IChemE

ENGINEERING BIOLOGY IN THE UK

IChemE submission to the House of Lords' Committee for Science and Technology

Introducing the Institution of Chemical Engineers

The Institution of Chemical Engineers (IChemE) is the qualifying body and learned society for chemical, biochemical, and process engineers in the UK and worldwide, with over 30,000 members. Our mission is to champion the input of chemical engineers to create a sustainable future. We welcome the government's interest in promoting engineering biology in the UK and are pleased to have the opportunity to submit evidence to this inquiry. Our response focuses on the areas where chemical engineers have particular insight - taking lab-scale innovations and scaling them up to widespread commercial and environmentally sustainable production - and it draws on both desk research and input from our network.

Question 3: How can Government policy support the development of engineering biology?

Does the Government's "National Vision for Engineering Biology" set out the right priorities for government to develop the engineering biology field in the UK? Was there anything missing from the strategy that should have been included? Does it build appropriately on earlier approaches to synthetic biology and life sciences?

The "National Vision for Engineering Biology" provides a welcome focus on promoting this field in the UK. We believe that it could be strengthened further by giving greater focus to the critical issue of how to support the scale-up of new innovations. At present, the difficulties of the scale-up process introduce a bottleneck into the pipeline from promising initial research through to 'widely deployed technology with commercial and social value'. This scale-up bottleneck threatens to undermine efforts to promote engineering biology such as those set out in the National Vision, and represents a likely critical point of failure for many otherwise promising developments. Without addressing this bottleneck, both our ability to reap the benefits of engineering biology in the UK, and our status as a world leader in this field, are threatened.

The National Vision for Engineering Biology does touch on the importance of scale up,[a] however, we believe that this phase of the process needs to be given greater emphasis to ensure that novel products can continue their development towards widespread use. Scale up is crucial to ensure that promising new technology does not remain stuck in Technology Readiness Level (TRL) four, but continue through TRLs five and six, also known as the 'Valley of Death' (as it is the point at which many promising new technologies fail) referred to in the House of Commons Science and Technology Committee's report titled: "Bridging the valley of death: improving the commercialisation of research" before entering TRL seven. Common causes for start-ups failing at TRL five and six include a lack of entrepreneurship skills,[1] a shortage of skilled staff, appropriate facilities to successfully pilot test new products, and as a lack of collaboration between academia (who focus on publications and patent filing) and businesses (who focus on sales and profit margin).
The 'Valley of Death' has been described as the gap that exists between the research-related funding available for novel projects and the commercial resources available for more mature technologies.[2]

a: The document recognises the importance of moving to the 'proof of concept' stage and highlights the role of pilot-scale facilities in achieving commercial viability. It also emphasises the need for skilled professionals like process engineers and fermentation scientists.

In other words, it is the gap between the laboratory and the market place.[3] Acquiring sufficient funds is regarded in the literature as the critical factor in technology successfully passing through the 'Valley of Death',[4] and this is where government has an important role to play, for instance by providing centres to support scale-up and entrepreneurship (for more, see below section on critical facilities), as well as providing tax exemptions and subsidies for nascent and successful spin-off and start-ups.[4]

The government should explore the case for setting up independent technology innovation centres around the UK to support scale-up and entrepreneurship, as well as for providing tax exemptions and subsidies for nascent and successful spin-off and start-ups[4].

Question 3: How can Government policy support the development of engineering biology?

> The Government has committed to spend £2 billion over the next 10 years on engineering biology. Is this scale of subsidy sufficient to be competitive? Where should this funding be focused to best support engineering biology in the UK? Is it more important to support facilities, skills, or flagship research projects? Which specific skills or facilities are most needed?

The proposed allocation of £2 billion over the next decade for engineering biology in the UK is a welcome investment in this area. However, given the significant resources that global counterparts such as China and the US are investing, there are limits to how much this funding can achieve - as such, it is paramount that this resource is targeted effectively. Drawing on consultation with our network, we believe that this funding would be most effective if it was balanced between fundamental (lab-scale) and applied (scale-up) research.

When looking specifically at the funds available for applied research, it will be important to ensure that that these are allocated towards several key areas: firstly, funding for skills development and secondly, financing for the provision of scale-up facilities and thirdly fostering a collaborative environment, not only between academic research groups, but also between industry and academia. Each of these three areas will be considered in the following sections.

Skills Development

To realise engineering biology's economic potential and societal benefit for the UK, there needs to be a strategic focus on cultivating specific expertise in the following three areas.

Chemical and bioprocess engineering: The skill set possessed by chemical engineers straddles both laboratory experimentation and large-scale manufacturing, and their typical work sees them developing production facilities for products that bridge the so-called 'Valley of Death'. A different way of thinking is required during the scale-up phase compared to that required in the laboratory and this is what chemical engineers are trained in: applying systems thinking to find the optimal process layout that will be commercially attractive to investors. The mindset involved is one that can consider multiple facets such as economics, sustainability, safety and operability. The UK needs access to sufficient numbers of people with these skillsets to ensure that it can realise the benefits of engineering biology.

We believe that the government should prioritise chemical and process engineering education and training at all levels – supporting significant expansions in technical and apprenticeship, undergraduate and postgraduate, and post-doctoral routes.

Entrepreneurship and business acumen: As mentioned earlier, researchers often suffer from a lack of entrepreneurial skills and poor understanding of the business environment. It should not be assumed that researchers who are trained to understand and manipulate science would also understand the business environment and how to run startups and spin-out companies, yet that is what is expected of them in the current UK innovation ecosystem. It would be wise to offer opportunities for developing these skills that include: business management, effective communication, strategic planning, marketing and most importantly leadership. These opportunities could take the shape of setting or supporting up mentorship programmes, offering subsidised short courses or publishing documents that catalogue the journey of successful ventures.

We believe that the government should invest in developing the entrepreneurial skills of researchers to ensure that they are able to reach commercialisation with their products and thus realise the benefit to the UK's economy and people.

Expertise in successfully translating academic to industrial success: Training opportunities such as the "Ready for Industry" programme by the Industrial Biotechnology Innovation Centre (IBioIC) in Scotland and University College London's biochemical engineering MBI course are excellent examples of giving academics the skills to work effectively with industry and navigate the different associated demands and challenges.

IBioIC partnered with the Biotechnology and Biological sciences Research Council (BBSRC) to offer a collaborative training partnership for PhD students in the field of industrial biotechnology. The program, called "Ready for Industry", provided technical, commercial, and personal growth training, and is industry-led, requiring participants to work with an industrial partner. The participants gained practical, commercial, and industrial experience, and became part of a UK-wide learning community that fosters connections between researchers, academics, and companies in the growing industrial technology sector.

We believe that the government should support training opportunities to help academics work effectively with industry and should learn from the experience of encouraging existing programmes such as the "Ready for Industry" programme by the Industrial Biotechnology Innovation Centre and University College London's biochemical engineering MBI course.

Critical Facilities

Scaling up lab-based successes poses substantial increases in cost and risk due to higher raw material and waste volumes, as well as the increased cost and space requirement of the equipment used. The increased risk and cost to researchers could be alleviated by setting up independent technology innovation centres around the UK that provide access to the right experts and equipment needed to move forward with product development. These centres could be strategically placed across the UK, to promote regional growth, and could each specialise in key sectors such as biopharma, sustainable foods, and novel materials, with a strong emphasis on technologies that foster decarbonisation and zero-waste practices.

An example of such a facility is the Centre for Process Innovation (CPI); who have nine sites across the UK which cater to different markets such as energy storage, pharma and materials. Not only do they provide access to scale-up equipment, but they also support researchers on their journey to commercialisation by offering hands-on support with technical problem-solving, scale-up advice, and supply chain development.

For such innovation centres to work effectively they need to be accessible in a number of ways, including: geographical location, range of equipment, organisational culture, specialist knowledge and payment model. At present there are significant barriers to accessing the scale-up facilities at CPI due to the requirement for projects to be financially self-sufficient. As a result, many companies are forced to seek more cost-effective alternatives abroad such as the BioBase Europe Pilot Plant in Belgium.

To avoid this cost barrier, an option could be to emulate the funding framework of Germany's successful Fraunhofer Institutes, who generate two-thirds of their budget with revenue from industry and publicly funded research projects which are acquired through competitive bidding. The German Federal Ministry of Education and Research, and the German states, contribute another third as base funding. Implementing a similar collaborative model in the UK could promote greater utilisation of such innovation centres by both emerging ventures and well-established corporations.

The government should explore the case for setting up independent technology innovation centres around the UK that provide access to the right experts and equipment needed to move forward with product development. To be a success these centres will need to be accessible across a number of different dimensions including: geographical location, range of equipment, organisational culture, specialist knowledge and – perhaps most importantly - payment model.

Fostering Collaboration

In order to advance engineering biology in the UK, fostering collaboration across research groups and between academia and industry is paramount. Government can create space for collaboration to flourish in the following ways.

The government should explore the case for funding the creation of an online platform that acts as a central hub for easily sharing and exchanging information among those working in this field. This could facilitate process optimisation, boost reproducibility and maximise the utilisation of advanced technologies like AI and machine learning for process automation. An example of such a platform is the Synthetic Biology Open Language (SBOL) standard which is used as a means of promoting global data exchange between laboratories and between software programs.

The Government should set a clearly defined mission for research funders that aligns academic and industrial efforts, in the vein of the Sustainable Chemical Feedstocks call issued by EPSRC in 2012. This was a similar call that focused on specific challenges, such as upgrading renewable raw materials available in the country and on becoming self-reliant in the production of active pharma ingredients/high-value intermediates.

The Government should facilitate industry-academia exchange programmes that promote knowledge transfer and foster a deeper understanding of the differing needs, challenges, and opportunities within each sector. Academic researchers could gain valuable insights into industrial-scale production, regulatory requirements, and commercial considerations. Conversely, industry professionals would benefit from exposure to cutting-edge academic research. By bridging the gap between academic research and industrial application, these exchange programs should help align research priorities with market needs, accelerating the translation of laboratory discoveries into scalable, impactful solutions.

A success story from the UKRI is the 13 Networks in Industrial Biotechnology and Bioenergy (BBSRC NIBB) established in 2014 together with support from the engineering and Physical Sciences Research Council (EPSRC). These networks were set up to foster collaborations between academia, industry, policy makers and non-governmental organisations (NGOs) to find new approaches to tackle research challenges, translate research and deliver key benefits in industrial biotechnology and bioenergy and look for international opportunities. This example should be learned from and drawn on in this area going forwards.

Question 3: How can Government policy support the development of engineering biology?

What should the role of UKRI be in supporting engineering biology? Which research councils are most involved in funding it? Are there areas where more could be done to support interdisciplinary research? What would the best mechanisms be for achieving this?

The UKRI has a crucial role in supporting the engineering biology sector in the UK, especially the BBSRC, EPSRC and Innovate UK. UKRI can act to bridge the gap between academic research and commercial applications, by placing more emphasis on EPSRC's activity in this area, since they have a fundamental focus on the central problem of scale-up.[b]

We believe that EPSRC should be given greater emphasis in UKRI's planning and activity related to engineering biology, to ensure that the challenges of scale-up can be better addressed going forwards.

In addition, our networks proposed a number of changes that could allow UKRI to more effectively support engineering biology.

We believe that the UKRI should consider changing the requirements it makes of research proposals, for instance adding a requirement for teams to be interdisciplinary/transdisciplinary and for applicants to demonstrate plans for process development and scale-up.

We believe that the UKRI should consider rebalancing its portfolio, to allocate additional grant funding to support research that focuses on bioprocessing techniques and equipment design during the scale-up stages.

Finally, we believe that the UKRI should consider implementing milestone-based funding and funding contingencies in case scale-up encounters challenges.

Sources Cited

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4. Gbadegeshin, S. A. *et al.* Overcoming the Valley of Death: A New Model for High Technology Startups. *Sustain. Futur.* **4**, 100077 (2022).

[b] EPSRC: "Our mission is to convene, catalyse and invest in close collaboration with others to build a thriving, inclusive research and innovation system that connects discovery to prosperity and public good"