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Introduction

We are a team of researchers from the University of Edinburgh's School of Social and Political Science and the University of Exeter's Business School. We specialise in the social, political and policy dimensions of engineering biology and have been active in the field since 2008. At the University of Edinburgh, we have participated in large research projects and centres, and led independent social scientific research (e.g. an ERC Consolidator grant 'Engineering Life'). In collaboration with the Biotechnology and Biological Sciences Research Council we have developed new approaches to responsible innovation in a large European funding programme (ERA CoBioTech). Our work on the governance of the life sciences has been widely published. Currently, our research focuses on the ESRC/NSF project 'Future Organisms: Synthetic Genomics and Responsible Research and Innovation in the UK, the USA and Japan' and the UKRI Engineered Genetic Control Systems for Advanced Therapeutics Hub, where we lead the responsible innovation work stream. At the University of Exeter, we have participated in and led social science and responsible innovation research grants (Wellcome, British Academy, UKRI) on biotechnology regulation and world-leading research on gene drive governance and regulation.

Summary

- Responsible innovation offers an approach to governance that complements rule-based regulatory approaches. It is essential for producing trustworthy and robust innovation in engineering biology that can deliver economic, environmental and public value.
- Responsible innovation holds that scientific developments should be responsive to and beneficial for society, emphasising long-term thinking and collaboration across disciplines. Biosecurity is important but not the primary focus of responsible innovation.
- The UK leads this area but needs continued investment and coordination to maintain it.
- Promoting collaboration between social scientists, policymakers, and other experts will maximise capacity for responsible innovation in engineering biology and ensure trust in its governing institutions.

Q1. What are the UK's key strengths in the area of engineering biology?

Responsible innovation is crucial in science governance and the UK is a world leader in its development. Responsible innovation grows from the recognition that technical expertise alone is not sufficient to introduce engineering biology into new social and commercial contexts, but requires complementary expertise in society, ethics and governance. It also emphasises building a culture of responsibility, rather than relying solely on regulation. The UK Synthetic Biology Roadmap [1] highlighted the importance of responsible innovation, and frameworks like the EPSRC's Anticipate, Reflect, Engage, Act (AREA) and the BBSRC's Agenda for Responsible Innovation in Biotechnology [2] have been influential internationally. As scale-up and commercialisation in the field accelerates, retaining and improving these capabilities for responsible innovation is vital. However, the UK's leadership in this area will slip without ongoing dedicated investment and coordination. Efforts should focus on supporting the social sciences and humanities to collaborate with policy makers, technical experts and other stakeholders.

Q3. How can Government policy support the development of engineering biology?

Engineering biology requires a workforce with skills that go 'beyond the technical' to develop innovations that produce social, environmental and economic value. Those involved need to understand the complexities of translation and scale-up to take products from idea to market. The capacity to recognise diverse ways of understanding the problems engineering biology hopes to solve, and put them in a wider social context, is essential. Engineering biologists need to be able to accommodate different societal values to engage with the social, ethical and political challenges of engineering life. Our research into human capabilities for responsible innovation, conducted with BBSRC, represents a framework for identifying, developing and disseminating these competencies across the engineering biology innovation system [3]. Government policy has a role to play in ensuring engineering biology supports and solves the societal challenges identified by Government ministries. Social science can connect engineering biology to societal problems by better understanding those problems and identifying the ones that engineering biology can address.

Integrating responsible innovation capacity throughout the innovation system is a major challenge and requires coordination. UKRI can support responsible innovation in engineering biology through investment. However, funding to date has been piecemeal and primarily tied to large initiatives like the Synthetic Biology Research Centres, which do not represent the full breadth of the National Engineering Biology Programme (NEBP). Responsible innovation is often an optional 'add-on' with limited influence beyond specific projects [4]. AI has significant responsible innovation investment (e.g. Responsible AI UK) but there is no similar support in engineering biology, despite the Government's Science and Technology Framework identifying it as a 'Critical Technology'. It is notable that ESRC and AHRC are not participants in the NEBP. Dedicated and coordinated funding would maintain the UK's position by creating a workforce with the skills and capacity for responsible innovation.

We recommend the formation and ongoing support of a national, interdisciplinary platform for governance and responsible innovation in engineering biology that works alongside technical investments. This network should engage in focused research on responsible innovation in mission areas, shape technologies for the public interest and address societal needs. It should also run cross-cutting activities, including open events for the engineering biology community. Because the field moves rapidly, flexible funding should be available to seed new activities in academia, industry and the public sector. The Norwegian Research Council's Digital Life Centre offers a potential model to follow. Similar recommendations were made by the recent Review of Pro-innovation Regulation of Technologies for the Life Sciences.

This structure would help participants address systemic questions across the UK's portfolio, such as equity in innovation, priority setting and evaluating sustainability of biomass feedstocks. It would assemble social scientists and synthetic biologists from across the UK's mission areas. Productive collaborations between social and natural scientists have been central to the UK's success in developing and implementing responsible innovation frameworks. Current interest in engineering biology offers an opportunity to renew the relations between the social and natural sciences, building an approach to responsible innovation with interdisciplinary collaboration. This would allow diverse groups to contribute to engineering biology that meets public needs, and signal that the public interest is a policy priority.

Q5. What are the risks posed to society by engineering biology?

It is crucial not to confuse responsible innovation with mitigating biosecurity and biosafety risks. Responsible innovation goes beyond these concerns to ask, "what kind of future do we want science and innovation to bring into the world?" [5]. It embraces diverse perspectives and voices, and can help foreground important questions about research directions and societal challenges (see Q3). We urge Government not to equate responsible innovation with risk-mitigation in its policies (e.g. the 2023 Biosecurity Strategy) and to think more expansively about it as a form of governance that builds a more diverse and resilient sector than would otherwise exist. For examples of how it can operate in this capacity, particularly for risk-laden technologies like gene-drive, see Q6.

One of the risks facing engineering biology is that it fails to address the problems it is designed to address. For example, our research (Hartley and Smith, in development) on emerging areas of gene drive research in the conservation field shows that stakeholder views of efficacy differ from technical views. Some stakeholders want gene drive grey squirrels to result in the return of red squirrels, whereas technologists want the drive mechanism to work. These different understandings of efficacy can be understood and addressed through a responsible innovation approach.

Q6. How should engineering biology be regulated?

The EU's status as a regulatory superpower demands ongoing UK engagement with its institutions, as well as other influential international regulatory bodies. In addition to the OECD and BWC, the UN Convention on Biological Diversity sets global norms for engineering biology governance. The last COP committed to establishing a horizon scanning facility and developing new gene drive risk assessment guidelines. Funding and actively participating in these discussions would enable the UK to shape international norms. Seeking partnerships with like-minded countries (such as Japan, Australia, Singapore, Norway, New Zealand, and the USA as well as several in the Global South) would also co-establish standards and norms in engineering biology. Each of these countries has invested in engineering biology and related technologies, as well as innovative governance models. UKRI should invest in research on engineering biology governance, including regulations, standards and norms, to maintain a leadership role in global discussions.

Regulation is important but limited due to the complexity and dynamism of engineering innovation. New engineering biology innovations challenge established regulatory categories and frameworks. One challenge is identifying how engineering biology products will be regulated based on their end-use. For example, biosynthetic menthol (a proof-of-concept compound for Manchester's SBRC) would be subject to different regulatory regimes if used in food or health products [6]. While researchers may treat these compounds as a single class, regulatory regimes, labelling standards, and consumers view them differently (ibid). Our experience as collaborating social scientists is that these analyses should be, but are often not, conducted earlier in the innovation process.

Creating products that trouble existing regulatory definitions is a related challenge. For example, the Arsenic Biosensor is a genetically modified *Bacillus subtilis* engineered to express a colour pigment in the presence of arsenic. It falls between existing categories of contained use and deliberate release, since it was neither intended to be used in a laboratory (the usual understanding of the former) nor intended to be released into the wild (appropriate for the latter). As a result, the researchers did not know which regulatory pathway to pursue when developing the technology. Similar examples include: 1) cell-free synthetic biology technologies, which are not GMOs but are produced from them (some countries, such as South Africa, regulate these technologies as GMOs); and 2) gene drive organisms, which are designed to spread, so they cannot be regulated under existing environmental release regulations that rely on field trial containment [7].

Regulation alone will not ensure engineering biology meets the UK's needs. Expansive thinking about new forms of governance can address its blind spots more agilely. Important innovation governance tools include upstream public engagement, horizon scanning, funding criteria, design processes, standards, certification, and cultural norms. For example, in biotechnology and gene drive governance scientists and regulators have called for stakeholder involvement in risk assessment [7]. The European Food Safety Authority (EFSA) and scientists at University of Exeter and Imperial College London have started to experiment with this engagement [8]. It is important for the UK to stay up to date with these efforts. The UK's Advisory Committee on Releases to the Environment will need to be more interdisciplinary, more open and more transparent as it takes on its role in the UK's new regulations under the Genetic Technology (Precision Breeding) Act 2023. This new Act provides an opportunity to rethink how regulations and the expert advisory committees can engage with stakeholders and the public to avoid the failures experienced 20 years ago when GM crops emerging in the UK.

Q7. What are the possible barriers and limitations to good and effective use of engineering biology?

Public acceptance of engineering biology-based technologies in the UK depends more on public trust in the institutions that create, promote and govern them than on public understanding of the science. Trust and legitimacy in technological innovation are not achieved through communication aimed at reassuring the public about the safety of new technologies. This approach falsely assumes that a lack of technical expertise is the primary source of resistance to technology and that technical expertise produces interest/acceptance [9].

Responsible innovation is a more effective approach to addressing public concerns and was developed alongside emerging technologies like synthetic biology. It focuses on building technologies in the public interest to address meaningful societal needs. This involves taking sustainability, public value, and safety seriously [10, 11]. Responsible innovation provides methods to reflect on engineering biology goals, anticipate consequences, and involve stakeholders in technology development [12]. It is about improving innovation quality and utility in the long term by being responsive to a diverse and changing society, rather than starting with questions of acceptability. We have two recommendations to improve the quality and utility of innovation in the public interest.

Future public engagement should build on previous work rather than reinvent the wheel. Much work has been done on public interests and concerns in synthetic biology, including the BBSRC/EPSRC Synthetic Biology Dialogue in 2010 [13], the findings of which have been replicated in public dialogues about genetic technologies and genome editing [14,15], landscape reviews [16], and topic-specific research on gene drives [17, 18, 19, 20] and bio-synthetic menthol [21]. The UK Synthetic Biology Roadmap highlighted five key questions that citizens think synthetic biology researchers, industry, and government should be able to answer: What is the purpose? Why do you want to do it? What are you going to gain from it? What else is it going to do? How do you know you are right? These questions remain as relevant today as they were in 2012. The House of Lords has itself produced several key reports addressing public trust and engagement with engineering biology. The House of Lords Select Committee on Science and Technology's report 'Science and Society, published in 2000, makes clear the need for public engagement. The same

Committee’s report on GM Insects in 2015, produced similar findings. Both these reports remain highly relevant today.

Engagement activities must connect to the development and governance of engineering biology. While public engagement exercises have been held repeatedly, there are few examples of these initiatives shaping the development and governance of engineering biology. Good public engagement involves creating opportunities for policy makers and scientists to integrate their knowledge into decision making [22]. We recommend research councils draw on lessons in public participation to shape research and innovation missions [23] and in creating programmes for responsible innovation (e.g. the Dutch NWO Responsible Innovation programme). Work from North Carolina State University’s Genetics and Society Centre on the Genetic Biocontrol of Invasive Rodents shows how stakeholders can shape key scientific decisions about, for example, gene drive field site selection.

Increased investment would create opportunities for public groups to shape engineering biology in the public interest. Expertise is available in academia and government agencies. For example, UKRI’s Public Engagement team has relevant expertise and should be consulted. Social science researchers with relevant experience are in Manchester (Balmer, Meckin, Shapira), Exeter (Hartley, Hadley-Kershaw, Molyneux-Hodgson), Bristol (Owen), London (Smallman, Stilgoe, Hughes) and Edinburgh (Calvert, Message, Smith, Stone).

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References:

[1] UK Synthetic Biology Roadmap Coordination Group 2012. https://shorturl.at/artvW; [2] Smith et al 2019. https://rb.gy/2i0s6o; [3] Smith et al. 2022. 10.5281/zenodo.7674613; [4] Smith et al. 2023. 10.1177/03063127231205043; [5] Owen et al. 2014. 10.1093/scipol/scs093; [6] Ribeiro and Shapira 2019. 10.1016/j.techfore.2018.11.020; [7] Hartley et al. 2022. 10.1111/rego.12452; [8] Hartley et al. 2023a. 10.1016/j.envsci.2023.02.009; [9] Marris 2015. 10.1080/09505431.2014.986320; 10] Wilsdon and Willis 2004. 10.13140/RG.2.1.3844.3681; [11] Macnaghten 2020. 10.1017/9781108871044; [12] Owen et al. 2012. 10.1093/scipol/scs093; [13] BBSRC/EPSRC 2010. https://bit.ly/3UyTSQy; [14] Nuffield Council on Bioethics 2018. https://bit.ly/3UtiUAF; [15] Nuffield Council on Bioethics 2021. https://bit.ly/3ybhAek; [16] Smith et al. 2018. https://bit.ly/3UM3Yiq; [17] Hartley et al. 2021. 10.1186/s12936-021-03682-6; [18] Hartley et al. 2023b. 10.1177/09636625221148697; [19] Kokotovich et al. 2020. 10.1093/aesa/saz064; [20] Russell et al. 2022. 10.1080/23299460.2022.2042072; [21] Meckin & Balmer 2018. 10.1177/0963662518808694; [22] Smith et al. 2021. 10.1177/0963662521999796; [23] Mazzucato 2016. 10.1080/13662716.2016.1146124