Response from the Royal Society of Biology to the BEIS Consultation on Building our Industrial Strategy

April 2017

The Royal Society of Biology (RSB) is a single unified voice, representing a diverse membership of individuals, learned societies and other organisations. We are committed to ensuring that we provide Government and other policy makers, including funders of biological education and research, with a distinct point of access to authoritative, independent, and evidence-based opinion, representative of the widest range of bioscience disciplines.

The Royal Society of Biology is pleased to offer these points in relation to the inquiry on this important topic.

1. Does this document identify the right areas of focus: extending our strengths; closing the gaps; and making the UK one of the most competitive places to start or grow a business?

Government is right to consider how industry might support the future wellbeing of people, and to try to develop a strategy to guide this. A nation's industrial activity draws upon, challenges, supports and enables science. In many ways any industrial strategy will be inextricably linked with a science strategy, whether formal or not.

Any industrial strategy should serve the people and inevitably relies upon them – the Government is right to highlight the importance of skills development throughout the UK. In line with this, we welcome the recent Government pledge to establish 1,000 new PhD places and fellowships, in order to increase the number of highly skilled researchers trained in the UK. The recent set-up of the independent Institute for Apprenticeships, and the potential for a boost for technical education by the introduction of 'T-Levels' between 2019 and 2020 may well be a step in the right direction, although the outcome is yet to be seen. We welcome the recent Government pledges to invest a further £4.7 billion in research and development by 2021.The Green Paper points out that public and capital investment in research and development is also key to improving national productivity, and indeed living standards. We would encourage Government to consider further such investment in the life sciences sector in particular, since such investment evidently *pays dividends. A recent PwC[1] report has shown, for example, that the average Gross Value Added (GVA) of UK life sciences industry employees[2] is more than twice the UK average. The report also found that each of these life sciences jobs in the UK supports roughly 2.5 jobs elsewhere in the UK economy, and that life sciences jobs appear to be distributed throughout the UK. Based upon these results, investing in the life sciences sector is likely to be highly effective in providing further well distributed benefits in economic terms within the UK.*

The Society is developing a Roadmap document outlining goals and opportunities for UK plant science over the next 25 years, and advising on the steps needed to realise them. This ongoing work should be highly relevant to conversations around the Industrial Strategy and Bioeconomy. The project is led by the UK Plant Sciences Federation (UKPSF), a special interest group of the Royal Society of Biology that brings together the broad community of UK plant scientists. The Roadmap is being developed as a consequence of the 2014 report, 'UK Plant Science: current status & future challenges'.[3] .

2. Are the 10 pillars suggested (below) the right ones to tackle low productivity and unbalanced growth? If not, which areas are missing?

1. Investing in science, research and innovation
2. Developing skills
3. Upgrading infrastructure
4. Supporting businesses to start and grow
5. Improving procurement
6. Encouraging trade and inward investment
7. Delivering affordable energy and clean growth
8. Cultivating world-leading sectors
9. Driving growth across the whole country
10. Creating the right institutions to bring together sectors and places

[1] PwC report, 'The Economic contribution of the UK Life Sciences industry', commissioned by the Association of the British Pharmaceutical Industry (ABPI) and supported by the Association of the British Healthcare Industry (ABHI), the BioIndustry Association (BIA), and the British In Vitro Diagnostics Association (BIVDA); Launched 06/03/17; URL: http://www.abpi.org.uk/our-work/library/industry/Documents/The_economic_contribution_of_the_UK_Life_Sciences_industry.pdf

[2] *Life Sciences firms were defined within the PwC report as belonging to three segments, "based upon the Standard Industrial Classification (SIC) system used by the UK Office for National Statistics and equivalent bodies around the world", namely: 1) development and manufacture of pharmaceuticals, 2) development and manufacture of medical technology and 3) life sciences research.[1]*

[3] *By formulating this roadmap, the UKPSF aims to inform and stimulate the continued growth of the UK plant science sector by identifying how the UK plant science community can play a role in addressing the challenges of food security, environmental stewardship and sustainability. It describes current knowledge and the revolutionary effects of new techniques to define a range of short-, mid- and long-term goals, and identifies the pathways required to achieve them. Whilst the Roadmap has been built for plant science, it recognises that working across sectors is essential and many areas are intrinsically interdisciplinary. Ultimately, this document isn't simply aimed at supporting plant scientists, but at creating a future where UK plant science can play its full part in solving the world's great challenges. The Roadmap is currently in draft review.*

In addition to the 10 pillars, and across all areas, the regulatory and fiscal environment for research and business is key. We must ensure that these operate to encourage and support innovation, research and development for a productive economy, whilst advancing the health of the public, ecosystems and the environment.

The Industrial Strategy will become a BEIS strategy document; therefore its appropriate integration with the strategies of other Government departments is of paramount importance. Many of the issues currently identified are multidisciplinary, multi-stakeholder, and involve a number of areas. For example, achieving a sustainable supply and use of affordable clean energy will be relevant to the Department of Transport, the Department of Health and the Department for Environment, Food & Rural Affairs; any energy strategy will impact public and ecosystem health as well as the economy.

Additionally, the Industrial Strategy ought to have regard to maintenance and restoration of natural capital in decision-making and implementation, so that well-balanced decisions are made between near term economic development and the longer term preservation of productive ecosystems, capable of providing important services into the future. Unsustainable use of natural capital or ecosystem services accrues risk and the potential opportunity cost should be considered. Guarding natural capital can also accrue benefits in terms of avoided costs, particularly in relation to environmental resilience and public wellbeing.
Public engagement is a powerful and arguably underutilised tool to encourage young people to study STEM subjects and consider careers in industry, and to involve members of the public in general in 'citizen science' initiatives and other new data gathering frontiers. It may be particularly important at the local level. More opportunities should be created for scientists (including entrepreneurs) to visit schools and workplaces and for teachers to visit employers, to encourage information and skills transfer. The Biochemical Society's STEM Insight scheme[4].is an example of an initiative that seeks to connect teachers with HEIs and industry.

In conclusion, the Government's Industrial Strategy should be long term and visionary but have achievable objectives particularly during the period ahead in which the UK is exiting the EU. Providing longevity and stability in the UKs goals for the science sector will encourage national and inward investment which will be crucial for continued success.

[4] http://www.biochemistry.org/Education/SchoolsColleges/STEMInsightProgramme.aspx

3. Are the right central government and local institutions in place to deliver an effective industrial strategy? If not, how should they be reformed? Are the types of measures to strengthen local institutions set out here the right ones?

When delivering technical training, professional bodies and local development agencies, amongst others, will play an important part. However, such organisations will require support in order to deliver their potential in terms of training and quality assurance.

Government departmental capacity for research and policy development, as well as procurement policy, are important elements. It is essential that Government has the human capital, in terms of trained personnel, and the resource, in terms of budget and facilities (including research institutions), for strategic delivery. Engagement between SMEs and local development agencies are often highly valued.

4. Are there important lessons we can learn from the industrial policies of other countries which are not reflected in these 10 pillars?

The development of industry-specific enterprise hubs or clusters has been important in the growth of bio-based industry in France and Germany[5]*, and measures to support their development here could help to bring sectors together, enable the sharing of expertise, and create a critical mass to attract skilled workers. In the UK, bio-based industry clusters are developing, including the BioVale cluster in Yorkshire and the Humber, an Industrial Biotechnology (IB) hub in Scotland around The Industrial Biotechnology Innovation Centre (IBioIC), and a biorefining cluster in Wales (The Biorefining Centre of Excellence) supported by the BEACON project.*

However, it must be noted that there are identifiable limitations to this more centralised model of industry support. Industry-specific enterprise hubs have been shown to be effective in forging collaboration between industry and academia, but careful choices are necessary in relation to existing areas of strength and infrastructure, for example, for research intensive activities that rely on strong patient links. All research and business operations need good access to infrastructure, such as fast broadband, which is critical for data transfer and communication, as well as housing, mobile networks and good transport links. Continued support for local business development services and infrastructure is particularly important in particular regions and could aid in balancing economic growth across the UK. Crucially, social capital- either existent or built between the research and innovation communities- is vital. Inevitably, it is the ease with which networks of people are created and maintained that makes the key difference in collaborative efforts.

Investing in science, research and innovation

5. What should be the priority areas for science, research and innovation investment?

[5] OECD, 2012 https://www.oecd.org/sti/outlook/e-outlook/stipolicyprofiles/interactionsforinnovation/clusterpolicyandsmartspecialisation.htm

Continued support for curiosity driven, translational and applied research and development programmes, in combination with support for productive and effective business interaction at all stages, is needed to maintain the strong and economically viable knowledge-base of the UK. It must be noted that the OECD average for R&D as a proportion of GDP across Europe (EU28) is 2.38%[6], and based on this, the UK has some ground to make up to meet the level of support in other EU countries. However, as a result of the Autumn and Spring Budget funding pledges, UK investment in R&D is nearing 2% of GDP by 2020. This is an increase that would be welcomed by the RSB and we strongly encourage the attainment of a higher level as soon as possible. Research support will become ever more important to enable UK competitiveness and collaboration post Brexit.

It is difficult to identify far in advance the types of research areas likely to bring large returns in terms of economic gain. However, ensuring a balanced portfolio of activity that reflects and supports national strengths, national needs for security and sustainability, and national capacity for further development, is vital. Picking winners is fraught with difficulty, and rather, support for excellence and the best science should be the determining factor in line with the Haldane Principle.

Research types for priority investment:

Fundamental research

Fundamental, basic, 'blue sky,' or curiosity-driven research is vital, despite the fact that its position (often ahead of current trends) means that the results of such research does not necessarily lead to commercially viable products in a linear fashion, or with immediate industrial application. However, this type of research is crucial for production of knowledge, and may lead to future development of trade, economic or welfare gains, as well as ensuring that the UK has absorptive capacity to benefit from advances made worldwide. Fundamental research also contributes to the development of skilled graduates and post-graduates, and drives development of scientific methodologies and instrumentation, all of which are key components of the process of innovation.[7] We encounter support for responsive mode funding to enable innovation in this area.

We welcome the Government's support for the Haldane Principle and further reiterate that this should be kept in mind when decisions are made on the allocation of funding (for example through the research Councils under UKRI) and skills capacity for fundamental research. Ideally, funding systems for fundamental and translational research should not focus exclusively on specific sectors or topics, but set up the right networks for specialist and interdisciplinary collaboration and innovation, since the routes through

[6] Campaign for Science and Engineering, R&D investment factsheet; updated December 2016; URL: http://www.sciencecampaign.org.uk/our-work/investment/r-d-investment-factsheet.html

[7] A reply from the Society of Biology to the House of Commons Science and Technology Committee Consultation on Bridging the 'valley of death': improving the commercialisation of research; February 2012

which major leaps in innovation might come are difficult to predict accurately. Equally, the skills base of UK bioscience (and other) researchers should be kept broad for the same reason.

Translational research

Translational research in the life sciences is typically long-term, complex and often multi- and interdisciplinary. Government support for innovation, through ensuring adequate research budgets across various Departments, and through stimulating private investment, is necessary to capitalise on public investment and potential for growth in the life sciences.[8] *The amount of long-term and follow-on funding required to bring fundamental research into a proof of concept can be significant, extending over many years and including support required for research, legal, and intellectual property costs. These costs may be difficult for universities and SMEs (for example) to meet, without adequate external financial support.*

Interdisciplinary research

Interdisciplinary research is essential to tackle complex issues, many of which are pressing global challenges, including food security, climate change and sustainability, air pollution, water quality and usage, waste disposal and recycling. In all these cases synergies align across public health (including the epidemiological sciences) agricultural, environmental and energy sectors, to name a few, and they require interdisciplinary approaches involving the sciences, technology, engineering, mathematics and medicine. In addition, input from the social sciences can be important, particularly economics and behavioural science. Some specific areas of interdisciplinary research are highlighted below. Further attention is therefore needed to improve grant assessment of interdisciplinary research; and to support development, training and networking for interdisciplinary communication and collaboration by researchers. Training in how best to think in broad terms and across disciplines has been highlighted as a challenge. One example of an initiative that is addressing it is Innovative Food Systems Teaching and Learning (IFSTAL) – 'a learning community and interactive resource designed to improve post-graduate level knowledge and understanding of the food system'[9]*. A further example of a successful cross cutting research investment is the Rural Economy and Land Use Programme (relu), which investigates 'social, economic, environmental and technological challenges faced by rural areas'*[10]*.*

Horizon scanning

It is important to ensure that systems are in place to enable consistent funding for regular horizon scanning, to keep the UK at the leading edge of research and development around real-world problems, and to enable benefit from improved awareness of new technology and knowledge wherever it arises. A good

[8] A reply from the Society of Biology to the House of Commons Science and Technology Committee Consultation on Bridging the 'valley of death': improving the commercialisation of research; Feb 2012.
[9] Innovative Food Systems Teaching And Learning; URL: http://www.ifstal.ac.uk/
[10] Rural Economy and Land Use Programme; URL: http://www.relu.ac.uk/about/

example of an effective horizon scanning effort within a specific sector is 'A 2017 Horizon Scan of Emerging Issues for Global Conservation and Biological Diversity' by William J. Sutherland et al. [11]

<u>*Dissemination of knowledge: researcher education and communicating the outputs of research*</u>

Support for the dissemination of knowledge arising from research is a key factor in the support for research itself. Knowledge transfer through and between industries, higher education (HE) institutions and other arenas for research (such as community laboratories and 'citizen science' initiatives) necessitates a cycle of education, collaboration and sharing of the results of research, wherever possible. This can be supported by open data and open access initiatives such as those required by the next Research Excellence Framework[12]*.*

In addition to financial investment, there is also a need to invest in training in translational science, and career development support for researchers engaged in it. Increased capacity to accommodate fellowships in translational science, in addition to those in fundamental science, would be beneficial. Better access to expertise and training from technology transfer professionals, and in relation to the systems of commercial investment, is also required to ensure that the outputs of this research can be efficiently implemented and/or commercialised, at the right time. Furthermore, since fewer publication outputs are likely from researchers in translational research, implications for conventional research assessment, support and incentives will be important.

There is also an important role for universities, with Government support, to disseminate the most up to date technological, ethical and sustainable advances and techniques to colleagues in industry, and vice versa (for example, modern molecular-based methods for analysis of microbes, which are important in the oil industry). This can be elicited in a variety of ways, for example through secondments and other placements for industry researchers in universities, in addition to fellowships as described above. Workshops, events, hubs and networks also work well to naturally stimulate information flow across and between higher education and industrial (and other) networks of researchers. Government interplay here is vital since standard operating practices (SOPs) and regulatory requirements which do not keep pace with advancing technology may hinder uptake of cutting-edge techniques in industrial processes. There is also a role for Learned Societies and similar organisations in facilitating networking and information sharing, and its use to inform and update regulation and legislation where appropriate (considering ethical implications). The Society incorporates special interest groups and committees which aim to enable this. The Animal

[11] 'A 2017 Horizon Scan of Emerging Issues for Global Conservation and Biological Diversity' by William J. Sutherland et al., The Cell, vol 32, issue 1, p31-40.
[12] http://www.hefce.ac.uk/rsrch/oa/whatis/

Science Group[13], for example, has a history of facilitating discussions to enable the sharing of knowledge on best practice between animal science researchers and Home Office regulators for this area of research.

Importantly, there is a role for all parties invested in research in Government, industry, academia and elsewhere to communicate the results of research, and associated effects on public policy, to the public themselves.

Research areas for investment:

All research areas outlined below depend on effective interdisciplinary collaborations. Many research areas, such as sustainability and AMR, also need input from the social sciences, to ensure that the innovative solutions created are workable in a real world context- for policy makers and the public.

Pharmaceutical and biomedical sciences

This is an active, diverse and successful sector in the UK, with strength in depth from basic bioscience to new therapeutics, diagnostics and from biotech start-ups to major pharma. A great potential for growth, with sufficient support, has been highlighted in (for example) the fields of precision medicine through diagnostics and therapies, including, but not limited to, immunotherapy for the treatment of cancers; paediatric drug development; virus and vaccine research; and rapid point of care diagnostics involving biomarkers and other novel techniques. It will be important that the NHS is considered during development of the Industrial Strategy, as a potential collaborative partner in R&D for healthcare systems, alongside its primary role in healthcare.

Antimicrobial resistance

Antimicrobial resistance (AMR) is a threat to public, animal and plant health, in the UK and globally, which makes it important to address from social, agricultural and environmental standpoints. The underlying causes are complex and increasingly well explored. As pointed out in the O'Neill Review[14], alongside the necessary investment in antibiotic discovery and development in the short term, a long-term strategy of continual surveillance for and discovery of alternatives to antibiotics (through the use of vaccines, for example) will be needed, as pathogens will evolve resistance to management. Many recommendations from the O'Neill Review were broadly echoed during the workshops held by the Learned Society Partnership on AMR (LeSPAR) for early career researchers held in 2015.[15]A focus on the development and use of rapid diagnostics to provide more targeted use of antimicrobials (with the aim of slowing the

[13] https://www.rsb.org.uk/policy/groups-and-committees/asg
[14] Tackling drug-resistance infections globally: final report and recommendations; URL: https://amr-review.org/sites/default/files/160525_Final%20paper_with%20cover.pdf
[15] Learned Society Partnership on AMR workshop report; URL: https://www.rsb.org.uk/images/LeSPAR_Workshops_Summary_for_the_web.pdf

emergence of AMR), and on the presence of antimicrobials and origin and transmission of antimicrobial resistance (in the environment and ecosystems), could reap significant benefits[16].

Agriculture

Food and drink is the largest manufacturing sector in the UK[17] *and is crucial to the UK's industrial success. Agri-tech centres have potential, and good practice examples are the German Fraunhofer-Gesellschaft organisation*[18] *and Catapult Centres in the UK.*

However, research in agriculture and other land-based industries has been underfunded in the UK for decades, despite the centrality of these areas in delivering resilient crops and crop protection systems to deliver food and nutrition security, and feedstocks/ biomass for industrial biotech, for the UK and abroad. Precision agriculture has been particularly highlighted as an area where continuing investment and support to bring ideas through to market is critically important to enable the UK to capitalise on our cutting edge position in this sector. Researcher numbers are also declining in some important specialisms (areas such as agronomy, natural fisheries management and aquaculture, weed science, crop physiology and forest ecology have been brought to our attention), a trend which has an impact on interdisciplinary research and resilience and warrants remediation. To encourage the next generation of agricultural researchers into the sector, support for better training opportunities is required; for example, this year, the Society is piloting a scheme to encourage trainees in plant health science, in collaboration with Defra (see https://www.rsb.org.uk/get-involved/grants/plant-health-ug-studentships). More such incentives for career development in agriculture and associated technologies could be highly effective.

The agri-food sector is also an area where further integration with the social sciences is necessary and requires incentive. To enable technological advances and best practice in the protection of the environment and animal welfare to reach UK farmers, and to work on the ground, a two way exchange of information is required with researchers and policy makers gaining a better understanding of the barriers to farmers taking on these advances; in order to meet their needs effectively. This two way flow of information should enable delivery of policy and regulatory requirements, and knowledge; to be tailored and implemented by farmers and other interested parties, in a way that can adapt to suit the locality. Tools and support to enable local decisions to be made, relating to positive environmental and commercial outcomes for the

[16] The FAO Action Plan on Antimicrobial Resistance 2016-2020; page 16; URL: http://www.fao.org/3/a-i5996e.pdf
[17] https://www.fdf.org.uk/corporate_pubs/FDF-Manifesto-A-New-UK-EU-Relationship.pdf; http://www.foodsecurity.ac.uk/food/uk-facts.html
[18] https://www.fraunhofer.de/en/institutes/institutes-and-research-establishments-in-germany/fraunhofer-groups/life-sciences.html

farming sector, will need to consider the complex farming landscape as a whole, using integrated indicators of performance on these fronts, rather than simplistic measures[19].

Innovative agri-environment schemes and integrated land-use measures, such as alternative crop production models (e.g. growing biomass to bioengineer protein, fuel or medicines) could help to: mitigate the effects of unsustainable agricultural methods; sustain those aspects of ecosystems that are vital for agriculture; and enhance the provision of ecosystem services. Challenges remain around developing our use, and improving our understanding and communication of the environmental ecological and ethical opportunities and implications of genetic technologies, and other new and emerging technologies. Some of these issues will be examined in the UK Plant Sciences Federation (UKPSF) Plant Sciences Roadmap, due to be published by September 2017 (cf Q1).

Furthermore, the very nature of the agri-food sector necessitates trade in produce and cooperation in the sharing of knowledge, information and research funding, in order to enable these advances to be shared and built upon internationally. For example, Easter Bush Research Consortium (EBRC) is one of the largest veterinary research consortiums in Europe, which works to advance sustainable animal agriculture. The UK could be a world leading country in livestock welfare and needs Government's support to continue to flourish. It is imperative that the UK retain good ties with Europe and other countries globally post Brexit.

Sustainability, Green Infrastructure and nature-based solutions

Volatility in oil prices and the changes of direction in regulation and policy have had impacts on investment in the areas of biotechnology and bioenergy which (like many research arenas) tend to require longer-term stability for investment. Energy crops including algae and other microorganisms (e.g. used for production of bio-fuel and in bio-photovoltaics systems) are relatively under developed and in need of support. Research into the development and use of modern technology to produce materials and chemical feedstocks from renewable sources, and from waste sources currently derived from non-renewable (often fossil fuel) sources, is also a burgeoning and potentially highly fruitful area of research in need of support. Such research arenas are key to realising substantial benefits in sustainability and competitiveness for the UK industrial sector and economy. It is important to note here that further research should also consider the sustainability of energy crops from a land-use and climatic-effects perspective, since some would argue against growing biofuels at the expense of food, especially when burning the product releases carbon dioxide. Thus, the industrial strategy should seek to provide support for fundamental and other types of research and innovation, to create processes and products which seek to mitigate these issues.

[19] Feeding the Future: Four Years On; A review of the innovation needs for British Farming; national farmers Union (NFU); https://www.nfuonline.com/cross-sector/science-and-technology/research-and-innovation-news/feeding-the-future-four-years-on-a-review-of-innovation-needs-for-british-farming/

Furthermore, the Government's Natural Capital Committee[20] have demonstrated the necessity of protecting and enhancing the UK's natural capital (the stock of natural resources that produce value to people) if we are to deliver sustainable economic growth. The Committee have also highlighted that critical natural capital assets are declining and at risk. Investment in research to better understand the provision of ecosystem services (the benefits we derive from the environment), their relationship to natural capital, and how to optimise them, is warranted. There is increasing recognition of the opportunities for business in understanding, recognising and accounting for the value of nature, as a new knowledge economy opportunity where the UK has a competitive advantage.[21] There is therefore a need to invest in developing and testing new business models and innovative approaches to develop these opportunities Development of more sustainable systems of waste water treatment has been highlighted as such an opportunity in collaboration with other Government bodies, would be useful here.

Cross-sector trends and points to consider:

- ***Public-private partnerships (PPPs):*** *PPPs stimulate innovative networks for collaboration and private investment and build on public initiatives, whilst enabling greater access to commercial expertise. There should be adequate support offered to deliver on these benefits. An example of a public-private initiative is the* AMR Centre*[22], which supports the development of new antibiotics and diagnostics. Fera Science Ltd[23], a joint venture between Defra and Capita PLC which allows both the maintenance of key national science capability, but also enhanced commercial freedoms to innovate and develop new science products and services, is another example. Further examples include the Structural Genomics Consortium[24] – a public private partnership (with 8 pharma company partners and public funders from the UK and Canada), focussing on research into new areas of human biology and drug discovery, particularly areas of the genome which are less well-studied, through open access research; and The Francis Crick Institute[25], which will see industry scientists embedded in laboratories working alongside academic scientists, allowing the sharing of ideas and facilities. Similarly, the CRUK-MedImmune Alliance Laboratory[26] has CRUK-funded scientists working alongside MedImmune scientists bringing together complementary expertise in cancer biology and biologics drug development*.

[20] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/585429/ncc-annual-report-2017.pdf
[21] Realising nature's value: The final report of the Ecosystems Markets Taskforce (published March 2013); URL: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/316101/Ecosystem-Markets-Task-Force-Final-Report-.pdf
[22] The AMR Centre; URL: http://amrcentre.com/
[23] Fera Science Ltd; URL: http://fera.co.uk/about-us/
[24] The Structural Genomics Consortium; URL: http://www.thesgc.org/
[25] The Francis Crick Institute; URL: https://www.crick.ac.uk/
[26] The CRUK-MedImmune Alliance Laboratory; URL: http://www.cancerresearchuk.org/funding-for-researchers/how-we-deliver-research/our-research-partnerships/cruk-medimmune-alliance-laboratory

- ***Appropriate incentives:*** *These are needed in AMR research[27] and in research into diagnostics and treatment for rare diseases, for example. Promoting investment in the development of new drugs, drug combinations and therapeutic repurposing could be beneficial. Incentives for innovative farming techniques e.g. aquaponics, have also been highlighted as a key route to maintain or increase agricultural sustainability, productivity and ecosystem functionality. Financial support and incentives could also benefit plant breeding initiatives that do not typically sit within Small and Medium Sized Enterprises (SMEs), because of the high cost, long timescale, and associated risks of breeding programmes.*
- ***Rapidly developing technologies*** *such as microbiomics; genomics, DNA sequencing and genetic technologies; synthetic biology; bio-refining, cellulosic fermentation and the use of microalgae e.g. in biophotovoltaics; and insect biotechnology and biological control, to name but a few, warrant attention and support to ensure the results of innovation ultimately benefit the UK economy and people.*
- ***Management and use of big data*** *is a zone of rapid development relevant to many areas of research and industry. Excellent bioinformatics facilities that are well curated, in addition to accessible repositories of data, are needed to facilitate efficient data use, sharing and storage*; *The Hartree Centre[28] and the Alan Turing Institute[29] provide examples of investment in this area. Enabling effective and efficient means for data use and interrogation is crucial in facilitating inter-operability whilst maintaining data security; and in providing training for researchers in data analysis and computer programming (e.g. in creating platforms for comparison of data from different disciplines, for example from environment and health research). Incentivising and enabling increased collaboration and communication between sectors of knowledge and research is key, for example in developing innovative methods for surveillance to effectively track and monitor air and water pollution, and other such environmental contaminants of risk to public and ecosystem health. Additionally, there is an indirect economic value of life science research addressing such societal challenges. For example, combating infectious diseases in humans, animals and plants has the potential to reduce healthcare burden and lost productivity*.

6. Which challenge areas should the Industrial Challenge Strategy Fund focus on to drive maximum economic impact?

Support for cross-disciplinary interactions and collaboration between complementary fields where there is overlap between technologies could enable advances in individual technologies to have positive impacts on other areas. For example, next generation computing and big data may have an impact on microbiome studies and synthetic biology (largely dependent on the microbial sciences), drug discovery, and the monitoring and tracking of environmental pollution, by enabling correct interrogation of the increasingly

[27] Tackling drug-resistant infections globally: final report and recommendations; The review on antimicrobial resistance chaired by Jim O'Neill; published May 2016; URL: https://amr-review.org/sites/default/files/160525_Final%20paper_with%20cover.pdf
[28] The Hartree Centre; URL: https://www.hartree.stfc.ac.uk/Pages/home.aspx
[29] The Alan Turing Institute; URL: https://www.turing.ac.uk/

large data sets that these current (and future) technologies are creating. Similarly, tailored or personalised medicine offers potential benefits by maximising individual risk benefit balance based on patient genome or other data, but requires analytic capacity.

In our response to the BEIS Consultation on the UK Bioeconomy[30], we highlighted areas with significant potential to drive economic benefit such as the £108bn (2014) agri-food sector; the high growth potential industrial biotechnology and bioenergy sectors; and the biomass and waste management sectors. Substantial growth is also expected in synthetic biology, with applications in medicines, healthcare, and new, as yet undiscovered markets. Overall the potential lies in creating the right environment for development and allowing science and innovation to deliver relevant opportunities and solutions – the timescale over which an industrial strategy operates will make picking specific winners difficult; the right environment is key.

7. What else can the UK do to create an environment that supports the commercialisation of ideas?

Support fundamental research
Bio-industry related research requires a long term vision. Fundamental research is valuable but may not have marketable products for some time. Even research with market potential can advance slowly. Translation phase problems can upend promising development and clear focus on avoiding the 'valley of death' in this regard would be useful. Additionally, innovative financial incentives have also been suggested, which incorporate the opportunity for 'risk sharing', where, for example, the risks associated with bringing a new product to market could be somewhat alleviated, in return for fair distribution of the rewards from a successful product.

Support effective collaboration and communication between business and academia
Business and universities operate differently and this results in a challenge to collaboration. Industry frequently needs research answers on a relatively short timescale, whilst universities do not often have a structure that can respond to such needs.

In our response to the Dowling Review[31] we noted the value of 'Intermediary forums' or third parties (both national and international), which sit between researchers and research users, and can act as facilitators, when industry, universities and private researchers discuss IP and other issues, thus increasing the efficiency of research translation into economically beneficial outputs. This role could be further developed by Catapult Centres, professional bodies and Learned Societies.

[30] Royal Society of Biology response to the BEIS consultation on the UK Bioeconomy January 2017; URL https://www.rsb.org.uk/images/RSB_response_to_the_BEIS_Bioeconomy_consultation_Final_response.pdf
[31] Royal Society of Biology response to the Dowling Review of collaborations between businesses and university researchers March 2015; URL. https://www.rsb.org.uk/images/Society_of_Biology_Response_-_DOWLING_REVIEW_2015.pdf

IP is also an often complicated but pertinent issue here, especially in relation to collaborations between business and academia. The role of IP in innovation policy should be considered alongside the Industrial Strategy, to enable appropriate protection to stakeholders, especially in light of Brexit and the resultant changes in EU collaborative networks that may ensue. IP advancements can be aided by improving the speed of obtaining IP and reducing the costs of their validation. One example of an initiative that could address these issues is the European Community Patent or "European patent with unitary effect"[32], which, even post Brexit, the UK could seek to be involved in. The Scottish universities' single IP agreement across all institutions to simplify IP issues for business is also an example of good practice, as is the Lambert toolkit[33]; industry sectors could be encouraged to do something similar.

Additionally, implementation of, for example, the Agri-Tech Catalyst, has been valuable in helping to bring products to market. However, return on investment is an important consideration and one which university based researchers may benefit from training in, as they currently continue to experience difficulties in finding commercial partners. For instance, in agricultural engineering and the manufacturing of robotic farming products, UK researchers have suffered a dearth of commercial partners, and the internationally competitive head-start gained by sector expertise is at risk. Further, as the funding for the Agri-Tech Catalyst is now exhausted, a means to pump-prime late-stage research has disappeared. There is a need for information to encourage new entry by substantial players, who can see the advantages and are open to innovation.

Overall, continuation of support for Catalyst and Catapult programmes, the future Innovate UK, and similar mechanisms that assist innovation, is required. PhD studentships themselves also offer opportunities to develop partnerships between researchers in private and public settings, particularly through the Industrial CASE Partnerships (ICP) programme. However, some limitations of the scheme have been identified by our members, particularly in relation to a change of focus towards doctoral training centres, which may lead to organisations/ companies having difficulty in identifying and selecting individual students and, in addition large organisations may not find reason to fund more than one student a year, due to a lack of suitable projects, which may lead to them choosing not to take up the scheme. Similar issues have been highlighted in relation to apprenticeships in dispersed industries, such as in the land-based sectors, where micro-businesses are common but may have difficulty in providing the necessary capacity for supervision of an apprentice individually. The delivery of apprenticeships would therefore likely benefit from an approach that engendered collaboration between employers, to allow the apprentices a full exposure to the necessary practical experience.

[32] https://ec.europa.eu/growth/industry/intellectual-property/patents/unitary-patent_en
[33] The Lambert Toolkit; URL: https://www.gov.uk/guidance/university-and-business-collaboration-agreements-lambert-toolkit

Partnerships with industry can also form to build on successful public research and bring complementary expertise, and should be supported; successful examples of these include the Rothamsted-Syngenta partnership on sustainable wheat[34]; or the BBSRC-funded Networks in Industrial Biotechnology and Bioenergy (NIBB)[35], which fosters collaboration between academia, industry, policy makers and NGOs.

Current initiatives and funding streams could also be more efficient and less complex. Currently they require significant resource at the application stage, with little knowledge about the likelihood of success. This is a significant hindrance to effective collaboration. Strategic calls; flexibility in duration of collaborations, and schemes that pre-approve collaborations between organisations could all help to make the route to funding more straightforward. Small and medium sized enterprises (SMEs) face challenges distinct from large industry when collaborating with university researchers, and may require distinct support.

Government support for small businesses to include mechanisms to build intellectual capital in SMEs, through incentivising partnerships and collaboration with HE institutions and associated colleges is welcome (the latter may represent a similar size business model in some cases). Again, knowledge intermediaries have a role to play here, opening up access to academic research for SMEs, and making partnerships with SMEs more attractive to researchers. Incentives are needed that reward collaboration at the research institute, research team and individual researcher levels; these incentives can be financial and reputational. A programme to facilitate contacts between UK SMEs and multinational companies and plan joint public and private investment in sectors of strategic importance could also help to attract large investors and companies that will aid the development of biotech clusters[36].

On a more specific point, a recent Science and Technology Committee (Commons) report on managing intellectual property and technology transfer[37] has suggested that "the UK's exit from the EU, combined with the Office for Tax Simplification's reviews of the VAT system, present an opportunity to revise VAT rules on the income from academic buildings in a way that facilitates greater collaboration with business", a suitable revision may have an effect particularly in large or long-term projects carrying out research that could be directly commercialised but that may not be covered by research council schemes.

Efficient equipment sharing that is logistically and financially straightforward is also desirable. The current VAT implications of equipment sharing add considerable cost and do not promote efficient resource sharing more broadly. VAT is zero-rated for certain equipment used for medical or veterinary research; applying

[34] http://www.rothamsted.ac.uk/news/rothamsted-and-syngenta-announce-multi-million-pound-scientific-partnership-develop-high

[35] Networks in Industrial Biotechnology and Bioenergy (BBSRC NIBB); URL: http://www.bbsrc.ac.uk/research/programmes-networks/research-networks/nibb/

[36] Royal Society of Biology response to the Dowling Review of collaborations between businesses and university researchers March 2015; URL.

[37] House of Commons Science and technology Committee Tenth Report of Session 2016-17 on Managing intellectual property and technology transfer; page 15; published March 2017; URL: https://www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/755/75502.htm

this also to research that has a direct impact on health and wellbeing and societal benefit in general, for example for research addressing food security and climate change issues could be considered. Appropriate equipment sharing within the HEFCE research excellence framework might also provide an incentive.[38]*The development of standard agreements for research collaborations (for instance the Lambert toolkit*[39]*), also has a role to play in overcoming some of these challenges.*

Resource sharing is already a mainstay within many institutions, and increasingly between institutions; it may be initially supported by the Research Councils and external funding from the private and third sector. Where these collaborative efforts are driven by researcher need, they often work very effectively. For example, research groups will often seek out other groups with similar needs and work together to gain initial investment and share the maintenance and ongoing costs of new equipment or facilities. Schemes to make resources available to other users including those in industry and the third sector is commonplace within collaborative or other mechanisms, with the aim of some cost recovery and self-sufficiency. Further Government support, and support from other bodies, is required however, to facilitate knowledge transfer on the most cutting edge techniques in industry. Effective communication channels between HE institutions, industry, Government and the public is necessary to smooth this information flow and technological advancement in the UK, whilst keeping track of the ethical considerations attached.

Furthermore, SMEs are often dependent on access to mid-range equipment that is available in higher education establishments. This collaboration mix can create significant economic benefits to both internal and external users (business and academic), and draws in investment that may otherwise have been spent outsourcing services overseas. It is important that the drive for these resources remain researcher and community led, rather than being driven by market demand, and public spending in this area is thus crucial. Capital spending in these areas will allow partnerships to emerge across the sector according to complementary skills and expertise[40]*.*

<u>Providing a fair, effective and stable regulatory environment</u>

The pharmaceutical industry is recognised as very important by the Government, with a healthy sector being of benefit to the wider economy. At present the UK is part of European regulatory frameworks and has helped drive effective regulation, including schemes such as PRIME[41]*, to speed up patients' access to new medicines. Globally there has also been a push to harmonise medicines regulation amongst regulators (EMA, FDA, PMDA) to ease and speed the cost of medicines discovery and development.*

[38] A response from the Society of Biology to the Department for Business, Innovation and Skills on proposals for long term Capital Investment in Science and Research; July 2014; URL.
[39] The Lambert Toolkit; URL: https://www.gov.uk/guidance/university-and-business-collaboration-agreements-lambert-toolkit
[40] A response from the Society of Biology to the Department for Business, Innovation and Skills on proposals for long term Capital Investment in Science and Research; July 2014; URL.
[41] PRIME; URL: http://www.ema.europa.eu/ema/index.jsp?curl=pages/regulation/general/general_content_000660.jsp

The fundamental principles of providing evidence of benefit and risk for medicines will continue to apply across the spectrum and thus ongoing cooperation in EU regulatory frameworks, and regarding data collection and sharing, should be considered as part of the future arrangements.

Following enactment of the 'Great Repeal Bill', attention will also turn to regulation of Genetically Modified Organisms (GMO) and other applications for genetic technologies. There is community interest in ensuring that regulations can accommodate advances in this field; this must be addressed in the full consideration of public concerns and acceptability with full/ proper information sharing and communication. Legislative changes post-Brexit may allow the UK to develop a unique position in this area. All regulation should be balanced to protect public and ecosystem health, and to preserve trade and collaborative research with other EU nations.

The Nagoya Protocol on Access and Benefit Sharing (ABS) has broad implications which bring broad support in principle, as well as specific areas of concern, for our members. The regulation may be difficult to implement and to adhere to. There is a danger that the Nagoya Protocol will limit researchers sharing information, and, depending on the country's ABS legislation, even sequence data. Continued stakeholder consultation and careful interpretation of the Nagoya Protocol (and other pertinent legislation) will be required.

Effective regulation has the benefit of providing a fair and stable framework to work within; thus any arguments for less stringent regulatory practices, once the 'Great Repeal Bill' comes into force, should be balanced with requirements for regulatory stability, longevity and protection of societal and ecosystem health. A good example is the EU Commission Fitness Check of the Birds and Habitats Directives[42]; this evaluation provided an evidence-based critical analysis to ensure that the Directives were fit for purpose, and provided clarity for developers. Harmonised regulations across the EU in some areas have provided a level playing field and collaborative space that has benefited research and innovation. It will be important to take the best features forward.

<u>Encourage private investment</u>
Patient capital (long-term capital) is needed for many areas of bioscience where return on investment may be slow. The creation of favourable conditions to encourage this is important.

UK public investment in R&D encourages private sector investment; schemes such as the UK Research Partnership Investment Fund (UKRPIF), that encourage strategic partnerships between HEIs and other research organisations, are welcome. Private companies investing in R&D are currently eligible for tax relief on their R&D expenditure; again this is welcome, as analysis suggests that "R&D tax credits [have been

[42] DirectivesFitness Check of the Birds and Habitats Directives URL: http://ec.europa.eu/environment/nature/legislation/fitness_check/index_en.htm

identified] as an important tool that could 'stimulate and incentivise spending on R&D'"[43], though there are caveats relating to the eligibility criteria and the extent to which these encourage collaboration with universities[29]. However capital expenditure is not usually eligible for tax credits as the investment results in business assets. This could be addressed to make research in the UK even more attractive to commercial investment, so that the UK can capitalise further on 'home-grown' research.[44]

<u>Entrepreneurship education and role models</u>

Early stage training in entrepreneurship and creative thinking would be extremely helpful- incorporating active entrepreneurship training into undergraduate and postgraduate (both, taught and research) syllabuses might be an effective approach. This should be followed through with processes and pipelines aimed at nurturing and supporting entrepreneurs, who may be putting their academic career on hold by commercialising their research. Enterprise education needs to be creative and engaging, and introduce students to interdisciplinary working. For example, business plan competitions at university where students from science and business degrees work together can be a useful approach stimulating creativity. Raising the profile of entrepreneurial scientists in the public and academic eye can add further encouragement to students and early career researchers considering a prolonged career in science and technology: improved communication of the benefits of research and development and the collaborations that lead to scientific advances is also an important factor in maintaining a fertile environment for those very advances.
There is also scope to improve on translational entrepreneurship training in the UK, which is not as developed as, for example, fellowships in basic science.

As an additional point here, charities are key to many research and regulatory agendas, (one of their many roles may be in upskilling researchers and promoting careers in science and technology). Please see the 'Developing skills' section for more comments on education and skills.

8. How can we best support the next generation of research leaders and entrepreneurs?

Stable research funding and career structures, investment in facilities and infrastructure, mechanisms to facilitate exchanges between industry and academia and support translational research, and facilitation of international collaborations, are the best way to support the next generation.

Some specific points have been raised by our members:

[43] House of Commons Science and technology Committee Tenth Report of Session 2016-17 on Managing intellectual property and technology transfer; chapter 2 point 18 (R&D tax Credits); published March 2017; URL: https://www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/755/75502.htm
[44] A response from the Society of Biology to the Department for Business, Innovation and Skills on proposals for long term Capital Investment in Science and Research; July 2014; URL.

- *Exchange programmes can be of great educational benefit, therefore policy placements should be provided alongside other areas, such as in business and Higher Education. This would further support the entrepreneurial, communications and soft skills development of researchers.*
- *There needs to be sufficient training and incentives for Early Career Researchers in interacting with industry and for industry in engaging with academics. In particular, management and interpersonal skills are of key importance as they will enable them to create effective partnerships with people from other disciplines and sectors, which will have a positive impact on their career progression.*
- *Job stability has been indicated as a key factor in attracting and keeping scientific talent in many sectors and fields, in academic settings, this could be improved by further support in addition to fellowships (as previously mentioned cf Q5).*
- *More funding is needed for outreach and engagement projects especially in disadvantaged areas.*

9. How can we best support research and innovation strengths in local areas?

The recent Research Excellence Framework concentrated on international excellence as the highest accolade, which is not always encouraging of local impact and engagement, both are needed. The impact of university research teams on local industry should be recognised and encouraged. This impact is often achieved through collaborations and flow of people, such as through CASE studentships[45].
Building prosperity in rural communities should be a goal for the Industrial Strategy, which should also seek to link with any changes to the agricultural support systems, initiatives and incentives laid out in the Common Agricultural Policy (CAP); these may be remodelled following enactment of the Great Repeal Bill. The development of the agri-food sector, for example, presents an opportunity to stimulate rural development with employment opportunities and infrastructure close to natural resources, and to create higher value-added products. Development of the biomass sector, with the potential for projects that use biomass close to their source, also presents further opportunities for rural communities. Sustainable delivery of ecosystem services and the effective valuation of natural capital should be tightly woven into the industrial strategy in relation to both rural and urban communities.

[45] Response from the Royal Society of Biology to the Stern Review of the Research Excellence Framework; Feb 2016.

Local business interaction funding would be helpful in bringing local academic, industry and other organisational communities together (e.g. local Knowledge Transfer Partnerships and local area trade shows). In addition, the need for funding to connect translational awards schemes in order to incentivise and highlight the importance of commercial self-sustainability, has been mentioned. Also, some members have said that a closer working relationship between the Intellectual Property Office and regional universities and businesses would help build local capacity to commercialise IP. Finally, with respect to biosciences, regional development is important, but care must be taken to avoid unnecessary duplication of effort. Equally, over-specialisation in any given region could also be problematic, thus a pragmatic approach should be taken towards the allocation of support based on geographic location.

Developing skills

10. What more can we do to improve basic skills? How can we make a success of the new transition year? Should we change the way that those resitting basic qualifications study, to focus more on basic skills excellence?

11. Do you agree with the different elements of the vision for the new technical education system set out here? Are there further lessons we can learn from other countries systems?

Lord Sainsbury's independent panel made valuable recommendations taken forward by the Government's Post-16 Skills Plan[46], to reform technical education. We recognise that the Government has already taken steps towards implementation and welcome the recent pledge in the Spring Budget 2017 to invest £500 million per year to support the new T-level technical routes.

The Society supports the proposal, set out in the Technical and Further and Technical Education Bill, to expand the remit of the Institute for Apprenticeships to include all technical education. The Institute for Apprenticeships and Technical Education will have an important role in setting and maintaining the standards for apprenticeships and technical education provision, as well as acting as the coherent body for technical education. The government should support the Institute to ensure that it has the capacity and expertise necessary to undertake this important role. The RSB looks forward to engaging with the Institute as it opens in April, in particular with the development of 'science and health' and 'agriculture, environmental and animal care' routes.

For the reforms to technical education to be successful, the academic and technical pathways must both have strong support. The options that young people have should not be limited by choices made at 16 years old and there should be clear processes for switching between pathways.

[46] BIS and DoE Post-16 Skills Plan; published July 2016
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536068/56259_Cm_9280_print.pdf

It is vital that both academic and technical pathways are well-represented and promoted appropriately to students in schools throughout primary and secondary education. Many teachers are unlikely to be familiar with routes into technical education, with most following academic routes to teaching. In some cases careers guidance services can be reluctant to promote vocational and technical qualifications 'due to the perceived risk of a "second class" qualification.'[47] *The government should support teachers and careers guidance professionals in delivering career provisions that showcase technical and academic pathways. Teachers should be encouraged to embed information about STEM careers into their STEM subject lessons where relevant and appropriate*[48]*.*

Where areas of high regional variation in the concentration of apprenticeships exist, STEM employers should be encouraged to collaborate to ensure apprentices acquire the full range of practical experience necessary.

To address the skills shortage in STEM young people and adults should be supported in developing technical skills. The 'Agriculture, Environmental and Animal Care' and 'Health and Science' routes should enable students and apprentices to develop the skills that are required to continue into further education in the biosciences or progress into the bioscience workforce.

12. How can we make the application process for further education colleges and apprenticeships clearer and simpler, drawing lessons from the higher education sector?

13. What skills shortages do we have or expect to have, in particular sectors or local areas, and how can we link the skills needs of industry to skills provision by educational institutions in local areas?

As highlighted in our response to the inquiry on closing the STEM skills gap,[49] *there is a wealth of evidence to suggest that the UK faces a shortage of skills across STEM subjects and within many areas of the bioscience sector. The demand for STEM graduates is expected to average 104,000 a year*[50]*, and the number of school leavers with relevant STEM skills falls short of current and future business needs. In addition we also face long-term shortages of people with technician-level skills and it is estimated that we will need 56,000 STEM technicians each year by 2020*[51]*. Over 1.5 million technicians make up the UK STEM workforce, but we are not producing enough skilled individuals to fill these roles*[52]

[47] Science industry Partnership (2016) Report on demand for skills in the UK science economy http://www.scienceindustrypartnership.com/media/529050/sip_science_industry_demand_for_skills_final.pdf
[48] Reiss, M. and Mujtaba, T. (2016) Should we embed careers education in STEM lessons? The Curriculum Journal http://www.tandfonline.com/doi/full/10.1080/09585176.2016.1261718
[49] http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/science-and-technology-committee/closing-the-stem-skills-gap/written/45123.pdf
[50] http://www.smf.co.uk/wp-content/uploads/2013/03/Publication-In-The-Balance-The-STEM-human-capital-crunch.pdf
[51] http://www.smf.co.uk/wp-content/uploads/2013/03/Publication-In-The-Balance-The-STEM-human-capital-crunch.pdf
[52] http://www.gatsby.org.uk/uploads/education/links-6838-gatsby-a5-technicians-brochure-2016-digital-aw-1.pdf

There is currently a skills mismatch with many technical level jobs being increasingly filled by graduates[53], many of whom are overqualified for the roles but need to build their practical experience after completing their studies. Implementation of the new technical routes may be able to alleviate some of these problems, but increased practical training in university courses is also needed.

Research from the ASPIRES project indicates that by the age of 10 many pupils have already decided that science "is not for them".[54] To help prevent students from ruling out a career in STEM, STEM employers should be engaging with pupils from an early age, starting in primary school.
Many STEM employers and universities have ongoing engagement strategies with schools and colleges and universities, including providing speakers, running workshops and training (for pupils and teachers), offering their facilities, sponsoring events, taking part in public engagement and outreach activities, for example, science and technology festivals, such as Manchester Science Festival[55]. These initiatives should be maintained and the development of wider initiatives should be encouraged to promote both technical and academic careers to young people.

STEM businesses should be encouraging their staff to become STEM ambassadors, mentors or Enterprise Advisors and be part of Local Enterprise Partnerships that are facilitated by The Careers and Enterprise Company.[56] Local Enterprise Partnerships create a coalition of local businesses that can engage with schools and colleges to support students to develop skills required for employment and the needs of local industry.

We are positive about the focus on encouraging employers to engage with the development of education and training programmes to meet the skills requirements of industry. The RSB Accreditation schemes have been developed with the input of employers and help ensure that degree courses have a solid academic foundation in biological knowledge and skills, as well as preparing graduates for the needs of employers.[57]

Within the bioscience sector, a wider range of apprenticeship standards need to be developed to enable both existing employees and new recruits to develop the skills required by employers. We are aware of the input of STEM employers, including STEM industry, into the apprenticeship standards through the Trailblazer schemes and hope to see this level of engagement continue with the development of technical routes.

[53] Science Industry Partnership (2015) Skills Strategy 2015 http://www.scienceindustrypartnership.com/media/529053/5202fd_sip_skills_strategy_2015_final_low.pdf
[54] Archer et al(2013) – ASPIRES: young people's science and career aspirations age 10-14 https://www.kcl.ac.uk/sspp/departments/education/research/aspires/aspires-final-report-december-2013.pdf
[55] Manchester Science Festival; URL: http://www.manchestersciencefestival.com/
[56] The Careers and Enterprise Company https://www.careersandenterprise.co.uk/enterprise-adviser-network
[57] https://www.rsb.org.uk/images/RSB_BIS_consultation_response_29.10.15.docx

Traditionally, funding provisions for the FE sector have been considerably smaller than funding for students in the HE sector. A 2015 report by London Economics indicated that funding for 16-19 students in FE was the equivalent to 42% of HE funding, while funding for 16-19 non-apprentices was equivalent to 54% of the funding per full-time undergraduate student from England studying in England in 2013/14.[58] Practical education and training is expensive, therefore, (for the FE sector to provide high-quality technical education, the government must provide adequate funding to support the sector. Local employers must invest in students at local education providers, in areas where particular skills shortages exist.

If the number of students undertaking technical education routes is to increase, it is expected that demand for high-quality technical teaching will also rise.[59] To meet this demand the Government should consider incentives to attract new recruits to the profession including those who have undertaken technical qualifications themselves, and consider strategies to retain educators in the profession there is likely to be competition for those with STEM skills, with higher wages offered in industry. There is evidence to suggest this competition becomes stronger when there is demand for particular skills or expertise from industry within the local areas. [60]

As well as shortages within the STEM technical sector, we also face shortages in the supply and retention of science teachers[61] [62] [63]which is key to having a healthy STEM pipeline and raising the number of students carrying on their study of STEM subjects. We encourage government to continue to focus on providing effective incentives for people entering, returning to and remaining in the teaching workforce. We need inspirational teachers of science in primary, secondary schools, further education colleges and higher education to encourage young people to enter STEM careers.

Many students and researchers from outside the UK bring new capabilities and skills that are not always readily available, contributing to the knowledge economy and helping to alleviate skills shortages. Within academic staff in UK universities 17% of academics workers in STEM are from the EU and 13% from outside the EU.[64] It is vital that the Government ensure the freedom of movement of STEM students and researchers, to enable to UK to attract the best international talent and remain competitive. The Government must also ensure that protections are in place to facilitate the recruitment of UK trained EU students who want to work in STEM shortage sectors within the UK.[65]

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58 https://www.ucu.org.uk/media/736/London-Economics---final-report-Mind-the-gap-Comparing-public-funding-in-higher-and-further-education-19-Nov-15/pdf/londoneconomics_mindthegap-publicfundinginheandfe_fullreport_nov151.pdf
59 http://www.gatsby.org.uk/uploads/education/reports/pdf/profile-of-the-set-teaching-workforce.pdf
60 https://www.nfer.ac.uk/publications/ETFS01/ETFS01.pdf
61 http://www.gatsby.org.uk/uploads/education/reports/pdf/key-indicators-in-stem-education-gatsby.pdf
62 https://www.rsb.org.uk/images/ASE_IOP_RSB_RSC_RS_Teacher_Supply_Response.pdf
63 https://www.rsb.org.uk/images/16-09-2016-MAC-teacher-supply-response.pdf
64 http://www.sciencecampaign.org.uk/asset/F50CF4C1%2D93C7%2D4F38%2D89E55D6B DBB70ED6/
65 https://www.rsb.org.uk/images/RSB_response_impact_of_Brexit_on_HE.pdf

Specific skills shortages
Whilst specific skills gaps are highlighted here, another theme that needs attention regarding the biosciences skills base is improved support and incentives for lifelong learning, adaptability and divergent, innovative thinking; of particular use when members of the bioscience sector (such as researchers) are collaborating with colleagues in different sectors.

As identified by the BBSRC and MRC 2015 Review of Vulnerable Skills and Capabilities, in collaboration with the then Society of Biology, there are key areas of vulnerability within UK biosciences and biomedical research,[66] these include:

- *Interdisciplinarity*
- *Maths, Statistics and Computation*
- *Physiology and Pathology*
- *Agriculture and Food Security*
- *Core Research and Subject-Specific Skills*

In addition to the areas of research above, forestry, pharmacology, drug discovery and microbiology are also areas facing shortages of skills and capability. It has been brought to our attention that several specific areas where skills shortages have been identified, such as in bioinformatics, are suspected to be a direct effect of students lacking confidence in core numeracy skills. This could begin to be addressed by increasing the importance placed on students continuing to study and utilise their maths skills post-16 years of age.

The tendency to subsume specialist disciplines into other umbrella degrees can lead to skills vulnerability. Microbiology has increasingly been absorbed within bioscience degree programmes and there are currently a small number of microbiology degrees offered within the UK. Whilst it is acknowledged that employers value the transferable skills acquired from a bioscience degree, there is a risk that "we are failing to capitalise on the specialist knowledge and training gained within the UK". [67]

Alongside broader skills gaps, we have concerns about the skills gaps in plant science, field studies and several 'niche' areas that require few individuals but have high strategic importance, such as plant breeding and entomology. These disciplines have seen a long-term decline in skills, with shortages worldwide, not just in the UK, and are facing a lack of succession planning when current professionals reach the end of

[66] BBSRC and MRC (2015) BBSRC and MRC review of vulnerable skills and capabilities http://www.bbsrc.ac.uk/documents/1501-vulnerable-capabilties-report-pdf/
[67] https://www.microbiologysociety.org/uploads/assets/uploaded/061b4696-7cac-4b5f-ab9408859842e2e5.pdf

their careers. A 2014 report by the Plant Science Federation[68] indicated that shortages of plant scientists and an inadequate skills base were the greatest barriers to meeting future challenges in UK plant science. Particular shortages of UK expertise in identification specialists, taxonomists, and plant pathologists, were identified.

In our response to the call for evidence on the UK bioeconomy, we note that the land-based disciplines, such as farming and forestry, face difficulties in recruiting technical and professional personnel. Our members have identified that this issue is partly to do with the very low profile of land-based jobs among school-leavers making their study choices. Advanced apprenticeships may prove to be a real opportunity to address the recruitment shortfall.

The biotech industry in the UK has also cited shortages of suitably skilled workers as a barrier to growth, especially in skills related to commercial awareness and entrepreneurship. A 2016 report by the Science Industry Partnership indicates that STEM graduates often lack the applied practical skills required by STEM employers. The report also indicated that there is a role for employers to play in supporting the development graduate practical skills, by working with higher education institutions to offer students access to specialist equipment and facilities. [69]

The future skills needs for scientific employers could be driven by key enabling technologies such as synthetic biology and biotechnology, advanced manufacturing, formulation technology and materials science, in addition to advances in the use and management of information and big data,[70].

14. How can we enable and encourage people to retrain and upskill throughout their working lives, particularly in places where industries are changing or declining? Are there particular sectors where this could be appropriate?

As we have highlighted in the previous section, there are a number of areas within the biosciences facing long-term skills shortages. As well as increasing the number of skilled individuals entering these fields, it will also be necessary to make up some of the short-fall by upskilling the existing workforce. The biosciences and biotechnology sectors are rapidly evolving areas and the current scientific workforce will need to upskill and receive additional training to keep pace with training in these fields. For instance, the Science Industry Partnership 2015 Skills Strategy notes that there will be a "need to upskill a large proportion of the existing scientific workforce, who received little or no informatics training during their

[68] UK Plant Science Federation (2014) UK Plant Science – Current status and future challenges
https://www.rsb.org.uk/images/pdf/UK_Plant_Science-Current_status_and_future_challenges.pdf
http://www.scienceindustrypartnership.com/media/529050/sip_science_industry_demand_for_skills_final.pdf
[70] Science Industry Partnership (2015) Skills Strategy 2025
http://www.scienceindustrypartnership.com/media/529053/5202fd_sip_skills_strategy_2015_final_low.pdf

education"[71]. There is a need for industries to horizon scan and consider what their future skills and training requirements could be.

STEM employers in both the public and private sector must invest in the training of their technical staff and recognise the importance of professional development. As we have previously recommended in our response to Closing the STEM Skills Gap, we believe employers should be encouraging their employees to work towards professional registration.[72] By achieving professional registration employees demonstrate their commitment to undertaking continual professional development as well as having a portable recognised qualification demonstrating their competency within their field.

The Royal Society of Biology offers four professional recognition and development awards to members under license from the Science Council (RSciTech, RSci, CSci and CSciTeach), in addition to our own Chartered Biologist (CBiol) qualification. We also offer progression to higher awards, which enables those in scientific roles to demonstrate the development of their skills throughout their career. Through professional registration, the professional bodies can offer scientists and technical staff the opportunity to chart their professional development and track their skills development.

The Government should encourage STEM employers to provide clarity around opportunities for staff to retrain and upskill. Improving opportunities to those individuals wishing to return to STEM careers after a career break could bring beneficial access to talent. We support the investment in training through apprenticeships and encouraging organisations to take on more apprentices to take advantage of funding from the apprenticeship levy. Efficient and effective processes for development of new apprenticeship standards, together with increased flexibility in use of the levy should be utilised and supported to best effect to encourage companies, universities and other relevant bodies to recruit and train more apprentices. However, it is also important that all staff are supported throughout their career. Investment in apprenticeships must not be to the detriment of investment in training the rest of the workforce. [73]

There are many challenges and barriers to individuals looking to retrain and upskill during their working life, including restricted ability to relocate, limited access to training funding and limited childcare provisions or carer support. The Government should provide incentives for STEM employers to enable their staff to upskill in areas of skills shortages in the sector and seek to engage with employers to alleviate some of the current barriers to upskilling. For instance, the Society welcomes the Government's commitment of £5 million towards promoting 'Returnships' to support people returning to work after long

[71] Science Industry Partnership (2015) Skills Strategy 2025 http://www.scienceindustrypartnership.com/media/529053/5202fd_sip_skills_strategy_2015_final_low.pdf

[72] http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/science-and-technology-committee/closing-the-stem-skills-gap/written/45123.pdf

[73] The Royal Society of Biology Response to the Sub-Committee on Education, Skills and the Economy Apprenticeship Inquiry; URL: https://www.rsb.org.uk/images/RSB_Apprenticeship_Inquiry_Response_final.pdf

breaks, and specific financial assistance could be offered to those returning to their career in STEM, retraining or taking significant time out of their work for continuing professional development. Difficulty in returning from a career break affects the spectrum of science careers including teachers, technicians and industrial scientists. Support for returners to re-enter the STEM workforce, particularly those who are typically underrepresented within the STEM sector, can help to alleviate skills shortages in certain sectors and promote diversity. The Royal Society of Biology supports returners to bioscience through its 'Returners to Bioscience' group.[74] The group seeks to provide resources and mechanisms to support scientists before, during and after a career break.

Supporting the professional development of the teaching workforce is a crucial factor in improving not only their knowledge and practice, but also their job satisfaction and retention.[75] An NFER report showed that science teachers were most likely to consider leaving the profession (at 31%).[76] STEM graduates are in high demand from other industries, which can often offer higher salaries than teaching. Science teachers may therefore leave the teaching profession to pursue more competitive job prospects in the STEM sector.[77]

The government should support teachers to enhance their STEM subject specialist knowledge and confidence, through professional development opportunities and during Initial Teacher Training (ITT) and Subject Knowledge Enhancement (SKE) courses.

Upgrading infrastructure

15. Are there further actions we could take to support private investment in infrastructure?

Many areas of bioscience require significant investment for development, and return on investment may be slow – i.e. patient capital is needed. Some capital projects are not supported by appropriate resource and technical support, which in turn runs the risk of underutilisation and reduced return on the investment that has been made upfront. Conditions favouring capital project support could remedy this situation and encourage continued capital investment in bioscience research projects, by reducing uncertainty in investment models.

UK public investment in research and development (R&D) leads the way for private sector investment; a key factor in the health of the UK's research ecosystem. Schemes such as the UK Research Partnership Investment Fund (UKRPIF), that encourage strategic partnerships between HEIs and other research organisations, are welcome. Private companies investing in R&D are currently eligible for tax relief on their R&D expenditure; again this is welcome, as analysis suggests increasing levels of investment in R&D in the

[74] https://www.rsb.org.uk/policy/groups-and-committees/returners-to-bioscience-group
[75] http://www.educationengland.org.uk/documents/pdfs/2011-teacher-training-plan.pdf
[76] https://www.nfer.ac.uk/publications/LFSB01/LFSB01.pdf
[77] https://www.publications.parliament.uk/pa/cm201617/cmselect/cmeduc/199/199.pdf

UK has resulted from these tax incentives[78]. However capital expenditure is not usually eligible for tax credits (as previously mentioned, cf Q7) as it as the investment results in business assets. This could be addressed to make research in the UK even more attractive to commercial investment.[79]

As mentioned in previous sections, common regulatory standards, in relation to those utilised by international trading partners, are likely to be an enabler for private investment from international business.

16. How can local infrastructure needs be incorporated within national UK infrastructure policy most effectively?

The Natural Capital Committee's recommendation, made within their fourth state of natural capital report 'Improving Natural Capital: an assessment in progress'[80], proposes that "The new National Infrastructure Commission (NIC) should incorporate natural capital, including its maintenance, restoration and recovery, into long term infrastructure plans; ensuring consistency with the objectives of the 25 Year Environment Plan" (page 4, point 8.); and "Embedding natural capital in England's national infrastructure plans will be critical to the success of the government's 25 Year Environment Plan, and will enrich thinking about priorities for infrastructure spending. Responding to repeated flooding, for example, is an issue on which joining up natural capital and infrastructure plans will deliver benefits and cost savings." (page 16).
Local infrastructure efficiencies can contribute nationally through demand management. For example, linking industries and production processes together (often covered by different Government departments) for the sustainable use of limited resources. Heat and carbon dioxide produced as a by-product from industrial processes has been used to create an effective growing environment in green houses for horticulture, reducing national grid reliance.

17. What further actions can we take to improve the performance of infrastructure towards international benchmarks? How can government work with industry to ensure we have the skills and supply chain needed to deliver strategic infrastructure in the UK?

Supporting businesses to start and grow

18. What are the most important causes of lower rates of fixed capital investment in the UK compared to other countries, and how can this be addressed?

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[78] House of Commons Science and technology Committee Tenth Report of Session 2016-17 on Managing intellectual property and technology transfer; page 15; published March 2017; URL: https://www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/755/75502.htm

[79] A response from the Society of Biology to the Department for Business, Innovation and Skills on proposals for long term Capital Investment in Science and Research; July 2014; URL.

[80] Natural Capital Committee's fourth state of natural capital report 'improving natural capital: an assessment in progress' (pages 8, 16); published in January 2017; URL: https://www.gov.uk/government/publications/natural-capital-committees-fourth-state-of-natural-capital-report

Our members suggest that, often, risk aversion to investment (particularly related to fundamental and translational research (eg early phase drug discovery), and lack of awareness of opportunities, are two very important causes for the lower rates of fixed capital investment in the UK. Improved incentives and information would likely aid investors in the decision-making process. Brexit is likely to increase uncertainty, a clear Industrial strategy could decrease it.

SMEs are vulnerable to investment trends driven by risks outside their control. Strategies by which Germany supports its 'Mittelstrand', through regional financial support programmes, have been praised.

19. What are the most important factors which constrain quoted companies and fund managers from making longer term investment decisions, and how can we best address these factors?
Investors (and some research programmes) are deterred by uncertainty and a lack of stability in policy. An increase in real or perceived risk has the knock-on effect of making investment more expensive financially. Examples of recent policy changes include the sell-off of the Green Investment Bank, the removal of climate change levy exemption for renewables, and the ending of grandfathering for biomass conversions in the Renewable Obligation.

20. Given public sector investment already accounts for a large share of equity deals in some regions, how can we best catalyse uptake of equity capital outside the South East?

21. How can we drive the adoption of new funding opportunities like crowdfunding across the country?

22. What are the barriers faced by those businesses that have the potential to scale-up and achieve greater growth, and how can we address these barriers? Where are there outstanding examples of business networks for fast growing firms which we could learn from or spread?
Greater clarity and stability in policy could be more important to bio-industry related growth than any specific intervention, by giving greater confidence to potential investors. Several reports have suggested the creation of an advisory body, similar to Germany's Bioeconomy Council, to ensure that long term policy reflects a vision shared by stakeholders and Government.

<u>Improving procurement</u>

23. Are there further steps that the government can take to support innovation through public procurement?
In the biosciences sector, targeted public procurement of sustainable bio-based products in preference to conventional alternatives will help to drive markets directly, improve awareness of these products and support new products entering the market. We welcome the commitment to 'buying greener products and

services' in the recent policy paper 'Greening Government Commitments 2016 to 2020', and would like to see this approach extended. The green paper 'Building Our Industrial Strategy' discusses improving procurement, with actions to assist small businesses through public procurement. However, a greater commitment to assessment of innovative and sustainable products in order to achieve the best overall value for the long-term would be welcome.

Furthermore, Government procurement is a powerful driver of the bio-industry sector, particularly relating to sustainable alternatives to fossil-fuel based products. Government initiatives provide opportunities which should be considered, for example, plans for new settlements in England could champion buildings with the highest standards of energy and carbon efficiency, thus encouraging developers to look beyond traditional building methods and towards bio-based building technology.

24. What further steps can be taken to use public procurement to drive the industrial strategy in areas where government is the main client, such as healthcare and defence? Do we have the right institutions and policies in place in these sectors to exploit government's purchasing power to drive economic growth?

The NHS Sustainable Development Unit has given consideration to a range of issues in healthcare.[81]

Encouraging trade and inward investment

25. What can the government do to improve our support for firms wanting to start exporting? What can the government do to improve support for firms in increasing their exports?

The agri-food sector is a strong export source in the UK, in 2014 it contributed £108 billion to the economy. In 2015 the value of food, feed and drink exports was £18.0 billion, a decrease of 4.3% on 2014[82]*. As previously explained cf question 5, further support for this productive sector is warranted - improving the opportunities for researcher development; integrating the social sciences into a two way flow of information with farmers to aid in policy implementation and dispersal of advances in animal welfare and technology, amongst other activities.*

Additionally, whilst we acknowledge the crux of this question, we would like to make a separate point about the importance of international routes for exchange of research materials.

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[81] http://www.sduhealth.org.uk/about-us/who-we-are.aspx

[82] Agriculture in the United Kingdon 2015; URL: https://www.gov.uk/government/statistics/agriculture-in-the-united-kingdom-2015

Within the EU single market, there is an established framework for the free movement of research materials, especially biological materials (for example genetic strains of plants and animals, DNA and tissue samples), which benefits ecological, evolutionary and medical research. Regulations relating to this, and whether any import or export permits will be required in the future, will need review and clear resolution. Many research projects and collaborations are long-term and require regular movement of people and materials. Reassurance or pre-emptive planning will be necessary to ensure that contact and exchange can continue along necessary or planned schedules; which will have direct and in-direct impact on commercial exports resulting from research.

26. What can we learn from other countries to improve our support for inward investment and how we measure its success? Should we put more emphasis on measuring the impact of Foreign Direct Investment (FDI) on growth?

<u>Delivering affordable energy and clean growth</u>

27. What are the most important steps the government should take to limit energy costs over the long-term?

A focus on reducing waste and improving the efficiency of energy use, through incentives and support to schemes both within and between sectors and businesses, which seek to combine and recycle energy production and energy needs, will help to abate this issue.

The opportunities presented by the use of renewable or low impact materials (such as rammed earth, sheep's wool and timber) as effective architectural insulators and building materials should not be ignored and could benefit from further research and implementation support. Also, incentives for improved sustainability and energy efficiency in housing have been raised as potentially useful, for example, through effective techniques in insulation, or the installation of solar panels on new houses.

28. How can we move towards a position in which energy is supplied by competitive markets without the requirement for on-going subsidy?

29. How can government, business and researchers work together to develop the competitive opportunities from innovation in energy and our existing industrial strengths?

30. How can government support businesses in realising cost savings through greater resource and energy efficiency?

Cultivating world-leading sectors

31. How can the government and industry help sectors come together to identify the opportunities for a 'sector deal' to address - especially where industries are fragmented or not well defined?

32. How can the government ensure that 'sector deals' promote competition and incorporate the interests of new entrants?

33. How can the government and industry collaborate to enable growth in new sectors of the future that emerge around new technologies and new business models?

Driving growth across the whole country

34. Do you agree the principles set out in this section are the right ones? If not what is missing?

35. What are the most important new approaches to raising skill levels in areas where they are lower? Where could investments in connectivity or innovation do most to help drive growth across the country?

Creating the right institutions to bring together sectors and places

36. Recognising the need for local initiative and leadership, how should we best work with local areas to create and strengthen key local institutions?

37. What are the most important institutions which we need to upgrade or support to back growth in particular areas?

38. Are there institutions missing in certain areas which we could help create or strengthen to support local growth?

The Society welcomes the Department's consultation on the Industrial Strategy. We are pleased to offer these comments which have been informed by specific input from our members and Member Organisations across the biological disciplines. The RSB is pleased for this response to be publicly available. For any queries, please contact the Science Policy Team at Royal Society of Biology, Charles Darwin House,12 Roger Street, London, WC1N 2JU. Email: policy@rsb.org.uk

Appendix A

Member Organisations of the Royal Society of Biology

Full Organisational Members
Academy for Healthcare Science
Agriculture and Horticulture Development Board
Amateur Entomologists' Society
Anatomical Society
Association for the Study of Animal Behaviour
Association of Applied Biologists
Bat Conservation Trust
Biochemical Society
British Andrology Society
British Association for Lung Research
British Association for Psychopharmacology
British Biophysical Society
British Crop Production Council
British Ecological Society
British Lichen Society
British Microcirculation Society
British Mycological Society
British Neuroscience Association
British Pharmacological Society
British Phycological Society
British Society for Cell Biology
British Society for Developmental Biology
British Society for Gene and Cell Therapy
British Society for Immunology
British Society for Matrix Biology
British Society for Medical Mycology
British Society for Nanomedicine
British Society for Neuroendocrinology
British Society for Parasitology
British Society for Plant Pathology
British Society for Proteome Research
British Society for Research on Ageing
British Society of Animal Science
British Society of Plant Breeders
British Society of Soil Science
British Toxicology Society
Daphne Jackson Trust
Drug Metabolism Discussion Group
Fondazione Guido Bernardini
GARNet
Genetics Society
Heads of University Centres of Biomedical Science
Institute of Animal Technology
Laboratory Animal Science Association
Linnean Society of London
Marine Biological Association
Microbiology Society
MONOGRAM – Cereal and Grasses Research Community
Network of Researchers on Horizontal Gene Transfer & Last Universal Cellular Ancestor
Nutrition Society
Quekett Microscopical Club
Royal Microscopical Society
SCI Horticulture Group
Science and Plants for Schools
Society for Applied Microbiology
Society for Experimental Biology
Society for Reproduction and Fertility
Society for the Study of Human Biology
Systematics Association
The British Library
The Field Studies Council
The Physiological Society
The Rosaceae Network
Tropical Agriculture Association
UK Environmental Mutagen Society
UK-BRC – Brassica Research Community
UK-SOL – Solanacea Research Community
University Bioscience Managers' Association
VEGIN – Vegetable Genetic Improvement Network
Zoological Society of London

Supporting Organisational Members
Affinity Water
Association of Medical Research Charities
Association of the British Pharmaceutical Industry (ABPI)
AstraZeneca
BASIS Registration Ltd.
Bayer
BioIndustry Association
Biotechnology and Biological Sciences Research Council (BBSRC)
British Science Association
Envigo
Fera
Forest Products Research Institute
Gatsby Charitable Foundation
Institute of Physics
Ipsen
Medical Research Council (MRC)
MedImmune
Pfizer UK
Plant Bioscience Limited (PBL)
Porton Biopharma
Procter & Gamble
Royal Botanic Gardens, Kew
Royal Society for Public Health
SynBiCITE
Syngenta
The Ethical Medicines Industry Group
Understanding Animal Research
Unilever UK Ltd
Wellcome Trust
Wessex Water
Wiley Blackwell