Written submission from Professor Geoff Baldwin, Professor Tom Ellis; Professor Karen Polizzi (ENB0030)

Respondents:

This submission is a collation of responses from Imperial researchers associated with the Centre for Synthetic Biology, led by Professors Geoff Baldwin, Tom Ellis and Karen Polizzi.

The Imperial College Centre for Synthetic Biology (IC-CSynB) provides leadership and vision for synthetic biology at Imperial, whilst developing an open, inclusive and collaborative environment for the best interdisciplinary research and ideas to flourish.

The Centre is currently composed of 36 research groups across six Departments from the Faculties of Engineering, Life Sciences, and Medicine; the largest critical mass of world-class synthetic biology academics in the UK.

Our Imperial-based academic (IC-CSynB) and industrial (SynbiCITE) activities in synthetic biology form the platform for a development pipeline that includes training from undergraduate to post-doctoral researchers combined with a world-leading research and a commercialisation and exploitation strategy. This presents a unique proposition and environment for research, development and application of synthetic biology to solve many of the challenges facing society, from healthcare to biomaterials to sustainable energy.

A full list of respondents is available at the foot of this submission.

Question responses:

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

1.1. The UK has developed several national strengths in engineering biology. In terms of applications, examples of UK strengths include:

- Immunotherapies
- Molecular tools (cell free systems and synthetic cells, whole cell biosensors, directed evolution, protein engineering, gene network engineering, nucleic acid nanotechnology)
- Synthetic genomes (genetic code expansion, genome recoding)
- Industrial biotechnology (biomaterials, speciality and fine chemicals)
- Plant synthetic biology (plant-driven drug/therapeutics synthesis, e.g. terpenoids; next-generation plant protection strategies, e.g. nanobody-based pathogen recognition)
- Protein folding prediction

1.2 The UK has also built several community/ecosystem strengths, including:

- Global leadership (early development of national action plan; effective 'start up' culture; clear national priority)
- Research community (Attracting talent; significant funding for both applications and platforms; support for PhD programmes; creation of effective and interdisciplinary research networks/centres)
- Streamlined technology sharing platforms, such as OpenMTA

1.3 The assessment of UK strengths should also be tempered with recognition of the areas in which the UK has fallen short or faced challenges. Examples of these include:

- Short-term thinking – extending both to the lengths of individual research funding awards and to the pressure to deliver short-term applications over longer-term fundamental and platform research.
- Doctoral study – ending sponsorship of engineering biology-related PhD programmes, and lack of consistency in PhD training (one single Centre for Doctoral Training per funding round, which has now been relocated three times).
- Some areas of strategic weakness – there are too many biofoundries and their use is often sub-optimal – lack of wider accessibility, need for more personnel capable of driving training and support for users; the national priority for engineering biology has not been matched by similar strategic initiatives in training and skills (which are needed); lack of engagement of larger companies and of investment in the 'scale up' aspects of innovative new startups.
- Lack of consideration of feedstocks and supply chain/requirements (e.g. sugar).
- The development of centres and hubs has been positive, but this needs to be matched by efforts to encourage engineering biology through traditional funding routes. The high-level approach is good for top-down national leadership but misses the capacity of bottom-up individual project funding to deliver genuine innovations.
- Design/Build focus with less development in Test/Learn - synthetic biology community should link better to analytic/phenotyping facilities, more of which could be made in response to the engineering biology-fuelled accelerated strain development.

There's limited emphasis on engineering biology outside the conventional cellular (top down) perspective in the Engineering Biology Vision. Government should take steps to encourage more interfacing, with (bio)chemistry for example, and the bottom-up development of complex function. There's a gap in the middle between these two approaches where designable systems with sufficiently complex functionality would ideally sit.

2. What are the key applications for engineering biology?

2.1 Some of the key application areas for engineering biology, all of which are priorities for the UK's future economic direction (as outlined by the Science and Technology Framework, Net Zero Strategy, Life Sciences Vision and Medical Technologies Strategy, among others) are:

- Personalised medicine and advanced therapies (examples of which include drug and vaccine bioproduction, precision edited cellular therapies, engineered biological therapies, and microbiome engineering)
- Alternative foods and fuels
- New materials
- Fine chemicals biosynthesis

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

3.1 Government policy would be more effective in support of the UK's engineering biology goals in at least three ways:

- Research – sustained funding through long-term research Hubs (capable of making longer-term project grants and resistant to short-term pressures for applications and returns), alongside a new national strategy and funding package for undergraduate and PhD/postdoc training (with streamlined processes for attracting the top international talent to work in the UK).
- Industry – improved strategic direction for the creation of investment, capital and tax incentives to maximise investment (particularly capital investment from large players); build on the current 'scale up' ambitions to strengthen UK ability to retain innovative startups; create additional co-funding options for SMEs (which many UK engineering biology firms are) to work more closely with researchers.
- Regulation – urgently consider streamlining 'novel foods' regulations before the UK loses the competitive edge that our current scientific and industrial capabilities has generated; work

towards genetic editing and modification acceptance in all organisms, which should be coordinated across the UK countries.

3.2 Some immediate priorities for new government commitments should be:

- Increasing the number of Centres for Doctoral Training in engineering biology.
- Dedicated new funds for undergraduate skills development, including the creation of a national fund to support entry into student competitions, such as the highly successful iGEM competition in synthetic biology.
- Commit to building a new set of national 'scale up' facilities that is regionally-balanced across the UK, inexpensive (e.g. users not required to pay Full Economic Cost), and easy to access for the widest variety of research and commercial entities (all sizes/stages of development).
- Encouraging responsible research, innovation and communication studies and training for students; more international collaborative funds, especially ones that encourage solving long standing application issues as well as progressing foundational research; and new funding for non-conventional synbio/organisms systems to widen future prospects beyond what is immediately visible.

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

4.1 To maximise the economic potential of developments in engineering biology, the Committee can consider pushing the government to:

- Support the foundational research base for engineering biology innovations, our undergraduate and doctoral training, plus the equipment and facilities needed to support them, are the base on which our economic future in engineering biology will be built.
- Understand the difference between the disruptive potential of startups/scaleups and the investment potential of established companies – both are key ingredients for the sector's success but will require/respond to different policy levers.
- Expansion of start up and scale up facilities, leveraging both public and private capital through strategic leadership.

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

5.1 The risk profile for engineering biology is not substantially different than for other industrial technologies. Potential risks that we can anticipate and plan mitigations around include:

- Accidental release of a genetically-modified organism into the environment.
- Engineering biology sometimes is communicated in hype-driven manners, and this combined with genetic engineering, which has been considered in a fear-based fashion by some parts of the society, may result in mistrust in the field or science as a whole.

6. How should engineering biology be regulated?

6.1 It should be noted that extensive regulations for engineering biology already exist (compared to similar industrial technologies).

6.2 In the spirit of the government's 'pro-innovation regulation of technologies' reviews, sector-specific regulation designed to address and mitigate harms and problems when they are identified, rather than prescriptive regulation that inhibits safe and responsible research, should be the target for the UK engineering biology sector.

6.3 Regulations in the area of novel foods, for example, may be shown to require less regulation and more streamlined regulation than in their current form:

- Government and regulators should be encouraged to engage in further consultation with the research and business communities on the topic of novel food regulation.
- Government should also give further consideration to the advantages for agile regulation in the engineering biology sector of co-locating regulatory teams with business and research organisations at innovation districts across the UK, such as at Imperial's White City campus.

Respondents (in alphabetical order):

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