Written evidence from Good Food Institute Europe (ENB0005)

About this submission

GFI Europe is an international non-profit think-tank working to accelerate the development of alternative proteins. We work with scientists, businesses and policymakers to advance plant-based foods, cultivated meat and fermentation-made meat and dairy – making them delicious, affordable and nutritious across Europe. GFI Europe is funded by philanthropy.

Can you give examples of particularly exciting or interesting applications? Where does engineering biology have the potential to add value over processes that are currently used?

Alternative proteins refer to a family of three production methods which replicate the sensory properties of meat, dairy, eggs and seafood, but without the negative impacts of conventional production systems. Each method involves different aspects of engineering biology:

- **Plant-based meat and dairy** - utilise crops like peas, oats and sunflowers to biomimic the experience of cooking and eating animal-based foods. An example of engineering biology in the plant-based space is the use of new precision breeding techniques or enzymatic treatments to remove 'beany' off-flavours from pulses and legumes.
- **Cultivated meat** - involves taking a small sample of animal cells and growing them in a bioreactor. The cells are fed a culture media, differentiated, proliferated, and harvested. The resulting cell mass - which is similar to ground meat - can be formed into foods that are indistinguishable from conventionally produced meat.
- **Fermentation** - can be used to make mycoprotein - a nutritious, fermented fungal biomass that has meaty characteristics. Microorganisms can also be engineered so that, when fermented, they express a particular protein (like whey); this is referred to as precision fermentation. Syngas fermentation is also a growing area of interest, whereby gases (e.g. carbon dioxide, nitrogen or methane) are used as a feedstock for engineered microbes.

Alternative proteins bring substantial benefits over conventional animal-based foods:

- **Mitigating climate change and biodiversity loss** - academic literature shows that alternative proteins use significantly less land and water, and produce fewer GHGs and air pollutants than animal-based foods. For instance, peer-reviewed data show cultivated meat could produce 92% fewer GHG emissions and 90% less land than conventional meat, when produced with renewable electricity. A recent study commissioned by GFI

Europe estimates that, depending on varying levels of innovation, between 21-57% of the UK's domestically farmed area could be released by 2050 due to alternative proteins displacing conventional meat, creating space for the expansion of extensive sustainable farming practices and semi-natural habitat creation and restoration.

- **Public health** - the UK is increasingly exposed to major health risks associated with intensive animal agriculture: in 1991, 700 million poultry birds were slaughtered annually in the UK, rising to 1.18 billion by 2021. These systems are ideal incubators for zoonotic disease risks like avian influenza. While the UK has made steady progress in reducing the use of antibiotics in farmed animals, evidence indicates that globally the picture is extremely different. Alternative proteins shortcircuit these risks since they do not require antibiotics and could drastically reduce our dependence on intensive production systems.
- **Food security** - the UK is a net importer of meat and dairy and a 'net importer of land', requiring a similar amount of land overseas as we use domestically to grow all of our food. Alternative proteins could help to rebalance this deficit, creating new economic opportunities in the bioeconomy and food production: Green Alliance has estimated that, by 2035, around 25,000 new jobs could be created in the UK, adding £6.8 billion to the economy annually.

On what timescales might the different applications for engineering biology be realised? Which applications are emerging now, and what is on the horizon in the next 5–10 years or further ahead?

Alternative proteins have been developed rapidly over the last decade or so (for more, see GFI's State of the Industry report series). To illustrate, the first demonstration of cultivated meat took place in 2013, but by 2023, there were 174 companies developing cultivated meat internationally, including 'full stack' and specialised businesses (e.g. cell line development). Today, UK consumers spend around £1 billion on plant-based meat and dairy products, and there is a huge potential addressable market, with surveys showing consistent public interest in reducing meat consumption.

There are some instances where engineering biology approaches to producing alternative proteins are already operating at commercial scale. Notably, Quorn operates several 170,000-litre fermenters to produce mycoprotein-based meat alternatives at competitive prices with animal-based equivalents. Precision fermentation has also been part of our food system for several decades, with most rennet now produced this way.

Broadly, however, alternative protein companies leveraging engineering biology are operating at the lab or pilot scale and remain between pre-seed and Series B.

In most instances, end products will require regulatory authorisation and no cultivated meat or precision fermentation-made products or ingredients are for sale in the UK at present. Several are progressing through the regulatory process with the Food Standards Agency (FSA). Israel, Singapore and the United States have approved cultivated meat and precision fermentation products in recent years.

Substantial cost and structural barriers remain and must be addressed if alternative proteins are to be competitive with conventional animal-based foods. To illustrate with two examples:

- The cost of culture media for cultivated meat will likely need to reach around $1 per litre or lower but, currently, prices are substantially higher due to a lack of low-cost, food-grade media ingredients. Evidence suggests that, although there are plausible pathways for producing significant volumes of affordable media, this will take time to scale.
- Globally, GFI estimates that there are only 16 million litres of food-grade fermentation capacity, capable of producing 0.4-2.6MM tonnes of alternative proteins. To put this in perspective, analysis suggests that for cultivated meat to reach even 1% of the global protein market by 2030 it will require 220-440 million litres of capacity. There is an acute shortage of food-grade facilities in the UK at pilot, demo and commercial scale, which we discuss below.

The field of alternative proteins is therefore still in its infancy. There remains a serious lack of fundamental science underlying alternative protein production due to relatively scarce public funding for open-access R&D. Very broadly, the key scientific and technical opportunities for engineering biology in the field of alternative proteins in the next five years are concentrated around the foundational technologies of large-scale omics data collection and analysis, next-generation precision breeding and expression techniques, computational modelling and AI, and bioprocess design and demonstration for commercial manufacturing.

The pace at which novel alternative proteins are developed and commercialised will heavily depend on technical uncertainties, the scale of public and private investment, and the speed of regulatory authorisations. Loosely, we expect that a limited number of cultivated meat and precision fermentation products will be available to UK consumers in the second half of the decade, whilst plant-based and biomass fermentation (mycoprotein) will also be further advanced by applications of engineering biology during this period. More price- and taste-competitive novel alternative proteins will likely enter the market towards the end of the decade and into the 2030s.

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?

We estimate that, to date, UKRI has invested at least £60 million in alternative protein R&D and commercialisation support. This makes it one of the most ambitious funding bodies globally, with landmark investments like the EPSRC-funded Cellular Agriculture Manufacturing Hub (CARMA) at Bath and the Microbial Food Hub at Imperial (part of the engineering biology mission hubs programme). However, we estimate that UKRI - and other public bodies like the UK Infrastructure Bank - will need to expand its ambition over the rest of the decade, investing a total of £560 million by the end of 2030 across a range of public funding instruments including academic grants, studentships, researcher networks and commercialisation support. (This estimate is based on Vivid Economics' Global Innovation Needs Assessment for protein diversification.)

Centres of excellence based at universities are a strong mechanism for overcoming silos and encouraging interdisciplinary research; it is positive to see that BBSRC and Innovate UK will fund a new £15 million alternative protein Innovation and Knowledge Centre in 2024. It is likely that there will need to be an expanded role for the EPSRC as the alternative protein sector scales to industrial volumes. For example, the EPSRC is well-placed to support the initial investment in CARMA by funding additional research on bioreactor design and downstream processing for novel alternative proteins. A final mechanism is for UKRI to drive bi- and multi-lateral funding mechanisms with international partners developing alternative proteins, particularly those with strengths in engineering biology such as Denmark and the United States. Innovate UK has already done so in partnership with Canada.

Which Government departments, and non-departmental public bodies, are engaged or should be engaged with engineering biology?

DSIT, FSA and UKRI (see above) have largely driven the UK Government's efforts to support the development of alternative proteins. The Cabinet Office's *Benefits of Brexit* review also raised alternative proteins as an opportunity area. It would be positive for Defra to adopt a clearer stance that it recognises how engineering biology can help address critical challenges in the food system.

Who is investing in engineering biology in the UK, and what is the scale of the investment activity right now? Where are the areas with significant economic and start-up activity?

In total, GFI estimates that since 2013, UK-based alternative protein businesses have received around £460 million of investment, with 52% of this funding being raised in 2022-2023 (Source: Net Zero Insights). UK-cultivated meat companies have been especially effective in fundraising, collectively receiving 42% of all the investments into Europe's cultivated meat businesses in 2022-2023. Venture capital has been the primary source of funding, with some ad hoc instances of public investment (for example, HigherSteaks (now Uncommon) received £1 million from Innovate UK to support a small pilot plant). Dependence on venture capital raises significant questions, as it is not a suitable instrument for making long-term capital investments in commercial-scale equipment and infrastructure, especially for high-volume, low-value outputs like food. (See our UK alternative protein ecosystem report for details on areas of significant potential for future industry growth.

How should the Government best support engineering biology startups to scale-up in the UK? Are there specific facilities that it would be helpful to invest in? Are the financial support mechanisms for start-ups and scale-ups appropriate and sufficient, or could they be reformed?

The National Vision for Engineering Biology recognises a critical shortage of food-grade infrastructure at the pilot, demo and commercial scale. The government should invest in a facility offering accessible and affordable scale-up support for fermentation and cultivated meat. Such infrastructure enables pre-revenue-making companies to transition from lab- or bench-scale to commercial-scale without investing heavily in capital; they also benefit from accessing skilled technicians at pilot plants. BioBase Europe in Belgium is often highlighted as an example. Similarly, there is likely to be a role for government in derisking the construction of 'first of a kind' facilities, such as commercial-scale cultivated meat factories (likely to include multiple 10,000ltr+ bioreactors and significant downstream processing capabilities for manufacturing read-to-distribute food products). Blended finance will be an important instrument here, and DSIT capital funding and the UK Infrastructure Bank would be priority sources of public funding to leverage in private sector patient capital.

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

This is certainly true for UK alternative protein companies leveraging engineering biology, who see other jurisdictions as offering a more appealing regulatory environment (discussed below) and many have considered establishing their first production facilities overseas. This would be a significant setback for the UK, since bolstering food security is a key opportunity created by alternative proteins. Notably, the University of Strathclyde spinout ENOUGH - who produce a mycoprotein-based meat product - founded its production facility in the Netherlands after receiving substantial EU funding and forming an agri-bio industry consortium.

Has regulation in this area evolved quickly enough? Are regulators sufficiently resourced, in terms of expertise and budgets, to keep up with the pace of change of science? How does scientific evidence feed into regulation of engineering biology? What should the Government do to ensure the regulatory environment is able to keep up?

New alternative proteins like precision fermentation-made dairy or cultivated meat are regulated by the Food Standards Agency, in collaboration with Food Standards Scotland. In the vast majority of cases, we expect new bio-based alternative proteins to be regulated under the novel foods framework. This includes a robust science-led risk assessment process undertaken by FSA scientists, with an opinion also given by the independent Advisory Committee on Novel Foods and Processes.

Concerns have been raised about the FSA's ability to implement the novel foods framework in a timely manner as part of its regulated products service. At present, the FSA is taking an average of 2.5 years to approve regulated products (n.b. this includes other regulated products such as animal feed and smoke flavourings), with 63 applications approved since 2021 and a current caseload of 450. The FSA has repeatedly stated that its resources are insufficient to cope with the current and predicted growth in its caseload. With the regulator's budget frozen since the last CSR, we believe that the UK is unduly holding back the development of alternative proteins due to a lack of regulatory capacity. An immediate funding uplift of £30 million is essential, and the regulator should also implement cost recovery fees to fund its regulated product service.

The FSA is progressing with a set of post-EU exit regulatory reforms, including removing the need for a Statutory Instrument following an authorisation decision by ministers; this is expected to reduce timelines for authorisation by 3-6 months. These initial reforms are welcome, and the FSA should be ambitious with its plans to use the risk assessment opinion of other trusted regulators internationally, whilst retaining autonomy to protect our high food standards. Many effective changes effective changes could also be made without legislation. Notably, there is a considerable lack of public information about what is needed to produce a complete dossier to submit a novel alternative protein product for approval, which leaves businesses in the dark and the regulator stranded with poor-quality submissions.

We strongly support the FSA’s bid to create a cultivated meat regulatory sandbox as part of DSIT’s sandbox programme for engineering biology. Should it receive funding, it will be important that the sandbox focuses on advancing the FSA’s understanding of the food safety considerations relevant to the robust approval of cultivated meat products and disseminating as much information publicly as possible to support the sector’s growth.

07 May 2024