Response to BBSRC Biosciences Consultation

Are you responding to this survey as an individual or on behalf of a group or organisation?

Group or organisation.

In what type of organisation do you or your group operate?

Public sector research.

Please tell us on behalf of what group or organisation you are responding:

Please limit your response to 500 characters or less (Required)

Environmental Biotechnology Network (EBNet, www.ebnet.ac.uk)

EBNet is one of six Networks in Industrial Biotechnology and Bioenergy (NIBBs) funded by BBSRC with additional support from the Engineering and Physical Sciences Research council (EPSRC).
Our remit focuses primarily on engineered microbial systems for environmental protection, bioremediation and resource recovery, including both pure cultures and complex microbial communities.

If you are happy for us to contact you further about this work, please tell us your name and e-mail address

Name: Sonia Heaven
Email address: ebnet@ebnet.ac.uk, S.Heaven@soton.ac.uk

Reflecting on BBSRC's current Forward Look, our remit, and the changes that have occurred since their publication: to what extent are the priorities still relevant for the next 5 to 10 years? Please provide information to explain your views.

Please limit your response to 3000 characters or less.

We believe the priorities identified in BBSRC's 2018 Forward Look for Biosciences of Bioscience for sustainable agriculture and food, renewable resources and clean growth and an integrated understanding of health remain highly relevant for the next 5-10 years.

What other priorities should BBSRC consider when developing the Forward Look for UK bioscience?

Please limit your response to 3000 characters or less.

A key area for prioritisation is enhanced consideration of context - both the wider real-world context of implementation, and specific knock-on effects of particular choices within a bioprocess. This can be broadly summarised as the need for whole systems thinking.

Biologically-mediated systems of all kinds are highly interactive with their environments. This is an exciting research field in own right, but also encompasses interactions with upstream and downstream technologies. To give an example, it is very simple to create volatile fatty acids (VFA) from mixed heterogenous organic wastes that are difficult to process by other means. But to be of value the product VFA must be separated and purified. How this is done - e.g. by in or ex situ extraction, with or without feedback loops - has major effects on system microbiology and performance; while any requirement for addition of chemicals such as mineral acids has not only a resource footprint, but also implications for treatment and valorisation of downstream residues. While it is clearly not possible to conduct full Life Cycle Assessment (LCA) at the discovery science stage, there is a need for systems thinking from the start, rather than different disciplines seeking bolt-on solutions to individual pieces of a problem. The Forward Look must promote and prioritise this kind of approach, from the earliest stages through to the million-litre bioreactor.

Mapping and scaling of resources is also essential to identify which ideas can make an impact. Current petroleum-based production systems are frequently predicated on ease of transport of feedstocks and huge scales of operation, neither of which are features of a circular bioeconomy. Engineering a micro-organism to improve yields of polyhydroxybutyrate (PHB) from wastewater is only worthwhile if ways to aggregate output to industrial quantities are also considered; developing small-scale hydrogen injection on-farm digesters may make sense, if there are markets for the additional methane yield. This is especially critical given the timescale on which solutions are needed: game changing discoveries that are years from implementation must be balanced with improvements to existing technologies that can be applied immediately, whether as part of the transition or a permanent component in a circular bioeconomy.

This approach also means that Environmental Biotechnology is at the heart of any initiatives in renewable resources and clean growth and in sustainable agriculture and food. No primary production or manufacturing bioprocess is without residues, and consideration of how to deal with these is essential to the optimal choice of technologies. Environmental Biotechnology is thus intimately linked to the whole systems thinking which is in turn vital to deliver a more sustainable society, and its role should be credited and prioritised as such.

We warmly welcome the BBSRC 2023 Science Futures Workshop report, which raises many of these points.

Is there any breakthrough (for example technological, new approaches, or new knowledge) that could enable significant progress in addressing grand challenges or enable a step-change in bioscience?

Please limit your response to 3000 characters or less.

The origins of industrial biotechnology, and the present interest in Engineering Biology, have tended to prioritise work on pure culture and model organisms. The untapped potential of novel wild-type organisms, mixed cultures and microbial communities is significant, and warrants more extensive exploration. Key questions include, what opportunities can they offer and when is the added complexity inherent in mixed cultures of value? What are the trade-offs (ecological, technological, economic, regulatory) when choosing between synthetic and wild-type organisms and communities, and between open and closed microbial systems?

Addressing these points involves the development of new tools for characterisation and manipulation of non-model organisms and for mixed culture/community engineering. Microbial metabolism and spatial and community structures are strongly influenced by the envelope of conditions they exist in;

conditions which in many cases can be adjusted by simple engineering-scale interventions. Better understanding of such interactions will open new opportunities for process development and optimisation. To achieve this understanding requires measurement of conditions within local micro-environments, and development of multi-scale models capable of bridging from genetic, cellular and community levels to thermodynamics and hydrodynamics. Above all stronger theoretical frameworks are needed for microbial ecology and microbiome engineering, including how such systems operate in real-world environments subject to immigration, competition, predation and mutation. The current revolution in biosciences is rapidly bringing such tools into reach, and will enable step changes in understanding.

Support for these areas will bring gains in fundamental knowledge; but is also deeply pragmatic if we want robust systems capable of dealing with the grand challenges of sustainability on realistic timescales. Building on microbial communities will provide both long-term and transitional solutions, adaptable to a wide range of economic and social conditions.

What key issues, barriers or blockers need to be addressed?

Please limit your response to 3000 characters or less.

One ongoing issue is lack of a clear definition of the term Engineering Biology as currently used by funding, policy-making and regulatory bodies. There has recently been significant investment in this area, which we welcome and have directly benefitted from. Uncertainty of definition persists, however, and is not trivial when it determines which areas have access to funding, and which do not. Does Engineering Biology encompass a full range of tools, including genetic, metabolic, biomolecular and microbial community engineering; or is it a much narrower discipline, focused only on the use of specified genetically modified organisms? EBNet members report having proposals rejected as out of scope due to the absence of a genetic modification (GM) element, even though other experts in this field regarded them as fully relevant and eligible. If a broad definition is intended, then much clearer guidelines are needed for those making recommendations and decisions in this area. If GM is an essential requirement, and other approaches are not included, much more fundamental research effort is needed to clarify when systems based on GM are potentially suitable and when they are not, or are not the most promising approach for unavoidable scientific or technical reasons.

EBNet members have repeatedly raised regulation and permitting as a barrier for new environmental biotechnologies. As these start to move up the TRL toward real-world applications, regulatory bodies such as the Environment Agency (EA) are often lacking in appropriately skilled staff and/or are too resource-constrained to develop timely and appropriate new monitoring and regulatory strategies. As one example, we are aware of one funded project where EA resource constraints led to a 2-year delay in issuing a permit variation. The opportunity for demonstration-scale operation was missed, and a great deal of project time and value was lost. We are also aware of small-scale technology providers who have been unable to deploy their systems in the UK, in part because the policy/regulatory framework favoured large installations; but also because the regulations regarding 'end of waste' are complex, and there is no streamlined option for demonstrating a process, however low risk. Oversight is crucial: regulators need to be as well-equipped as innovators with regard to their skills, and to have or develop the institutional expertise needed to understand and respond nimbly to initiatives in this sector.

What do you or your discipline or sector look to BBSRC to provide, support, or do? Is BBSRC unique in any of these roles?

Please limit your response to 3000 characters or less.

In general, BBSRC's consultation and support mechanisms work well for us, and we particularly welcome its cross-disciplinary initiatives.

While academics understandably prioritise direct research funding, there is huge benefit from the networking activities supported by BBSRC and other Research Councils. This is particularly true for early career researchers (ECRs): while large research groups may have internal opportunities to exchange ideas and support, many institutions have only one or two people working on a given topic area. The value placed on networking is evidenced by the healthy percentage of ECR members in the current NIBBs and the scale of ECR events. A similar role is played by Working Groups set up by our members to address specific areas of interest: BBSRC funding has enabled these to develop into a this has been a highly successful mechanism for knowledge exchange and development.

Access to equipment and instrumentation is often dispersed across universities nationally, while safe working is essential even at small and pilot scale. Further initiatives to share training and expertise in health and safety, hazard identification and hazard operability (HAZOPS) should be promoted. BBSRC has a special role in this area because of its access to a vast range of expertise across biosciences and biotechnology.

We have heard from you of the need to increase connectivity and partnerships to enable progress and impact. What partnerships do you consider to be important and why? What do you consider to be BBSRC's role in connecting and partnering?

Please limit your response to 3000 characters or less.

As noted in the previous response, BBSRC plays a major role in supporting connectivity between ECRs at different institutions, particularly through the NIBBS and similar networking initiatives.

Two other key areas are industry academic partnerships, and international partnering. In the former, the reputation of UK Bioscience has a huge reach, but there has been a notable diminution in UK interaction with Europe in the last 8 years, especially in biotechnology. This has persisted beyond the period when UK scientists were unable to participate in EU calls, and BBSRC has an important role to play in enabling contacts to be formed or re-made.

Lack of trust by investors is an issue for all new technologies, especially across the Biosciences area because of its relative novelty. Increased investor confidence could be promoted by identifying or creating new business cases with real positive societal, environmental and economic impact; as well as by more focused support for technology translation and commercialisation. While this is outside BBSRC's direct remit, active support for inclusion of such activities in appropriate research grants would be valuable.

UK Universities typically show lack of agility in contracts procedure and IP management. Research Councils and other UK funding bodies could and should assist in simplifying this by encouraging the development and sharing of sample agreements and templates.

What change to the research and innovation system would make the biggest positive difference?

Please limit your response to 3000 characters or less.

We applaud current UKRI efforts to provide cross-remit funding that specifically encourages and enables collaboration between disciplines, as demonstrated in several recent and open calls.

A key change that would benefit technology translation and progression is improved coordination at the transition between research and innovation. There is a clearly articulated need for dedicated funding streams to support scale-up, from lab to pilot and demonstration scale; and for improved mechanisms to access such facilities where they already exist. This is particularly critical for industrial and environmental biotechnology because of the interaction between microbial systems and their environment, which is strongly impacted by scale effects. Innovation funding that allows significant ongoing input from academic partners would help to address this. R&D and demonstration funding with longer horizons is also needed to ensure the UK's place as an innovation leader rather than a follower.

Transparent reporting that facilitates comparison and sharing of data, models and practices is vital for rapid progress and efficient iteration between research and pilot implementation. There is a need to develop and promote agreed formats that allow 'anonymised' results to be collated for data mining across a wide variety of biosciences and biotechnology applications. Previous UKRI initiatives requiring accessibility of data and other outputs have been very effective in this respect and should be continued and strengthened.