ANNEX D

SSAC REPORT – Engineering Biology: Opportunities for Scotland

SUMMARY OF SURVEY RESPONSES

The questions in the survey were as follows:

1. What is your current involvement in Engineering Biology
2. What are the key contributions that Engineering Biology is already making to Scotland
3. Where are the greatest opportunities for Scotland in Engineering Biology in the next 10-20 years
4. Which countries will be the most important international partners for Scotland in relation to Engineering Biology, and what is required to enable/sustain these partnerships
5. What skills will be needed in the Scottish workforce to support the expanding Engineering Biology sector in the next two decades?
6. Are there any other comments you would like to make on the opportunities to Scotland offered through Engineering Biology?

In total we had 30 responses to the survey representing the views of individual stakeholders or organisations and conducted 12 individual interviews. Due to the large number of detailed responses, the text below reflects a collated summary of the views of the respondents. Whilst original wording has been retained where possible, it has been edited for conciseness, to remove repetitive information and personal identity information. Not all respondents provided a response to every question.

1. What is your current involvement in Engineering Biology?

This question was used for context, responses were not reported here. For the written survey, we had seven responses from industry, 20 from academia (some of which also had involvement in industry/start-ups) and three supporting organisations (Skills Development Scotland, IBioIC and Scottish Bioeconomy Council). Interviewees are listed in Appendix B.

2. What are the key contributions that Engineering Biology is already making to Scotland?

A wide range of contributions were highlighted across multiple sectors, however in several areas respondents mentioned that much of the activity is early-stage and still at research level, with slower translation to clinical and industrial application for a variety of reasons e.g. crop and soil science.

<u>General economic impacts</u>

- Opening up new markets
- Creating new small companies (for examples, see Appendix F)
- Attracting advanced technology companies e.g. globally leading Japanese stem-cell company Reprocell has its European headquarters in Scotland

- Creating highly skilled job opportunities and a promising and rewarding workspace for College and University graduates, and potentially for highly skilled individuals from other sectors and around the world
- Creating IP for licensing and gross-value added e.g. the Roslin Institute was estimated to have contributed £18.9Bn GVA worldwide in 2019/20 alone (including £81M GVA specific to Scotland) through its contributions to the agriculture and aquaculture sectors, increasingly through Engineering Biology (link).

Environmental and sustainability impacts

- Promoting sustainable manufacturing practices that reduce waste and lower environmental impact in industries such as chemicals, energy, and materials
- Exploiting waste materials and valorising co-products that are abundant and specific to Scotland (e.g. from the whisky/brewing industry or fisheries) enhancing the circular economy and decarbonising chemical manufacture
- Contributing to Net Zero goals

Health/medical impacts

- Advanced therapies to address complex diseases that currently have only limited treatment options e.g.
    - Resolution Therapeutics developing engineered cell therapies for end-stage liver disease, where the only existing option is transplant
    - Trogenix (spin-out from Edinburgh University) developing gene therapies for glioblastomas
- Drug and vaccine discovery and manufacture e.g.
    - Production of mRNA or live-attenuated vaccines:
        - The remarkable vaccine response to the Covid-19 pandemic was only possible through the use of genetic technologies
        - Medicines Manufacturing Centre in Renfrewshire
        - Ongoing research at the Roslin institute for livestock vaccines
    - RoslinCT were involved in producing the first CRISPR-based therapy (where gene-editing is done in the body) for sickle cell and beta-thalassemia disease (Cascevy). This is a Vertex product of which RoslinCT are exclusive manufacturers.
    - Improved drug screening and trials, reducing time-to-market and improving drug efficacy/personalised medicine e.g. Roslin Institute is pioneering the use of genome edited animals as models of human diseases, enabling the evaluation of therapies such as enzyme replacement and gene therapies for complex and rare diseases
- Regenerative medicine e.g. Centre for Regenerative medicine, Edinburgh
- Improved diagnostics

Global status, fundamental research and talent attraction

- Scotland has a strongly competitive research sector in Engineering Biology/genetic technologies, both academically and commercially with many global leaders in life sciences (special reference to clusters in and around Edinburgh, expertise in industrial biotechnology, mammalian cell engineering, cell and gene therapies etc.)
- Academic contributions are above expectation for a country of 5.5 million, creating world leading, high impact research in Scotland (with a key historic example being the cloning of Dolly the sheep). This serves to enhance Scotland's reputation for scientific excellence, attract global talent, and lay a robust foundation for future innovation and growth across both industrial biotechnology and the broader bioeconomy.

Investment

- Attracting significant research funding due to Scottish academic expertise, especially in Edinburgh, Strathclyde, Glasgow, Heriot-Watt and Dundee (from both academic research council and industry e.g. investment into the new UKRI Advanced therapeutics hub in Edinburgh)
- Attracting capital investment, which is used for the development of scientific infrastructure and progression of scientific research
- A growing pipeline of spin outs and start-ups winning private investment with several SMEs now attracting larger funding rounds

Many respondents highlighted the strong existing support from:

- Strong Higher Education framework (undergraduate up to PhD)
- Edinburgh Genome Foundry
- IBioIC
- RSE Enterprise fellowship
- Scottish Enterprise funding
- Scottish Agricultural Organisation Society (SAOS) - helping to identify and connect suppliers to valorisers for circular economy applications

3. Where are the greatest opportunities for Scotland in Engineering Biology in the next 10-20 years?

The future opportunities are dependent on the regulatory landscape. There are many short-term opportunities which can be achieved with current technology and regulations, especially those related to health and industrial biotechnology. However, the full scope of the opportunities, especially in areas such as agriculture and aquaculture, could only be realised if Scotland moved towards regulatory alignment with England & Wales and the EU regarding precision bred/gene edited organisms.

Engineering Biology can be supportive of Scotland's net zero and circularity goals as outlined in the Circular Economy (Scotland) Bill, support an ageing population with

new therapies and regenerative medicine, and address global food shortages for a growing population.

Many responses focussed on Scotland's unique strengths, including but not limited to:

- **Natural assets:** marine environment, seaweed/macroalgae, renewable energy, water
- **Industrial strengths:** strong agricultural base, brewing, whisky, fisheries, oil and gas etc. can provide feedstock for bioprocesses to utilise waste in a circular economy, skilled personnel and infrastructure for new and emerging industries
- **Academic strengths:**
    - **Life Sciences** - general strength and world-renowned expertise in discovery-driven research
    - **Data/AI** - Scotland has clear USPs and existing skills base in data science and AI

The early stage of the field was presented as an opportunity by some respondents, offering the chance to influence the development of the field in a significant way:

- Opportunity to develop a "solidarity bioeconomy" based on more co-operative/collective economic models – this term is all about organising things differently to allow more people to benefit and share the profits, avoiding the exploitation of nature/people to extract profits for small numbers of individuals etc. For example, one of the opportunities of EngBio includes enabling small-scale distributed biomanufacturing which aligns with this principle (vs clustering and big centralised facilities)
- Opportunity to market Scotland as an ideal place to be a "disrupter" for emerging technologies in life science and biotech with incentives for early start-ups to stay in Scotland. It is becoming harder to be a "disrupter" in crowded spaces such as Silicon Valley.

<u>Health/biomedicine</u>

Scotland has existing strength across the full landscape and is well placed to take a leading role in this emerging sector (with academic strength led by the new Advanced therapeutics Hub at the University of Edinburgh and the Edinburgh Genome Foundry, a substantial manufacturing and testing infrastructure, and the necessary supply chains and clinical/regulatory expertise). Currently the sector is supported by the Cell and Gene therapy catapult and the Scottish Advanced therapy and vaccine network. Investment is also relatively easy to raise as investors are more familiar with the return-on-impact for this sector:

- **Advanced therapies**: Advanced therapies, including gene and cell therapies, is an emerging sector. There are currently over 1000 trials globally in advanced therapy medicinal products. Only ~20 are approved at the moment, but rates of approval are increasing, so forecasts anticipate an upturn in the near-future. In the longer-term, advanced therapies may sit alongside small molecules and biologics as a third major sector within biomedicine.

- **Drug discovery and screening**: EngBio can be used to develop advanced screening approaches for therapies of any type, enabling better prediction of patient-to-patient variability and thus reducing the time-to-market
- **Precision and regenerative medicine**: Pluripotent stem cell banks and individualised manufacturing paradigms could revolutionise individual treatment for diseases, giving an off-the-shelf bespoke therapy for specific tumour types and other diseases e.g. there is a trial currently in the US for ocular disease treatment using patients own cells
- **Vaccine development and manufacture**: an opportunity that is already well developed and commercialised
- **Microbial** therapeutics: using living microbes to manipulate the microbiome (human microbiome, as well as soil microbiome for agri tech etc.)

There were some concerns that the health sector is already dominated by the Golden triangle, but Scotland hosts significant expertise and the health/biomedicine sector is the most developed within Scotland at the moment. Advancements in this field could support an ageing population and improve general health.

Industrial biotechnology

Engineering Biology is an enabling technology that can take biomanufacturing from being a “neat idea” into something that is commercially viable, creating better systems and processes that can compete with fossil fuel-based manufacture. Many of the existing industrial biotechnology companies in Scotland companies could deploy EngBio in their processes to improve productivity or functionality of products.

Key areas of application include:

- Sustainable manufacture of chemicals, especially high-value smaller scale chemicals e.g. flavours, fragrances etc.
- Production of enzymes, proteins, single cell protein & lab-grown meat (e.g. for food)
- Production of biobased products, fuels and materials from renewable resources and/or wastes from other industries, avoiding fragile supply chains and reducing dependency on fossil fuels
- Combining traditional manufacturing/industry with biomanufacturing providing biological carbon capture

The main barriers include lack of regulatory clarity, access to infrastructure to scale, and access to suitable feedstock.

There were some concerns that within the Scottish climate, the production of biomass crops cannot reach significant scale without direct competition with food crops and will struggle with seasonality. Furthermore, there are economic and regulatory challenges with accessing resources such as the seaweed on the West coast. However, waste as a feedstock could be the most promising.

Data and AI

The fusion of AI, machine learning, and big data analytics with biological engineering will streamline R&D, enhancing discovery and process development efficiency, and ultimately reducing time-to-market.

Food and agriculture

Impacts in this area generally depend on shifts in the current policy and regulatory frameworks, but could be transformative for the future of Scottish farming and food production in the face of the multi-faceted challenges posed by climate change, population increase and international competition. Climate change will undermine existing varieties in terms of developmental/seasonal temperature and water availability optima, as well as seeing disease pressure (and type) and extreme weather events increase. The National Farmers Union for Scotland (NFUS) noted that climate change is a huge concern and challenge for farmers and that for farming to be successful, we need to have all the tools available to cope with the ever-increasing challenges. Furthermore, Scottish farmers are concerned about the impact on their competitiveness in the market as other countries start to adopt some of the higher-yielding, more robust crops and breeds derived from gene-editing, whilst Scottish farmers are prohibited from adopting these. For example, dairy is a UK-wide sector but the farmers have different options in Scotland compared to those south of the border.

Applications of EngBio in this sector are listed below. Many of these have been developed and deployed elsewhere in the world, but are listed as an opportunity for Scotland as it is not currently deployed here:

- **Disease resistance and prevention:**
    - Gene editing crops that are more resistant to disease and have the option to not use, or use less pesticides is very attractive for protection of biodiversity and crop yields
    - Gene-edited animals for disease resistance can have implications on yield, sustainability, animal welfare and human health
    - Oxitec have produced engineered tick that do not reach sexual maturity, providing a potential solution to tick-borne diseases of cattle
- **Climate change/drought resilience**: Scotland currently has an advantage with its level of rainfall, but for adaptability to the future, plants that are resistant to drought/excessive rain would be another tool in the toolbox to cope with the future challenges
- **New varieties**: gene editing can generate new varieties that open up markets for crops that previously could not be sustainably or economically grown in Scotland e.g. high-value crops such as fruits, or improving nutritional content of existing crops
- **Reduced emissions from livestock**: engineering ruminants or gut microbes for livestock that produce less methane
- **Gene-editing in potatoes**: Scotland has a strong reputation for its seed potato stock (Northern cold and wet climate typically gives good disease resistance because of lower numbers of disease-transmitting aphids).

Potatoes are usually grown one year in ten, on rented ground as a high input, high value crop, requiring high investment and high risk to the farmer. Poor yields or worse, an infection requiring the full crop to be destroyed, could lead to substantial economic loss. However, gene-editing to confer resistance to disease such as leaf roll virus and potato cyst nematodes can de-risk potato farming, enabling strong economic returns.

- **Scottish whisky profitability**: The whisky industry is currently operating with poor margins and needing to import a lot of grains. If farmers could cut costs through not having to use pesticides, or having perennial cereal crops it could aid profitability for the industry.
- **Protein crops**: Scotland imports a lot of soy for animal feed. There is ongoing research into lupins, peas and beans for providing protein-rich crops.
- **Nitrogen-fixing crops**:
    - Legumes such as pulses and beans are good to include in crop rotations for soil health, but not grown so often in Scotland because you get a mixed results. Would be great to get hardier varieties
    - Longer-term, nitrogen-fixing cereals to avoid needing a rotation with a legume, or reduce fertiliser use

Scotland has leading expertise through focussed research institutes such as the Roslin Institute, James Hutton institute, SRUC and the Moredun Research Institute. These are all key assets to Scotland in this area, should Scotland choose to exploit them. For example, the Roslin institute has pioneered strategies to engineer the genomes of chickens, pigs, sheep and cattle, both to study biological processes but also to demonstrate the potential of genome editing in enhancing the productivity, health and welfare of food-producing animals. The James Hutton Institute hosts the International Barley Hub, which is a key resource of genetic information on cereal crops.

<u>Other applications</u>

- Environmental bioremediation e.g. Removal of pfas “forever chemicals”
- New technologies for generating electricity in challenging settings

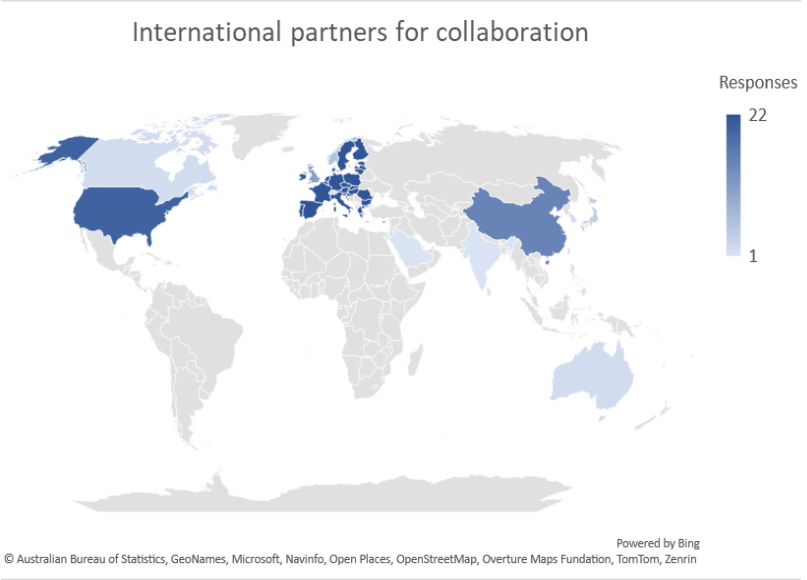
4. Which countries will be the most important international partners for Scotland in relation to Engineering Biology, and what is required to enable/sustain these partnerships?

Respondents answered with different levels of geographical granularity and detail. Countries mentioned were generally divided into potential collaborators, competitors, potential markets or beneficiaries.

Europe/EU was the main area mentioned in terms of potential market opportunities (due to geographical proximity, and as Scotland and the UK’s largest trading partner). The importance of regulatory alignment, harmonised standards and clear regulatory pathways were highlighted, to simplify trade and enable commercialisation of the end-product for Scotland-based SME’s.

Where respondents focussed on competition, the USA and China emerged dominantly as global leaders with different magnitudes of funding available, far outweighing that in the UK/Scotland. Risks from this competition included the offshoring of companies to more favourable environments. England was also mentioned as a competitor/leader in the health biotech space.

The remaining analysis of responses focuses on countries mentioned in terms of collaborative opportunities (Figure 1). Note that the USA and China also feature high on this list, even after removal of responses where they are solely referred to as a competitor.



Collaborator	Responses
EU-27	22
USA	20
China	15
United Kingdom	11
Norway	6
Japan	4
Canada	2
Australia	2
South Korea	2
Singapore	2
Israel	1
Switzerland	1
Taiwan	1
Saudi Arabia	1
India	1

Figure 1 Collated responses from questionnaires and interviews in response to Question 4: Which countries will be the most important international partners for Scotland in relation to Engineering Biology.

Many responses highlighted the benefits of our strong existing collaborative relationships, more details of which are in Appendix H. Several emphasised the top priority being with the rest of the United Kingdom, or with England. Both have been recorded as United Kingdom. Regarding European countries, where any individual EU country was mentioned it was counted as EU-27, as it is politically challenging to pursue bilateral partnerships within the EU. Within the EU, the countries/regions most often mentioned individually were: Germany (6), Scandinavia/Nordic countries (4), Netherlands (3). Norway was often mentioned (6), either alongside the other Nordic countries, or individually. It is included separately as a non-EU state.

A few responses referred to regions, or generic groupings as a whole without specifying key countries (Middle East (1), Africa (1), South America (1), “low income countries” (1)). These are not shown in the summarised data.

Several answers specified an order of importance for relationships, or for the timescale of developing these partnerships, which was generally in the order of geographic proximity e.g rest of UK, then EU, then countries outside of Europe (e.g. **“a strong European consortium would be more beneficial at the first stage”**). Other orders were also suggested, with some featuring the USA above Europe, but without consensus. The consideration of other factors, such as distance and

environmental credentials, were also suggested to be important when developing sustainable partnerships for the future e.g. concerns over China's reliance on coal-power for collaborations around industrialisation/scale-up.

The geopolitical context was acknowledged in several cases. Most notably the uncertainty around the future of Engineering Biology and life sciences research in general in the USA due to the political upheaval, trade tariffs and funding volatility e.g. the 2022 Act "Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy" was revoked in March 2025, and there have been funding cuts to many research programmes such as those by NIH and NSF under the Trump government. There is general concern about pursuing collaborative relationships in the face of such uncertainty. Opportunities highlighted around this might be in pairing with particular states with favourable policies or existing relationships e.g. California, Texas, New York, or in benefitting from the loss of the USA's competitive advantage and the attraction of talent and investment that is now looking elsewhere for a more stable and supportive environment.

Reasons for collaborating with countries included:

- **Knowledge partnerships:**
    - To advance research and forge technological progress in key areas e.g. Japan & stem cell technologies
    - To co-develop applications of technologies together e.g. countries with similar profiles, natural assets and key industries such as Scandinavia/Norway
    - General scientific research collaboration with countries with a lot of academic institutes, relevant expertise and organisation e.g. UK, China, selected EU countries, USA
- **Facilities and scale-up**: Investors are typically reluctant to fund production scale facilities, so access to shared facilities enabling translation and scale-up is essential
    - UK Centres of Excellence in Engineering Biology with the capacity of scale including: Sanger Institute (Cambridge), Imperial College (London), University of Manchester, The Nucleic Acid Therapy Accelerator (UKRI) at Harwell
    - EU-funded scale-up facilities:
        - **"The EU has funded these facilities for its deep tech SMEs to enable them to maximise their impact and be capable of competing with competitors in USA/China etc. However UK-based companies cannot access these investment vehicles which impedes scaleability"**
    - Partners for infrastructure, industrialisation and cost reduction e.g. to develop centralised biomanufacturing and scale-up (EU, China, USA)
- **Funding and investment opportunities**:
    - USA, China – different magnitude of funding available (Saudi Arabia also mentioned in this respect)

    - Competitive bids for UK research council funding
    - Access to EU funding (e.g. Horizon Europe) through collaborations involving EU member countries
    - Global philanthropic funding- especially relevant for areas of EngBio application such as tackling disease - Scotland has been relatively successful in the past with this

Suggested actions to enable and sustain these partnerships included:

- **Sustainable, long-term collaborative funding opportunities to incentivise collaborations, e.g.**
    - Joint funding calls for research partnerships
    - Pump-priming funding to strengthen new and existing collaborations with countries where engineering biology is happening at a field scale
- **Agreements that will promote collaboration, exchange of knowledge and personnel with these countries**
    - Continued support for Horizon Europe
    - Oversight of regional programmes/clusters of expertise that are complementary
    - Viable immigration/VISA policies that allow skills exchange
    - Exchange programs
    - Facilitation of interactions with industry
    - "dating" events (workshops) to bring potential collaborators together
    - Commit to clear and consistent IP policies to protect innovations while encouraging open collaboration
- **Regulatory alignment**
    - Harmonise standards and clear regulatory pathways to facilitate smoother cross-border collaborations for both R&D and commercialisation of end products e.g. regulatory alignment with EU to sell into those markets/simplify trade
- **General relationships**
    - Rebuild trust with EU partners (re-introduction to the EU in an ideal world)- especially important for access to EU funding and EU-funded scale-up facilities
- **General environment**:
    - Secure stable, long-term investment in research, infrastructure, and education
        - "**I do not think focus on Engineering Biology specifically dictates any change to overall scientific and economic partners, as the challenge across multiple sectors is structural. Private sector job increases are required to make partnerships more attractive. Attracting investment is key to drive stable and increased opportunity**."
    - Make Scotland an attractive place to develop, commercialise and scale-up biotechnologies:

- Some responses highlighted specific examples of countries where EngBio is successfully combined with bio-entrepreneurship to enhance the positive impact of the scientific outcome (e.g. Ireland, Belgium, Netherlands – e.g. around Rotterdam) or with a strong and focussed national strategy (e.g. Italy for crop and soil science)
- Incentivise technology development in priority areas e.g. through jurisdictions which actively promote new growth for low carbon products, wherein Engineering Biology is a key enabler. Examples include the EU with CBAM and ETS.

5. **What skills will be needed in the Scottish workforce to support the expanding Engineering Biology sector in the next two decades?**

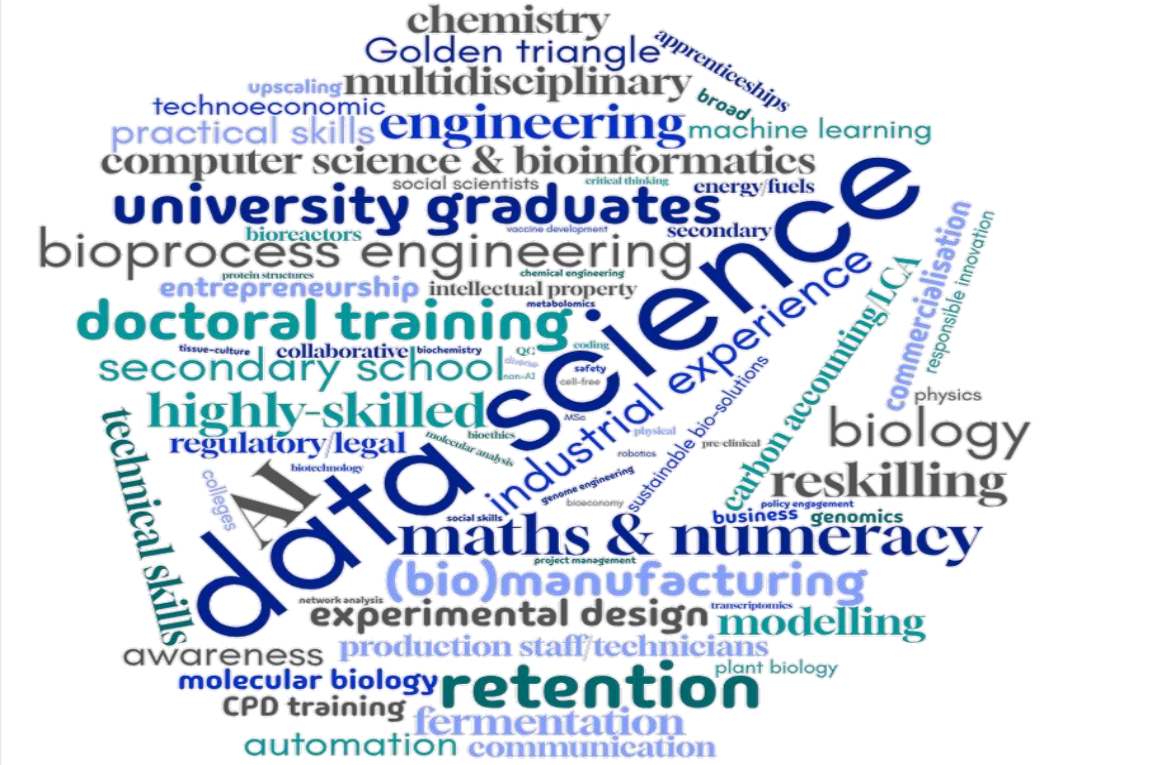


Figure 2 A word cloud noting keywords mentioned by responses, scaled by frequency

Respondents emphasised three types of skilled personnel essential for expanding the Engineering Biology sector in Scotland:

- highly-skilled trained scientists and data analysts
- technical/operational staff with specific skills in fermentation and biomanufacturing

- engineering skills for bioprocess development and scale-up (e.g. chemical engineering, bioengineering, bioreactor design)

A broad range of areas of technical expertise were highlighted to be important. The most commonly mentioned skill was data science or data analysis skills, alongside AI, modelling and machine learning, alluding to the scale of data that is now available for understanding and learning to manipulate biological systems. Automation is also essential for future growth, noting that the advanced therapy sector is surprisingly lacking in automation compared to similar industries.

Many responses highlighted the existing strong educational and academic system in Scotland, with good doctoral training in the Life Sciences in general. However, others mentioned a lack of focus on Engineering Biology in the existing doctoral training opportunities relative to other areas of the UK. Plant biology was another particular branch of the biosciences that was felt to be lacking. It is imperative to continue funding PhD studentships in Engineering Biology in Scotland to maintain critical mass of skilled scientists coming into the workforce.

Several responses focused on the problem of retention of talent, both within the sector and within Scotland e.g. generating “sticky” people and businesses. Several noted the strong attraction of the “Golden triangle” region of Oxford-Cambridge-London and the need to provide incentives and attractive career prospects for people to stay in Scotland after a PhD. Appropriate skills provision and training is only one part of the puzzle required to make Scotland “sticky”. To develop “sticky people” the workforce should be developed from the ground up (providing opportunities at every level so that people can see the career development opportunities and pathway when entering at any stage), and also have the right workplace culture to attract and retain individuals. To have “sticky businesses” you also need a supportive wider infrastructure and environment, which the enterprise agencies can contribute to.

Awareness of the opportunities within EngBio, and clear strategic commitment and focus from the government could help to attract highly-skilled people e.g. those trained in data science and informatics, into the bio-sector. Within academia, there could be improved support from funding bodies and universities to enable long-term collaborative or entrepreneurial work at post-doc level and beyond, currently limited by the systemic problems of short contracts, precarious funding and publishing pressure.

Regarding the wider pathways of school and undergraduate education, some noted that university graduates are not equipped with the necessary experimental and multi-disciplinary skills to fulfil the requirements of industry. Having a broad base that is not too specialised/narrow was important. Maths, numeracy and coding skills, and a good understanding of experimental design were felt to be lacking by several respondents. Scotland’s four-year honours system can be seen as an advantage that doesn’t exist in the more compressed English system, giving undergraduates the opportunity to acquire a broader base and focus on complementary aspects alongside the core scientific content such as the social dimensions of science.

It was noted that postgraduate level education was not required for several of the technical/operational roles that are expected to see increased demand with the

growth and scaling of EngBio in Scotland. Further education providers, including apprenticeships and colleges, should communicate with industry to ensure that the training pathways meet the needs of the industry as it develops. Companies in particular noted demand and difficulties recruiting fermentation scientists for the scale-up of bioprocesses, and technical staff for the complex manufacturing of advanced therapies. Current skills training initiatives include the RESILIENCE medicines manufacturing programme, and the Advanced therapy skills training network (ATSTN) which trains new entrants to the sector in biological principles including aseptic techniques and GMP/GLP.

Re-skilling was discussed as a relatively quick way to expand the workforce, attracting those with relevant industry experience and key transferable skills from other sectors. In particular there is an opportunity to harness the knowledge from other sectors such as the oil and gas and chemical sectors. For industrial biotechnology, the scale-up process and downstream purification are largely an engineering challenge. The additional biological aspects could be covered within a few months to a year to adequately retrain a skilled process engineer from another industry. There used to be funding streams such as the National Transition Training Fund for upskilling and reskilling individuals e.g. SDS have had previous schemes on practical lab skills for life and chemical sciences, climate literacy, leadership & management etc.

Other supporting skills that were highlighted included, but were not limited to: business/commercialisation skills, quality and regulatory affairs and life-cycle and technoeconomic analysis. Whilst these areas can be covered by specialists in other sectors, it was felt that they needed a deeper level of understanding and tailoring towards EngBio.

6. Are there any other comments you would like to make on the opportunities to Scotland offered through Engineering Biology?

Responses to this question have been directly quoted but not attributed, and are grouped by topic.

Governance

- “We need to get policy (Government), industry and academia lined up and ALL pointing in the same direction. In terms of Scottish government this cannot solely rest with Cabinet Secretary for Rural Affairs, Land Reform and Islands, and needs to bring in Acting Cabinet Secretary for Net Zero and Energy, Economic Development Directorate etc.”

Public education

- “In order to achieve widespread acceptance and market traction it is also important that there is greater public knowledge of what engineering biology is and the benefits that this sector can deliver. This should extend to political and financial decision-makers to ensure that the sector receives the necessary support at all levels.”

- “Public perception is critical; mishandling this had a devastating effect on EU agriculture, isolating itself from being able to use genetic technologies.”

Infrastructure

- Requirement for additional lab space, as most existing spaces are reaching capacity
- Scotland needs to make itself a more ‘attractive’ location to scale up biotechnologies.
- Need lab spaces for R&D, test spaces for scale up, and suitable sites for industrial level production
- “scale-up facilities have been a good starting point but as these technologies become more mature, infrastructure to translate this at scale (without transporting feedstocks large distances) will be required”
- “a challenge, and therefore an opportunity, is in scale-up to manufacture”
- “cost of access to infrastructure should not be an unnecessary barrier to nascent industry”
- “innovative biotechnology start-ups are often required to build costly demonstration scale facilities at a relatively early stage in the commercial journey to de-risk their technology to investors, to enable fundraising to build fully commercial manufacturing facilities… “This major obstacle is frequently overcome by an early-stage trade sale of the technology, often moving the innovation out of Scotland and the UK. Supporting the development and construction of such facilities in Scotland is not only key to the move towards a Net Zero economy; it is also a necessity for the development of secure and resilient local supply and manufacturing chains that recent events have brought even more starkly into focus”...
- There is an opportunity for Scotland to “commit to supporting companies further into their demonstration and early commercial journeys” than the wider UK National Vision for Engineering Biology does

Collaborative networks (industry-academia) with clear IP policies

- “Cultivating collaborative networks among academia, industry, and government, with clear intellectual property policies that encourage cooperation, will create a vibrant innovation ecosystem that accelerates breakthroughs”
- “It is very important that industry needs to talk to academia to tell them what they need ... this is very often the biggest stumbling block…. If we knew what industry needed help with solving this would be transformative for both sides.”

Definition and strategy

- Engineering biology is a broad term that can vary in meaning across different contexts. For Scotland, having a clear definition is crucial to effectively prioritize investment. By doing so, Scotland can strategically focus on key areas, drive innovation, and support economic growth in the biotech sector

- “Although there is aways a problem with definition and “mission creep” the EngBio community needs to avoid being too protectionist about its synthetic biology history and its “fabrication of biological components, systems, and materials from biological elements” definition – which is quite narrow. History amply demonstrates that innovation and progress does not respect semantic definitions.”
- “Scotland has a formidable legacy linking to engineering biology, and should strategically position itself to be recognised as a European Leader going forward. It will be essential that siloes are pulled down, that no fiefdoms are created, and that Scotland works together, inclusively in team.”

Policy

- “Policies on GM/GE need to be reviewed in order to fully exploit the potential of Engineering Biology, particularly plant/algae focused”
- “For crop and soil science, the “elephant in the room” is the regulatory framework. For instance, Scotland considers genome edited/precision breeding plants as genetically modified organisms which cannot be released in the environment. Conversely, England and the EU adopted comparable legislations, fast-tracking the authorisation for experimentation with genome-edited plants. Without an “alignment” of the regulatory framework, scientists and stakeholders [including growers] based in Scotland won’t be in the position to collaborate and/or compete with colleagues in the rest of the UK and Europe. “
- Lack of clarity around future regulations is one barrier to adoption of genetic technologies e.g. additional regulations are being proposed for products that are derived from a GT source or produced with a GT element and the need to demonstrate end products as free from DNA molecules. Such regulations create a perception of risk where none exists and create confusion and uncertainty that hinders companies looking to develop better and more sustainable products, and therefore hinders economic growth.
- “Scotland needs a visa scheme that will enable engineering biology employers to attract and retain the best scientific talent from around the world – otherwise they will continue to live and work in places like the USA”

Natural resources

- Scotland would best deploy its resources by considering two modes of exploitation:
    - Distributed biorefineries – Scotland’s peripheries are sparsely populated with economically precarious communities. Small-scale, low-tech biorefineries to exploit local biomass sources could provide valuable economic boost at the country’s margins. Production would necessarily be restricted to organisms that do not require full containment (i.e. GRAS GMOs). This is not dissimilar to MiAlgae’s approach to parachuting the bioreactor into farm settings where

agricultural co-product is used as feedstock. Key to this approach is the assured market for the operator to sell their intermediate product to a central site for on-processing/purification. The final product must have sufficient value to support the process i.e. biofuels should not be considered, rather food/feed additives (flavours/nutritional enhancers etc.), nature-identical molecules (proteins, enzymes), and biomaterials (alginates, hydrogels) make promising targets.

    - Intensive Biomanufacturing – Scotland should show some ambition to create and retain a megacorp of its own. The wealth of opportunity that exists around cell and gene therapies for human and animal health is hugely attractive. But whilst we can and should develop early pre-commercial companies in this space, it's very difficult to imagine these residing in Scotland as we do not have access to the scale of investment needed to fully transition them to addressing market opportunities. Such companies are always going to be vulnerable to acquisition by existing multinational pharma and off-shoring.
- Scotland's peripheries are well-served with renewable energy sources (wind/wave) to power bioreactors and the essential abundant fresh water e.g. The "Algal Solutions for Local Energy Economy" initiative centred around Ardnamurchan was a pioneering exemplar of this approach