Response from the Royal Society of Biology to the Science and Technology Committee of the Commons inquiry on the

Balance and effectiveness of research and innovation spending

September 2018

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 policymakers, 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 welcomes the opportunity to respond to this inquiry on Government's proposed allocation of funding for research and innovation and the strategy to boost investments towards the goals of 2.4%/3% of GDP targets.

Summary

- UKRI's potential to coordinate a balanced and responsive funding landscape with support for fundamental, applied and interdisciplinary research holds promise but is a huge challenge and delivery will require readjustments from the community as well as new approaches, continuous monitoring and regular review from UKRI.
- The life sciences encompass a range of disciplines spanning molecule to ecosystem and environment to biomedicine; a challenge focus is appropriate alongside discovery led research – all can deliver personal, societal and economic benefit.
- Capacity to nurture early career researchers of promise; to promote professionalism and career opportunities for researchers and technical staff; and to support entrepreneurs and links to business, where appropriate, is key. A talented, diverse and inclusive workforce is one of the pillars onto which successful public investment in R&D should be built, with the help of supportive education and immigration policies.
- The spatial distribution of funding on a national scale will have to take into account the existence of both clustered (hubs) and distributed research centres. Working with devolved administrations and with Government department-supported research facilities could help towards more distributed expertise and collaborations; deriving benefit from existing and strategically important expertise.
- The assessment of existing infrastructure already underway should be used to inform future strategic investment. Community advice will be essential to achieve the right balance.
- Both project and resource funding are important in bioscience, and progress depends upon the availability of ample support. The dual support system is well suited to this and can accommodate the

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relatively high funding requirements of the biosciences - but it is vital that the proportion available for project funding can expand to respond to opportunity.

- Measures that facilitate collaboration between academia and industry, such as knowledge exchange programmes and tech transfer offices at universities, should be promoted and aim at closing the existing 'translational gap'. Biomedical Catalyst-type grants should continue to be funded and extended to other areas of the biosciences.
- Achieving a 2.4% of GDP investment in R&D is an historic opportunity but also a challenge because private investment must be encouraged at the current high ratio to public investment. Maintaining a skilled base through education and mobility is essential, as well as maintaining a broader fiscal environment that encourages investment.

Detailed response to the inquiry on:

1. **The effectiveness of public spending on R&D, including through mechanisms such as:**

1.1. the Industrial Strategy Challenge Fund

1.1.1. The RSB is supportive of government's mission-orientated strategic thinking and funding mechanisms that support coordination between different fields of research, collaborations between academic and industrial partners and a focus on providing solutions to global challenges and consolidating the UK's status as a global economy. We have highlighted in earlier responses to Government's consultations how investment in the life sciences can contribute towards meeting the Grand Challenges set out in the Industrial Strategy[1] and support British economic growth[2]. We also stress the crucial importance of discovery-led, curiosity-driven research which opens new fields of opportunity and provides tangible and intangible benefits.

1.1.2. Translation of research and effective knowledge exchange are key to this. The activities of the University Tech Transfer Offices (TTOs) and effective industry access to and engagement with research will play a role in the success of the Industrial Strategy Challenge Fund (ICSF). However, alongside the ICSF sufficient and consistent funding should be devoted to horizon scanning[3] and to basic research projects that might provide the ideas and solutions to tackle as yet unrecognised threats and priorities.

1.2. the Strategy Priorities Fund

1.2.1. Horizon scanning and discovery-led research supported by individual Research Councils could identify emerging priorities or opportunities for future scientific development. The particular value of Strategic Priorities Fund should be to provide sufficient funding to

[1] The Royal Society of Biology, (2017). Response to the BEIS Consultation on 'Building our Industrial Strategy'. Pages 8-11, 12-13. URL: https://www.rsb.org.uk/images/article/policy/RSB_response_to_BEIS_consultation_Building_our_Industrial_Strategy.pdf
[2] The Royal Society of Biology, (2017). Response to the BEIS Consultation on the UK Bioeconomy. URL: https://www.rsb.org.uk/images/RSB_response_to_the_BEIS_Bioeconomy_consultation_Final_response.pdf
[3] The Royal Society of Biology, (2017). Response to the BEIS Consultation on 'Building our Industrial Strategy'. Pages 6-7. URL: https://www.rsb.org.uk/images/article/policy/RSB_response_to_BEIS_consultation_Building_our_Industrial_Strategy.pdf

respond to new research initiatives promptly and in an agile manner. At the same time the administration of this will require cross-council coordination and a direct link to Government departments. The way UKRI plans to administer this fund and the way it will operate are not yet known.

1.2.2. Given the fact that part of this fund will receive bids for "multi-disciplinary and inter-disciplinary research, receiving bids for activities that cross boundaries between the Research Councils"[4], an inter-council development programme, which builds on UKRI expertise across areas of research, should develop the human capital required to be able to asses and review inter and multi-disciplinary and inter council research grant applications not only on the merit of science. There is also a need to build expertise on translational, economic and non-market impact measurements, to improve grant awarding, monitoring and assessment of impact in relation to the underlying research.

1.3. the UKRI Budget

1.3.1. Despite the fact that the creation of UKRI coincides with the largest uplift in Government's spending in R&D in more than 40 years – a commitment that will help UKRI accomplish its mission – allocated funding to single Research Councils (RCs) show variable levels of increase (figures 1A-B in appendix 1). Particularly, research councils supporting fundamental research in the life sciences, such as the Biotechnology and Biological Science Research Council, the Medical Research Council and the Natural Environment Research Council, have grown their budgets comparatively less than other organisations within UKRI relative to pre-UKRI times (table in appendix 2) – going from a combined 46.3% of total RC funding pre-UKRI to a 42.7% for the years 2017-2020, a decrease in proportion of allocation of 3.6%. The MRC and BBSRC rank roughly midway in relation to other Research Councils in terms of planned allocations for Science Infrastructure Capital (with an annual budget of 59 £M for the MRC and 60 £M for the BBSRC over the next three years)[5].

1.3.2. Our members have highlighted the importance of developing and sustaining investment and access to infrastructures and facilities that support basic and applied research, for example: biological resource collections; reference and high-containment laboratories; and databases and cloud infrastructure for genomic and other data. Investments and funding agreements should recognise that for laboratory facilities to function baseline of funding and income is needed – building in long-term support for maintenance, development and training.

[4] Nurse Review, Department for Business Innovation and Skills, (2014). Ensuring a successful UK research endeavour. Page 28 URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/478125/BIS-15-625-ensuring-a-successful-UK-research-endeavour.pdf

[5] Department for Business, Energy & Industrial Strategy, (2018). The allocation of funding for research and innovation - Annex 4. Page 14. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/731507/research-innovation-funding-allocation-2017-2021.pdf

1.3.3. In order to avoid underspending on fundamental research in the life sciences, UKRI should ensure an appropriate balance of funding is reached between pure and translational research. This should ensure a consistent pipeline of research and prevent a 'pendulum' approach to science funding where priorities alternate between encouraging pure and then translational research, or areas of established leadership.

1.3.4. We welcome UKRI's commitment to take into account the existing body of evidence, such as the Science and Innovation Audits and the Research Excellence Framework, as well as the advice of stakeholders across the research communities to inform decisions on research funding allocations. This will insure that emerging and strategically important fields of research are rapidly identified and appropriately supported in a timely manner.

2. The rationale needed for deciding on the balance of public R&D funding between:

2.1. individual research disciplines, research councils and cross-disciplinary schemes

2.1.1. In an earlier response to the Lord's Science and Technology Select Committee inquiry into the Life Science and the Industrial Strategy, the RSB has raised concern that "the creation of UKRI as a single body driving research and innovation may lead to investment focused more narrowly within prioritised sectors of the life sciences"[6]. Single disciplines and research in niche areas with the potential for excellent research outputs should not be neglected and should find dedicated funding within Government's R&D budget. Equally, "adequate support to research institutes run directly by the individual research councils and those sponsored by Government departments, such as executive non-departmental public bodies Royal Botanic Gardens Kew and the Natural History Museum, and executive agencies such as Forest Research, will be important to maintain contributions to public-domain research"[7].

2.1.2. UKRI could be effective in boosting the development of cross-disciplinary support schemes and facilitating researchers' access to funding opportunities for interdisciplinary projects. UKRI should facilitate research councils to look closely at how the boundaries between the individual councils can be managed to ensure that applicants for interdisciplinary projects are encouraged to see opportunities, and that high quality research can be supported. UKRI's Cross-Council Funding Agreement sets out principles and a processes to "ensure that no gaps develop between the Councils' subject domains and to ensure equality of opportunity for proposals at the interface between traditional disciplines, where many of the major research challenges of our time are located"[8].

[6] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. Paragraph 2.11, page 8. URL: https://www.rsb.org.uk/images/RSB_response_Life_Sciences_Industrial_Strategy_inquiry_submitted.pdf

[7] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. Paragraph 1.9, page 3. URL: https://www.rsb.org.uk/images/RSB_response_Life_Sciences_Industrial_Strategy_inquiry_submitted.pdf

[8] https://www.ukri.org/funding/how-to-apply/applications-across-research-council-remits/

2.1.3. This approach is welcome and to secure successful outcomes it would beneficial 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"[9]. Cross-Council funding and funds from the National Productivity Fund could support these goals. UKRI's commitment to fund interdisciplinary projects should also be more broadly communicated to stakeholders who are often discouraged from applying by the perception that interdisciplinary projects will be harder to justify to one or both of the research councils.

2.2. the two research funding streams of the 'dual support' system

2.2.1. The RSB is supportive of a dual support system, which aims to be broadly proportionate and reach a balance between funding in response to calls from funders, and quality-related funding based on the assessment of outcomes by the Research Excellence Framework[10]. The outcomes of the previous REF2014[11] showed that the top five units of assessment[12], based on the overall quality profile of research at 4* and 3* levels (which informs quality-related (QR) funding) are all bioscience-related disciplines (more information is provided in appendix 3). The excellent quality of the research in the life sciences carried out by HEIs receives significant support from Government through QR funding. Because these two funding streams serve different purposes and allow research institutions to undertake different activities (which may include, for example, fundamental research, teaching, and/or applied research), it will be critical to maintain the right balance between them – in light of cross-disciplinary initiatives, general research trends and emerging gaps and opportunities.

2.2.2. One of UKRI's roles will be to advise Ministers about what exactly a reasonable balance entails in terms of funding distribution. In order to accomplish a delicate decision-making process and take into account its broad consequences, UKRI proposes to "build their evidence, responding to new challenges, opportunities and wider changes"[13]. Greater coordination enabled by UKRI as well as its commitment to move 'beyond project- or programme-level evaluation' should help this purpose, and could facilitate holistic assessment of projects (particularly those interdisciplinary in nature) as opposed to assessing direct project outputs. This, however, must not be to the detriment of research that is not captured within the Government's 'priority areas'.

[9] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the BEIS consultation on Building our Industrial Strategy. Page 6. URL: https://www.rsb.org.uk/images/article/policy/RSB_response_to_BEIS_consultation_Building_our_Industrial_Strategy.pdf
[10] The Royal Society of Biology, (2016). A response from the Royal Society of Biology to the Stern Review of the Research Excellence Framework. Executive summary, page 1. URL: https://www.rsb.org.uk/images/pdf/FINAL_RSB_response_to_Stern_Review.pdf
[11] All datasets and results are freely available at https://results.ref.ac.uk/(S(mex0lcjhonq0uhljsnftcabe))/
[12] The first five UoAs based on the average overall quality profile at 4* and 3* levels (quality-weighted according to HEFCE methods, see appendix 3) are clinical medicine (UoA 1); public health, health service and primary care (UoA 2); biological sciences (UoA 5); psychology, psychiatry and neuroscience (UoA 4) and agriculture, veterinary and food science (UoA 6).
[13] UK Research and Innovation, (2018). Strategic prospectus: building the UKRI Strategy. Page 23. URL: https://www.ukri.org/files/about/ukri-strategy-document-pdf/?pdf=Strategic-Prospectus

2.2.3. UKRI's strategy outlines how the results of REF[14] and a culture of evaluation[15], based on effective data and metrics across domains of research and innovation, will shape and inform this decision-making process. However, we await more details about the process of evaluation which are due to be released at a later stage. The RSB welcomes the commitment to consult stakeholders in the scientific community, public sector and learned societies about the strategy for evaluating research and directing funding. The proposed decision of REF sub-panels not to use "journal impact factors (IFs) or any hierarchy of journals in their assessment of outputs"[16] answers earlier suggestions by learned societies such as RSB against "the use of IF as a proxy for research quality […] throughout the whole process of selecting outputs for REF submission"[17]. This advice to REF reviewers has been made in the past so UKRI must take into account that research institutions still rely on impact factors for awarding academic positions and career progression, a situation that warrants improvement[18] and for which an alternative culture of evaluation fostered by Government[19] could have positive transformative effects, if developed in collaboration with the scientific community and communicated actively to all stakeholders involved.

2.2.4. Research institutions in devolved administrations must understand how UKRI plans to work with devolved Governments on access to funding, particularly in relation to common strategic goals for investment. Currently, the Strategy Prospectus does not provide examples or evidence of how UKRI will interact with the Scottish Funding Council or analogous bodies in Wales and Northern Ireland. The outcome of REF directly informs QR-related funding in Scotland through the Scottish Research Excellence Grant (REG) and understanding how new arrangements will operate is important for planning.

2.3. **research and innovation**

2.3.1. Coordination and collaboration between research institutions, industry and users throughout the life of a research project – not merely at the end of it – will drive innovation, support commercialization and easier routes to market[20]. The RSB welcomes UKRI's focus on business-led innovation both through direct funding to business-led initiatives administered by Innovate UK and potentially to the HE sector via the Knowledge Exchange Framework administered by Research England, whose development is underway and whose outcomes will need to be reviewed in due time. Concomitantly, funding to fundamental science, irrespective of the market implications,

[14] UK Research and Innovation, (2018). Strategic prospectus: building the UKRI Strategy. Page 24
[15] UK Research and Innovation, (2018). Strategic prospectus: building the UKRI Strategy. Page 28
[16] Research England, (2018). REF 2018/01 (July 2018) - Guidance on Submissions. Paragraph 208, page 50.
[17] The Royal Society of Biology, (2016). A response from the Royal Society of Biology to the Stern Review of the Research Excellence Framework. Paragraph 12, page 3. URL: https://www.rsb.org.uk/images/pdf/FINAL_RSB_response_to_Stern_Review.pdf
[18] Nuffield Council on Bioethics, (2014). The culture of scientific research in the UK. URL: http://nuffieldbioethics.org/wp-content/uploads/Nuffield_research_culture_full_report_web.pdf
[19] House of Commons Science & Technology Committee, (2018). Research integrity. Sixth Report of Session 2017-19. URL: https://publications.parliament.uk/pa/cm201719/cmselect/cmsctech/350/350.pdf
[20] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. Paragraph 2.8, page 8. URL: https://www.rsb.org.uk/images/RSB_response_Life_Sciences_Industrial_Strategy_inquiry_submitted.pdf

must provide the 'seed corn' for future knowledge capable of driving unforeseen impacts and solutions to emergent needs.

2.3.2. Within the framework of knowledge exchange, focus is needed to allow university TTOs to keep pace with industry requirements and to work with industry to monitor the economic outcomes. Despite several success stories of economic benefit to the UK in licensing technology, the time taken to transition agreements and contracts is highly variable and the skills needed are often unavailable.

2.3.3. An ecosystem that supports appropriate commercialisation of publicly funded research should be further developed because a 'translational gap' in sources of funding for research that is in the early stages of commercialization still persists. While initiatives such as Wellcome's Innovator Awards offer funding of up to £750,000 for researchers who are transforming ideas into healthcare innovations, a challenge remains in progressing ideas from academia into commercially viable products. As long as a 'start-up gap' continues to exist, innovators will not be able to secure the necessary funding to demonstrate the evidence required to attract commercial investors.

2.3.4. The Government should foster an environment of entrepreneurship within the science sector and consider how best a virtuous circle of investment in R&D in the UK leads to social, economic and fiscal benefit for the UK. To that end, assistance would be welcome for researchers based in the UK to commercialise their research, alongside the current incentives that encourage investment from businesses.

2.4. pure and applied research

2.4.1. The RSB supports a portfolio of publicly-funded research that consists of 'a balance of fundamental, translational and applied programmes'[21]. We have commented elsewhere about the importance of fundamental and applied/translational research in the life sciences[22].

2.4.2. The interdependence of pure and applied research is such that they complement each other and this is just one of the reasons to safeguard a healthy balance of funding for both. In addition, knowledge has intrinsic value and fundamental research often leads to unpredicted breakthroughs and enhanced capability for people to thrive (albeit not always sustainably). There is more to research than simple commercial value but UKRI will have means to assess the state of financial support to pure and applied research and therefore could base future investments on evidence about opportunities and gaps. Businesses too are supportive of the UK as a public investor in fundamental research and the UK is an attractive destination for investment because of its creative and skilled science base. In

[21] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. Paragraph 1.2, page 2.
[22] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy.

order to achieve an overall 2.4% of GDP investment in R&D, the confidence of business in the UK environment for research, and research-enabled business must be maintained and grown.

2.4.3. The role played by international collaborations in supporting fundamental research should be considered carefully. For example, large-scale multi-national research consortia play a proportionally large role in some areas – e.g. physiology[23] – and therefore the capacity to engage in these collaborative exercises is relatively important for these areas of bioscience.

2.5. block funding, responsive mode funding and directed funding for the Industrial Strategy

2.5.1. We made comments related to block grants, strategic modes of funding and the necessity of funding to support discovery-led research under other points of this inquiry. We would like to comment here on the breadth of the Life Science Industrial Strategy[24].

2.5.2. The RSB uses the term 'life sciences' to describe all areas of the science of life, from molecules through whole organisms and ecosystems, and across all biological specialisms[25]. UKRI will lead on the mission to implement the new Life Sciences Industrial Strategy. As such, we believe "it is important to recognise that 'Life Sciences' spans a range of disciplines extending beyond pharmaceuticals and healthcare. A new Life Sciences Industrial Strategy should also consider other areas, for instance: animal and plant health, biomanufacturing, microbiology, synthetic biology, industrial biotechnology, biofuels, agriculture and crop improvement, among others. The Strategy should also address the environment […] and the link between human health and wellbeing and the health of natural systems […]"[26]. In a following oral evidence session, RSB CEO, Dr Mark Downs, commented that "the report[27] has focused on the pharmaceutical biotech sector […] and we understand why that is important. What concerns us is that it misses out on some opportunities to make the linkages across the whole of bioscience. Yes, it is a big sector, but £112 billion is the gross value added of the agri-food sector, from the farm

[23] As an example, ONCORNET (Oncogenic GPCR Network of Excellence and Training) is a recent EU-funded training consortium that involves multidisciplinary teams including physiologists and pharmacologists, some of whom are based in the UK. The consortium has brought together the leading research scientists and labs in Europe with an interest in G protein-coupled receptors (GPCRs) to train 15 early stage researchers (ESRs) in the study of two receptors (CXCR4 and CXCR7) intimately involved in cancer. The aim was to use the latest multidisciplinary research technologies to understand the role of specific receptors for diagnostic and therapeutic purposes. The ONCORNET consortium offered an extensive multidisciplinary training programme to the ESRs to ensure that they can operate in today's drug discovery environment. The consortium involved universities (Nottingham, Glasgow, Vrije Amsterdam, Madrid, Wuerzburg), institutes (CNRS, Max Planck, INSERM) and industry partners (ArgenZ, Griffin Discoveries, Actelion, Almac, Cisbio, Euroscreen, Vivia Biotech, 24MLabs) covering multiple disciplines. The programme was funded (€3,893,984) by the European Commission as a Marie Skłodowska-Curie Actions ITN.

[24] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. URL: https://www.rsb.org.uk/images/RSB_response_Life_Sciences_Industrial_Strategy_inquiry_submitted.pdf

[25] Royal Society of Biology. https://www.rsb.org.uk/

[26] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. Paragraph 5.1, page 14. URL: https://www.rsb.org.uk/images/RSB_response_Life_Sciences_Industrial_Strategy_inquiry_submitted.pdf

[27] Sir John Bell, (2017). Life Sciences Industrial Strategy - A report to government from the life sciences sector. URL: https://www.gov.uk/government/publications/life-sciences-industrial-strategy

through to sales in supermarkets. Agri-food areas generally are massive parts of the economy and a large part of the bioeconomy. […] I do not think there is anything fundamentally wrong with the strategy focusing on that area, but it concerns us that Government and the public at large might now believe that life sciences are only that area, when they are so much broader, and there is huge benefit by interlinking those areas and building on the experience of both blue-sky research and applied research across the whole of the bioeconomy"[28].

2.6. the 'golden triangle' of London, Oxford and Cambridge, and the rest of the UK

2.6.1. There are already successful R&D centres developing outside of the 'golden triangle', which provide good examples of successful support for investment in different parts of the UK. We have cited before the examples of "the BioVale cluster in Yorkshire and the Humber, the IB hub in Scotland around IBiolC, and a biorefining cluster in Wales supported by the BEACON project. Additionally, strategically placed clusters should be supported and developed elsewhere (whilst maintaining the integrity of current hubs), for example in the Midlands"[29]. Other examples of note are the Institutes of Life Science and the Centre for NanoHealth at the University of Swansea, which have leveraged EU invested assets to develop this research hub. These are particularly worth considering in light of the sparse concentration of professional, scientific and technical activities and R&D-rich industries in Wales, compared to other countries and regions of the UK[30,31].

2.6.2. Non-traditional hub approaches could also be considered to bring the UK's best and significantly publicly funded assets close to industry. It is not always necessary to be physically clustered or in a geographical Hub to leverage the expertise and research assets that are within the partner institutions for the benefit of various industry partners, and vice versa. One example is the EPSRC Centre for Innovative Manufacturing in Large Area Electronics, a polycentric multi industry research collaboration[32] to create a national centre in design, development, fabrication and characterisation of a wide range of products, which include bio-materials. Academic research at early technology readiness levels in the areas of agriculture, food and drink, electronics, energy healthcare, manufacturing and industrial biotechnology can leverage further research funding as well as direct industrial input.

[28] Science and Technology Select Committee of the House of Lords, (2018). Life Sciences Industrial Strategy: Who's driving the bus? Page 1288. URL: https://www.parliament.uk/documents/lords-committees/science-technology/life-sciences-industrial-strategy/Life-sciences-industrial-strat-evidence.pdf

[29] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. Paragraph 1.8, page 3. URL: https://www.rsb.org.uk/images/RSB_response_Life_Sciences_Industrial_Strategy_inquiry_submitted.pdf

[30] Office for National Statistics, (2015). The spatial distribution of industries in Great Britain: 2015. URL: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/thespatialdistributionofindustriesingreatbritain/2015

[31] Office for National Statistics, (2016). Gross domestic expenditure on research and development, UK: 2016. URL: https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgrossdomesticexpenditureonresearchanddevelopment/2016

[32] The partnership brings together 4 UK academic Centres of Excellence, including the University of Cambridge, Imperial College London, Swansea University and the University of Manchester

2.6.3. In order for science bases to flourish in other regions, they will need an appropriate supply of skills and education, as well as physical infrastructure such as transport and communication links. Successful diversification of the UK's science base will benefit from co-development of other aspects of the UK's infrastructure. R&D spend cannot succeed in a vacuum and developments in other aspects of the UK economy will be a vital contribution to success. Public-sector research establishments, linked to Government departments – such as BEIS, Defra and the Department of Health, are located across the country – including outside of the London-Oxford-Cambridge triangle - and they could act as catalysts for specialised research in their remit.

2.7. global challenges and other strategic/national priorities

2.7.1. Collaboration between the UK, other European partners and countries across the world will be a cornerstone of the future success of UK science[33]. Funding from both the Official Development Assistance Fund and the Fund for International Collaboration will be instrumental to foster partnerships.

2.7.2. We have commented in responses to earlier inquiries about the challenges presented by the UK leaving the EU on a number of issues affecting the scientific community at a national level[34] and on its impact on global challenges, such as biosecurity[35]. We welcome UKRI's commitment to "support the Government to establish an agreement on science and innovation that ensures the valuable links between us continue to grow, specifically in exploring the successor programmes to Horizon 2020 and Euratom Research and training"[36].

2.7.3. Accessibility to global knowledge, resources and infrastructure plays a key role in successful collaborative innovation. Important also is the human capital on which the knowledge is built. The freedom of mobility for knowledge movement is key, allowing for researchers and postgraduates to spend time in other world-leading labs and research institutes, granting them the ability to gain new knowledge to the advantage of both their research and the global research enterprise. UKRI's strategic focus on nurturing talent must be supplemented by equally effective policies for the attraction and retention of talent, particularly immigration policies. For example, Government should evaluate carefully how the proposed salary threshold for skilled immigrants might act to disbar

[33] World Economic Forum, (2015). Collaborative Innovation: transforming Business, Driving Growth. Regional Agenda. URL: http://www3.weforum.org/docs/WEF_Collaborative_Innovation_report_2015.pdf
[34] The Royal Society of Biology, (2018). RSB response to the Science and Technology Committee of the Commons Brexit science and innovation Summit Inquiry. URL: https://www.rsb.org.uk/images/article/policy/RSB_response_to_HoC_STC_Brexit_science_and_innovation_Summit_inquiry_for_submission.pdf
[35] The Royal Society of Biology, (2018). Letter to Lord Teverson, Chairman of the EU Energy and Environment Sub-Committee in relation to the inquiry Brexit: plant and animal biosecurity. URL: https://www.rsb.org.uk/images/RSB_response_to_the_HoL_EU_EESC_inquiry_Brexit_plant_and_animal_biosecurity_for_submission.pdf
[36] UK Research and Innovation, (2018). Strategic prospectus: building the UKRI Strategy. Page 50

young scientists (such as PhD students and post-docs) from coming to the UK, and act accordingly to mitigate this.

2.7.4. UK-US partnerships will be another area worth supporting[37]. Similarly, collaborations with the US National Science Foundation (NSF), National Institute for Health (NIH) and other US funding bodies need to be promoted to ensure their continuation. These larger initiatives can only come about built on many years of collaboration and engagement between UK and US partners. UKRI should find ways to facilitate promising exchange between researchers, entrepreneurs, firms and policy-makers who can mediate processes that lead to successful collaborative innovation[38].

2.7.5. A thorough review of international publicly funded research collaborations could be instructive, in order to assess key areas of success and potential for UK investments, as well as exemplifying the funding required to seed fund projects and development mechanisms to sustain them. A number of recent reports have considered some important aspects of this[39,40,41,42]. UKRI has been active in building networks but the task is extensive.

2.7.6. A focus on international collaborations is essential to harness global innovation opportunities. In the past targets have tended to focus on collaborating outside of the UK and with industry which can lead to competition within the UK. Therefore, one of UKRI goals should be to ensure that a healthy balance between collaboration and competition is maintained.

2.7.7. We welcome the principle of alignment pursued by UKRI in relation to international collaboration[43]. UK overseas collaboration has also supported the development of improved standards of research practice in partner countries, particularly in improved animal welfare. The practice by UK research institutions, funders and publishers[44] to demand that partners in scientific collaborations meet or exceed UK standards of animal welfare has had a positive long-term impact in driving up national standards in other

[37] As an example, recently the UK Department for International Trade agreed to form a "BioBridge" to advance life sciences innovation and research with The Texas Medical Center in Houston Texas, to provide a link and channel for emerging technologies, boost UK exports and drive scientific innovation.
[38] World Economic Forum, (2015). Collaborative Innovation: transforming Business, Driving Growth. Regional Agenda. URL: http://www3.weforum.org/docs/WEF_Collaborative_Innovation_report_2015.pdf
[39] Universities UK, (2017). International research collaboration after the UK leaves the European Union. URL: https://www.universitiesuk.ac.uk/policy-and-analysis/reports/Documents/2017/international-collaboration-uk-post-exit.pdf
[40] Department for Exiting the European Union, (2017). Collaboration on science and innovation: a future partnership paper. URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/642542/Science_and_innovation_paper.pdf
[41] The Royal Society, (2017). The role of the EU in international research collaboration and researcher mobility. URL: https://royalsociety.org/~/media/policy/projects/eu-uk-funding/phase-2/EU-role-in-international-research-collaboration-and-researcher-mobility.pdf
[42] The Wellcome Trust, (2017). The impact of collaboration: the value of UK medical research to EU science and health. URL: https://wellcome.ac.uk/sites/default/files/impact-collaboration-value-uk-medical-research-to-eu-science-health.pdf
[43] UK Research and Innovation, (2018). Strategic prospectus: building the UKRI Strategy. Page 42
[44] The Physiological Society's two journals, Journal of Physiology and Experimental Physiology, receive a large number of submissions from non-UK researchers. However, whenever experimental animal welfare standards are not demonstrably rigorous enough the manuscripts cannot be considered for publication in the society's journal.

countries. Standards of collaboration relevant to all aspects of research integrity, ethics included, must be safeguarded when collaborations are to be supported by Government.

2.8. creating social and cultural impact

2.8.1. Government's funding and policies that support science to make valuable contributions to health, well-being and environmental sustainability should also have in place the right reward structures to succeed[45,46]. Routes to positive impact are best delivered along routes to positive research culture, embracing diverse approaches and the products of research at different scales, and drawing upon individuals and teams of collaborators, along established and non-standard career routes. Knowledge integration across the academic and non-academic domains must be a priority and Government should support the exchange between practitioners, stakeholder groups and researchers, and the organisations and activities that facilitate this exchange. Focus on impact in QR-related funding is welcome but care is needed on how impact is measured and "judgement of research contribution and impact could consider input from non-academics engaged"[47] in relevant areas. We also welcome Government's interest to understand and estimate the value of non-market impacts of investment in research and development[48]. This interest could spur more opportunities and incentives for private-sector companies to better-align their R&D investments to societal goals and increase the number of market-based solutions to societal and environmental challenges.

2.8.2. How to balance funding appropriately across these scales and towards different research questions will be a critical task for UKRI in cooperation with its research base and society at large to "enable the co-production, communication and application of knowledge to spur sustainable development solutions"[49].

2.9. talent strategy and skills gap

2.9.1. The nurture of talent and a diverse and inclusive workforce is one of the pillars onto which the success of public spending in R&D will be built[50]. We welcome UKRI's plan to "draw on the capabilities of the Skills Academy Panel, the learned societies and industrial businesses and institutions"[51] to reach this goal. The Royal Society of Biology launched 'Advanced Accreditation' in October 2012, supported by Government funding from the UK

[45] The Lancet editorial team, (2018). UK life science research: time to burst the biomedical bubble. URL: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)31609-X/fulltextLancet editorial on the biomedical bubble
[46] Irwin E.G. et al., (2018). Bridging barriers to advance global sustainability. *Nature Sustainability*, 1, pp. 324–326. URL: https://www.nature.com/articles/s41893-018-0085-1
[47] Irwin E.G. et al., (2018). Bridging barriers to advance global sustainability. *Nature Sustainability*, 1, pp. 324–326. URL: https://www.nature.com/articles/s41893-018-0085-1
[48] Department for Business, Energy & Industrial Strategy, (2018). Non-market impacts of investment in research and development. URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/706067/research-and-development-non-market-impacts.pdf
[49] Irwin E.G. et al., (2018). Bridging barriers to advance global sustainability. *Nature Sustainability*, 1, page 325. URL: https://www.nature.com/articles/s41893-018-0085-1
[50] UK Research and Innovation, (2018). Strategic prospectus: building the UKRI Strategy. Page 14
[51] HM Treasury, (2018). Treasury minutes of Government response to the Committee of Public Accounts on the Thirty First to the Thirty Seventh reports from Session 2017-19. Page 12. URL: Government Response to the Committee of Public Accounts (page 12)

Commission for Employment and Skills (UKCES)[52]. The establishment of registers is another area of work that learned societies like the RSB have focused on, which will promote professional standards across the workforce (e.g. including workers with technical, academic, industry background).

2.9.2. Member organisations of the RSB have tried to tackle additional issues related to deficiencies in the pipeline. The Physiological Society is currently working alongside the British Pharmacological Society to establish an agreed university curriculum[53] for training in '*in vivo*' skills which would help replenishing the limited pipeline of 'in vivo' researchers. The Daphne Jackson Trust works address the portion of STEM *leaky pipeline* due to limited opportunities for STEM researchers to return to work at a level commensurate with their skills and experience after a career break for family, caring or health reasons. The Trust offers flexible, part-time Fellowships in universities and research institutes in the UK[54]. In practice the majority of those the Trust assists back to research careers are women, this makes a contribution to addressing the gender and diversity gap in STEM. The RSB has also promotes awareness of routes back to work and of the available talent pool in returners to bioscience through its initiative[55].

2.9.3. Funding opportunities for early-career researchers and technical staff are another area of importance. The need for more 'skills' training fellowships in relation to multi-disciplinary work – especially with the requirement for cutting edge techniques and approaches – has been highlighted in areas of microbiology. Additionally, our members stressed the importance of supporting staff scientists and technicians towards sustainable careers in infrastructure and service provision. Crediting taxonomy, bioinformatics and other relevant skills more could be important to ensure such services and support can be delivered.

2.9.4. A strong focus on nurturing talent must be accompanied by balancing focus on attraction and retention of skilled individuals, and those with potential, at all qualification and professional levels across the STEM community[56]. Amongst the factors that must be considered are: (a) supportive immigration policies, especially after the UK exit from the EU; (b) policies that support UK scientists to readily access equipment and knowledge exchange facilities (such as conferences) overseas; and (c) support for positive movements between academia and business, and vice versa (there is different emphasis

[52] The RSB Advanced Accreditation scheme rigorously and independently assesses programmes to ensure that degree courses have a solid academic foundation in biological knowledge and skills, as well as preparing graduates for the needs of employers. The Advanced Accreditation criteria require evidence that graduates from accredited programmes meet defined sets of learning outcomes, including substantial research experience. In September 2018, 240 degree programmes at 22 universities had achieved Advanced Accreditation through the RSB.
[53] https://www.bps.ac.uk/education-engagement/research-animals/curriculum-for-the-use-of-research-animals
[54] https://daphnejackson.org/about-fellowships/
[55] https://www.rsb.org.uk/policy/groups-and-committees/returners-to-bioscience-group
[56] The Royal Society of Biology, (2018) RSB response to the Science and Technology Committee of the Commons' inquiry on an immigration system that works for science and innovation URL:
https://www.rsb.org.uk/images/Policy/RSB_response_to_HoC_STC_An_Immigration_system_that_works_for_science_and_innovation_inquiry_for_submission.pdf

in the two sectors, on items such as publications/ grant awards versus product development, and conditions of employment).

3. **The effectiveness of and balance between the different available UKRI/Government levers for encouraging innovation, including:**

3.1. **R&D tax credits, the Small Business Research Initiative (SBRI), Innovate UK loans and grants, measures proposed in the 'patient capital' review, and other initiatives**

3.1.1. Innovate UK (IUK) has a strong reputation in the sector. While IUK's budget increased over 200% between 2011/12 to 2017/18, this was from the low starting point of £301m. In the planned funding allocations, IUK's budget will increase from £714m in 2017-18 to £906m in 2019-20, however, £211m of this is tied up in the ISCF wave 2. The government has therefore not yet delivered on its commitment in the Autumn Statement 2016 of a "substantial increase in grant funding through Innovate UK," apart from via ISCF.

3.1.2. Sector specific funding, such as IUK grants and the Biomedical Catalyst, provide assurance to companies and overseas investors that the sector can have access to some long-term dedicated funding. While open funding programmes are valuable, they should not replace sector-specific ones.

3.1.3. R&D tax credits and the Patent Box are valuable aspects of the tax regime. On R&D tax credits, a government review in 2015 estimated that for every pound spent on R&D tax credits, between £1.53 and £2.35 is additionally spent on R&D by UK companies[57]. Ensuring that HMRC can promote accessibility to credits for those who wish to invest in UK R&D is important. The Patent Box enhances the global attractiveness of the UK for companies that obtain profits from patents.

3.1.4. We have highlighted in 2.3.3 the existence of a 'translational gap' in sources of funding for research that is in the early stages of commercialisation. We have commented in responses to earlier parliamentary inquiries that such gap is "a barrier to work on validating and developing new innovations at scale or in relevant environments (i.e. at technology readiness levels 4-6). This applies to small spin-outs from academia, which cannot afford initial outlay without support"[58]. Alongside attracting big companies and stopping their exodus from the UK, the aim of the Industrial strategy should be to "achieve a high level of engagement with life science companies across all relevant industries, and across all sizes of company. […] The responsibility (in the implementation of the Industrial Strategy) should not be limited to larger organisations; SMEs could also have a role in

[57] HM Revenue & Customs (2015). Evaluation of Research and Development Tax Credit. URL: https://www.gov.uk/government/publications/evaluation-of-research-and-development-tax-credit

[58] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. Paragraph 2.12, page 2. URL: https://www.rsb.org.uk/images/RSB_response_Life_Sciences_Industrial_Strategy_inquiry_submitted.pdf

implementation of the Strategy, so that all views from the sector are represented. As many SMEs are spin-outs from the academic sector, their inclusion brings in this voice also"[59].The Enterprise Investment Scheme (EIS), which offers tax relief for SMEs that invest in UK R&D encourages investment, and forms part of what needs to be a concerted effort to make investing in UK R&D as attractive as possible, as well as managing the risk involved for smaller investment.

3.1.5. Improved knowledge exchange programmes, such as Innovate UK's Knowledge Transfer Partnerships, and engagement between public and private sector is needed. Improvements could be mediated by funding internships for masters and Ph.D. students to spend terms or semesters working in the private sector to build experience among the researcher community and to build networks.

3.1.6. Additionally, there should be support for prototyping and scaling facilities within UK universities to help facilitate the validation and translation of research with commercial potential. This could act to ensure transparency and potentially enable reduction of the risks involved with this research transfer process, thereby facilitating a faster process to economic impact with industrial partners.

4. **The most appropriate phasing of the increase in R&D spending by UKRI over the next few years, in order to meet the Government's 2.4%/3.0% of GDP targets, and what if any changes will be needed in the forthcoming 2019 Spending Review to deliver these targets**

4.1. The research community is keenly anticipating Government's "clear strategy for increasing total UK investment to 2.4% of GDP, which addresses issues such as under-funding by business and the potential loss of EU funding"[60]. The life science sector is also interested in the Government's phasing strategy and keen that it to move as quickly as possible to offset historic underinvestment in R&D and move beyond the OECD average expenditure in order to be in the upper quartile of OECD R&D spending over the next 5 years[61].

4.2. Meeting 2.4% will be a challenge but must be the beginning and not the end of a process to capitalise on the UK's established excellence and not allow it to wither. The period after reaching 2.4% and while moving towards 3% will provide a timely opportunity to review the impact of increased funding for R&D and to propose gearing solutions to fine tune mechanisms to ensure the improved funding environment benefits the right areas.

[59] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. Paragraph 14.3, page 18. URL: https://www.rsb.org.uk/images/RSB_response_Life_Sciences_Industrial_Strategy_inquiry_submitted.pdf

[60] House of Commons Committee on Public Accounts, (2018). Research and Development Funding across government, Thirty-third Report of Session 2017 – 19 (March 2018). Recommendation 1, page 5. URL: https://publications.parliament.uk/pa/cm201719/cmselect/cmpubacc/668/668.pdf

[61] Sir John Bell, (2017). Life Sciences Industrial Strategy - A report to government from the life sciences sector. Page2. URL: https://www.gov.uk/government/publications/life-sciences-industrial-strategy

4.3. It may be challenging to capture correlations between R&D expenditure and changes in GDP, or to pin-point the underlying factors. It was noted by analysts that "in the United States […] patent applications began three years after funding and continued for up to 15 years. In medicine, the lag from initial public R&D investment to the development of new drugs can exceed two decades"[62].

5. Assumptions about the public/private mix in delivering the 2.4%/3.0% of GDP targets, the extent past patterns will be replicated in future and the levers that can be used to increase private sector spend on R&D

5.1. Historically public investment in R&D in the UK has crowded in private investment, and publicly funded researchers are highly likely to engage with the private sector. We have noted "the growth of research hubs and networks, enlarging the Catapult and Catalyst schemes, and developing larger public-private partnerships" as part of increasing of the private sector spend on R&D. Catalyst funding, encouraged GSK to develop collaborations with the Universities of Strathclyde and Birmingham, and the BBSRC Networks in Industrial Biotechnology and Bioenergy (NIBB), which encourage collaborations between academia and industry and generated a strong sense of community. Funding for the Catalyst and NIBB schemes has not continued, "leaving previously funded Feasibility Projects without follow-on funding opportunities […]. The recently-announced closure of the Precision Medicine Catapult is a regrettable loss of a dedicated centre for supporting this critical area of medicine"[63].

5.2. There is strong evidence that both IUK and Biomedical Catalyst grants leverages private investment.[64]. It is vital that the government commits to continuing the Biomedical Catalyst beyond 2020-21.The government should look for similar opportunities in areas as agri-tech and agri-food[65].

5.3. In order to maintain the current approximate ratio of private to public investment of 2:1 we will need to maintain the attractiveness of UK environment for investment – otherwise reaching the 2.4% target will place greater strain on the public purse. Companies like the available talent pool in the UK, in particular the good supply of graduates and postgraduates and ease of access to the international talent pool. University and mobility policies are very important in this respect.

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[62] https://www.natureindex.com/news-blog/measuring-the-impact-of-r-and-d-spending

[63] The Royal Society of Biology, (2017). Response from the Royal Society of Biology to the House of Lords Science and Technology Committee inquiry into Life Sciences and the Industrial Strategy. Paragraph 1.10, page 4.

[64] For example, Biomedical Catalyst grants to businesses totalling £130 million leveraged over £100 million of additional private capital for the projects. In addition, those companies went on to raise over £1bn in further private finance.URL: https://www.bioindustry.org/uploads/assets/uploaded/11a19dc6-ed68-422d-ac3a3a2dce128718.pdf

[65] "Research in agriculture and other land-based industries has been underfunded for decades. There are a declining number of researchers in some specialisms (areas such as agronomy, weed science, crop physiology and forest ecology have been brought to our attention). The technological advances that have brought about the bioeconomy are anticipated to drive transformational changes in agriculture, for instance accelerating the breeding of more resilient crops and developing smart crop protection systems (Karp et al., Nature Plant 2015)" from the RSB response to BEIS Consultation on the 'UK Bioeconomy'. URL: https://www.rsb.org.uk/images/RSB_response_to_the_BEIS_Bioeconomy_consultation_Final_response.pdf

5.4. Third parties or 'intermediary forums' (both national and international), which sit between researchers and research users "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"[66]. Learned societies play a crucial role in the promotion of science as well as collaboration between researchers, institutions, business and government. They are repositories of information and unique in their ability to drawn on sector-wide experts from across the UK and beyond rather than departmental specialisms. Learned societies have a significant role to play in communicating the work of their members to business, government and the wider public alike.

The Society welcomes the Committee's inquiry on the 'Balance and effectiveness of research and innovation spending'. We are pleased to offer these comments, which have been informed by specific input from our members and Member Organisations across the biological disciplines (Appendix 4). 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; alessandro.coatti@rsb.org.uk

[66] The Royal Society of Biology, (2015). Response from the Society of Biology to the Dowling Review of collaborations between businesses and university researchers. Paragraph 7, page 2. URL: https://www.rsb.org.uk/images/Society_of_Biology_Response_-_DOWLING_REVIEW_2015.pdf

Additional material and appendices

Appendix 1

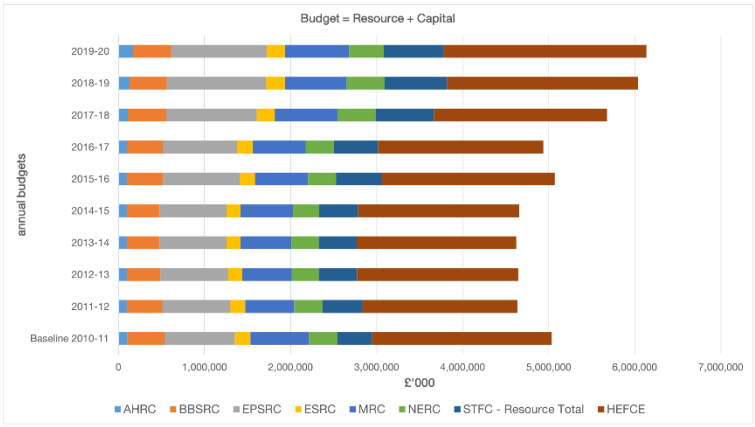
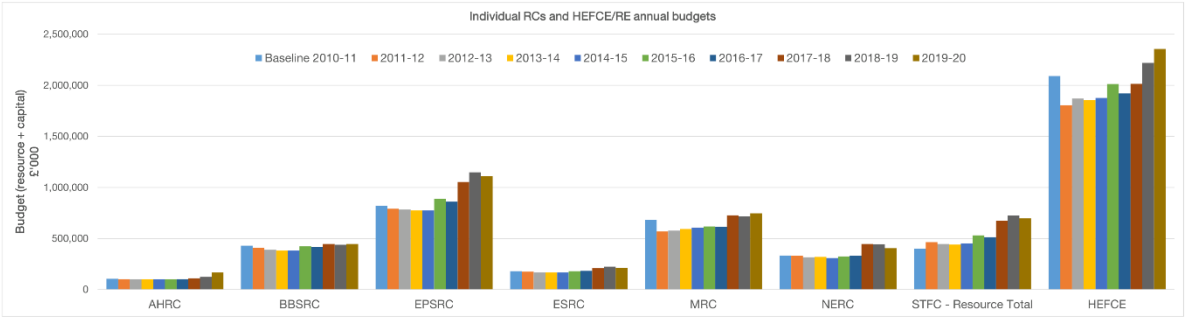


Figure 1A

Figure 1B



Data about allocation of science and research funding was gathered from the following sources[67]:

- For the years 2010-2015: Department for Business, Innovation & Skills. Science and research funding allocation: 2011 to 2015. URL: https://www.gov.uk/government/publications/allocation-of-science-and-research-funding-2011-12-to-2014-15
- For the years 2015-2016: Department for Business, Innovation & Skills. The allocation of science and research funding 2015/16. URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332767/bis-14-750-science-research-funding-allocations-2015-2016-corrected.pdf
- For the years 2016-2017: Department for Business, Innovation & Skills. The allocation of science and research funding 2016/17 to 2019/20. URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/505308/bis-16-160-allocation-science-research-funding-2016-17-2019-20.pdf
- For the years 2017-2021: Department for Business, Energy & Industrial Strategy. The allocation of funding for research and innovation. URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/731507/research-innovation-funding-allocation-2017-2021.pdf

[67] Excel spreadsheets with the data can provided upon request to alessandro.coatti@rsb.org.uk

These data are used in the following table, too.

Appendix 2

BUDGET	Baseline (annual average 2010-2016)	2017-18	2018-19	2019-20	annual average (2017-20)	% budget increase after UKRI inception	Ranking based on budget increase
	£'000	£'000	£'000	£'000			
Research Councils	2,930,761	3,664,000	3,817,000	3,780,000	3,753,667	28	
AHRC	99,737	110,000	124,000	167,000	133,667	34	6
BBSRC	403,977	446,000	438,000	445,000	443,000	10	1
EPSRC	812,603	1,052,000	1,148,000	1,110,000	1,103,333	36	7
ESRC	173,330	210,000	224,000	211,000	215,000	24	4
MRC	607,336	727,000	717,000	746,000	730,000	20	3
NERC	322,549	445,000	441,000	404,000	430,000	33	5
STFC - Resource Total	462,515	674,000	725,000	697,000	698,667	51	8
HEFCE / Research England	1,917,001	2,013,000	2,217,000	2,355,000	2,195,000	15	2
Total RC + HEFCE	4,799,047	5,677,000	6,034,000	6,135,000	5,948,667	24	

Fraction of total RC budget to individual councils (percentage)	Baseline (average 2010-16) (%)	UKRI budget (average 2017-20) (%)	change over baseline (%)
AHRC	3.5	3.6	0.1
BBSRC	14.0	11.8	-2.2
EPSRC	28.2	29.4	1.2
ESRC	6.0	5.7	-0.3
MRC	21.1	19.4	-1.6
NERC	11.2	11.5	0.3
STFC - Resource Total	16.0	18.6	2.6
	100	100	
BBSRC+MRC+NERC combined funding (as percentage of all RC funding)	46.3	42.7	-3.6

In blue, the average of funding allocations to individual research councils (RCs) and HEFCE over the years 2010-2016, obtained from BIS/BEIS publications (cited in the previous page).
In red, the funding corresponding to the current and coming years, which is administered by UKRI.

The additional budget devoted by Government to the R&D sector (after the 2016 Statement and 2017 Budget) impacted positively on the budget of all RCs and HEFCE (now part of Research England). However, the percentage increase over the next three years relative over the average baseline funding for the years 2010-2016 is variable. The BBSRC is the one that grows less with a 10% increase (ranked 1, the lowest amongst UKRI organisations) while the STFC is the one that grows the most (51% increase).

The overall RC budget is apportioned to individual councils in a roughly similar way, pre and post-UKRI. However, we note a combined decrease in funding allocated to the councils (BBSRC, MRC and NERC) that all fund research in the life sciences. Their corresponding combined fraction goes from 46.3% to 42.7%, a modest decrease of 3.6%.

To note: the funding allocations to councils exclude the crosscutting National Priority Investment Fund and the Official Development Assistance Fund. For the years 2010-2016, the figures of budget allocation consist of both resource and capital.

Appendix 3

Rank	UOA	UOA name	Main panel	Profile Type	4*	3*	2*	1*	U/C	Total quality outcomes multiplied by weightings (4:1)
1	1	Clinical Medicine	A	Overall	1.56	0.44	0	0	0	**2.00**
2	2	Public Health, Health Services and Primary Care	A	Overall	1.56	0.41	0	0	0	**1.97**
3	5	Biological Sciences	A	Overall	1.48	0.46	0	0	0	**1.94**
4	4	Psychology, Psychiatry and Neuroscience	A	Overall	1.52	0.4	0	0	0	**1.92**
5	6	Agriculture, Veterinary and Food Science	A	Overall	1.4	0.41	0	0	0	**1.81**
6	31	Classics	D	Overall	1.36	0.42	0	0	0	**1.78**
7	8	Chemistry	B	Overall	1.12	0.63	0	0	0	**1.75**
8	3	Allied Health Professions, Dentistry, Nursing and Pha	A	Overall	1.24	0.5	0	0	0	**1.74**
9	29	English Language and Literature	D	Overall	1.32	0.41	0	0	0	**1.73**
10	9	Physics	B	Overall	1.12	0.6	0	0	0	**1.72**
11	10	Mathematical Sciences	B	Overall	1.16	0.55	0	0	0	**1.71**
12	18	Economics and Econometrics	C	Overall	1.2	0.48	0	0	0	**1.68**
13	30	History	D	Overall	1.24	0.44	0	0	0	**1.68**
14	32	Philosophy	D	Overall	1.24	0.42	0	0	0	**1.66**
15	13	Electrical and Electronic Engineering, Metallurgy and	B	Overall	1	0.62	0	0	0	**1.62**
16	28	Modern Languages and Linguistics	D	Overall	1.2	0.42	0	0	0	**1.62**
17	15	General Engineering	B	Overall	1.04	0.56	0	0	0	**1.60**
18	12	Aeronautical, Mechanical, Chemical and Manufacturir	B	Overall	1	0.57	0	0	0	**1.57**
19	16	Architecture, Built Environment and Planning	C	Overall	1.16	0.4	0	0	0	**1.56**
20	25	Education	C	Overall	1.2	0.36	0	0	0	**1.56**
21	7	Earth Systems and Environmental Sciences	B	Overall	0.96	0.59	0	0	0	**1.55**
22	35	Music, Drama, Dance and Performing Arts	D	Overall	1.16	0.39	0	0	0	**1.55**
23	20	Law	C	Overall	1.08	0.46	0	0	0	**1.54**
24	27	Area Studies	D	Overall	1.12	0.42	0	0	0	**1.54**
25	36	Communication, Cultural and Media Studies, Library	D	Overall	1.16	0.38	0	0	0	**1.54**
26	23	Sociology	C	Overall	1.08	0.45	0	0	0	**1.53**
27	14	Civil and Construction Engineering	B	Overall	0.96	0.56	0	0	0	**1.52**
28	21	Politics and International Studies	C	Overall	1.12	0.4	0	0	0	**1.52**
29	33	Theology and Religious Studies	D	Overall	1.12	0.4	0	0	0	**1.52**
30	17	Geography, Environmental Studies and Archaeology	C	Overall	1.08	0.42	0	0	0	**1.50**
31	22	Social Work and Social Policy	C	Overall	1.08	0.42	0	0	0	**1.50**
32	24	Anthropology and Development Studies	C	Overall	1.08	0.42	0	0	0	**1.50**
33	11	Computer Science and Informatics	B	Overall	1.04	0.44	0	0	0	**1.48**
34	19	Business and Management Studies	C	Overall	1.04	0.43	0	0	0	**1.47**
35	34	Art and Design: History, Practice and Theory	D	Overall	1.04	0.42	0	0	0	**1.46**
36	26	Sport and Exercise Sciences, Leisure and Tourism	C	Overall	1	0.41	0	0	0	**1.41**

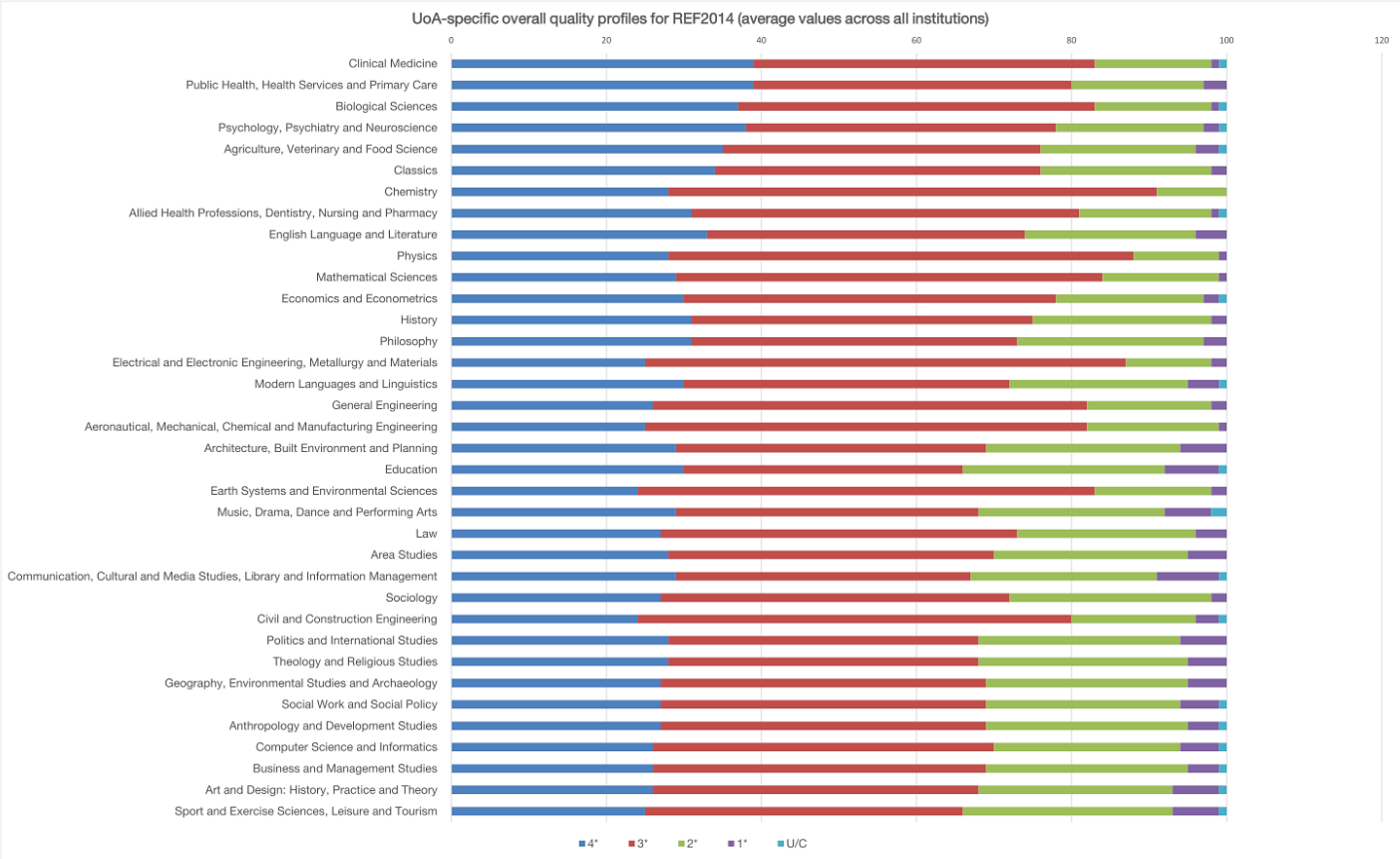
Based on the methods described to allocate quality-related funding[68], the average overall quality profile for each UoA[69] (which is a weighted combination of the output, impact and environment assessment) is here considered and category-normalised to 1 (namely, the sum of quality levels for each UoA, from unclassified to 4*, adds to 1; this initial normalisation is not shown here). Only research of quality 3* or greater is considered for funding allocation, therefore columns 2* or below are not taken into account (zero values in the table above). These profiles are further quality-weighted to give research at 4* level a 4:1 weighting ratio relative to research at 3* level. The final column in the table above sums up the contribution of 4* and 3* research and gives an idea of which disciplines score higher in terms of the overall quality of their research. To note, the exact allocation of money also depends of the volume of research (based on the number of submitted-active staff) and the subject cost weights (reflecting, for example, the fact that

[68] http://webarchive.nationalarchives.gov.uk/20180319130913/http://www.hefce.ac.uk/rsrch/funding/mainstream/

[69] Mainstream QR funding is first separated into three 'pots' according to the contribution that the three elements of research assessed in the Research Excellence Framework (REF) make to overall quality profiles (65 per cent for outputs, 20 per cent for impact and 15 per cent for environment). The values in the table above are the overall profile values for each UoA, averaged across all institutions that submitted to REF2014.

laboratory-based research is more expensive than library-based research), both these parameters are not included in this analysis.

In following graph, depicting the UoA specific overall quality profiles for REF2014, the overall quality profiles for all units of assessments are shown as average percentages of all submissions in each UoA meeting the standards for 4*, 3*, 2*, 1* and unclassified. The UoA are ordered top-down based on descending overall quality according to the HEFCE's quality-weighting of 4*:3* research in a 4:1 ratio computed in the previous table and used to direct funding allocations. Bioscience-related disciplines are represented in the top five UoA, based on the overall excellence assessed by REF2014.



Appendix 4: 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 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 of Plant Breeders
British Society for Plant Pathology
British Society for Proteome Research
British Society for Research on Ageing
British Society of Animal Science
British Society of Soil Science
British Society of Toxicological Pathology
British Toxicology Society
Daphne Jackson Trust
Drug Metabolism Discussion Group
Fisheries Society of the British Isles
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 Field Studies Council
The Physiological Society
The Rosaceae Network
Tropical Agriculture Association
UK Environmental Mutagen Society
UK-BRC – Brassica Research Community
University Bioscience Managers' Association
Zoological Society of London

Supporting Organisational Members
Affinity Water
Association of the British Pharmaceutical Industry (ABPI)
AstraZeneca
BioIndustry Association
Biotechnology and Biological Sciences Research Council (BBSRC)
British Science Association
CamBioScience
Envigo
Ethical Medicines Industry Group
Fera
Institute of Physics
Ipsen
Medical Research Council (MRC)
MedImmune
Northern Ireland Water
Pfizer UK
Porton Biopharma
Procter & Gamble
Royal Society for Public Health
Syngenta
Understanding Animal Research
Unilever UK Ltd
Wellcome Trust
Wessex Water
Wiley Blackwell