverse range of communities were well represented in the dialogue the recruitment specification included a boost for people:

- Aged 18 to 25;
- From minoritised ethnic backgrounds
- Of faith;
- Experiencing financial vulnerability and from areas of higher deprivation;
- These boosts were informed by the Index of Multiple Deprivation (IMD) and Office for National Statistics (ONS) data.

Recruitment sought to reflect a range of views about the role of engineering, science and new and near horizon technologies in society. Participants took part on the understanding that they would participate in all elements of the dialogue programme. They received a £385 thank you payment for their time, with travel and accommodation provided as required for the in-person workshops. Accessibility support was also provided where required, including equipment, internet access and support for caring responsibilities to reduce barriers to participation.

2.3 What dialogue participants did

Dialogue participants took part in 15 hours of deliberation over the course of four workshops in May and June 2026: 3 online and 1 in-person in each location. This time also included spending about 2 hours over the course of the six week deliberation using an online platform (Recollective) as a thinking space in their own time. Additionally, a sub-set of participants (3-4 from each location) took part in a fifth workshop at the end of June 2026 to work with stakeholders to review and refine the early dialogue findings (Appendix F).

The workshop outlines are below. Summary programmes for each workshop are shared at Appendix D.

Online workshop 1, 6-8pm, 5th May: Briefing and context

- An introduction from DSIT and Ministerial welcome video from the Minister of State for Science, Research and Innovation in the UK;
- An introduction to the public dialogue and to the history and idea of EB.

Online workshop 2, 6-9pm, 7th May: Responsible innovation and governance

- Discussions on the benefits and risks of new applications of science and technology;
- An introduction to the concept of governance in the context of EB;

- An exploration of responsible innovation and balancing risks and opportunities in the development of EB;
- An introduction to the five key application areas in the dialogue.

Online workshop 3, 6-9pm, 19th May: Ethical dimensions of EB

- Discussions on the case studies participants had viewed in the online space;
- Information on the research, development and ethics of EB;
- A panel discussion on the opportunities and challenges of EB.

In-person workshop 4 in each of the four locations 11am to 4pm on either 6th or 13th June: Considerations and recommendations on the governance of EB

- A review of all presentations and stimulus material shared throughout the dialogue;
- A panel discussion on the main considerations participants should take into account when thinking about the governance of EB.

In the online space participants could:

- Explore a catalogue of case studies following their own interests;
- Re-watch presentations made in the workshops;
- Share notes on the conversations they had with their friends and family on EB applications;
- Think about what needs to be balanced when considering the governance of EB before coming to the in-person workshop.

Additionally, a workshop was held at the end of June 2026 to bring a small group of participants (3-4 from each location) together with stakeholders involved in EB funding, research, development and regulation to review the early draft dialogue findings.

Summary programmes from each workshop are shared at Appendix D, and stimulus materials at Appendix E.

3. The journey through the dialogue

For the most part participants came to the dialogue knowing little or nothing about EB. Many said they had never heard the term before the first workshop, and some described feelings of overwhelm at the beginning of the process because of the wide dialogue scope and the broad spread of applications under consideration in the five areas. Over the course of the workshops and time spent in the online space, participants spoke about how their knowledge, interest and, for some, their views, had shifted.

This chapter shares what participants found surprising, interesting or eye opening along their journey through the dialogue.

3.1 Discovering that EB was already familiar

A common moment of surprise for participants was realising that, while the term was new, the ideas behind it were not. For some, the connection to the technologies that underpin EB applications and their development such as AI and gene editing helped the topic click into place. Others were struck by how much they had already encountered EB in everyday life without recognising it.

> *"I've never heard of engineering biology. This term is completely new to me. However, the more I'm looking at the case studies, the ideas are actually things I am familiar with through looking at things like genetic modification."* Workshop 3

> *"I thought it was interesting that even though I would never have known the term or thought of the term engineering biology, how much I had seen it and just not identified it as that."* Workshop 4, Edinburgh

3.2 Surprise at the breadth of applications and the scale and urgency of the challenges

Participants were often surprised by how wide the reach of EB is, across food and agriculture, health, materials and chemicals, waste and environment, and fuels. Understanding of the nature, severity and extent of the problems faced across the planet strongly affected how people responded to EB. For some, this changed how they saw the technology. Their views moved from a focus on concerns, for example about gene editing, to an appreciation of how practical and pragmatic many applications are, using what already exists in nature to find solutions to the problems society is facing.

> *"One of the things that's really struck me is just how wide the applications are for engineering biology. I would say I knew minimal about it beforehand. I was quite concerned about things like gene editing and that stuff. But it's really come across to me how every day some of these applications are, and how useful."* Review workshop, dialogue participant

Some participants described being amazed, and at times shocked, by the evidence on the challenges EB might help to address, particularly on food security, climate change and sustainability. This led a few to reflect that there are risks in not acting, as well as in acting.

"I was quite amazed by how needed some of the technologies are, like it's much more urgent than I thought... I hadn't realised it was at that stage. So yeah, the risk of not doing things as well as the risk of doing them is clear here." Workshop 3

"This has actually turned out to be literally mind blowing, particularly that last presentation (Prof. Paul Freemont on the applications of EB). And I just didn't realise there was so much. It's literally life changing for me individually and for the planet." Workshop 2

3.3 Changing minds, in various ways

At the beginning of the dialogue participants expressed some ambivalence for the involvement of the public in discussions on EB. Some questioned whether their taking part in a public dialogue on the subject would be in any way useful to policy and decision makers. By the end of the process there was consensus that people across society should be involved in all aspects of the governance of EB. They believed by the end of the process that public voices were essential in informing the shape and implementation of EB governance.

Some participants said their opinions had changed markedly over the dialogue. One participant described their thinking as having undergone an enormous shift from believing nature should be left alone to feeling that EB is needed to help repair the damage done to the planet.

“I want to pick up very quickly on something (another participant) said about nature. When I came into this process, I'm old school. (I thought) leave nature alone. Nature will do whatever it needs to do. Today my opinion has changed 180 degrees. I think we've made such a mess of the planet, and we have to do something to repair it. It's a no brainer for me. So that's it.” Review workshop, dialogue participant

Others described themselves simply as more open about EB applications than when they started. They said this was due to hearing from specialists and also to discussing the issues of governance with other participants.

"I'm far more open to it today than I was in the first workshop. I’ve learned from the speakers, and from everyone in the conversations." Review workshop, dialogue participant

Changes of view were not all in one direction, however. Becoming better informed led some participants to think more deeply about, and sharpen their concerns for, EB. This shift was particularly focused on understanding whether those developing and governing applications were acting with honesty and transparency.

"I did know about some things, but I didn't know that they were called engineering biology. I think during the workshops I’ve become less open to these innovations. I just think there could be honesty when things go wrong, and I don’t see that happening." Workshop 4, Bristol

Alongside interest and excitement, many participants spoke about how overwhelming the topic could feel, given the volume of information, the technical language and how futuristic some of it sounded. Some said it took time for ideas to sink in. By the end, several felt the process had made the topic far more understandable than they had expected.

> *"When this whole process began, I must admit I was completely daunted. I'm now not an EB expert by any means, but... it's made it far more understandable and much more rewarding than I thought it was going to be."* Review workshop, dialogue participant

3.4 A lasting interest, and value in hearing others

For many, the dialogue sparked an interest that went beyond taking part in the workshops. Participants described researching the topic on their own and talking about it at home. Many also valued hearing the views of people from different walks of life, and were struck that, despite holding a range of views, people often shared the same underlying values.

> *"If you had said to me I was going to spend this much time talking about engineering biology, I just would have laughed at you, absolutely not, but I have and I have enjoyed it."* Workshop 4, Edinburgh

> *"It has been, honestly, very interesting listening to everybody's point of views. They have been different but they have all been aligned with the same values at the same time. I'll keep my eye on this over the coming years."* Workshop 4, Edinburgh

Chapter 3: key takeaways

- Most participants came to the dialogue knowing little or nothing about EB, and many felt overwhelmed at first by its scope and technical language.
- Many were surprised to find the ideas behind EB were already familiar, and that they had encountered EB in everyday life without recognising it.
- Learning about the breadth of applications, and the scale and urgency of challenges such as food security and climate change, changed how some participants saw the technology.
- Participants ended the dialogue strongly believing in the value of the public voice in shaping and implementing the governance of EB.
- Views changed in different directions. Some became markedly more open to EB, while others sharpened their concerns, particularly about honesty and transparency.
- By the end, several felt the topic was far more understandable than they had expected, and some continued to research and talk about it outside the workshops.
- Many valued hearing from people from different walks of life, and noticed that despite a range of views being expressed, these often rested on the same underlying values.

4. Participants' vision for EB: hopes and concerns

In this section we share how participants navigated the wide scope and complexity of the topic. The focus is on participants' reactions to the five application areas: health, chemicals and materials, food and agriculture, low-carbon fuels, waste and environment. The broad hopes and concerns that participants have for EB are described in this chapter as these are the foundation stones for participant discussions on governance and responsible innovation set out in subsequent chapters. Participants described their high hopes for EB, and equally that their support for particular applications is contingent upon their concerns around them being addressed. Broadly participants had more hopes for health applications and more concerns for food and agriculture applications, than the other applications.

4.1 Looking across the EB landscape

Participants had high hopes for EB

Across all the application areas, participants expressed a great deal of hope, excitement and enthusiasm for EB applications. Many wanted scientists, researchers and government to be ambitious in using biology-derived products to address what they felt to be some of society's biggest challenges: the cost of living; ill-health and climate change. These feelings were rooted in a desire to improve the lives of people across society, and provide mechanisms for achieving net zero targets and to live more sustainably. Participants hoped that the UK would take a bold approach to EB. They felt that EB applications could give people hope given the severity of the crises being faced on many fronts.

> *"Keep the ambition level high, keep trying to find new creative ideas to fix some of our big problems. We have big problems in the environment, economy, health, NHS, and we need bold ideas in the UK. Be bold."* Review workshop, dialogue participant

The context for many participants' discussion was the belief that life in the 2020s is difficult for people in many ways. Participants' hopes for EB concentrated on reducing human suffering including reducing the impact on the environment of greenhouse gas emissions; addressing pollution in air, land and water; reducing waste by focusing on the recycling and re-use of resources. Some also saw EB as providing a route to lower costs for things on which we all depend such as food and energy.

> *"This has just given me so much comfort that we can create foods, we can create fuels, we can look after everyone and it's not as bleak. I think we do have an existential crisis that requires this."* Workshop 2

Many shared the view that humans have caused the challenges being faced now, and many issues are at crisis level. As such, they felt that the government should put all the policy, scientific and technological efforts at its disposal into finding solutions.

> *"I think that (EB) can finally fix some of the problems and crises we've caused. If done responsibly, it's actually really exciting that we can fix a problem that we as society have caused." Review workshop, dialogue participant*

Some participants expressed their hopes for the UK to be a global leader in EB. They believed the long-term benefits that would accrue from taking these early-stage technologies further are potentially vast, bringing economic, environmental and social benefits to the country. These views were informed by the pride many participants felt in the UK's academic research sector.

> *"We're at the infancy of this and the potential is just enormous. You wonder what's going to happen in another ten years and how far these sorts of things will move on. Then if I could just add to that, that we as a country need to take advantage of this. We are so well-positioned in this because we've got such a wonderful university network and much better than other main countries and I think we could really take advantage and become a leader in this field."* Workshop 4, Norwich

Participant support is contingent on addressing concerns

While participants expressed strong interest in, support for, and hopes and ambitions for EB applications, these were rarely expressed without also acknowledging concerns. This was particularly the case given that many of the applications they explored are still in the early stages of development.

Across all applications, participants' greatest concerns were about the unintended effects of novel and early-stage technologies, particularly as they have yet to be deployed at scale. For example, participants worried about unintended effects on a human body for some health applications, and the impacts of prolonged use on people and the environment, which they thought would be hard to test in laboratory conditions.

> *"I found these case studies really interesting because they show how engineering biology could completely change healthcare in the future. The benefits sound amazing, especially for cancer treatment, diabetes and rare blood disorders, but I also think there are important concerns about safety, long-term effects, particularly over time."* Recollective

Additionally, some participants thought about the repercussions of developing EB applications in relation to other routes to solving global challenges. They were concerned that some EB applications could halt, divert attention from, or reverse actions towards reducing intensive resource use, or other paths towards achieving net zero. A few participants felt that creating more sustainable bio-materials or recycling technologies could undermine efforts to reduce overall consumption, providing a quick fix rather than a long term solution.

> *"I still feel like these are short term answers to long term problems. In so far as engineering biology is not addressing why as a society we have so much food and clothing waste."* Recollective

Over the course of the deliberations, participants came back to the idea of the challenge of solving one problem, whilst creating another one. They cited examples from the development of plastics, pesticides and industrial fertilisers to vapes and affordable fashion where efforts in one direction have caused issues that society is now having to resolve. They wanted to have reassurance that EB is not just another solution which then creates its own problems.

4.2 How hopes and concerns differ across application areas

Broadly participants had more hopes for health applications and more concerns for food and agriculture applications.

Participants had greatest hopes for health applications

Participants expressed greatest hope in health applications. These included their aspirations that EB health applications could:

- Reduce suffering associated with treatment (e.g. the development of SimCells for treatments and addressing drug-resistant bacteria);
- Help develop more proactive/preventative interventions (e.g. arming the body against cancer, detecting hypoglycaemia in the body);
- Improve people's quality of life;
- Have indirect impacts for the economy, such as more people being able to work, and reducing the burden on the NHS.

Case studies on cancer and diabetes had a particular resonance for participants. Many referenced their own experiences as a patient, or family member of a patient, experiencing cancer or diabetes. This suggests that familiarity with the health condition and its impacts increases the acceptability of EB applications.

> *"As someone who lost her husband to cancer, whose treatment caused him huge suffering, don't let's dismiss anything. Let's focus on the possibilities, things that could happen for the better using engineering biology for treatments."* Workshop 2

Many participants saw the potential of EB applications in this space as life changing and definitely worth pursuing.

> *"This is meaningful. You look at the health one and you say, "My dad's got diabetes". The case study tells us smart insulin researchers have developed tiny molecules to attach insulin and make it respond automatically to changes in blood sugar levels, making diabetes treatment much safer. Like that is such a tangible, amazing benefit that would simply not exist if they didn't do engineering biology."* Workshop 4, Chester

Many participants were also positive about developing and using EB applications for rare conditions e.g. rare blood disorders as shown in case studies (Appendix E). They felt that these could have life-changing or life-saving impacts for patients who otherwise have few options.

> *"The first thing that really had an impact on me (in this dialogue) was the example of lab grown blood cells and what could be done to detect serious disease. 30 years ago, my ex-wife and I lost our first child to a very rare blood disorder. And I think if this had happened today maybe EB could have been a way of dealing with that."* Review workshop, dialogue participant

Participants considered health applications in slightly different ways to other areas. Some felt that the fact that health conditions can be an emergency or a life-and-death situation meant that they would be willing to accept higher risks, because patients have nothing to lose.

> *"I find this so powerful as its disarming the cancer cells, why not go for it, better than the alternatives."* Recollective

Additionally, some participants said they felt that the development of EB applications in health felt like a natural progression for medical research. Some identified that existing health technologies such as vaccines are examples of EB with which people are already familiar and this familiarity suggested to them that there is less of a risk in their development and wide-spread use.

Participants had concerns for health applications despite support

Concerns about EB health applications fell into five main categories:

1. The potential for human error, with particular reference to known examples of historic medical harms such as the contaminated blood scandal, or the use of thalidomide for morning sickness.
2. That there would be unequal access to EB applications in health, with profit being prioritised over improving health leading to situations where only the wealthiest in society would have access to, and benefit from, these health applications.
3. In a related point, participants were concerned that genetic evidence does not yet cover the full diversity of ethnicities in the UK, making genetic EB treatments ineffective for many people.

    > *"Another one that we thought was really important was around ethnic backgrounds to ensure that testing is covering the majority of ethnic backgrounds, not just a small minority. That ties in with the health stuff again, with like stem cells to ensure different races and ethnicities get the benefits from EB developments for health."* Workshop 4, Edinburgh

4. A few participants were concerned that science is meddling in nature in a way that they didn't feel was right; for some people this was driven by their religious beliefs, whilst others felt concerned about its implications for potential misuse such as eugenics.
5. Informed consent: a fear that people may not feel that they have a choice, if non-EB developed treatments were no longer available, or if they were unable to consent in a medical emergency.

Concerns about food and agriculture applications

Participants expressed greatest concerns in the food and agriculture application area on, for example, the impact on farmers and farming communities and their livelihoods of new methods of food production; safety; foods not being considered natural; and lack of choice on whether people can avoid EB developed foods if they wish to.

Perhaps the most discussed concern was about the impact on farmers and rural farming communities. Many participants were worried that loss of employment in food production could be devastating to rural ways of life and farmer livelihoods. Some participants felt that traditional farming and cellular agriculture could co-exist, and many felt the worry and the hope of co-existence simultaneously. But many more were concerned that there would not be adequate planning for impacts on farmers and their communities. For example, if, in time, cell cultivated meat is preferred over traditionally bred livestock for meat what are the consequences for both farmers and livestock?

> *"I think cultivated meat and existing meat can live alongside each other. If we can sustain the greater population using something that is cultivated,*

> *providing that it is properly tested, then I think it's a route we need to go down. You can't cultivate meat on a farm so what will happen to the farmers and the livelihoods of people living in rural communities needs to be considered properly. But like I say, I think the two things can, can coexist together and people can have the choice of organic, natural, farmed food, or cultivated meat."* Workshop 3

Many participants felt concerned about the safety of foods developed through cellular agriculture, particularly meat. Some participants expressed a vaguer sense that foods produced using EB were in some way not natural. They felt uneasy about them, often in the context of a general feeling that people were increasingly disconnected from the origins of their food already, which could be worsened by EB applications in this area.

Some participants were concerned about unequal access to foods. They considered that if food made using EB became cheap, and food made using traditional methods became correspondingly more expensive (because of a decline in supply), then those on the lowest incomes would not be able to make a meaningful choice.

> *"I can see this becoming tricky. We already live in a really divided society, what if EB food became just like ultra-processed foods are now, the cheap, but less good alternative to healthy foods. I can see a scenario where poorer people can only afford EB goods with naturally farmed foods becoming luxury items for the rich."* Workshop 3

These participants felt that existing inequalities in access, such as organic food being more expensive than non-organic food, would be reproduced and further widened through the use of EB applications. They feared that those on lower incomes would increasingly have less choice about their food, and would be forced to take the affordable option.

> *"It's important for everyone in the future to have a choice or it could get dystopian. If it's cheaper and more sustainable to just make things ourselves and just synthesise them, and it becomes even easier over time, then it just gets to a point where we're actually just eating nothing real."* Workshop 4, Bristol

When it came to laboratory processes being used to make meat products, some participants were concerned that this was, *"a high-tech solution to the wrong problem"* (Workshop 4, Bristol) and that it could undermine paths towards reducing overall meat consumption needed in efforts to combat climate change.

Food security now and for future generations

When thinking about food and agriculture applications, some participants expressed hope that EB could help contribute to food security globally, addressing some of the issues related to the warming planet caused by human activity.

> *"All the stuff we consume and eat, and all the things we want, have created global warming which is affecting people in countries where they don't have the choice that we've got. And can't grow crops because of the heat. If EB can find some solutions to that, then that should be explored." Workshop 2*

Much of the focus of discussions on food applications was on the acceptability of meat grown in laboratories. For some participants this application has the potential to free up land currently used to graze livestock or to produce feed crops for livestock.

They were also hopeful that this could help to reduce greenhouse gas emissions and the pollution of rivers with the by-products of livestock farming.

> *"I was always interested in this about feeding future generations and all of this work that's being done with enhanced nutrition and fertiliser use and growing crops. So, who has got the joined-up thinking? If our land is going to be so precious for new crops being developed even on low-grade land, then why wouldn't we explore that fully?"* Workshop 4, Norwich

Whilst participants had a range of reasons for their dietary choices, a handful of participants spoke about their own experiences with vegetarian or vegan diets, with some expressing hopes that they might be able to eat meat again if it were produced in laboratories. This was one of the areas in which some participants expressed direct hopes about EB making food cheaper and felt more work should be done to explore the feasibility of scaled-up EB food production and related food costs.

> *"Cultivated meat is one of the areas of EB I am most interested in. As a failed vegan who regressed to eating meat as a result of experiencing anaemia whilst on the vegan diet due failing to take supplements, cultivated meat would allow vegans to eat meat guilt free. This area of EB has many positives and advantages over traditional farming and food production, such as land preservation, water conservation, reduction in use of antibiotics, increased food security and a potential reduction in the cost of food."* Recollective

Concerns across applications focused on waste and environment, low carbon fuels, and materials and chemicals were broadly similar

Across the applications explored in relation to waste, environment, fuel, materials and chemicals, participants most commonly discussed concerns about uncontrollable releases of EB technologies into the environment. They referred to the examples of bacteria engineered to eat plastic, or micro-algae engineered to make bio-oils, both the focus of dialogue case studies (Appendix E).

Participants cited examples of invasive species like Japanese knotweed or grey squirrels to show how difficult, or even impossible, some things are to eradicate or control when released into the environment.

> *"If you introduce a non-native fish to a river, that fish can take over the ecosystem for all the other fishes who then become extinct because that thing has been introduced. Like when they introduced grey squirrels, the red squirrels died out."* Workshop 3

Ecosystems were frequently referenced by participants. They spoke of rivers and lakes as a complex balance between different living things. They were concerned that the potential for one very targeted organism to be released into these complex environments could have catastrophic effects and felt like such releases were likely.

> *"My biggest worry with EB is that the system around it becomes too lax and something ends up occurring which isn't reversible and could genuinely damage the systems that the world runs on."* Recollective

Some participants noted the use of waste streams from other industries in these applications for example waste products from whisky production being used for fuel. These participants were concerned that this could act as a perverse incentive to halt

waste-reduction strategies, or that applications might be vulnerable or unviable if there were changes to these waste streams.

In the case of chemicals and materials, some participants also expressed concerns about the impact on workers in industrial or textile manufacture, who might lose their livelihoods and who might also be vulnerable to poverty already.

Across all the applications participants expressed a broad optimism about the benefits, but they felt that if EB products and services could not be developed at scale then it might not be worth the risk. They wanted to believe that in time everyone could benefit from these developments, not just a small, wealthy percentage of the population.

Hopes for EB applications that address the climate crisis and resource use and energy challenges

Participants' hopes for low-carbon fuels, chemicals and materials, and waste and environment EB applications were broadly similar. They included ambitions for the applications to support efforts to reduce greenhouse gas emissions, tackle pollution and use resources sustainably, not wastefully. Some participants felt strongly about the need to clean up land and water polluted by human activity. They hoped that EB applications could reduce or even prevent such pollution happening in the future. Many participants were concerned about microplastics and admired the EB technologies being developed to help address that issue.

> *"The entire world, and all living organisms will benefit from this technology, preventing microplastics (and larger) from entering the environment, the food chain, water, land, and the bodies of all living things."* Recollective

Participants were surprised to learn about the high levels of water used in certain industries, such as clothing manufacture, and felt positively towards technologies that aimed to reduce water use, or re-use existing materials.

> *"If the application of engineering biology to plastic waste can reduce our dependence on fossil fuels (to make new plastic) and reduce the level of microplastics currently entering our food supply, our waterways and our bodies, then it's clearly a positive endeavour worthy of scientific innovation and investment."* Recollective

Participants were particularly hopeful about applications which they felt had multiple benefits for the environment and people, such as the Colorifix dye case study they were shown (Appendix E):

> *"This dye made from biological materials has a positive impact on the environment, ecosystem and the community; there's no adverse effects."* Workshop 4, Norwich

A few participants favourably compared EB applications to other technological solutions to climate, environment and resource use challenges, such as preferring low carbon fuels to electric cars, or solar energy generation, usually on the basis of the type of land used (for example solar panels on farmland) or the use of resources (such as lithium batteries).

> *"I feel very strongly about our need to care for our environment and the climate emergency. I feel like our government bodies are not moving swiftly enough so some of the example of engineering biology are quite inspiring and*

promising. For instance the non-synthetic clothing, that doesn't produce micro plastics, or the potentially more efficient way of recycling metal from our batteries. Some of these technologies are needed now but I don't think that is a reason to stop researching it if they think it will still take years to fully develop." Recollective

Participants used words such as, "empowering", "amazing" and "powerful" to describe how important they feel these applications are. They were amazed by the scientific discoveries that have been made in recent years in the field, and their potential to address some of the profound challenges that are being faced by people, wildlife, the environment and the planet.

> *"I'm really empowered by this. I love the fact that like there is a way where you can be more sustainable with energy. So I think for me the big benefit is those lower emissions, it's gonna be significantly better for the environment, and that's great to see. The fact that you can create something like this with biology, it just feels so powerful."* Recollective

A sense of relief imbued much of participants' thinking. In the face of shocks to many global systems: climate, food, fuel, energy and global trade, products derived from EB applications could provide the UK with a measure of self-sufficiency. They felt that low carbon fuels, for example, could make fuel cheaper and steer the UK away from dependence on fossil fuels.

> *"There is a lot in favour of low carbon fuels because currently the whole wars and all that, we're not self-sufficient. This will help us to be more stable economically. If we can push these, there's a direct benefit to lower energy costs and all that, so I'm absolutely in favour of EBs in that sector."* Workshop 4, Edinburgh

> *"Turning algae into biofuel I thought was a really fascinating case study because that could just absolutely change everything. If we don't need oil anymore, if we can just get it from these algae, then there's just going to be algae farms everywhere in the world. And when we need some, you know, oil, we just go get it there. I just think about how this could just change so much stuff. It's pretty cool."* Workshop 3

Chapter 4: key takeaways

- Participants had high hopes for EB across all five application areas, rooted in a desire to tackle the cost of living, ill-health and climate change.
- Their support was contingent on concerns being addressed, and they rarely expressed hopes without also acknowledging concerns.
- Their greatest concern across all applications was the unintended effects of novel, early-stage technologies, particularly once deployed at scale.
- Participants worried about EB solving one problem while creating another, and about some applications diverting attention from reducing consumption and emissions.
- Health applications prompted the greatest hope, especially where participants had personal experience of conditions such as cancer or diabetes.
- Concerns included human error, unequal access, the diversity of genetic evidence and informed consent.

- Food and agriculture applications prompted the greatest concern, particularly about the impact on farmers and rural communities, safety, naturalness and choice.
- For waste and environment, low-carbon fuels, and chemicals and materials, participants hoped for less pollution and lower emissions, but worried most about uncontrollable releases into the environment.

5. Principles for governance

> *"I think this is a unique opportunity to create a new governance model, something that doesn't currently exist." Review workshop, dialogue participant*

Participants came to this public dialogue with a spectrum of attitudes towards governance, regulation and government intervention. But they shared a strong sense that in EB governance, the stakes are high. The potential benefits for society and humanity are great, but the risks felt real. In-depth discussions on governance brought together aspirations for the UK to lead in EB innovation, with clear requirements for safety, public benefit and environmental protection. What emerged was not a set of contrasting perspectives about more or less governance and regulation, but a universal desire for something better which is described in this chapter. Participants wanted to see a new kind of governance that is both robust and flexible enough to ensure that EB innovation brings genuine improvements to all our lives.

5.1 The fundamental principle for good governance: EB should benefit people and the planet

> *"We should be seeing results. We should be able to smell the air and feel good."* Workshop 4, Norwich

As we have seen in the previous chapter, participants strongly believed that EB should be governed in a way that benefits humanity as a whole and has a positive impact on our environment. EB applications should aim to improve quality of life in tangible ways; technological advancements should be shared equitably, and benefits to nature and the environment should be considered in their development. Participants emphasised that EB development and application should preserve what matters to people and their histories, cultures and natural environments.

Many participants felt that political and commercial interest can often be at odds with public good and environmental protection. They believed that economic growth from innovation does not automatically equate to benefits for UK society; it can end up benefitting a small number of individuals or enriching foreign corporations. If public benefit is the ultimate goal of EB governance, public money, shared knowledge and the use of planetary resources in EB can be managed in a way that brings shared benefits back to UK society and the natural world.

"There's government investment in the industry, then there's got to be some benefit that comes back for the community, be that better, cheaper food, better medical treatment, something that's available to all of us. So, there's that outcome that we can all benefit from too. It's not a financial thing, but it's an improved quality of life." Review workshop, dialogue participant

5.2 Responsive, flexible governance is required

Many participants perceived UK governance mechanisms to be cumbersome, bureaucratic and slow to act. They wanted to see more dynamic and agile systems capable of keeping up with the fast pace of EB development in an ongoing way, particularly with AI potentially supercharging the pace of innovation.

> *"Constantly assess whether the benefits to society will be outweighed by any new risks identified as the project develops. Be open minded to other possibilities and outcomes."* Recollective

This responsiveness is also a way to take advantage of novel opportunities; being risk aware rather than risk averse can provide the necessary reassurance for researchers and investors to move forward.

> *"Make it so people want to invest in it so you are future-proofing everything and regulation helps with that because you might think there is no regulation, I do not want to invest all my money because if it is not tightly controlled or something goes wrong, I am going to be sued in 10 years' time."* Workshop 4, Bristol

Participants were clear that this agility does not mean changeable or non-binding guidelines where loopholes can be found. It meant to them governing and regulating in a smart and adapted way according to the application and its context.

For some participants flexibility could mean providing spaces for innovation which are curiosity driven and not bound by commercial, political or social pressures. It could also allow the time necessary for creation and innovation to dictate the pace of development, and for mistakes or u-turns to be made in the service of important new ideas.

> *"If the government just says we want to put money into research because it will repay us, you've already put a restriction on it. Hopefully it will repay you, but you can't have really new things happening if you've said we're looking for a commercial return in this length of time. At some point you've got to say, 'go and do it and we won't be cross if it takes a while or it doesn't happen'."* Workshop 4 Norwich

Well-planned exit strategies are also part of this responsiveness. If an application is not working as anticipated, is becoming too costly or serious risks are emerging, mechanisms must be in place to control and stop further development. Some participants said they liked the idea of a traffic light system, which incorporates a red light for when an innovation should stop until further notice.

> *"The governance needs to be flexible and positive but also willing to say no when things are going wrong. Governance should not just be restricted to making it work. If it's not going to work, they should be able to step back and say no, we're not going forward with this."* Workshop 3

5.3 Learning from the past to enable proactive governance

Participants felt strongly that EB governance must learn from current and previous governance successes and failures in the UK and internationally. They wanted mechanisms to be put in place to anticipate and prevent harm, rather than in response to crises.

The high standards of governance in the health sector in the UK were a source of pride and reassurance for many participants which they believed could set an example for other sectors.

> *"The fact that we have a very strong, and very serious, and one of the best regulatory systems in the world for medicines means that we know how to do it and we can do it in any industry."* Review workshop, dialogue participant

Participants felt that robust standards coupled with universal healthcare have enabled the UK to both innovate and keep the public safe. One participant used the example of fentanyl and the opioid crisis in the United States of America (the US) as an example of what can happen if health regulation is lax and commercial interest is prioritised over public safety.

The development and rollout of the Covid-19 vaccine in the UK was given by several participants as a positive example of flexible governance responding to an evolving situation at pace. They said the right conditions were created for accelerated innovation to succeed which they saw as being immediately beneficial to UK society.

Many participants also expressed a sense of reassurance about the high standards of food safety in the UK, particularly in contrast to the US and China, with a few giving the example of UK restrictions on GM crops.

But participants were keenly aware of ongoing governance failures which are having a tangible negative effect on human and environmental health. Fossil fuels, single use plastics and tobacco were repeatedly cited as long-standing examples of heavily marketed industries which have become woven into the fabric of society, without their harms being acted upon in a timely way.

Vaping was frequently given as an example of a newer innovation, hailed as a safer alternative to tobacco, where research is now showing harms. Participants said these risks should have been obvious sooner, yet regulation is still weak.

> *"There's now more people vaping than smoking (...) Surely all these regulatory bodies were in force then, how did this possibly get through the net? They should have worked out that sucking chemicals into your lungs is going to do something long-term."* Workshop 4, Norwich

Participants frequently cited social media as being a product causing harms that in retrospect appear to have been foreseeable for many years, but which are only now prompting serious regulatory intervention.

> *"Social media came in the '90s…and look at the harm that's done. Surely you can't be lagging behind 30 years?"* Workshop 4, Norwich

Similarly, participants expressed serious concerns about AI as an example of a fast-growing technology with significant implications for society, which, pushed by powerful corporations, has been adopted by our businesses and institutions at pace, in the absence of meaningful governance.

> *"If you're big enough and rich enough the government will let you off, like AI and data centres, they have lax planning, they have more advantageous risk policy and less employee protection. That's part of what makes them advantageous to business. If you don't hold everyone accountable, this is what's happens, it's kind of what the government's doing right now."* Workshop 4, Norwich

Many participants frequently mentioned the failure to regulate water companies effectively in the UK as an example of a fragmented and underfunded regulatory system. They used this as an example of an approach which they felt is ill equipped to protect the public and the environment against private interest.

Several participants spoke about ultra-processed foods (UPFs) to show how poor industry governance can exacerbate inequality, worsen public health, and lead to solutions which don't address the root of the problem.

> *"Those ingredients aren't there to make it more nutritious or healthier. They're there to make it last longer and make it more profitable. There's an obesity crisis and we know that it's poorer people who get to eat all the processed food because it's cheaper. And everybody who's going off to Waitrose and buying their organic whatever, they're all right. It's just adding more and more instead of paring it back."* Workshop 3

Participants said lessons from governance successes and failures point to the necessity for a more anticipatory and proactive approach from the outset, particularly before a product is released more widely. They felt that with the experience and technology we now have, potential harms may be obvious enough to ensure they are addressed at the earliest stages of product development.

Equally, participants pointed out it is not always the innovation or product itself that is harmful, but how society chooses to use and manage it. They cited mobile phones and plastics as inventions with ground-breaking benefits, but where governance has failed to provide safeguards as the industries are scaled and products sold to the public.

> *"Plastic is still wonderful. It is fantastic for medical devices, for things that we really need it for. It is the misuse, the single-use rubbish plastic. So it is the application of anything. It is not the actual development of it, it's what we do with it afterwards."* Workshop 4, Bristol

The UK leading in proactive governance

Participants wanted to see the UK leading not just in EB innovation, but in the way EB is governed. Participants did not want to see overly stringent regulation hampering innovation and leaving the UK behind, but equally participants did not want to see a race to the bottom where the country with the weakest EB governance makes the fastest progress. Some participants suggested that a balance can be struck by using the UK's reputation for high standards as an asset, and a way of leading by example.

> *"What we need to do is keep up with what is going on and show how to do it in an exemplary way and the best way rather than just leaving it to be like a wild west. You just cannot be a luddite and say we are not going to do it. I think it is going to happen and I think it is better to lead with excellence of standards."* Workshop 4, Bristol

5.4 Ensuring the UK benefits from its own EB sector

Participants saw the UK as a world leader in research, science, medicine and innovation. Yet during the course of the dialogue they were disappointed to learn about a long-running pattern in EB in which British ideas are developed and profited from elsewhere. They say this often involves public money being provided to start-ups or for new ideas, but in the absence of the infrastructure or funding to scale, companies fold or sell out to wealthier nations, particularly in the US. All of this leads to a loss of returns, tax revenue, talent, knowledge and reputation for the UK, and sometimes the necessity to buy back products that were first developed here.

Many participants saw this as a priority area for new governance models, and proposed a range of mechanisms to ensure a return for the UK when investments are made with taxpayers' money. Some participants put forward the idea that as an investor, the government should take a stake in any company it funds, to receive dividends and have a say in company governance. Others suggested direct forms of public ownership of EB industries, particularly in agriculture and health where critical public goods and services are concerned.

> *"Spending on engineering biology must be closely governed, and the companies that receive this money should be partially owned by the public as a result of taking our money."* Recollective

Several participants also spoke about the need to cultivate the conditions to attract and retain talented researchers who can stay and scale their work in the UK, including by subsidising small businesses and having fewer visa restrictions for international researchers.

5.5 Long-term, non-partisan investment and planning

Many participants spoke about their lack of trust in a political system where a four-year electoral cycle leads to short-termism and adversarial politics causes a pendulum swing in the opposite direction of any progress made by a previous government.

> *"You really don't want government to go off on a hobby horse on a 4-year cycle and leave us, leave the public, to pick up the pieces."* Review workshop, dialogue participant

Some participants said that frequent changes of government and ministerial positions undermine the build-up of policy expertise and institutional knowledge, so ministers are not always best placed to make effective long-term decisions.

> *"A lot of politicians don't have backgrounds in the departments that they're put in. So, you could have someone who's a politician and they're the leader of transport, but has no idea about infrastructure and engineering. I think the government should be involved, but I think governance should be multi-faceted."* Workshop 2

Many participants shared their strong view that EB governance must sit apart from the electoral cycle and the narrow self-interest of party politics. Consistent planning, steady long-term investment and joined-up thinking, particularly from the civil service, were seen as essential in making substantial progress, in a safe way, within such a complex field.

> *"You are never going to make EB fuel in four years. You need 10 years to develop it plus testing etcetera, so once the government is giving money, it commits to it for 10 years before it can back out."* Workshop 4 Bristol

5.6 A collaborative, independently governed regulatory body

Participants emphasised the importance of robust independent oversight to overcome political, economic, professional or intellectual interests. They wanted to see a collaborative approach between the civil service, stakeholders from research and industry, and the general public, overseen by an independent third party from outside the world of EB.

> *"The main thing for me is that there is a third party that oversees all EB related ventures or even ideas. There needs to be in-depth research and deliberation about every single EB application so that there are not any stones unturned."* Recollective

The aim for participants was to open up siloed thinking to paint "the bigger picture" (an expression participants frequently used) of what any particular EB application could mean for society and the environment, now and in the future. Importantly, participants said this includes planning for and mitigating worst case scenarios and unforeseen circumstances. They wanted a collaborative approach to bring any narrowly focussed or risky goals into contact with pragmatic considerations from the general public, as well as with other stakeholder perspectives.

> *"If I was a scientist and I developed something, I mean, I'd become so passionate that this was the right answer. I perhaps might need somebody to calm me down a bit and, you know, perhaps look at the bigger picture."* Workshop 3

Participants said that any regulatory body should not be funded by organisations with a stake in EB, and mechanisms should be in place to ensure it does not become a vehicle for lobbying or industry "marking its own homework".

> *"I don't think regulatory bodies should be governed by anyone who has a monetary interest in what is involved. That is where corners are cut and allowances are made to make sure money gets made."* Recollective

5.7 Honesty, transparency and openness at all times

Participants frequently expressed their weariness with the prevailing context of mistrust between the public, and government and big business, and stressed how refreshing a forthright and honest approach to EB governance would be.

> *"It's so sad how jaded the general public is with issues like this because we can see time and time and again where we've been lied to."* Workshop 2

In particular, many participants said they would be reassured to hear more about when things go wrong in EB; what happened, why, and what was done about it, rather than only hearing success stories. They appealed to those developing and communicating about EB to trust the public with the uncertainties, risks and mistakes, as these are important to know and part of public's learning process for this new and "amazing" area of science.

> Participant 1*: "Mutual trust between the public, the companies and the government so that stuff like this is more common knowledge and open to all."*
>
> Participant 2: *"Yeah, the government and companies trusting the public to be able to cope with the fact that things are uncertain and to share that with them."* Workshop 4 Bristol

Participants recognised this would potentially require a culture change, where mistakes are valued and researchers are encouraged to be open about them. Discussions in the final workshop involving stakeholders showed how current research culture favours dissemination of success stories.

> *"That's a difficult concept in research; you don't get rewarded for publishing what doesn't work. Culture change is necessary around what is valued in*

research. In practice things that didn't work get passed on to colleagues but not necessarily get published. You don't get more funding for things that haven't worked. In the lab if you push boundaries 99% of the time things don't work. How do you maintain confidence in that situation, that is that is nature of R& D. It's a long path" Review workshop, stakeholder

Participants also stressed the importance of clear and honest definitions and communications, around EB in general, but particularly in marketing and advertising. They wanted to see clear labelling of products made using EB, to make sure consumers can make informed choices about who has produced what they are buying and how.

> *"If they're buying a chemical that was developed in the lab, they should know it's a chemical developed in the lab and not just call it olive oil. It's kind of lying."* Review workshop, dialogue participant

5.8 Clear lines of accountability and long-term monitoring

Participants felt strongly that clarity is essential for accountability, and some suggested this is best achieved with individuals being named as personally responsible for particular applications.

> *"Someone has to be there to make people own up, someone needs to be in charge. We need to know where exactly the buck stops."* Review workshop, dialogue participant

At the same time, participants said they believed that accountability mechanisms should be designed to cover long timescales, far beyond the development and scaling of a product. Systems need to be built to withstand change and outlive individual careers or the fortunes of private companies, so that potentially unforeseen long-term consequences of EB innovations on society are covered.

> *"When this technology goes wrong, they're not going to be here to pick the pieces up in 30 years' time, are they? Who is going to pay the price over generations?"* Workshop 4, Norwich

Participants emphasised that accountability goes beyond blame; clear plans for who will resolve problems and how and importantly, who will pay, need to be in place so that swift action can be taken in the event of something going wrong.

Appropriate and timely sanctions should support this. Some participants spoke about fines being insufficient to deter wealthy corporations from malpractice. Equally, participants were not satisfied with vague and unenforceable guidelines and wanted to see legislation governing high-stakes EB applications which can be acted upon decisively.

> *"The regulations made need to have the backbone of law, to keep people accountable, which is where politicians would come in to make sure these laws are created."* Recollective

> *"We have a lot of long inquiries these days but we see that the findings of these inquiries are not legal obligations to act upon. Maybe if we set up legal enquiries into certain important aspects of EB with an assumption that Westminster has to act in some sense on the results. It's disappointing where we the taxpayer spend millions on these big piles of paper and nothing is done."* Workshop 4, Bristol

Participants also spoke about the importance of clear routes for recourse for individuals, where two-way channels of communication are open between the public and those responsible for EB developments. One participant suggested an EB equivalent to a yellow card scheme, where the public can flag safety concerns related to medical products in the UK.

Ongoing monitoring of measurable outcomes

Participants said transparency and accountability should be supported by a well-resourced, independent, statutory monitoring of outcomes against stated goals over a particular timeline. Those developing EB applications should be held to account for their promises.

> *"There needs to be external audits, when technology is so abundant, we can just have the whole thing recorded 24/7. And if there's any question ever of what happened, you've got a perfect record. They can't just be coming out with a finished product and not show us the 40 other iterations of the cycle."*
> Workshop 3

Participants suggested measurable targets that would be meaningful to the public, such as carbon emissions reductions, pollution levels, or amounts of plastic in soil or waterways. The money spent on EB applications should also be carefully monitored to ensure efficiency and appropriate use of public funds.

Participants wanted to see qualitative details about processes, unexpected issues, and if and how they were resolved. The ongoing nature of this monitoring was particularly important to participants, many of whom were wary about unintended consequences of EB over time.

5.9 International EB governance is important

Participants recognised that EB innovation will have social, environmental and political implications on a global scale. As a result, many said they believe corresponding international governance is essential.

A key guiding principle of EB governance for participants was that it should protect and repair our climate and environment. Participants emphasised that any application that affects our global commons, such as our atmosphere, oceans or rainforests, will affect us all. They said that robust environmental standards in the UK must extend to our international EB activities and supply chains, to prevent EB innovation simply exporting pollution, or importing goods that have been produced in harmful ways.

Fairness and social justice prioritised in EB governance

Connected to this global imperative was the guiding principle that EB innovation should benefit humanity as a whole. Participants prioritised fairness and social justice both in the UK and at an international level. To achieve this they said EB governance must consider the effects of the deployment of these applications on livelihoods and natural environments outside of the UK. They emphasised that people or nations who are likely to be affected by EB developments should have a voice at the governance table alongside countries like the UK with a strong or fast-growing EB industry.

> *"We should recognise that there are some countries that bear the brunt of environmental impact maybe more than we do and those countries should also have a voice."* Workshop 4 Chester

Fulfilling these principles requires a collaborative approach, both to prevent harm and to maximise opportunities. Participants were keenly aware, in part due to the experience of a global pandemic, that biological entities do not respect international borders. As a result they highlighted the importance of mechanisms for international cooperation and knowledge sharing in EB being in place to prevent or contain mistakes, accidents or leaks which could have global ramifications.

> *"Just imagine if plastic eating bacteria was created and then released in a different part of the world. If they've got no governance, it doesn't matter if we've got all the loveliest governance in the world. If that ends up in the oceans, gets washed up on the shore, somehow gets transferred, and then before you know it, everybody's medical devices are disintegrating all over Britain because somebody at the other side of the world made something."* Workshop 2

At the same time, participants emphasised the opportunities that international collaboration should bring, to improve, test, scale and potentially speed up innovation, as well as making governance and regulation itself more efficient and useful.

> *"You'd like to see regulatory bodies all working closer together, learning from each other, working collaboratively even with other countries, like what have they learnt from this specific thing rather than us all doing it separately - that's not an efficient use of time, is it?"* Workshop 4, Chester

There was much discussion about what shape this international governance should take, and the challenges it would face. A recurring theme was a lack of trust in the US, which participants perceived as having lower standards of governance than the UK in important EB application areas like food, agriculture and health. They also talked about the volatility of the current US administration, and its pro-fossil fuel and deregulatory position around climate change.

To counter this instability, some participants said that closer collaboration in EB with our immediate neighbours in Europe could be part of the answer. Some felt that shared European values around climate change, food security and universal healthcare would lead to more fruitful collaboration across EB application areas. These participants emphasised the need for stable and straightforward Europe-wide EB governance to include the UK, rather than increasingly divergent approaches to governance which could hamper progress, limit markets and funding, and cause future complications. A few suggested special agreements for EB between the UK and Europe, like a "Schengen for EB" which they said could circumvent the instability and red tape around our current interactions.

Other participants emphasised the importance of a fully global approach more akin to a UN global accord or OECD agreement on EB. Without a global approach they felt the impact of international governance would be too limited.

Some participants spoke about the risk of countries racing to innovate and cutting regulatory corners, or copying a product and reproducing it with fewer safeguards which could lead to harm. They spoke about the importance of international

protections for UK intellectual property and mechanisms to ensure innovations are then applied in responsible ways internationally.

5.10 Governance carefully tailored to each application area

Whilst recognising the importance of coherent and joined-up EB governance, participants agreed that each application area has its own complexities, considerations and priorities for governance which require a specific approach.

Applications with a direct effect on the human body require the most stringent and carefully paced regulation

Participants said that there is a particular duty of care in health and food where the products of EB are ingested or act on the human body, and mistakes could have serious consequences for individuals.

> *"There's a duty of care if you are dealing with say red blood cells (…) in future years suddenly these transfusions are really bad for people and then my blood now has been damaged, which then produces a big scandal and people's lives are ruined."* Workshop 4, Norwich

They said this area also requires the most robust public involvement to include lived experience over time in development. They felt this high level of regulation should also apply to waste and environment applications that may affect water supplies or food growing.

> *"I'm a big fan of a strong regulatory environment being in the medical research world, it's one of the most regulated industries. And yes, it's a pain on the one hand, but it's really good to see that there are many, many hoops you have to jump through before anything is allowed to get to market."* Workshop 2

Governance should influence the pace of development according to the application context

In health and food applications where there is a particular duty of care, some participants said that speed is not always the right approach; caution and getting it right is more important here, and they suggested that the public accepts that.

> *"This is why it's really important that they do rigorous testing and people are patient. I know that there's a bit of anticipation of, 'Oh my gosh, there's this new thing coming out, why is it not out yet?', but there's a reason why it takes so long for things to come out because they need to make sure that people are safe and that they're doing things properly because the impact it has later on in life affects them as well."* Workshop 4, Norwich

One exception to this principle applies in terminal illness, where participants agreed that if a patient does not have time to wait for an innovation to go through the standard processes and is willing to try it, they could be enabled to do so.

The Covid-19 vaccine development in the UK was given by some participants as an example of flexible and effective governance which enabled speedy rollout of a new innovation to respond to urgent necessity. But there was unease amongst others around this example setting a precedent for EB innovations. There was a perception amongst a few participants that the vaccines were rushed out without transparency on how widespread and serious side effects could be. One participant said the legal

immunity granted to the vaccine manufacturers should not happen outside of the very particular set of circumstances of a pandemic.

Where there is urgency, regulatory sandboxes were a popular governance solution. Participants responded positively to stimulus material explaining the regulatory sandbox model, to enable experimentation and exploration in a controlled environment where scientists work closely with regulators. Many saw this is seen as a safe and efficient way to accelerate important innovations and share learning where a novel idea or technology does not fit neatly into existing processes.

Wide-ranging applications that could affect the environment require long-term regulations with global reach

Participants called for robust and specific regulation of applications which could have a wide-ranging effect that people may have little choice over, such as anything with the potential to affect the environment. They contrasted such applications with consumer products such as flavourings or dyes, that people could choose to use or not. As shown in chapter 4 participants expressed a high level of concern about the possibility of escape and contamination, particularly in applications using algae for biofuels or bacteria which can digest plastics. In consequence, participants said regulation should require strict rules about development in secure, closed environments. They suggested that biosecurity measures must be agreed on at a global level, to prevent what participants see as a strong possibility of cross-border contamination. And crisis management plans must be thoroughly prepared to quickly mitigate and remedy worst case scenarios.

> *"Strong biosecurity measures. Concerns about escape into the wild: regulation to keep it in a controlled environment and have a plan that enables quick action if it escapes."* Recollective

Participants frequently returned to the example of single-use plastics to make the case for international and long-term governance around responsible disposal of novel chemicals and materials. There was a perception that when plastic was invented, there was a lack of knowledge and foresight about how long it would take to break down, and what the implications of this would be.

Participants said that now we know about the damage done by forever chemicals, which can remain in nature for centuries and contaminate human bodies, governance of chemicals and materials should encompass a multi-generational timeframe. Governance should seek to answer the question, 'What effect could the invention of this material have on the world in 100 or 1000 years' time?' Participants said that testing and regulation should ensure that new materials can break down naturally or will be fully disposed of in a responsible way.

Low carbon fuel applications must be supported by stable policy and avoid greenwashing

Participants said that low carbon fuels should be governed in a way that enables secure, long-term policymaking. Stability is necessary to support construction of the corresponding public infrastructure, and also because people make important life decisions based around fuel policy such as buying a car.

This is an area where some participants felt there may be other more effective solutions to reducing transport emissions. They wanted to see governance mechanisms in place to ensure that technology that aims to reduce carbon emissions does not overpromise around its environmental impact or detract from behaviour change and emissions reduction measures.

Genetic engineering requires care and thoughtful communication

Many participants expressed unease about certain applications involving gene editing. Processes they saw as being relatively traditional and close to nature, like combining similar organisms in precision breeding, seemed low risk, and something humans have been doing for a long time.

> *"I think there are two different types, they do it with crops. There are the ones where they, what Agnieszka was doing, where it's genes from similar organisms and then there's ones where you just take something completely different and put in something completely different. I think those two should have different governance."* Workshop 4, Norwich

But for some, very different organisms being combined to create something novel and unusual felt risky and unpredictable. They suggested these processes require much more stringent governance as well as careful, honest communication, as the public imagination around genetic modification is often characterised by suspicion and distrust.

> *"Making sure those two things are known to be different would make a big difference to how the public reacts, because the public reacts far more inevitably to the science fiction picture you get in your head of what a GMO does rather than if you cross this potato with this potato that sounds like pretty much what we've always done."* Workshop 4, Norwich

Applications concerning public health or food security should be protected from commercial interests

Some participants expressed the view that governance mechanisms should be in place to limit the influence of commercial interests in applications related to health and in food and agriculture, as these areas relate to essential public goods which should not be exploited for private gain. They said these mechanisms are less important in areas such as manufacturing or fashion where the public has more of a choice about using an EB based product.

> *"We need to categorise and prioritise different aspects of EB, according to whether they are in the commercial or public interest."* Recollective

5.11 In-depth public involvement at every stage

> *"Technologies are nothing without the people they're applied to."* Workshop 3

There was strong consensus amongst participants about the need for robust public collaboration in EB governance, and the mutual benefits this could bring. Participant discussions indicated a great appetite for ongoing public participation. Participants emphasised that because EB is an emerging technology it requires novel approaches to mitigate risk, seize opportunities and account for the shifting contextual complexity of innovations. They said that the ongoing involvement of a broad swathe of stakeholders, specialists and lay people would build public trust in

the sector and enable effective, democratic, well-informed, and future-proofed decision making. Stakeholders from funding bodies, industry and the scientific community who participated in the final dialogue workshop shared this enthusiasm.

> *"To have that agility have we've got to have citizens everywhere - in the funders, in research, in governance, that voice coming through at every level"* Review workshop, stakeholder

Who should be involved in EB governance?

Participants agreed that the broadest, most inclusive possible public should be involved alongside specialists and stakeholders as described in the following bullet points:

- **A robust cohort of laypeople**, or as participants put it "ordinary working people".

> *"A lot of society and myself included feel that we are not thought of in government in new things that happen and policy decisions and that is only going to get worse unless we see real proof of working people put into these decision-making processes."* Workshop 4, Bristol

- **Affected communities**, according to each application area, for example patients who may benefit from a particular medication, or nurses who might administer it.

- Those with **minority or marginalised views**, such as religious beliefs.

> *"As a practising Christian, I worry that there is a risk of scientists or companies trying to "play God" by taking too much control over the creation and redesign of life. I believe innovation is important, but it should be guided by humility and strong ethical boundaries. Decisions should not be made by scientists and businesses alone; the public, faith groups and ethicists should also have a voice."* Recollective

- **Multidisciplinary specialists** beyond EB stakeholders, including sociologists, ethicists and environmental scientists.

> *"This is such a new area of technology that sometimes the products created don't fit into an existing framework, so it is hard to regulate them. This is why I think people from different backgrounds should be involved, not only EB scientists and the government, but social scientists, doctors, environmental scientists and chemists as well."* Recollective

When should the public be involved?

Participants not only discussed who should be involved in EB governance, but when these diverse groups of people should be involved:

- **In early research funding decisions.** Public benefit emerged as the number one governance principle in EB; participants believed that citizens and taxpayers should define from the outset what is important to society and where their money should or should not be spent.
- **In development and optimisation.** Participants said the public should be involved in ongoing anticipation and discussion of risk and opportunity, weighing up trade-offs, incorporating less quantifiable factors like emotional or cultural considerations, and ensuring the pace of innovation is appropriate.

- **In adoption, scaling or commercialisation.** Participants said that a public forum which is already involved the process can quickly feed back on how applications are affecting people's everyday lives, to make improvements, prevent potential harms and ensure that what is important to people is being protected.

- **In communication and knowledge sharing.** Participants spoke about the public's struggle to navigate a saturated media ecosystem rife with misinformation. They suggested that ordinary citizens could play the role of trusted messengers in a two-way interaction between stakeholders and the general public. In this way specialist knowledge could be shared beyond academia, industry or government, and the public could feed back to improve communication strategies.

What ongoing public involvement could achieve

Participants also spent time discussing what public involvement in governance could achieve, with building trust as a key outcome:

- **Trust.** Participants said that robust public involvement is an increasingly necessary part of the democratic process and could cultivate a sense of both collective consent and public backing.

  > *"The biggest risk is keeping the public in the dark. Decisions about biology and national infrastructure shouldn't be had behind closed doors, people need to be involved in the conversations as this will shape the future."* Recollective

They also said that mutual trust is necessary; this dialogue shows that the public is a willing and capable partner in EB governance. Several participants said the concept of procedural justice that they learned about during the dialogue resonated strongly as an aspiration.

> *"There's a lack of trust in the public from government, but we do know what we're doing."* Review workshop, dialogue participant

- **Accountability and transparency.** Many participants held the view that the public trust each other in a governance role, often more than they trust those with a specialist interest in EB. They felt that there is an important lay person's role to play in holding others to account and acting as whistleblowers if necessary.

  > *"For example, one of us on the board saying, 'actually this is wrong. Lobbying is happening. VIP fast lanes on the left'. You need somebody there to make sure transparency, accountability is upheld. If you have all these private investors, individuals, politicians, you also need the people to be represented. If anything goes wrong or anything shady is happening, you can always rely on that person to be honest and act with integrity."* Workshop 3

- **Better informed decision making.** Particularly in a context where effects and outcomes are unknown, participants believed a wide range of perspectives can prevent harm or mistakes which could later be costly or challenging to fix. They said that having members of the public embedded in the process from the beginning could be an efficient way of making effective governance decisions.

  > *"I think the best way to manage uncertainty is to have a plethora of experts from around the world weigh in on any turbulent situation regarding EB. The*

fact they are not from a singular place means that hopefully their mindsets can mirror all the stakeholders for that specific EB application, and their expertise may help in keeping tensions calm and progressing that application whilst effectively dealing with said uncertainty and providing valuable information for those key decision makers to end up choosing the right pathway to go." Recollective

- **Collective responsibility.** Participants believed that an ethos of collaboration where the goal is finding the best outcomes for everyone, could mitigate competitive business interests or the pendulum effect and blame culture of electoral politics, to enable more constructive governance.

  "Having more public involvement in decisions would mitigate a bit of that party effect, 'oh well, that was the party before us who did this and that was rubbish'. It would make it easier if it turns out that things are not working and something has gone wrong. We would all be publicly accountable for that. There would not be a blame game, and we would just be able to go, 'OK, that didn't work. Let's move on and do this', rather than finger pointing." Workshop 4, Bristol

Chapter 5: key takeaways

- Participants did not divide into those wanting more or less regulation. They shared a desire for a new kind of governance that is both robust and flexible.
- The fundamental principle was that EB should benefit people and the planet, with benefits shared equitably.
- Participants wanted governance to be responsive and agile but nevertheless carefully framed, with clear exit strategies to stop development if serious risks emerge.
- They wanted governance to learn from past successes and failures so it can anticipate and prevent harm, and for the UK to lead in proactive governance.
- They wanted the UK to benefit from its own EB sector, including a return when public money is invested.
- They wanted long-term planning that sits apart from the electoral cycle, overseen by an independent, collaborative body not funded by those with a stake in EB.
- Honesty, transparency and clear accountability were essential to participants, including openness about mistakes, long-term monitoring against meaningful goals and enforceable sanctions.
- Participants saw international cooperation as essential, because biological entities do not respect borders.
- They wanted governance tailored to each application area, with the most stringent regulation where products act on the human body.
- There was strong consensus on in-depth public involvement at every stage, from early funding decisions to communication.

6. Trust in the governance and applications of EB

In this chapter we have created a summary of the key points participants made about trust in relation to EB applications and governance. These include that participants recall where they felt trust in governance had been eroded in the past and their belief that robust regulation builds trust.

6.1 Past failures colour present trust in governance

In many workshops across the public dialogue participants gave examples of where they felt trust had been eroded because of what are perceived as past failures in governance. Participants gave specific examples in relation to Covid-19, for example the perceived side-effects of vaccines which were rolled out swiftly, and PPE contracts going to people with government connections.

> *"One example could be the Covid vaccine. My opinion is we felt that we had to have it. It was obviously produced very quickly for a very good reason. And we had to trust that our government was doing the right thing. But you know, the AstraZeneca vaccine had very big side effects, and we weren't told about that. We were only told that we would have to have it in order to continue to have our freedom. And you know, obviously everything that came out of the whole Covid time that the amount of people that benefited and who gave their friends in government certain contracts and made millions."* Workshop 2

Participants shared a broad sense that in the past there have been a number of issues and government decisions that people couldn't trust.

> *"Well, I think we've agreed that engineering biology could be responsible for major changes for the better, but that can only happen if people trust it and I want people to know that they can trust it. Because history shows an awful lot of things that have been done, that we can't trust."* Workshop 4, Bristol

The key point related to trust here is that participants felt that if issues are hidden away and there is little transparency in both the governance process, and the development of the applications, then trust will be eroded. They suggested that one failure can outweigh many successes because that's what people will read about and share on social media, rather than all the positive things that EB could bring. If the public is part of the governance process, and mutual trust is built between those governing the applications, those developing them, and those making use of the products that emerge, then this will benefit the governance process and the development of applications.

> *"I think everything is built on mutual trust and confidence between us and people making decisions. So the government, politicians, decision makers, corporations, private interests, whoever they are, so we trust you to do the right thing. If there are failures, we learn from the failures. I think it is by building on the successes that you produce as an industry in terms of biological engineering."* Workshop 4, Bristol

Honesty and transparency about uncertainty are required for trust

Many participants said they would trust something more if its limits were openly acknowledged, including acknowledging:

- What has and hasn't been tested?
- What are the risks and mitigations for them?
- How will the governance of EB applications be monitored?

> *"As long as you say we have tested X, Y and Z but we have not been able to test this because we cannot simulate 50 years' time. As long as you present the risks, present any mitigations that are there and then monitor it. That is all you can do, but yes, I would definitely trust people more if they said that there is uncertainty and why."* Workshop 4, Edinburgh

People can't trust what they don't understand

Participants were clear that it is near impossible for people to trust technologies that they do not yet understand. They wanted a programme of education and awareness to be built into EB development and governance. They do not want just to be told something is good for them and to expect that they should believe this unquestioningly.

> *"We need to be educated and informed every step of the way."* Workshop 4, Norwich

Equally in this case participants said that there is a risk if there isn't absolute transparency, because people will fill the gaps with misinformation or conspiracy theories seen on social media. They raised concerns about influencers replacing the role of journalists, and people putting their trust in the former which would be a serious issue for trust in EB. They called for advice, information, support and clarity so that people can distinguish opinion from fact.

> *"Our trust in public knowledge is being eroded because it used to be that there would be sort of journalistic rigour, and you would trust what you would hear. Now it is just influencers who basically have got their own axe to grind, and people do not really know what is real and what is not. We should try and restore public trust by allowing people to know what an unofficial opinion is, and what is actual fact and have it as a two-way channel."* Workshop 4, Norwich

6.2 Strong regulation builds trust

Participants in the in-person workshops and in the final draft findings review workshop said that the UK regulatory system for many of the areas in which EB will be operating, such as health and food, is seen as trustworthy. They held the medicines regulatory model up as being particularly rigorous.

It was important to participants to make sure the technologies and applications are future-proofed and horizon scanning has been carried out. This is to make sure that no matter how fast-paced developments are in EB, and in the technologies that underpin them, the governance framework and regulations are flexible enough to keep up. They suggested that public trust was dependent on such future-proofing being done, not just for the applications, but for the technologies that have contributed to their development.

> *"The one for me which stood out was the AI because, good or bad really, I know AI could be useful, but a lot of the models like ChatGPT and everything they're not that trustworthy either. So, how much actually can we trust AI with stuff like this?" Workshop 4, Bristol*

Participants mistrusted anything that felt like spin, or the use of one word to mean another because that word was seen as more publicly acceptable. Genetic modification and gene editing were discussed in this context.

> *"I do wonder if genetic engineering is just genetic modification with another name. And as the public understands genetic modification, I wonder what kind of angle they're trying to spin here. I think that's what's causing a lot of mistrust in the public. It's that instead of approaching the problem with what we all recognise it as they hide behind some sort of word salad." Workshop 3*

As we have seen at the end of the previous chapter participants stressed that involving lay people in decision making and governance on EB applications is important. This builds trust because it gives a level of accountability which is welcome and they do not think can be achieved by government alone. For example, many said that current regulatory systems do not penalise industry severely enough for wrongdoing, and if there were public participants involved in governance they would call this out and ensure that appropriate and meaningful measures are in place.

> *"There is unclear accountability, and that's frightening. We've talked about the fact that companies can make mistakes. These fines can be like 1% of their total revenue. So, they're willing to take these risks." Review workshop, dialogue participant*

Participants pointed to their work in this public dialogue as evidence that they can be involved in governance processes. A theme emerged in many of the discussions on involving people in governance: that if peoples' views are taken seriously they will respond thoughtfully, and this in turn would build trust in EB applications.

> *"With this public dialogue, with our views being shared and heard and also being presented in a report and also the fact that this could influence the final decision in some certain degree, I think makes a huge difference. Yeah, I think this will only go a long way in strengthening people's trust in engineering biology and what that has in store for us." Review workshop, dialogue participant*

Chapter 6: key takeaways

- Participants' trust in governance was coloured by what they saw as past failures, including examples from Covid-19.
- They felt one failure could outweigh many successes, and that a lack of transparency would erode trust.
- They said they would trust EB more if its limits were openly acknowledged, including what has been tested, what the risks are and how governance will be monitored.
- Participants felt it was near impossible to trust what people do not understand, and that gaps in knowledge risk being filled by misinformation.
- They saw the UK's regulatory systems for health and food as trustworthy, and held up the medicines model as particularly rigorous.
- They felt public trust depended on governance being future-proofed to keep pace with EB and the technologies that underpin it.
- Participants mistrusted anything that felt like spin and felt involving lay people in governance would build trust through greater accountability.

7. Innovation and society

The focus of this chapter is what good would look like for participants, if the ethical, social, environmental and economic consequences of EB innovation are properly considered. Participants emphasised the importance of a selective and discerning approach to EB innovation; they want to see fairness and equity both in terms of accessibility and who bears the burden of risk; they wanted livelihoods protected in the UK and overseas; honest, impactful environmental solutions that respect natural systems, and a public that is well-informed enough to hold decision makers to account. If these elements materialised for EB governance, they believed this will demonstrate responsible innovation in action.

7.1 Prioritise EB that solves major societal challenges

The major challenges society is facing, particularly climate change, food insecurity and an overextended health service, came up regularly throughout the dialogue. Participants frequently spoke about the effects of the real and harmful pressures on household finances and the struggling public services that are having an impact on their lives. In this context some were surprised to hear about the substantial investment of public money into EB applications. As a result, participants felt that frivolous or purely commercially driven EB applications should not be prioritised by the EB sector, especially as they saw EB development as expensive, sophisticated and potentially risky.

Grapefruit flavouring became emblematic of this perspective during the dialogue. Participants saw this application as something society can easily live without. Participants discussed case studies relating to bringing back extinct flowers to make perfume or recreating mammoth DNA to make meatballs. They saw these examples of EB applications as gimmicky and wasteful of researcher skills, the technologies employed, and, most importantly, public funding.

> *"My local library has had to shut down due to funding cuts, but money was found so that perfumes can smell like grapefruits."* Recollective

Participants wanted to see EB being used in cost effective ways, to solve the major issues of our times and meet genuine needs, rather than feeding consumerism. To do this they wanted to see a broad swathe of public voices involved in deciding on priorities for EB investment.

7.2 A fair and equitable sharing of EB benefits, risks & choices

> *"The communities most harmed by pollution or food insecurity are often the last to benefit from the solutions."* Recollective

Participants wanted to see mechanisms in place to ensure equitable access to valuable EB developments for all, particularly in sectors which concern the necessities of life such as health and food. Participants were particularly concerned about the involvement of private EB companies in health applications leading to treatments which are unaffordable to the NHS and the general public.

> *"It's nice to have all the innovations, but do people have access to them? For example, blood technology, would people have to pay for it? Will it be*

reserved for the wealthiest? People can't access it because it's too expensive. NHS doesn't provide it because it's too expensive to provide?" Workshop 3

To achieve equitable access, some participants emphasised the importance of preventing profiteering in the EB sector.

> *"Everyone's allowed to turn a profit. But it's a fact that we still need to have access for all. Sometimes things cost what they cost, but then there's inordinate profit margins because they know that there is a demand, and that is profiteering at the end of the day. You know that someone is going to pay £1,000 for this thing that you made for £100, whereas actually if you sold it for £200, you'd still make profit, and more people would be able to access it."* Workshop 4 Bristol

Another important aspect of accessibility for participants centred on the public retaining choice over whether or not they use products developed through EB. If processes lead to the manufacture of EB equivalents, such as blood, being cheaper, participants were concerned about patients, particularly those who are vulnerable or without the means to pay for private healthcare, being somehow compelled to use it.

"When you go into the clinic, there will be synthetic blood but you might not have a choice whether you use it or not, so a private company would move in and say, 'we have got real blood over here and we will sell that to you for such and such a price'. It creates that dual market once again where private companies benefit more and you have to accept what you are given." Workshop 4 Bristol

Retaining choice in the food system was also important to participants, particularly for people who are less well off. Some said they did not want food produced using EB to become cheaper and more widely available than fresh produce, as they have seen happen with UPFs, so that only wealthy people can eat healthily.

> *"If for some reason there's belief that these lab grown alternatives are less nutritious, are less something, they'll end up being the cheapest option. As a society that will then become the default for working class because we're living in the cost of living crisis. When these things hit the shelves, will you be priced towards certain choices and then lose our choice in that process?"* Review workshop, dialogue participant

Participants wanted to see the risks around EB development borne equitably. They wanted to avoid scenarios where poorer communities, either in the UK or overseas, end up bearing the social or environmental costs of wealthier regions' innovations. Participants emphasised that a broad range of affected communities should be brought into planning around mitigating risk.

> *"It is frustrating to read that communities most severely affected by PFAS contamination are often lower-income and marginalised communities and of course the least able to afford premium water treatment solutions. We don't want to see repeated examples of people being made to suffer for what they have no direct control over."* Recollective

Some participants also spoke about the importance of intergenerational fairness and balancing the risks and benefits for people in the future.

> *"Being someone who was born long after the invention of plastic. I have had no say in plastic stuff, but it's now in my food, it's in the air and it's in the water. We don't have any choice now. We're just going to be full of plastics forever."* Workshop 4 Bristol

7.3 Jobs are created, livelihoods protected and the EB industry makes the UK more resilient

Participants wanted to see a thriving EB sector creating a wide range of jobs across the country, particularly in small businesses, and well beyond specialists and researchers. They called for a commitment to a fair transition into this emerging industry, with new opportunities and retraining for anyone who may lose their livelihood due to EB development. This was particularly important in a context where AI appeared to participants to be severely destabilising the job market. At the same time, participants agreed on the importance of preserving existing industries, traditional skills and ways of life that we value as a nation.

> *"We've created new jobs, a new industry but we've protected the people. There's still a farming community. We've kept our green and pleasant land."* Workshop 4 Norwich

> *"Rather than just saying, we're not going to do that anymore, have something ready as a standby before you shut something down completely. Those jobs, that is money you are taking out of the community."* Workshop 4 Bristol

Some participants also felt that the products of a thriving domestic EB industry should contribute to making the UK more resilient and self-sufficient. They said this was particularly in the context of current global conflicts, disrupted supply chains and making energy, food, medicines and other necessities of life less expensive.

> *"Making us as a country more resilient, less reliant on imports. Agriculture, yields from crops, biofuels, fertilizers, we could grow our own. In health and drugs, we could produce our own and get benefits there. Whenever global disasters happen, there are panics e.g., sunflower oil. How much can we produce our own?"* Review workshop, dialogue participant

7.4 Honest climate solutions are required

Participants welcomed climate solutions using EB applications if they were seen as honest, respectful of natural systems, and work as a solution which does not perpetuate the problem. They expressed excitement in learning about the range of ways EB could replace fossil fuels in our economy. They shared a sense of urgency to use everything we have at our disposal to tackle the climate crisis.

However, they feel EB innovation has the potential to worsen the climate and nature crisis in three broad ways:

- By further destabilising delicate and sophisticated natural systems, with man-made solutions to man-made problems;
- By greenwashing and propping up carbon-intensive industries that require society to continue using fossil fuels and associated infrastructure;
- By diverting attention and resources away from simpler, potentially more impactful emissions reductions measures which tackle the root of the problem.

> *"A lot of these issues that we're trying to fix are to do with the climate crisis. There is a danger that we are creating lots and lots of solutions, but are we redirecting things where they don't need to be? A lot of them have simple solutions. Things like using less cars, using less plastic, rather than having to create all these amazing applications and technologies. Are they needed? Is it a culture change that's needed for a lot of this?"* Review workshop, dialogue participant

Some participants wanted to stress that responsible innovation in this area requires humility, working with care and respect for nature and other forms of life using whole systems thinking.

> *"What matters to me is that (…) other life forms are given equal consideration to humans. Systems engineering must be considered within the system of the planet."* Recollective

Participants felt it requires honesty about the impacts and intentions of potential solutions and must avoid greenwashing and influence from the fossil fuel industry. Several participants gave aviation fuel as an example of an application which seemed to them to overpromise on its positive environmental impacts, as it requires a continuation of fossil fuel use, rather than proposing something new.

The benefits of often sophisticated and resource-intensive EB applications must be carefully balanced against their potential impact on solutions which aim to reduce consumption and emissions. Some participants suggested that EB applications to make the fashion industry more sustainable would have limited benefit if they encourage continued consumption of fast fashion. Others gave the example of dealing with food waste as a more economical and common-sense priority in tackling food security and equity, before engineering higher-yield crops.

> *"It seems like it's piling more ingenuity on to stuff that really can go back to basics. We need to get rid of all these micro plastics from clothes because there's so many clothes. Well, stop making so many clothes. Do that first and then try and solve the problem of repurposing it or what have you."* Workshop 3

The idea of inaction being a greater risk than action resonated with many participants during the dialogue. But they said it is essential that applications concerning climate and nature are deployed in a systemic way that maximises overall impact.

7.5 The public must be well informed about EB

As we have seen in previous chapters there was a feeling amongst participants that the public know very little about EB. During the dialogue many were surprised to hear about the range of applications being developed that could affect people's lives, as well as the amount of public money being invested. Participants felt strongly that for innovation to be ethical and democratic it is the responsibility of government and academia to build a solid foundation of public knowledge.

> *"I think a lot of people don't know what EB is. There needs to be that awareness in order to hold people accountable."* Workshop 4 Chester

Communication should meet the public where they are in both a practical and emotional sense. Participants suggested there is likely to be scepticism or

nervousness amongst the public about EB. They expressed the view that public awareness campaigns should be created with clear and honest communications, covering opportunities and risks without trying to persuade or market EB applications, which could further undermine trust.

Many participants spoke about the importance of outreach and communication beyond the obvious digital channels to:

- Make sure seldom heard communities are included;
- Providing opportunities for people to engage in their local areas;
- Or even opening the doors of EB facilities so the public can learn about EB in a tangible way.

Including EB in school curricula and training schemes was important to participants in part to provide pathways to employment in the sector. They also thought it would be valuable to inform younger generations so they can have a say in developments which could impact them in the future.

Chapter 7: key takeaways

- Participants wanted EB to prioritise major societal challenges, and saw frivolous or purely commercial applications, such as grapefruit flavouring, as a poor use of public money.
- They wanted fair access to the benefits of EB, particularly in health and food, and were concerned about profiteering.
- Retaining choice over whether to use EB products mattered to them, especially for people who are less well off.
- They wanted risks shared fairly, so that poorer communities in the UK or overseas do not bear the costs of others' innovations, and future generations are considered.
- They hoped for a thriving EB sector creating jobs across the country, with a fair transition for anyone whose livelihood is affected, while preserving existing industries.
- They welcomed climate solutions that are honest, respectful of natural systems and do not perpetuate the problem, but were wary of greenwashing and of diverting attention from simpler emissions reductions.
- Participants felt government and academia had a responsibility to build public knowledge of EB, through honest communication that meets people where they are and through schools.

8. Conclusion

Deliberations over the course of this six-week public dialogue revealed that participants across the UK saw real promise in EB. As seen throughout this report, for the most part participants came to the dialogue knowing little or nothing about EB. Over the course of the workshops, they became informed, engaged and thoughtful contributors to discussions on how it should be governed. For many, learning more opened their eyes to what EB could achieve. For some, it also sharpened their concerns, particularly about honesty and transparency. From the dialogue we can see that participants were very open to EB technologies, but continued openness and trust in them being able to meet their potential depended on the EB sector being governed well.

Optimism about EB's potential to tackle society's biggest challenges

Participants expressed a great deal of hope and excitement about what EB could achieve. They saw it as a way of addressing some of the most pressing challenges of our time: climate change, food insecurity, pollution and plastic waste in the environment, and an overstretched health service. Health applications, particularly for cancer, diabetes and rare conditions, gave participants the greatest hope. Many also felt relief that EB could help the UK become more resilient and self-sufficient at a time of global instability. They called for the UK to be ambitious and bold in the development of EB applications.

That optimism is conditional

Hope was rarely expressed without concerns alongside it. Participants worried about unintended consequences, particularly the release of engineered organisms into the environment and long-term effects on people's health. They were also concerned about the impact on farmers and rural communities, and about solving one problem only to create another. They wanted EB to be used where it meets genuine needs, not for applications that feel frivolous or purely commercial, especially when public funds are being used. They also wanted it to complement, rather than distract from, simpler solutions such as reducing consumption and waste.

Public benefit as the foundation of good governance

The fundamental principle for participants was that EB should benefit people and the planet. Participants wanted to know that where public money is invested, the benefits will flow back to UK society. Those benefits might include better and cheaper food, better medical treatment, a cleaner environment or substantial efforts to reduce dependency on fossil fuels and thus help the country to combat climate change. Participants felt that ideas developed in the UK do not always receive the investment in this country to scale them up into marketable products. As a result, such products are developed and profited from elsewhere in the world. They called for governance which would prioritise benefits being accrued in the UK and public benefit being seen in new jobs and exciting solutions to UK challenges.

A new kind of governance

Participants did not divide simply into those wanting more or less regulation but rather shared a desire for something better. They wanted governance that is robust yet flexible enough to keep pace with innovation, and proactive rather than reactive. They felt that good governance should be tailored to the risks of each application area and be independent of commercial and party-political interests. They were keen that developments should be planned for in the long term, far beyond the electoral cycle and connected internationally. The lessons of past governance failures weighed heavily on some participants. They cited plastics, vaping, social media, forever chemicals and water pollution as issues which have not been tackled through good governance. They wanted those mistakes not to be repeated with EB.

Honesty, transparency and accountability build trust

Trust was a thread running through every workshop. Participants said they would trust EB if its limits were openly acknowledged, including what has and has not been tested and what happens when things go wrong. They wanted clear lines of accountability, long-term monitoring against meaningful goals, and consequences for wrongdoing. They see the UK's strong regulatory record in medicines and food as a source of reassurance, and a set of models on which to build.

Fairness at the heart of responsible innovation

For participants, responsible innovation means the benefits and risks of EB are shared fairly. People should be able to access valuable EB developments whatever their financial means and should retain choice over whether to use EB products. Livelihoods should be protected in the UK and overseas, and future generations should be considered as well as people today.

People across society should be involved in governing EB

There was strong consensus that the public should be involved in EB governance at every stage. That runs from early decisions about research funding, through to development and scaling up, to communication. Participants wanted this involvement to include ordinary working people, affected communities and those with minority views, alongside specialists. They see it as essential to building trust, holding decision makers to account and making better-informed decisions. They also wanted the wider public to be much better informed about EB, through honest communication that covers risks as well as opportunities. Participants pointed to their own work in this dialogue as evidence that the public is a willing and capable partner in governance.

Taken together, participants' messages for government were that EB could bring genuine improvements to people's lives and to the planet, but only if it is governed in a way that is honest, fair, accountable, and shaped by the public it is meant to serve.

Acknowledgements

HVM would like to thank all the participants in the *Public Dialogue on the Governance of Engineering Biology* who, from May to June 2026, explored the topic of EB and its governance with such care, thoughtfulness and kindness. Their commitment to their responsibility of hearing the evidence, reviewing the information and forming their conclusions was impressive and profound.

We are grateful to the project team from BIST, UKRI Sciencewise and the evaluation team from Navigator Consulting and Graphic Science. Your expertise in the topic and in deliberation has been an essential guide to the process.

Thank you to members of the project's OG, expertly co-chaired by Prof. Sarah Hartley and Dr. Robert Smith, who have given impartial, informed advice, challenge and guidance on the wide scope and complex science of EB. The group worked hard to ensure the evidence, content, and stimulus materials presented to the public dialogue participants shared a range of perspectives and covered the key issues under review.

We also thank those who took part in the design workshop in the scoping phase of the project and the review workshop towards the end of the process. Both these events have helped to shape and inform the public dialogue process and the findings presented in this report.

We are very grateful to all our specialist speakers. They generously gave their time to ensure that public dialogue participants heard evidence and a range of views on this, at times, sensitive topic.

Thank you to our partners at Acumen Fieldwork and Postcode Films, who worked tirelessly to deliver the recruitment of our dialogue participants and the public dialogue films. These have both been essential to HVM's robust and transparent process.

Appendices

Appendix A: Oversight Group members

Name	Organisation	Role
Robert Smith	University of Edinburgh	Oversight Group Co-Chair, Lecturer
Sarah Hartley	University of Exeter	Oversight Group Co-Chair, Director, Centre for Responsible Innovation
Anne Osbourn	John Innes Centre (Also EBAP member)	Group Leader/ Fellow of the Royal Society
Joy Zhang	University of Kent	Director, Centre for Global Science and Epistemic Justice
Rowan Mckibbin	BBSRC	Associate Director: Frontiers and Foundations
Emily Jesper-Mir Rebecca Asher (job-share)	Wellcome Trust	Public Initiatives
Sophia McCully	Nuffield Council on Bioethics	Futures Lead
Florence Young	Campaign for Science and Engineering (CaSE)	Public Opinion and Policy Officer
Pat Thomas	Beyond GM/A Bigger Conversation	Director
Philip Simister	BioUK	Head of Science & Entrepreneur Advocate
Linda Bedenik	BIA	Head of Biosolutions & International Policy
Leslie Galloway	Ethical Medicines Industrial Group (EMIG)	Chairman
Jen Vanderhoven	BBIA	Chief Operating Officer

Appendix B: Recruitment Specification

Public dialogue on the governance of engineering biology

Recruitment specification

1. Aim & objectives:

This public dialogue has been commissioned by the Department for Science, Innovation & Technology (DSIT). It is being co-funded and supported by the UKRI programme Sciencewise.

The objectives of the dialogue are:

1. **Explore** the public's perspectives on the generic opportunities EB presents to solve societal challenges, as well as any potential concerns and how to mitigate them.
2. **Identify and understand** the public's perspectives on the opportunities of EB, any specific concerns and how to mitigate them in five application areas:
    a. Health;
    b. Chemicals and materials;
    c. Low carbon fuels;
    d. Agriculture and food;
    e. Waste and environment.
3. **Understand** the drivers that underlie dialogue participants' perspectives of EB.
4. **Map** how perspectives vary across a diverse range of public participants, including people with different lived experiences and those who are typically less likely to be engaged in EB discussions.
5. **Inform** government policy, aspects of future governance principles and wider public debates by providing well-rounded public perspectives on EB and the associated social and ethical concerns.

2. Recruitment summary

This recruitment specification is focused on the recruitment of 56 participants reflecting a broad demographic of the UK population.

We will be gaining informed consent from participants in terms which comply with Data Protection Act 2018 and UK GDPR 2021 - the UK's implementation of the General Data Protection Regulation (GDPR) and will allow identifiable data to be transferred and stored securely by Hopkins Van Mil for future research. Data shared between HVM and our recruitment agency Acumen fieldwork will be password protected at all times. HVM is registered as a data controller with the Information Commissioner's Office no: Z2969274.

Participants are required to take part in all the activities listed below for which a payment of £385 per participant has been allocated. In addition, HVM will arrange and pay for travel and overnight accommodation (as required) for the in-person workshops. Support will be given for carers/ caring responsibilities as required.

Please note support will be provided for participants who need either equipment or data to take part, they will not be excluded for not having access to a laptop, tablet or insecure/ no internet connection.

The following summarises the commitment participants will be making.

Optional tech support sessions 4pm 29th and 30th April – online on Zoom

- Workshop 1 Tuesday 5th May, 2 hours online using Recollective 6-8pm
- Workshop 2 Thursday 7th May, 3 hours online using Zoom 6-9pm
- Workshop 3 Tuesday 19th May, 3 hours online using Zoom 6-9pm
- Workshop 4 Saturday 6th and Saturday 13th June, 5 hours in-person 11am-4pm

Table 1: Indicative recruitment and workshop locations			
Region	Recruitment location (60-mile radius)	In-person workshop 4 locations	Number of participants
Scotland & Northern Ireland	Glasgow; Edinburgh; Belfast	Edinburgh 6th June	14 (10 Scotland/ 4 Northern Ireland)
South Wales and Southern England	Cardiff; Bristol; Oxford; London	Bristol 6th June	14 (4 Wales/ 10 Southern England)
Mid & North Wales & North West England	Liverpool; Manchester; Wrexham; Chester	Chester 13th June	14 (6 Wales/ 8 North West)
North East & Eastern England	Teeside; Norwich; Cambridge	Norwich 13th June	14 (7 North East, 7 Eastern England)

Payment schedule:

- Workshop 1 and 2 and asynchronous use of Recollective, 5 hours = £60
- Workshop 3, 3 hours = £50
- Workshop 4, 6 hours = £275

3. Screener to include:

Table 2: Participant recruitment criteria and targets	
Criteria for 56 participants	Target – a broad diversity of UK demographics
Gender	Appropriately balanced mix of people who identify as male / female / non-binary.
Age	Good age distribution across age groups from every adult life stage from 18 upwards. The sample should be somewhat boosted for 18-25 year olds.
Life stage	A broad range of life stages from students, young professionals, raising young children to empty nesters and those who are retired
Minoritised ethnic groups	A boosted sample so that for each group of 14 participants a minimum of 4 are from minoritised ethnic groups above current census data (acknowledging this will be more achievable in some geographic locations than others). Asian, Asian British - ideally 1 Black, Black British, Caribbean or African - ideally 2 Mixed or Multiple ethnicities - ideally 1 Other ethnic group - ideally 1
Religious diversity	A boosted sample so that for each group of 14 participants a min of 4 participants identify as having religious faith, exceeding current census data. The aim is for a diversity of faiths (e.g. Christian, Muslim, Hindu, Jewish, Sikh, and others).
Current working status and type	A range of people who are employed (part-time/ fulltime/ self-employed) and unemployed, plus those who are retired.
Social Grade	Mix of AB (3 participants) C1C2 (7 participants) DE (11 participants) for each group of 14 people
Household income	A balance from across socio-economic groups, but weighted (at least 5 participants in each group of 14 participants) for those in vulnerable financial circumstances.
Geographic location	Using the geographic locations in table 1 priority should be given for those living with IMD areas in line with ONS data The whole cohort should include those from rural, urban, suburban and coastal areas (as appropriate depending on location).
Experience of market research/ dialogue	Should not have taken part in a market research project in the last six months. Should not have taken part in a public dialogue/ Citizens' Jury/ Citizens' Assembly or public dialogue in the last 3 years, whether conducted by HVM or another agency. This includes but is not limited to:

	• Making sense of UPFs • The public dialogue on Solar Radiation Modification • Genomics, Healthcare and You • People's Panel on AI • Citizens' Panel on Sentencing Reform • The Future of Flight
Attitudes to science and technology	When you think about the future of the UK how do you feel about the use of engineering, science and technologies such as AI to solve challenges faced by society? a. Very positive b. Quite positive c. Neither positive nor negative d. Quite negative e. Very negative

Important note: please **do not** recruit friendship pairs or use snowballing techniques.

4. Exclusion criteria

Given the specification of this project, please do **not** recruit people currently or recently (in the past 12 months) working in communications, media and journalism on engineering biology.

Appendix C: Specialist presenters

18 specialists provided information and evidence to dialogue participants in the online and in-person workshops. They also answered questions in formal Q&A sessions and informally during breaks and in small group sessions.

- Lord Vallance, Minister of State for Science, Research and Innovation of the United Kingdom: A welcome video.
- Emmet McCallion, Engineering Biology Responsible Innovation Lead, DIST: An overview of DSIT and the dialogue objectives.
- Dr. Lalitha Sundaram, Centre for Existential Risk, University of Cambridge: An introduction to the role, history and applications of engineering biology.
- Sara Holland, IP Advisor, Potter Clarkson: An introduction to the governance of engineering biology.
- Dr Robert Smith, Lecturer, Science & Technology Studies, University of Edinburgh: An introduction to responsible innovation and balancing risks and opportunities in the development of engineering biology.
- Professor Paul Freemont, Head of the Section of Structural and Synthetic Biology in the Department of Infectious Disease at Imperial College, co-founder of the Imperial College Centre for Synthetic Biology and Innovation: An introduction to the five application areas under the broader issues they're looking to address.
- Mark Renshaw, Co-head of Engineering Biology at Department for Science, Innovation and Technology: An introduction to research and development.
- Professor Sarah Hartley, Professor of Technology Governance, University of Exeter; Professor Joy Zhang, University of Kent; Dr. Adam McCarthy, University of Manchester: A panel discussion on the opportunities, challenges, risks, benefits and other ethical dimensions of engineering biology.

In each of the in-person workshop locations, a panel of specialists discussed the main considerations for the governance of engineering biology:

Edinburgh:

- Prof. Joyce Tait, Innogen Institute, University of Edinburgh;
- Martin Tangney, OBE, Founder & Scientific Adviser, Celtic Renewables;
- Dr. Sophie Stone, Research Fellow (Responsible Research and Innovation | Advanced Therapeutics) University of Edinburgh.

Bristol:

- Dr. Eleanor Hadley Kershaw, University of Exeter;
- Dr. James Riley, CARMA Research Fellow, Royal Agricultural University;
- Professor Imre Berger, Professor of Biochemistry, University of Bristol.

Norwich and Chester:

- Dr. Jim Ajioka, senior lecturer, Cambridge University and co-founder of Colorifix;
- Dr. Agnieszka Witek, Postdoctoral Scientist, The Sainsbury Laboratory;
- Prof. Nick Le Brun, Professor of Biological Chemistry, University of East Anglia.
-

Appendix D: Sample workshop programmes

Online workshop one: Context setting: Tuesday 5th May 6-8pm

This is the first of three online workshops in the public dialogue, ahead of in-person workshops in June. It introduces participants to the dialogue, its purpose and how they will work together, and provides briefing and context on engineering biology, including the Government's definition and a presentation on the idea, history and applications of engineering biology.

Timings	Activity	Who
5:45 – 6:00	Check-in: participants join the Zoom early to check their video and the chat and settle in.	All
6:00 – 6:30	**Welcome and introduction to the dialogue:** HVM welcomes participants to the first workshop, introduces the team, speakers and observers, and shares the aims of the dialogue, the overall programme, the final report and its purpose, and this evening's programme. Participants can put questions about the dialogue in the chat throughout. Participants respond to a short online poll: whether they had heard of engineering biology before being invited to the dialogue, what comes to mind when they hear the term, and three words they associate with "governance".	HVM
6:30 – 6:35	**Ministerial welcome:** HVM shares a welcome video from Lord Vallance, Minister of State for Science, Research and Innovation.	HVM
6:35 – 6:40	**Introduction from DSIT:** Emmet McCallion introduces the objectives of the dialogue and why it is important to hear from participants over the coming weeks.	DSIT
6:40 – 6:55	**Questions in the chat:** Participants put questions to HVM and DSIT about the purpose of the dialogue and their role in it.	All
6:55 – 7:05	Break	—
7:05 – 7:10	**Defining engineering biology:** HVM introduces the Government's definition of engineering biology, which is used as the main definition in the dialogue. There is no universal definition, that terms such as synthetic biology and biotechnology are also used, and that the definition sits alongside DSIT's commitment to responsible innovation.	HVM

Timings	Activity	Who
7:10 – 7:40	**Presentation: introduction to engineering biology:** Dr Lalitha Sundaram, University of Cambridge, gives a short presentation on the idea of engineering biology, its role, history and applications, followed by questions from the chat.	HVM and speaker
7:40 – 7:50	**Mentimeter poll:** Participants share their expectations for taking part in the dialogue and what they would like to learn more about.	All
7:50 – 8:00	**Look ahead to Workshop 2:** Information about Workshop 2 and the importance of attending every workshop. Before then, participants are asked to rewatch presentations if they wish, review two handouts on Recollective, and complete the pre-task: sharing one image of a technology or scientific discovery they feel solves a problem, and one they feel creates a problem.	HVM
8:00	Close	—

Online workshop two: Context setting: Thursday 7th May 6-9pm

The second online workshop of the public dialogue and introduces responsible innovation and governance. Participants work in small groups with facilitators for the first time, share the images from their pre-task, hear presentations on governance, responsible innovation and the five application areas of engineering biology, and share their first reflections on how engineering biology should be governed.

Timings	Activity	Who
5:45 – 6:00	Participant check-in	All
6:00 – 6:10	**Welcome** HVM introduces the team, speakers and observers, and shares the aims of the second workshop.	HVM
6:10 – 6:15	**Mentimeter** Participants share one thing they felt was important, interesting or surprising from Workshop 1.	All
6:15 – 6:40	**Small group discussion: introductions and pre-task** In small groups, participants introduce themselves and talk through the two images they shared on Recollective, one of a technology that solves a problem and one that creates a problem.	Facilitators

Timings	Activity	Who
	They then reflect on what is surprising, similar or different across the group's images and any themes that emerge.	
6:40 – 6:50	**Presentation: introduction to governance** Sara Holland, IP Advisor at Potter Clarkson, introduces the concept of governance in the context of engineering biology. Participants note questions in the chat to pick up in their small groups.	Speaker
6:50 – 7:00	**Presentation: responsible innovation** Dr Robert Smith, University of Edinburgh, introduces responsible innovation and balancing risks and opportunities in the development of engineering biology.	Speaker
7:00 – 7:15	**Small group discussion: developing questions** Participants discuss what they have heard, gather questions and points of clarification for the speakers, and agree two priority questions to put to them. Any questions not answered on the night are answered on Recollective.	Facilitators
7:15 – 7:35	**Q&A** Each small group puts a question to Sara and Rob, with a second round of questions if time allows.	HVM and speakers
7:35 – 7:45	Break	—
7:45 – 8:05	**Presentation: engineering biology applications** Professor Paul Freemont, Imperial College, introduces the five application areas in the dialogue. He considers them alongside the wider issues they aim to address. This is followed by a short Q&A in the chat.	Speaker
8:05 – 8:45	**Small group discussion** Participants share their reflections on what they have heard about responsible innovation, governance and the application areas, how it connects with their images, and their initial thoughts and feelings on the governance of engineering biology.	Facilitators
8:45 – 8:50	**Mentimeter** Participants share what they want to keep in mind before the next workshop.	All
8:50 – 9:00	**Look ahead to Workshop 3** Information about Workshop 3. Before then, participants are asked to rewatch presentations if they wish, review two	HVM

Timings	Activity	Who
	handouts on Recollective, and review the case studies on risks, benefits and alternatives.	
9:00	Close	—

Online workshop three: Context setting: Tuesday 19th May 6-9pm

Workshop 3 is the final online workshop of the public dialogue and focuses on research and development (R&D) and the ethical dimensions of engineering biology. Participants reflect on the case studies they reviewed on Recollective, hear about the R&D cycle, explore ethical opportunities, challenges and risks with an expert panel, and begin to consider the implications for governance ahead of the in-person workshops in June.

Timings	Activity	Who
5:45 – 6:00	Participant check-in	All
6:00 – 6:10	**Welcome** HVM welcomes participants to the third workshop. Tonight's focus is on research and development and the ethical dimensions of engineering biology.	HVM
6:10 – 6:15	**Mentimeter** Participants share one thing they felt was important, interesting or surprising from Workshop 2 on governance and responsible innovation, and a thought they have had about engineering biology while reading the case studies.	All
6:15 – 6:45	**Small group discussion: case studies** In new small groups, participants introduce themselves and share what is on their mind about the dialogue. They then reflect on the case studies they reviewed on Recollective across application areas, considering the potential benefits and risks, who benefits and who is driving the technology forward, how it might affect daily life, and how they weigh up benefits and risks.	Facilitators
6:45 – 7:05	**Presentation: research and development** Participants watch a Government Office for Science explainer film, hear from Mark Renshaw, Co-head of Engineering Biology at DSIT, on the research and development cycle, and watch a short film featuring Stephen Wallace.	DSIT and HVM

Timings	Activity	Who
7:05 – 7:30	**Small group discussion: research and development** Participants discuss how they feel about the ongoing Design, Build, Test, Learn cycle, including failure rates, development time, costs and benefits, and the challenges of scaling up. They then share first thoughts on the implications of engineering biology as a fast-developing set of technologies and what matters in managing R&D responsibly.	Facilitators
7:30 – 7:40	Break	—
7:40 – 8:10	**Panel discussion: the ethical dimensions of engineering biology** A panel of Professor Sarah Hartley, University of Exeter and Co-Chair of the oversight group, Professor Joy Zhang, University of Kent, and Dr Adam McCarthy, University of Manchester, each give a short opening statement on the ethical dimensions of engineering biology. They then discuss its greatest opportunities and challenges, how society should weigh up risks and benefits, and an ethical dimension they think participants should keep in mind.	HVM and speakers
8:10 – 8:20	**Q&A** The panel responds to questions from participants.	All
8:20 – 8:50	**Small group discussion: ethics and governance** Participants capture the key ethical dimensions they heard from the panel, then consider what these mean for the governance of engineering biology, drawing on Workshop 2, including what governance should deliver for society. These points will be built on at the in-person workshops.	Facilitators
8:50 – 8:55	**Mentimeter** Participants share what they want to keep in mind before meeting in person in June.	All
8:55 – 9:00	**Look ahead to Workshop 4** Information about the in-person workshops.	HVM
9:00	Close	—

In-person workshop 4: Saturday 6th & 13th June 11am-4pm

Workshop 4 is the final in-person workshop of the public dialogue, held in Bristol and Edinburgh on 6th June and in Chester and Norwich on 13th June. It brings together everything participants have seen, heard and discussed across the online workshops. Participants explore what governance means in everyday life, hear from a panel of experts, discuss the trade-offs and uncertainties involved in governing engineering biology across the five application areas, and imagine governance working well in 2040 to develop their key messages for DSIT and others working in the field.

11:00am – 4:00pm, Saturday 6th June (Bristol and Edinburgh) and Saturday 13th June (Chester and Norwich)

Bristol: Origin Workspace, 40 Berkeley Square, Bristol, BS8 1HP.

Edinburgh: Dovecot Studios, 10 Infirmary Street, Edinburgh, EH1 1LT.

Chester: Crowne Plaza Chester, Trinity Street, CH1 2BD.

Norwich: Clore Learning Centre, Castle Hill, Norwich, NR1 3JU.

Timings	Activity	Who
10:30 – 11:00	Arrival and registration	All
11:00 – 11:15	**Welcome to our final workshop** HVM welcomes participants to the final workshop and explains how the day will work. The team reminds participants of the purpose of the dialogue, the whole programme and the ways of working agreed together, gives a brief recap of everything heard so far, and sets out what the day is building towards.	HVM
11:15 – 11:35	**Small group discussion: governance in everyday life** Participants work in pairs or threes to note down as many examples of the governance of technology as they can think of, from everyday life to government policy or the actions of large companies. Groups then discuss the key elements of governance that emerge and what learning might apply to engineering biology.	Facilitators
11:35 – 12:20	**Carousel: reviewing the dialogue so far** HVM gives a brief overview of the presentations from the online workshops. Small groups then rotate around three areas covering context, governance and responsible innovation, and R&D and ethics, with case studies throughout. In each area participants note down and discuss what stands out to them as important or interesting, and what to bear in mind when considering the governance of engineering biology.	Facilitators

Timings	Activity	Who
12:20 – 12:50	**Panel discussion** A panel of experts gives opening statements on what is in the balance when governing engineering biology, including global perspectives. They then discuss the main considerations for governing it well, where people disagree and why, and how governance can cover such a wide range of technologies, processes and products, before each giving a closing statement. Participants write down questions as the panel speaks. In Bristol: Dr Eleanor Hadley Kershaw, University of Exeter; Dr James Riley, Royal Agricultural University; and Professor Imre Berger, University of Bristol. In Edinburgh: Professor Joyce Tait, University of Edinburgh; Professor Martin Tangney, Celtic Renewables; and Dr Sophie Stone, University of Edinburgh. In Chester and Norwich: a shared panel held in Norwich, with Chester participants joining live via Zoom. Dr Jim Ajioka, Colorifix and University of Cambridge; Dr Agnieszka Witek, The Sainsbury Laboratory; and Professor Nick Le Brun, University of East Anglia.	HVM and speakers
12:50 – 1:05	**Q&A** The panel responds to questions from participants. In Chester and Norwich, questions alternate between the two locations.	All
1:05 – 1:45	Lunch	—
1:45 – 1:50	**Plenary presentation** HVM shares a summary of what participants said on Recollective about what needs to be balanced when governing engineering biology across the application areas.	HVM
1:50 – 2:40	**Small group discussion: balancing priorities** Participants discuss what matters most to them about governing engineering biology and the tensions or trade-offs that need to be balanced, across ethics, opportunities and benefits, and risks and harms. They then consider how and why their views change for each application area, and what is important when it is not known how successful some applications will be.	Facilitators
2:40 – 2:55	Break	—

Timings	Activity	Who
2:55 – 3:40	**Small group discussion: governance in 2040** Participants imagine it is 2040 and engineering biology is being used across the application areas. They discuss what governance is achieving when it works well, how it is being done, what changed to get there, and what good governance looks like. Each group then agrees the key messages they want DSIT, stakeholders and those developing these technologies to hear.	Facilitators
3:40 – 3:50	**Plenary reflections** Groups compare their findings and reflect on how they have arrived at their priorities over the past few weeks. Observers reflect back on what they have heard, what has been important in the discussions and what happens next.	All
3:50 – 4:00	**Wrap-up, next steps, close** HVM explains next steps: the team will analyse everything shared across the online and in-person workshops, some participants will be invited to a further workshop with people working in the field to discuss the draft findings, and a report will be shared with participants in summary and in full.	HVM

Appendix E: Sample stimulus materials

Words and terms we'll use in this public dialogue

In this public dialogue we'll be discussing science, scientific discoveries and new technologies. We'll also be talking about how those things are managed for the good of society. You do not need to know anything about these things to take part. We are using this space to share some words and phrases that may come up. You do not need to learn these, but this might be a useful space to get to grips with some of the things we are talking about.

There is an image below for the key terms we are talking about in the first few workshops.

You can come back to this anytime you like to remind yourself of the descriptions and definitions given here.

Engineering biology

- There is no universal agreement on a definition for Engineering Biology (EB). You will hear different definitions of EB used in this dialogue.
- You'll sometimes hear other words used instead of EB such as 'synthetic biology' or 'biotechnology'. Don't worry about that, they are broadly referring to the same umbrella term for a range of uses of the science.
- The Government's definition of EB will be used in the dialogue as the main way of describing it:

  '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. It draws on the tools of synthetic biology to create the next wave of innovation in the bioeconomy'.

- The words in this definition are described on other definition



Governance

Governance is the system of **rules, processes, and people** that direct and control how an organisation, institution or country operates. It is used to make decisions, ensuring those decisions are fair, someone is responsible for what happens because of the decisions and there are benefits for people in society.

Some examples:

Family: Parents setting house rules (bedtime, jobs to do, meals).
School: A school board of governors managing



Responsible innovation

Is about creating new technologies, products, or services that are good for people and the planet, bringing benefits to society whilst minimizing the risks.

It is about pausing to ask, "what if?" and "what now?" before developing a new programme or idea to ensure it does not cause harm.

Key Aspects:

Anticipation: Predicting potential risks or unintended negative consequences.
Inclusion: Involving people across society and diverse stakeholders in the design process.
Reflexivity: Reflecting on the motives and assumptions behind the innovation.
Responsiveness: Adapting the design based on feedback and changing needs



Case studies used in this public dialogue

In our workshops you have said how much you want to know about EB applications: exactly what EB could be used for, and what uses are being researched currently.

The application areas we are exploring in this public dialogue are on:

- Health
- Food & agriculture
- Chemicals & materials
- Waste & environment
- Low carbon fuels.

In this activity we are sharing with you case studies focused on **health**. You can think about the other application areas in the next activities on the activities page.

To review the case studies click on the files below. At the end of each case study are some things to think about.

If you have any questions you can add them to the questions area. You don't have to look at all the case studies, just follow your interests and explore what you think

would help you to discuss EB in more detail in our next workshops. Please add any comments or reflections you have on the case studies to the text box below. You could also use the video or audio functions below to share a voice or video message on your thoughts - it's up to you!

Health

- **Bacteria to fight cancer (Prokarium):** A disarmed, genetically engineered strain of bacteria (ZH9) that seeks out tumours and prompts the immune system to attack them, with a lead programme in bladder cancer.
- **Programmable cells for cancer treatment and disease detection (University of Oxford):** SimCells, bacteria whose own DNA is replaced with designed instructions and which cannot reproduce, being developed for targeted cancer treatment, disease detection and cancer prevention vaccines.
- **Synpromics: an on/off switch for genes:** An Edinburgh company developing synthetic gene switches made from human DNA, so gene therapies only activate in the right cells at the right time.
- **Manufacturing for vaccines (GlycoCell Hub, University of Nottingham):** Using engineering biology to make glycans, sugars on the surface of cells, faster and cheaper to design and test, to support more effective and affordable vaccines.
- **Gene therapy development (Advanced Therapeutics Hub, University of Edinburgh):** Using engineering biology to make gene therapies for cancer, heart disease and rare diseases safer and better targeted.
- **Therapeutics to treat cancer (LabGenius):** An AI and robotics platform used to design antibodies that tell healthy and cancerous cells apart by the density of proteins on their surface.
- **Lab-grown blood cells (BrisSynBio, University of Bristol, with NHS Blood and Transplant):** Using gene-editing to grow red blood cells in the lab that can suit more blood types or be loaded with enzymes to treat disease.
- **Smart insulin: medication that responds to your body (University of Bristol):** Molecules that attach to insulin so it switches on when blood sugar is high and off when it drops, aiming to prevent dangerous hypos.

Food and Agriculture

- **Bio-based sweeteners (MadeSweetly, SynbiCITE):** Using yeast and precision fermentation to produce sweet proteins found naturally in berries as zero-calorie sweeteners.
- **Cultivated meat:** Meat grown in a lab from animal stem cells rather than from animals raised on farms.
- **Using microbes to support changes to our food system (Microbial Food Hub, Imperial College London):** Exploring foods made by microbes such as yeast and fungi through fermentation as a more sustainable alternative to some farmed foods.
- **AI-powered herbicide discovery (Moa Technology):** Using miniaturised plants and AI to find new ways for herbicides to work, to tackle weeds that have become resistant to existing ones.
- **Using microbes to make protein (Deep Branch):** Microbes that turn carbon dioxide into a protein for use in fish and chicken feed, as an alternative to soy and fishmeal.

- **Natural grapefruit flavouring (University of Oxford):** A biological process that makes nootkatone, the compound behind grapefruit flavour, from orange flavouring, so it can be labelled as natural.
- **Self-fertilising cereals (Universities of Oxford and Cambridge):** Exploring ways for cereal crops like wheat and barley to capture their own nitrogen from the air, reducing the need for chemical fertilisers.

Chemicals and materials

- **Creating new textile dyes (Colorifix):** Engineered bacteria that produce natural colours and fix them onto fabric, replacing toxic petrochemical dyes.
- **Silk fused into ultra-strong materials (Imperial College London):** A solvent-free method using heat and pressure to turn natural silk fibres into strong solid materials, with possible uses including medical implants.
- **Underwater glue (Zentraxa):** A biodegradable adhesive made from engineered peptides, inspired by marine mussels, that sticks to wet and submerged surfaces and is being developed with defence funding.

Low carbon fuels

- **Engineered microalgae that produce biofuels (Phycobloom):** Microalgae developed to produce oil that can be used as a biofuel or as a feedstock for other products, to help decarbonise transport.
- **Power to liquid fuels:** A synthetic jet fuel made from green hydrogen and carbon dioxide captured from the air, designed to work in existing aircraft and airport infrastructure.
- **Bacteria to convert waste into ethanol (LanzaTech):** Engineered bacteria that consume waste carbon gases from heavy industry and convert them into ethanol, a building block for fuels and other products.

Waste and environment:

- **Clean fuels (C3 Biotechnologies):** A low-cost process using microbes to ferment agricultural and food waste into fuels that work in existing vehicles, engines and aircraft.
- **Breaking down and recycling nylon fibres (Epoch Biodesign):** Engineered enzymes that break synthetic materials, currently Nylon 66, down into their building blocks so they can be remade into new materials.
- **Microbial metal recycling factories (University of Edinburgh):** Engineered microorganisms that recover critical metals such as lithium and cobalt from electronic waste and end-of-life batteries, without toxic chemicals or high-energy processing.
- **Removing pollutants from water (Puraffinity):** An engineered surface material that attracts and traps PFAS, known as "forever chemicals", and can be fitted into existing water treatment systems.
- **Creating new materials (Modern Synthesis):** Bacteria that produce nanocellulose, which is combined with a textile backing to make a vegan, biodegradable leather-like material.

A public dialogue on the governance of engineering biology

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Human Voices Matter

sciencewise

