Written submission by the British Pharmacological Society to the Industrial Strategy Green paper

The British Pharmacological Society (BPS) is the primary UK learned society concerned with research into drugs and the way they work. The Society has around 4,000 members working in academia, industry, regulatory agencies and the health services, and many are medically qualified. The Society covers the whole spectrum of pharmacology, including laboratory, clinical, and toxicological aspects. Pharmacology is a key knowledge and skills base for drug development in the pharmaceutical and biotech industries, and is therefore fundamental to a thriving UK pharmaceutical and healthcare industry and the future of research and development. The Society publishes three scientific journals: the British Journal of Pharmacology, the British Journal of Clinical Pharmacology, and Pharmacology Research and Perspectives.

The Society would be happy to discuss our response in more detail. Please contact Dr Anna Zecharia (Head of Education, Training & Policy) via anna.zecharia@bps.ac.uk

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Consultation questions

1. Does this document identity 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?

1. We support the proposed areas of focus and believe that, when read alongside the ten pillars, these have the potential to provide an overarching structure for the 'Sector Deal' approach set out in the green paper. However, we would also like to note that there are potential benefits to combining a social mission approach to industrial strategy. In particular, directing focus to key areas of challenge or potential impact could have the advantage of stimulating economic activity across multiple sectors.

2. The Society is a stakeholder in the Life Sciences Sector deal as a point of contact, brokerage and support for pharmacologists across academia, the NHS and industry. Our response to this green paper is made in the context of changes to the UK Life Sciences landscape and the challenges and opportunities that this brings. The shift in the UK pharmaceutical industry over the last decade has been significant[1]. The landscape is fragmented with a reduced footprint of large multinational pharmaceutical companies, in favour of an increase in small and mid-sized companies, contract research organisations (CROs) and academic drug discovery centres. This shift in the company landscape mirrors a shift in research and development activity in the UK. The ABPI note that:

> *"These data reflect a dynamic and changing drug discovery landscape in the UK. Large companies are increasingly moving to a networked model for early drug discovery; combining in-house strengths, with external outsourcing and collaboration. Internal laboratory staff in large companies have decreased, but staff coordinating global activities have increased. There are also trends towards increases in drug discovery employment in specialist service providers, and smaller companies. Overall, however, there are indications that the UK is losing out relative to wider global investment."*

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[1] The Association of the British Pharmaceutical Industry, The Changing UK Drug Discovery Landscape, 15 August 2016, http://www.abpi.org.uk/our-work/library/industry/Documents/the-changing-UK-drug-discovery-landscape.pdf (accessed 11 April 2017).

Extending our strengths

3. The green paper recognises the Life Sciences and as part of this, drug discovery, as a significant UK strength. The Society believes that these strengths span three key areas and that building on them is central to the success of industrial strategy:

A. An excellent science base
    - The UK represents just 0.9% of global population, 3.2% of R&D expenditure, and 4.1% of researchers, it accounts for 9.5% of downloads, 11.6% of citations and 15.9% of the world's most highly-cited articles[2]

B. Access to research partners through a high density research community
C. Access to patients and real-world data through the NHS.

4. A recent report from the ABPI indicates that UK Life Sciences contributed £30.4bn to the economy, supported almost half a million jobs and contributed £8.6bn to the Exchequer in 2015.[3] There is huge potential to develop a Life Sciences strategy that protects the UK's strong science base, access to the NHS and thus patients for clinical trials and capacity in translational research and clinical trial delivery. It is also important that such a strategy makes full use of the diverse UK talent pool, removing barriers to access and progression for people across a range of careers. Therefore, investment in the UK Life Sciences sector is expected to deliver a strong economic return.

5. In terms of impact, Research Councils UK (RCUK) released impact statements[4] from the various councils in March 2017 summarising the impacts as follows:

- *"In 2016 Medical Research Council (MRC) funded research provided the first UK-specific estimate of spill-over benefits from medical research. The analysis concluded that investment in medical research had stimulated the private sector to invest more in UK research and development, equivalent to a return on investment from public and charitable funding for medical research of 15-18 per cent. When added to the health gain from cardiovascular disease and cancer research, the total return on investment from medical research is estimated to be 24-28 per cent."*[5]
- *"Including historical data, and data submitted to researchfish in 2014, Biotechnology and Biological Sciences Research Council (BBSRC)*[6] *has identified 374 spin-out companies with links to BBSRC investments. Of those, 267 were still active in 2016, employing 2,375 people in the UK"*

6. In addition, the Society is collaborating with Cranfield University to explore the impact in the context of drug discovery and development through analysis of impact case study submissions to the 2014 Research Excellence Framework exercise (REF2014). We explored how research problems were formulated, what forms of cross-disciplinarity were employed, and what channels of knowledge transfer, translation and negotiation were utilised. We also focused on the role(s) that pharmacology plays in drug discovery impact, specifically whether pharmacologists acted in leading, key partnership or

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[2] Elsevier, International Comparative Performance of the UK Research Base, 2013, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263729/bis-13-1297-international-comparative-performance-of-the-UK-research-base-2013.pdf (accessed 11 April 2017).

[3] Pricewaterhouse Coopers, The Economic contribution of the UK Life Sciences Industry, March 2017, http://www.abpi.org.uk/our-work/library/industry/Documents/The_economic_contribution_of_the_UK_Life_Sciences_industry.pdf (accessed 11 April 2017).

[4] RCUK, Impact of £3.4Bn investment demonstrates the UK place as a global leader in research and innovation, 27 March 2017, http://www.rcuk.ac.uk/media/news/170327/ (accessed 11 April 2017).

[5] MRC, 24 March 2017,https://www.mrc.ac.uk/news/browse/impact-report-shows-healthy-return-on-public-medical-research-spending/ (accessed 11 April 2017)

[6] BBSRC, Delivering a healthy, prosperous and sustainable future, Impact Report 2016, http://www.bbsrc.ac.uk/documents/impact-report-2016-pdf/ (accessed 11 April 2017).

supporting roles. We would be happy to discuss this work. Our initial findings indicate that pharmacology is integral to delivering impact in drug discovery and development:

- We assessed impact case studies submitted to REF 2014 for impact in drug discovery and development, comparing database tagging of pharmacology case studies with that determined through expert analysis. Analysis of 268 case studies showed that pharmacology contributions assessed through using tagging in the publicly accessible REF impact case study database (50 case studies) are a significant underestimate of actual pharmacological involvement (176 case studies)
- Further, looking at all 268 case studies, pharmacology acted as a partner or supporting discipline in 51% of studies, leading the work in a further 15%.
- Pharmacology made contributions to impact in drug discovery and development across pre-clinical and clinical work
- We recommend that REF2021 should include data collection mechanisms that allow submissions to be used as both a research and assessment tool, and have communicated this to HEFCE as part of their consultation.

Therefore, our response focuses on the key themes that we believe will bring increased cohesion across a fragmented sector:

- Building strong and trusted relationships
- Coordination of funding mechanisms
- Access and mobility

Closing the gaps

Removing barriers to equality

7. The Society welcomes the Prime Minister's foreword, which stated the desire to make Britain "a country that really does work for everyone." The Society would like to see fuller consideration of how investment in the strategy will reduce inequality in the UK in an inclusive and coordinated way, from the education system through to democratising access to funding, networks and jobs. The UK operates an increasingly liberal welfare regime, favouring low levels of decommodification (allocation of social services as a matter of right, e.g. shifting a greater proportion of the cost of higher education onto the student) and high levels of stratification (the social hierarchy produced by welfare state policies).[7] The high stratification may be observed in research commissioned by the Society that indicates that 27% of pharmacology students came from the highest socioeconomic bracket in 2014, compared to 22% in 2007. Only 5% of students accepted onto pharmacology courses are from the lowest socioeconomic bracket. This is reflective of trends in comparable subjects and indicates that the life sciences are not reaching the full range of talent through graduate entry. King's College London noted that building 'science capital' through awareness and experience of a pathway, and engagement with role models within it, are pre-requisites to following any career path, as shown at a school level by the ASPIRES project.[8]

8. In light of this, the Society supports widening participation approaches that target engagement with schools without access to science capital and that leverage relationships across academia, industry and the learned societies to build this.

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7 Willemse & de Beer (2012), *Journal of European Social Policy*, 22(2), 105-17.
8 King's College London (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 (accessed 11 April 2017)

9. These principles of democratising awareness, experience and access should be applied across career decision points (e.g. promotion, access to grant funding) and embedded in the processes that shape this landscape. For example, setting up UKRI is a huge opportunity to ensure an inclusive approach to research across the board. Diversity and inclusion should be embedded across decision-making and UKRI has an opportunity to do this – both enshrining the principle of equality and removing barriers that are currently preventing the UK from realising the potential of its talent pool.

10. The Society agrees with the points raised by Professor Sir Paul Nurse in his review of the UK Research Councils regarding diversity and his recommendation that *'Diversity should be protected in researchers, approaches and locations – recognising that novel approaches and solutions to problems sometimes emerge more readily outside the mainstream. The best research should be funded wherever it is found.'*

11. More precisely, as discussed by Nurse, in order to ensure that research is as successful as possible and reflects diversity, the following points must be adhered to:

- Diversity on grant panels is essential, but panel cohesion must also be ensured. Acknowledging that it is more difficult to recruit panel members from the commercial sector and under-represented communities is important and high quality engagement with these communities is therefore vital
- Funding mechanisms should be available for pilot, project and programme research support and available for researchers at all stages of their career. Constructing 'best practice' in research funding is therefore advisable.
- Doctoral training programmes must be flexible to ensure graduate students can be supervised by a diverse range of quality researchers
- Research Councils must strengthen links to the research community and ensure diversity in funding options.

12. We note the emphasis on "inclusive growth" in the green paper, and the wider acceptance that the drive for economic growth at a national level must be balanced with effective wealth redistribution policies. Within the context of higher education policy, care must be taken to ensure that policies and mechanisms which emphasise concentration of research resources in a small number of elite institutions and clusters do not compromise social cohesion aims[9]. Research carried out by the Society and Cranfield University (see paragraph 6) has established that in the context of drug discovery and development, both research commercialisation (patent licencing and academic venturing) and university-industry collaboration occur across the UK, albeit with a concentration in the London-Oxford-Cambridge triangle. Therefore, as universities take on a role of local anchors of regional growth and development, drug discovery and development should be a prioritised sub-sector, and efforts should be made to familiarise specific Local Enterprise Partnerships with the life sciences sector.

13. We strongly support efforts to improve basic numeracy and literacy as fundamental to increasing both opportunity for individuals and UK productivity as identified by a recent OECD[10] report. However, to convert this investment in education into successful research and companies (through mobile and flexible career pathways), it is vital to invest in the structures that give students, teachers and professionals access to

9 Maassen & Stensaker ,The Knowledge triangle, European higher education policy logics and policy implications, *Higher Education*, Vol 61, Issue 6, 2011.
10 OECD, Building Skills for all: A review of England (2016), https://www.oecd.org/unitedkingdom/building-skills-for-all-review-of-england.pdf (accessed 11 April 2017)

information about careers and to the networks that will help them realise these opportunities.

14. Finally, a potential piece of infrastructure which is currently lacking in the UK is the means to systematically track benefits of publicly-funded research and the effect of changes in research funding on the production of scientists. STAR METRICS[11] is a data platform that is being voluntarily and collaboratively developed by U.S. federal science agencies and research institutions to address a similar problem. Adoption of such a system in the UK might be of use in ensuring a more equitable spread of funding nationally and in identifying skills gaps.

15. Although the green paper takes into account the importance of fair access to educational opportunities for all young people, the Society wishes to highlight that there is no specific reference to the importance of supporting women in STEM. The Women's Business Council (WBC) was set up in 2012 to advise the Government on how to maximise women's economic contribution to the economy, and the Royal Society has done extensive work on equality and inclusion.

16. In 2012, the Council made a variety of recommendations for government and the business community, designed to raise girl's aspirations and maximise women's career opportunities. The approach not only benefits women by enabling them to achieve their aspirational goals, but simultaneously enhances global competitiveness by utilising the talents and skills of women and, maximising returns on investment in education and training.

17. The Society strongly recommends that equality, in terms of access to opportunity for everyone and specifically women, is embedded throughout the strategy. The Society is aware that The Department for Business, Energy and Industrial Strategy has a Diversity Steering Group that is likely to be well-placed to advise on such matters.

18. The new apprenticeships levy ensures business invests in apprenticeships and it puts business in control of apprenticeship provision. The aim is to create the right framework to incentivise business to invest in skills alongside public investment. *'English Apprenticeships: Our 2020 Vision'* includes the commitment to increase the quality and quantity of apprenticeships in England, reaching 3 million starts in 2020.

19. From April 2017, the apprenticeship levy will fund a step change in apprenticeship numbers and quality. The Institute of Apprenticeships will be operational by April 2017, to support quality standards.

- In 2014/15, 51.3% of apprenticeship starts were female but these were mainly in lower paid sectors.
- 55% of those who completed an apprenticeship last year were female.
- Women made up only 5.5% of those who completed a STEM apprenticeship.

More could be done to invest in apprenticeships for older workers**.**

Access to the sector

20. The Society believes that meeting skills needs requires accessible mechanisms for proactive collaboration with educators at all levels. The Society would support a strategy that enables educators to build networks and partnerships between academia and industry in a way that supports responsive integration of needs into education programmes and enhances opportunities for work experience and placements. It is also important to note that future skills needs, particularly those around disruptive

11 STAR METRICS www.starmetrics.nih.gov (accessed 13 April 2017).

technologies may be areas which industries are reluctant to explore, and it is vital that there are established and agreed ways of responding to this, for example through effective links to global innovation clusters as a source of knowledge and foreign direct investment (FDI).

21. As discussed in our response to Question 8, the Society believes supporting the next generation should focus on embedding awareness of what is involved in these careers from an early stage, role models and giving opportunities to embody these behaviours. In brief, such schemes include:

- STEM Insights. This scheme connects teachers with HEIs and industry – investment in it could support teachers as a nodal point for disseminating careers advice and opportunities to students.
- Nuffield Research Placements[12]. These placements prioritise those who attend schools in deprived areas and who do not have a family history of University attendance and therefore believe in the importance of diversity and equality. They seek to provide exposure and experience by providing young people with the opportunity to work with scientists, technologists, engineers and mathematicians. Nuffield placements usually fulfil the criteria for a Gold CREST (Creativity in Science and Technology) award
- CREST Awards[13]. The CREST Awards scheme is the British Science Association's flagship programme for young people. They provide science enrichment activities to inspire and engage five to nineteen year olds. They provide students with the chance of participating in hands-on science through investigations and enquiry-based learning and students are able to progress through the six CREST Award Levels.
- Online mentoring platforms such as Brightside[14] which provide young people with the knowledge, support and connections to make informed decisions and fulfil their potential regardless of background
- Institute for Research in Schools[15] offers a range of projects with the aim of transforming the student and teacher experience of science. By involving them in real science, it is both inspirational for young people and can be considered the best professional development for teachers.
- Alumni networks and those offered by professional bodies, learned societies and organisations like ScienceGrrl[16] are extremely important in this regard. Networks allow people to see the pathways that might be open to them, the training that is required and allow them to build the science capital to enable them to turn this into opportunity.

22. Another aspect is the need for more rounded support for STEM at a school level, including support for teachers, practical skills, work experience and careers advice. Investment in STEM Ambassadors as a mechanism for building science capital for teachers and students, through equipping them with resources and training that support real world learning. The Society is building support for our members in this way, through engagement bursaries and resources. We would be keen to increase our impact as part of a national approach. This is as important in terms of widening participation in STEM as it is for addressing skills gaps.

23. The Society recommends that government considers these initiatives in more detail and suggests working with these and other organisations to provide further opportunities

[12] http://www.nuffieldfoundation.org/nuffield-research-placements (accessed 11 April 2017).
[13] CREST Awards, http://www.crestawards.org/ (accessed 11 April 2017).
[14] Brightside (Online mentoring) http://www.thebrightsidetrust.org/ (accessed 11 April 2017).
[15] The Institute for Research in Schools http://www.researchinschools.org/ (accessed 11 April 2017).
[16] ScienceGrrl, www.sciencegrrl.co.uk (accessed 11 April 2017).

for young people to gather the skills and knowledge required in the UK regardless of their background.

Mobility across the sector

24. Both the Dowling Review[17] and HM Government[18] in their recent responses recognised that support for transfer of ideas, movement of people and commercialisation is critical. The Dowling Review also stressed the need for simplicity and ease of access to collaborations and funding. The top key success factor cited by the review was building 'strong and trusted relationships'. As outlined in our introduction to this question, the Society believes that supporting relationships and networks is critical for success: these relationships are the channels of collaboration.

Building relationships: clusters and Smart Specialisation

25. Another mechanism to close the gaps that arise through fragmentation is to build on mutual strengths through bringing people together in clusters. When choosing where to form clusters however, it is clearly essential to consider the utility of forming them in certain areas to ensure that they are appropriately located. Many universities are now setting up Incubator Type Units to help develop their intellectual property and help foster start-up companies. To avoid 'reinventing the wheel' and helping ensure efforts, resources and expertise are not too thinly spread there needs to be a mechanism for ensuring that the clusters that are set up on a regional basis are supervised and coordinated.

26. Clusters can broadly be divided into those defined on the basis of geography (e.g. Northern Health Science Alliance) or by therapeutic expertise (e.g. Alzheimer's Drug Discovery Alliance, with Institutes at UCL, Cambridge and Oxford). In the UK, geographic clusters would likely benefit from being associated with Catapults and Local Enterprise Partnerships to ensure they have access to relevant knowledge, skills and networks, and we would therefore welcome increased rollout of Smart Specialisation strategies associated with clusters centred on existing academic excellence, for example in the area of translational medicine.

27. Research from the Society indicates that research impact in drug discovery (including spin outs and university-industry collaborations) is distributed across the UK and not solely restricted to the traditional clusters e.g. 'golden triangle' (although it is heavily concentrated here). We see this as an opportunity to be tapped. However, we also note that there are potential downsides to clusters, such as overspecialisation, lock-in, congestion and increasing house prices.[19] It is therefore essential that effective policies, structures and capabilities are built. This includes supporting infrastructure and strategies, and access to private and third sector capital at local and national levels, for example, the What Works Centre for Local Economic Growth[20]. It also includes effective transnational networks to encourage knowledge transfer, FDI and trade. Our analysis suggests that global networks between UK centres of research excellence and foreign industries, in particular spin-outs, are underdeveloped. The Society supports efforts from National Centre for Universities and Business to develop Konfer.Online[21], an online platform for such identification purposes. In addition, RCUK hosts 'Gateway to Research',

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[17] *Business-university research collaborations: Dowling review - government response, 20 December 2016,* https://www.gov.uk/government/publications/business-university-research-collaborations-dowling-review-government-response (accessed 11 April 2017).

[18] Dowling Review of Business-University Research Collaborations (Government Response), December 2016, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/579119/business-university-research-collaborations-dowling-review-government-response.pdf (accessed 11 April 2017).

[19] OECD, Clusters, Innovation and Entrepreneurship, 17 July 2009, http://www.oecd.org/publications/clusters-innovation-and-entrepreneurship-9789264044326-en.htm (accessed 11 April 2017).

[20] What works Centre for Local Economic Growth, http://www.whatworksgrowth.org (accessed 11 April 2017).

[21] National Centre for Universities and Business, http://www.ncub.co.uk/konfer-online.html (accessed 11 April 2017.)

[22]which is a widely-used system that allows users to "search and analyse information about publicly funded research".

Starting/growing a business

28. The Society agrees that it is hugely important that the UK is one of the most attractive places to start/grow a business. Commercialisation of research by academia has recognised and measured risks where they are well known. Attrition is a huge problem within drug discovery and the subsequent development process e.g. target identification and transitions from phase II and II trials. For every 10, 000 lead compounds identified, only 1 reaches the market authorisation stage. Research from Tufts University expands on this and shows the cost of bringing a new drug to market as over $2.5 billion[23] and as having a typical timescale of 10 years. Funding mechanisms that help de-risk drug discovery are essential, particularly to support early translational work. De-risking later successes is about unmasking failures as early as possible. This needs to be reflected in the messaging of funding schemes and the culture of drug discovery in an academic setting, by ensuring there are supplementary mechanisms to protect and support an academic career. The two major pitfalls are at the target identification stage and at phase 2 and 3 trials. To bridge these gaps, support for cross-disciplinary working and early access to human data respectively are needed. Applying each of our key themes (strong relationships, co-ordinated funding and access/mobility) would help solve these problems and through increasing the success of the drug discovery process, will have a ripple effect into the development of successful businesses that are capable of commercialising academic research and growing.

29. The pharmaceutical sector has recently shifted away from in-house R&D and towards collaborations with academia and/or university spin-outs, pre-competitive research consortia and contract research organisations in an effort to improve innovation and reduce costs and risk[24]. This has led to a plethora of new technology-based firms (typically university spin-outs) which are distributed across the UK and which build local and regional innovation capabilities through ongoing collaboration with host institutions and job creation. However, life sciences New technology based firms (NTBFs) are not well represented in rankings of fastest growth science-based companies in the UK. For example, the Royal Society Science 50 Index[25] lists only three life sciences companies within the 50 fastest growing NTBFs. Furthermore, the UK lags behind the US and other leading economies in the relative proportion of scale-up companies.[26]

30. The Society would therefore welcome support for life sciences NTBFs in the below-mentioned areas. In particular, we would regard support for NTBFs which operate in the early phases of target identification and translation for drug discovery as a strategic priority.

[22] RCUK http://gtr.rcuk.ac.uk/ (accessed 12 April 2017).
[23] DiMasi JA, Grabowski HG, Hansen RA. Innovation in the pharmaceutical industry: new estimates of R&D costs. Journal of Health Economics 2016;47:20-33.
[24] The Association of the British Pharmaceutical Industry, The Changing UK Drug Discovery Landscape, 15 August 2016, http://www.abpi.org.uk/our-work/library/industry/Documents/the-changing-UK-drug-discovery-landscape.pdf (accessed 11 April 2017).
[25] Royal Society (2014), http://www.svc2uk.com/the-royal-society-science-50-index/ (accessed on 07 Apr 2017)
[26] Coutu (2014), The Scale-up Report on UK Economic Growth, http://www.scaleupreport.org/scaleup-report.pdf (accessed 11 April 2017.)

a. Productivity. We note the recent claim by Andrew Haldane[27], Chief Economist at the Bank of England, that the performance of UK firms is highly skewed with a long tail of poor performing firms, and that a contributing factor to this is poor management skills. We look forward to recommendations which emerge from the Mayfield Productivity Council.
b. Scale-up. It is recognised within the field of science & technology studies that sustainable advantage does not come from new technologies alone, but from better business models that are co-evolved and integrated with those technologies.[28] Therefore, focus must not only be placed on value creation (identification of and engagement with innovation customers) but also on value capture (delivery and monetisation of innovation).
c. Access to private capital. Funding mechanisms to de-risk drug discovery and translational activities are crucial, as outlined above. This could take the form of public funding. In addition, our analysis shows that most drug discovery NTBFs accessed venture capital. Mechanisms to improve access are needed, and the Society is also concerned that the culture of venture capital funding in the UK (drip-feeding small amounts based on outcomes) needs improvement. In the US, venture capital funding is more likely to be larger amounts over longer periods of time. This gives a more supportive framework for research and commercialisation. We therefore look forward to recommendations which emerge from the on-going Patient Capital review.
d. Foreign Direct Investment (FDI). Drug discovery is a global business and the UK is already attracting FDI in this area. However, the Society's own research has indicated that FDI from non UK-based multi-national corporations and particularly NTBFs appears underdeveloped. As the UK seeks to forge new international trade links, we would welcome new opportunities which emerge.

Leaving the EU

31. Whilst recognised within the narrative, the green paper gives insufficient attention to the potential impact of exiting the EU. The Society believes that this needs to be taken into account in much more detail. The number of EU citizens currently working and studying in the UK is extremely high. Available data from 2015 suggests that approximately 3.2 million EU migrants are living in the UK.[29] Provisional International Passenger survey (IPS) data[30] from the year ending June 2015 suggests that 47,000 EU nationals came to the UK to study.

32. It is therefore essential to consider how industry would function without these individuals, in addition to future EU citizens being dissuaded from coming to the UK. There is therefore a need for Government to clarify the situation regarding movement and provide certainty to EEA nationals which will ensure that the skills of such individuals are not 'lost'. As noted in the Society's response to the Leaving the EU inquiry of the

[27] Haldane (2017), http://www.lse.ac.uk/website-archive/newsAndMedia/videoAndAudio/channels/publicLecturesAndEvents/player.aspx?id=3789, (accessed on 07 Apr 2017)
[28] Chesbrough (2010), Long Range Planning, Vol.43, Issues 2-3, 364-363.
[29] Migration Statistics, House of Commons Library, Briefing Paper, 7 March 2017 http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06077 (accessed 11 April 2017).
[30] Population Briefing. International Student Migration: What do the statistics tell us?, January 2016, https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwicuey1nZLTAhVsK8AKHQGgD0gQFggaMAA&url=https%3A%2F%2Fwww.ons.gov.uk%2Ffile%3Furi%3D%2Fpeoplepopulationandcommunity%2Fpopulationandmigration%2Finternationalmigration%2Farticles%2Flongtermmigrationalmigration%2Finternationalstudentmigrationwhatdothestatisticstellus%2Finternationalstudentmigrationtcm77431150.pdf&usg=AFQjCNGhJfJCl18wWebT6th7u3S2Bgxj4g&sig2=OyAroV4VKsYW44_gY3ectQ (accessed 11 April 2017).

Science and Technology committee[31], there is a clear risk associated with exiting the EU in regards to a skills shortage in the science sector.

33. Further, the Certificate of Completion of Training (CCT) programme in Pharmaceutical Medicine run by the Faculty of Pharmaceutical Medicine is recognised internationally as one of the few places in the world that doctors can get specific training to work in the pharmaceutical industry and the Regulatory Agencies. The Faculty tells us that many postgraduate medics come to the UK for this purpose and the majority come from the EU due to free movement of the workforce. Losing this will affect the training programmes and availability of skilled people to the industry: currently approximately 50% of Pharmaceutical Medicine CCT trainees from outside the UK. Please see our response to Question 5 regarding potential solutions for clinical pharmacology and pharmaceutical medicine skills gaps.

34. The Society's response to the 'Leaving the EU inquiry' of the Science & Technology committee proposed that Government should focus on the following:

- Freedom of movement of researchers, scientists and students
- Access to collaborations and partnerships
- Access to funding and funding strategy
- The opportunity to improve connections with scientists on a global scale
- Legislation and regulation

35. Specifically, we would like to see a commitment to removing students from being counted in official immigration figures. The UK's Higher Education system is internationally recognised.[32] It also makes a significant contribution to the UK economy. The Society is concerned that counting students in this way could negatively affect the sector if international students are deterred from studying in the UK.

36. We also recognise that HEIs are increasingly choosing to internationalise, predominantly in teaching offerings. A number of nations also have begun to adopt internationalisation policies in research and innovation.[33] As an example, Singapore's Smart Nation policy positions the country as a city-sized laboratory for new technology development. The UK has recently signed a 10-year Innovation and Research Partnership with Singapore to encourage innovation diffusion between the two countries. We would recommend that the UK seek to establish more of these partnerships.

37. In regards to collaboration, more than 60% of the UK's internationally co-authored papers are written alongside EU partners. The UK produces 16% of the world's most highly cited articles from only 4.1% of the world's researchers in spite of only representing 1% of the world's population. As international collaborations are often effective ways of producing excellent pieces of research (and aid in the promotion of research), the effects of leaving the EU are necessary to take into account here, too.

38. Access to funding is of particular concern and must be covered in this review. The UK won 16% of research funding from the recent European Framework Programme (FP7) with only 12.7% of the EU-28 population. Horizon 2020 is the largest EU research

[31] Written submission by the British Pharmacological Society to the Leaving the EU inquiry of the Science and Technology Committee, House of Commons, 22 August 2016, https://www.bps.ac.uk/getattachment/About/Policy-positions/Consultation-responses/Articles/Response-to-Leaving-the-EU-inquiry/Leaving-the-EU-inquiry-response-(1).pdf.aspx?lang=en-GB (accessed 11 April 2017).
[32] Times Higher Education World University Rankings 2017 https://www.timeshighereducation.com/world-university-rankings/2017/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats (accessed on 11 April 2017).
[33] OECD, Cluster Policy and Smart Specialisation, (2012), https://www.oecd.org/sti/outlook/e-outlook/stipolicyprofiles/interactionsforinnovation/clusterpolicyandsmartspecialisation.htm, (accessed 07 Apr 2017)

programme, aiming to allocate €74.8 billion for research and innovation from 2014-2020. As such, it is essential that the Government prioritises continuing UK access to such partnerships and develops a clear strategy to address any resulting deficit. MRC, Wellcome, Regional Northern Powerhouse among others all provide "seed money," and many start-ups fail due to lack of sustainable funding pathways. There is a need for transformative investment in public-private-national initiative. Patent-Box and other forms of government funding for start-ups should be reviewed and revitalised where necessary.

39. The Society is concerned about the impact that leaving the EU will have on medicines and other life sciences regulation. Please see our response to Question 2 for more detail.

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

40. The Society agrees that the ten pillars suggested are all important areas to consider in detail. However, although regulation is covered to some extent throughout the green paper, the strategy could be much more substantial if there was a specific pillar for regulation. In developing and seeking approval for new drugs, regulation can be seen as a burden due to unforeseen issues and delays if research and development is not taken into account when introducing legislation or making changes to it. As such, the strategy must create a process which does not impact unnecessarily on the discovery and subsequent development of new drugs. The UK is in a good position to be a leader in regulatory systems for research and development. The Industrial Strategy should take up this challenge with enthusiasm and look to streamline life sciences regulation through the use of regulatory proxies where appropriate (e.g. MHRA/Ethics Committee approvals) and through building 'research use' exemptions into new legislation where otherwise it may have unintended consequences. For example, the Society worked with the ABPI, Academy of Medical Sciences, the Royal Society and others to help define a 'bona fide research' exemption in the Psychoactive Substances Act to avoid unintended consequences on medical research. A 'big picture' approach to regulation as part of a strategy for the life sciences could set the tone for UK leadership.

41. Leaving the EU could have a significant impact on the regulation of medicines, medical devices and *in vitro* diagnostic products within the UK. The regulation of such medicinal products, both for those under development and as approved products in the UK, is heavily reliant on the Regulations and Directives that come from the EC via the European Medicines Agency (EMA). The EMA is a decentralised agency of the European Union (EU) which was created in 1995. Its creation followed the decision by the EU Heads of State and Government in 1993, choosing London as the location for EMA's premises. Since the inception of the EMA, the majority of the regulatory processes that are now utilised to regulate medicines in the UK have originated from within the EC as developed by the EMA. When the UK leaves the EU, much of our own legislation to cover the activities that utilised the EU medicines regulatory legislation will have to be re-written.

42. In addition, the MHRA has an internationally recognised reputation due to the contribution it makes to the global regulation of medicines and devices. In our response to the House of Commons Science and Technology inquiry on Leaving the EU,[34] the Society noted:

[34] Written submission by the British Pharmacological Society to the Leaving the EU inquiry of the Science and Technology Committee, House of Commons, 22 August,

"Located in London, the EMA is responsible for the scientific evaluation, supervision and safety monitoring of medicines developed by pharmaceutical companies for use in the EU (since 1995)[35]. It is the largest EU body in the United Kingdom with a full-time staff of more than 600 people. British experts were leaders or co-leaders in examining 27 new drug applications in 2014[36]. The EMA ensures a 'centralised authorisation procedure' allowing a single marketing authorisation application to make a medicine available to all EU member states and the European Economic Area (EEA) countries Iceland, Liechtenstein and Norway[37]. The UK's Medicines and Healthcare Products Regulatory Agency (MHRA) works closely to support the EMA, for example it[38]:

- *led a third of all EU-wide safety reviews since legislation was introduced in 2012*
- *was a rapporteur or co-rapporteur in 20 centralised procedures that led to granting of a Marketing Authorisation*
- *was appointed Reference Member States (RMS) in 43% of procedures where a UK licence was sought*
- *held 319 regulatory or advisory meetings to help applicants*
- *helped shape regulation and approvals through 96 European Scientific Advice meetings*

The level of work undertaken on behalf of the EMA is considerable, representing 6.4% of total gross income in 2015/6[39]. This indicates that loss of MHRA expertise would put a considerable burden on EMA processes. This influence is expanded upon in the House of Commons Science and Technology Committee report "EU regulation of the life sciences"[40], where evidence from the Bioindustry Association stated that "the MHRA has been able to exploit its reputation, leadership and expertise to positively influence the EU medicines regulatory regime."[41] The report

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2016,https://www.bps.ac.uk/getattachment/About/Policy-positions/Consultation-responses/Articles/Response-to-Leaving-the-EU-inquiry/Leaving-the-EU-inquiry-response-(1).pdf.aspx?lang=en-GB (Accessed 10 April 2017).

35 EMA (2016) About us, 29 June 2016. Available from: http://www.ema.europa.eu/docs/en_GB/document_library/Other/2016/08/WC500211862.pdf (Accessed 22 August 2016).

36 Hirschler, B. (2016) Brexit threat hangs over London-based EU medicines agency, *Reuters*, 29 January 2016. Available from: http://uk.reuters.com/article/us-britain-eu-medicines-idUKKCN0V71AS (Accessed 22 August 2016).

37 EMA (2016) Authorisation of medicines. Available from: http://www.ema.europa.eu/ema/index.jsp?curl=pages/about_us/general/general_content_000109.jsp (Accessed 22 August 2016).

38 MHRA (2016) Medicines and Healthcare products Regulatory Agency Annual Report and Accounts 2015/16. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539679/MHRA_annual_report_and_accounts_2015_to_2016.pdf (Accessed 22 August 2016).

39 MHRA (2016) Medicines and Healthcare products Regulatory Agency Annual Report and Accounts 2015/16. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539679/MHRA_annual_report_and _accounts_2015_to_2016.pdf [Accessed 22 August 2016]

40 Great Britain, Parliament, House of Commons, Science and Technology Committee (2016) *EU regulation of life sciences,* HC 158, 11 June 2016. Available from: http://www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/158/158.pdf (Accessed 22 August 2016).

41 BioIndustry Association (2016) Written evidence submitted by the BioIndustry Association (UKL0022), EU regulation of the life sciences inquiry, the Science and Technology Select Committee, House of Commons.

also discusses several instances of how MHRA has influenced EU regulation, for example Clinical Trials Regulation and Pharmacovigilance legislation."

43. As things stand, on leaving the EU the UK would be unable to participate in the European wide approval system for new medicines and the revisions to already approved products, to participate in the Orphan Drug Designation and the Small to Medium Sized Enterprise schemes that the EMA operate. In addition, we would be unable to participate in the centralised approval process for paediatric drugs and the process that supports new medicines development for children. We would also lose access to the EU wide Pharmacovigilance networks and the EU Clinical Trials Database. Not participating in such regulatory activities and processes could have serious implications from the public health perspective in the UK and in particular for patient safety.

44. At present, it is not at all clear whether the UK could continue to collaborate with the EMA in some way relating to medicinal product regulation and pharmacovigilance activities. If possible, some form of collaboration would be beneficial to both parties and should help avoid the possible impacts on public health.

45. However, being outside the EMA could also have its own benefits. For example, it could be easier to implement the outcomes of the Accelerated Access Review and introduce new and innovative medicines into the UK earlier than other countries and include the other benefits of the review, if we so desired. We could also focus much more than we currently do on utilising the NHS clinical facilities and patients for new drug research, development and evaluation.

46. The Medical Research debate at the House of Commons which took place on Tuesday 28 March 2017[42] highlighted similar concerns in regards to regulation. It noted that the new regime on approving drugs would mean that the NHS may not supply some newly approved drugs for up to three years. It is therefore necessary to consider how this would impact on research and industry as it is likely to result in investment in research in the UK being viewed as less attractive.

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 and below the right ones?

47. BioHubs operated by a life science incubation specialist, The BioCity Group, supports the creation and growth of successful life science companies. This is achieved by creating the optimum environment for emerging businesses to thrive by offering world class state-of-the-art laboratories and commercial office space, shared services, training, business support and access to investment.

48. Examples of which include the BioHub at Alderley Park that enables emerging pharmaceutical, biotech and life science companies to take advantage of some of the UK's best invested research and development facilities, scientific heritage and industry experts, while operating entirely independently. The success of this formula is supported by the 91% survival rate of BioCity-based companies over 12 years, marking BioCity as an international hub for entrepreneurial activity in the life science sector.

Available from: http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/science-and-technology-committee/impact-of-european-regulation-on-uk-life-sciences/written/30086.html (Accessed 22 August 2016).

[42] Medical Research, House of Lords debate, 28th March 2017 https://hansard.parliament.uk/lords/2017-03-28/debates/56D4E574-0641-4358-A69D-69B99F7DA30D/MedicalResearch (accessed 11 April 2017).

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

49. The University of Sussex Science Policy Research Unit (SPRU)[43] notes that for industrial policy to succeed, it is necessary that ministerial leadership cannot be the only force and it must be embedded with policies developed by the business department. For example, innovation led growth has been possible through decentralized leadership which highlights that a top down approach is not advisable. It is also suggested that avoiding a solely sectorial approach and focusing on coordination of problems is preferable as it will avoid focus on private interests and encourage spillover to other sectors. In addition to this, it is advisable that the UK moves from spending more money on indirect spending through tax reliefs or credits to direct spending on innovation as this encourages "additionality", or investment that would not otherwise have been made. In addition to this, it is advisable that the UK moves from spending more money on indirect spending to a direct approach. It is necessary for the government to be the first resort even if this means absorbing risk as it is likely that private investments will follow. As discussed in this article, in both France and Germany in 2014, both countries were spending 10 times more than the UK on Research institutes with the aim of unlocking private investment.

50. The article also notes that although several countries have sought to achieve innovation-led growth as a route to higher living standards, few have achieved this. In order to skilfully construct an industrial strategy, it is important to learn from the lessons of others. For example in the US, when it was generating innovation-led growth, there was not a strict division of labour between the public and private sectors and the same is essential for a successful UK approach. It is also important that demand is created through public policies rather than by focusing on market creation demand policies and supply side innovation.

51. The OECD note that most OECD countries promote a cluster-based approach to innovation and the Society suggests that Government consider this report in detail in order to make valuable comparisons to the formation of clusters in other countries. Argentina, Belgium, France and Portugal have made cluster policies an integral element of their national innovation strategies or plans and other countries have programmes to promote the creation of new clusters or to strengthen existing clusters.

52. National and regional governments are attempting to enhance the competitiveness of firms and clusters by promoting "smart specialisation" strategies. *"Smart specialisation is an evidence-based policy framework which uses indicators, technology foresight and other priority-setting tools to help entrepreneurs and firms strengthen existing scientific, technological and industrial specialisation patterns while identifying and encouraging the emergence of new domains of economic and technological activity."*[44]

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

53. As outlined in our response to Question 1, the Society believes that the industrial strategy should aim to build on our strengths in the Life Sciences (including

[43] Response to BIS Committee Inquiry: Industrial Strategy http://www.progressiveeconomy.eu/sites/default/files/Industrial%20Strategy%20Inquiry%2027Sept16%20-%20SPRU.pdf (accessed 11 April 2017).
[44] OECD, 2012 https://www.oecd.org/sti/outlook/e-outlook/stipolicyprofiles/interactionsforinnovation/clusterpolicyandsmartspecialisation.htm

pharmacology) to deliver economic and health impact from the early commercialisation of research:

1. An excellent science base
    - The UK represents just 0.9% of global population, 3.2% of R&D expenditure, and 4.1% of researchers, it accounts for 9.5% of downloads, 11.6% of citations and 15.9% of the world's most highly-cited articles[45]
2. Access to research partners through a high density research community
3. Access to patients and real-world data through the NHS

54. The UK must capitalise on the NHS and a focus on developing strong partnerships between funders of research across academia and industry and the National Institute for Health Research (NIHR) will be fundamental to this, in terms of access to people and funding. As outlined in the Accelerated Access Review[46], the UK is well-placed to be a 'global hub for innovation in healthcare'. As part of the Industrial Strategy, the government should ensure leadership in terms of vision and funding required to implement the recommendations of this review.

55. However, it is vital that government approaches this opportunity with ethical and patient-focused issues at the forefront of considerations. It is imperative that patients and publics are fully engaged in conversations about the use of their data (and data protection issues) to avoid setbacks such as that seen with care data in the future.

Funding

56. This ties into one of our key themes: co-ordination of funding mechanisms to ensure maximum impact. A joined-up funding landscape that flexibly supports research across the sector and encourages collaboration would be ideal. ***The Society recommends a review of research funding with the aim of removing barriers to access/collaboration and identifying gaps in the landscape.*** Similarly, it is vital that funding schemes are visible and accessible to all partners. We suggest that funding should be reviewed in these areas:

- **Funding streams to support mobility and develop cross-sector/cross-discipline skills e.g. placements, exchange fellowships**
  These are available, but not used as effectively as they could be if these links were built at an organisational level. Similarly, cultural barriers still exist to partnering with industry. In its response to the consultation on the second REF (available on request), the Society recommended use of the Environment statement to focus the attention of HEIs on supporting collaboration within academia and across the sector.
- **Funding streams to support knowledge transfer e.g. Knowledge Transfer Partnership[47], impact acceleration[48]**
  Again, these are under-utilised. The Society would support efforts to raise the profile and esteem of these schemes within academia, and additional funding for 'scoping or seeding partnerships' to de-risk development of broader collaborations and ultimately make them more successful when they do begin.

[45] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263729/bis-13-1297-international-comparative-performance-of-the-UK-research-base-2013.pdf
[46] Accelerated Access Review: Final Report, October 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/565072/AAR_final.pdf (accessed 11 April 2017).
[47] Innovate UK http://ktp.innovateuk.org/ (accessed 11 April 2017)
[48] RCUK http://www.rcuk.ac.uk/innovation/impact-accelerator-accounts/ (accessed 11 April 2017).

- **Platforms and networks to facilitate knowledge exchange/partnership-building exist e.g. Knowledge Transfer Network[49], InnovateUK**
  Awareness is a real issue. More needs to be done to ensure that both academia and industry know about these schemes and how to use them with the backing of their organisation. The schemes have the potential to have much greater impact. Similarly, it is important that the organisations leading these schemes have the right expertise and networks.
- **Funding to support translation & commercialisation e.g. MRC as part of the Biomedical Catalyst Developmental Pathway Funding Scheme, CRACK-IT[50]**
  There are a number of funding schemes and it would be helpful to evaluate them and understand gaps in the offering. For example, the Wellcome Trust Seeding Drug Discovery scheme is no longer running and its evaluation should be considered as part of this process. It would be helpful to look at these funding schemes in the context of long-term strategic partnerships in the sector, for example the Sussex Drug Discovery Centre[51].

57. Funding cannot exist in a vacuum and must be integrated into the research community alongside non-monetary support e.g. access to facilities, networks, mentorship and expertise. Actively leveraging Catapults within clusters is one way of doing this e.g. the Northern Health Science Alliance. We are interested in the role of the new Medicines Discovery Catapult to provide oversight and coordination of funding schemes. However, we strongly suggest that a move in this direction should be accompanied by strong relationships with leaders in drug discovery. We are not sure to what extent this expertise is currently represented in the Catapult, but believe that additional expertise on the Board or clearer partnerships with industry and associated networks could help make the Catapult an important hub. In our analysis of REF impact case studies, we also note the importance of joint funding across government, industry and charities. It is essential to consider how funding schemes fit together and how funding is coordinated in order for it to be efficient.

58. For example, the Society recently released an evaluation of the Integrative Pharmacology Fund (IPF) in December 2016[52], which shows the potential of leveraging funding across sectors. The fund was originally a £4million investment from AstraZeneca, GlaxoSmithKline and Pfizer for education and training in the use of animals in research. This fund was leveraged to £22million through coordination of public funding. The holistic approach to education and training, serving both academic and industry interests was successful. The principles of success were:

- Open pathways
  - Building collaborative and sustainable ways of working that recognise, value, develop and use the diverse routes and roles to and within in vivo research.
- Networked communities
  - Creating connected communities of educators and shared educational resources for good practice in in vivo research.
- Embedded partnerships
  - Ensuring that long-term collaborative relationships are built between academic researchers and research institutions and researchers and

[49] Innovate UK https://www.ktn-uk.co.uk/ (accessed 11 April 2017).
[50] CRACK IT https://www.crackit.org.uk/crack-it-challenges (accessed 11 April 2017).
[51] University of Sussex http://www.sussex.ac.uk/sddc/ (accessed 11 April 2017).
[52] Lowe JWE, Collis M, Davies G, Leonelli S, Lewis DI and Zecharia AY (2016) An evaluation of the Integrative Pharmacology Fund: Lessons for the future of in vivo education and training. London: British Pharmacological Society. Available online at: www.bps.ac.uk/futureinvivo (accessed 11 April 2017).

institutions operating outside of academia, for instance in industry or the NHS.

- Responsive leadership
    - Recognising that organisations, including the British Pharmacological Society and partners, need to take flexible and responsive leadership roles in facilitating community engagement, brokering resources and taking a long-term view of in vivo skills needs.

Building relationships: clusters

59. The Society (with partners in the Drug Discovery Pathways Group: Royal Society of Biology, Royal Society of Chemistry, Biochemical Society) has previously put forward a proposal for Therapeutic Centres of Excellence (TCE). We proposed that these centres should be embedded within academic institutions, providing an environment for drug discovery experts with industry experience to work in partnership with academic scientists to support the critical step of translation of academic research into commercial and therapeutic success. Our proposed model stated:

> *"By locating these discovery centres close to existing hubs of translational and clinical research, there would also be the expectation that drug discovery is able to collaborate with fully engaged with NHS in helping to inform clinical trial design/patient selection to reduce cost and scale of the process and maximise chances of success.*[53] *As part of this Therapeutic Centres of Excellence model, there is the need to encourage precompetitive collaboration and cross-sector knowledge exchange. This will help ensure early research effort is focused on the most compelling areas of science in a way that opens-up opportunity space while minimising duplication and avoiding major investments in approaches that have already found to be flawed by other research groups. The proposed level of investment recognises that the invention of successful therapeutic agents is a long-term and high risk endeavour requiring a high level of expertise applied to a portfolio of drug discovery programmes over a sustained period of time."*

60. As mentioned in our response to Question 1, focus on raising the visibility and investment in academic strengths can help attract industry investment. The Society and partners believe that building on existing models of TCEs (e.g. Alzheimer's Drug Discovery Alliance) would create highly visible hotspots for collaboration and commercialisation. TCEs align with SPRU's concept of a mission-oriented approach to industrial strategy, rather than a sectoral approach. In addition, our analysis of REF impact case studies indicates an overwhelming focus on impact claimed in cancer drug discovery in the UK. This raises interesting issues about the UK's research and commercialisation focus given known challenges of an ageing population and the health and economic impacts that this will bring. Similarly, the UK has a global responsibility to the UN's Sustainable Development Goals and UK industrial strategy should also look to maximise impact against these. Please see our response to Question 32 for further evidence on this point.

Clinical pharmacology

61. The first in human (FIH) study is a key inflection point on the journey of a potential new medicine, representing the tangible interface between the target science and clinical development. For the UK to realise its ambition to be a leader in translational medicine,

53 For a recent example of a centre being established in Canada, funded by Public Private Partnership to bridge the gap between early-stage research and later stage drug development, see http://business.financialpost.com/2012/11/23/pfizer-astrazeneca-team-up-with-quebec-on-new-approach-to-drug-research/. (accessed 11 April 2017).

capability in this space is critical. Safety is paramount in FIH studies and the UK has a world leading position on the qualifications required to be Principal Investigator (PI) in these studies. PIs must be medical doctors specialising in Pharmaceutical Medicine (PM) who have an additional post-graduate qualification (such as the Diploma in Human Pharmacology), or medical doctors who have completed specialty training in Clinical Pharmacology & Therapeutics (CPT). Although this ensures quality, a limited supply of appropriately trained individuals represents a capability gap in both the academic and industrial settings. The first ABPI skills report in 2005 identified Clinical Pharmacology /Experimental Medicine as an area of high unmet skills needs (with respect to both the quality and number of candidates) and also highlighted the future importance of this skill set.[54] These are still priority concerns for industry, as shown by the 2008[55] ABPI skills report and the most recent report in 2015[56]. The Society has been discussing this issue with ABPI, MRC and NIHR as part of a parallel approach to addressing skills needs across the sector (see paragraph 63). These organisations agree that training a sufficient number of physicians with the right translational skills in this area requires partnership between NHS, academia and industry. Successful realisation of this will directly enable the life science strategy providing the leaders needed to translate excellent science into patient benefit. ***The Society, together with the Faculty of Pharmaceutical Medicine, recommends that a new dual training certificates in clinical pharmacology and pharmaceutical medicine would offer a clear training route for this important role, and support permeability across the sector.***

62. In addition to the medical skills gaps, industry cites challenges[56] in recruiting people with the skills to take a drug through the development process – and further challenges in recruiting these people from the UK. Non-medical routes for this work are varied and include scientists with biomedical training at BSc and PhD level and pharmacists. Their contribution is in understanding drug metabolism, pharmacokinetics, pharmacodynamics, potential toxicity and compound characteristics. They follow a drug through pre-clinical stages, developing protocols for FIH studies, early and late phase clinical trials, and have a role in preparing packages for regulators. They provide continuity for a drug and getting the dose right for different patient populations across the process. These scientists are called 'clinical pharmacology scientists' because of their expertise in the design and quantitative analysis of human pharmacology trials. The UK could be training a wider pool of people with these critical skills, further securing the UK as a development base. Degree apprenticeships and/or specialist courses may help close this gap. ***The Society, together with the Faculty of Pharmaceutical Medicine, recommends a focused appraisal of career pathways, and education and training requirements.***

63. The Society and the Faculty have discussed these options as part of our contribution to developing the Life Sciences sector deal. The Society has also discussed our long-standing campaign to increase the number of clinical pharmacology consultants in the NHS to 150 by 2025 as part of a longer-term plan for growth in the context of benefits to patient safety, efficiency in the NHS and industrial strategy. Clinical pharmacology is the only medical specialty in the NHS focusing on the safe, effective, and cost-effective use of medicines. The specialty provides leadership in the use of medicines and the

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54 The Association of the British Pharmaceutical Association. (2005) Sustaining the skills pipeline in the pharmaceutical and biopharmaceutical industries. Available from: http://careers.abpi.org.uk/your-career/undergraduates/Documents/_publications_pdfs_2005-STEM-Ed-Skills-TF-Report.pdf

55 The Association of the British Pharmaceutical Association. (2008) Skills needs for biomedical research. Creating the pools of talent to win the Innovation Race. Available from: http://www.abpi.org.uk/our-work/library/industry/Documents/skills-biomedical-research.pdf

56 The Association of the British Pharmaceutical Society. Bridging the skills gap in the biopharmaceutical industry. Maintaining the UK's leading position in life sciences. (2015) Available from: http://www.abpi.org.uk/our-work/library/industry/Documents/Skills_Gap_Industry.pdf

benefit is felt across the broader NHS; in primary and secondary care, but also in areas such as regulation and medicines assessment/appraisal. Supporting clinical pharmacology within the NHS will also have a positive spillover effect for industrial strategy. Many of these clinical pharmacologists will work within academic environments and lead on the clinical trials that support thriving drug development programmes. However, there are only 72 consultants in post in the NHS, despite a recommendation from the Royal College of Physicians (London)[57] that there should be about 440. A recent cost-benefit analysis commissioned by the Society[58] showed that every £1 invested in clinical pharmacology could save the NHS £5. The Society is calling for a strategic approach to invest in clinical pharmacology through a review of training pathways, workforce planning and by attracting the trainees of the future.

In vivo sciences

64. Following the intervention of the IPF as mentioned above, and also likely due to outsourcing and fragmentation in the sector, industry is less concerned about recruiting individuals with the skills to use animals in research than in previous years. Recent discussions between the Society and ABPI indicate that the main need is around translation. That is, the creation and use of reproducible models and the ability to work with clinicians to refine models and identify biomarkers. As mentioned in our response to Question 1, it is crucial to create a research environment that supports target identification. This requires support for bringing together scientists across disciplines and the sector. Whilst the sector is looking to move away from the use of animals in the long-term, animals in research are still a key part of the drug discovery and development process. It is essential that such studies should generate the highest quality, translatable data. ***The Society recommends a focus on supporting education and training in translation and reproducibility of studies.***

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

65. The Society recommends that the ICSF should target areas where the UK has significant academic strength and industrial capability, acting as a catalyst to support cross-sector collaboration and commercialisation. We strongly support continued investment in addressing challenges of an ageing population.

Accelerating Access

66. We welcome the announcement that the initial wave of engagement with ICSF will support "accelerating patient access to new drugs and treatments through developing brand new medicine manufacturing technologies, helping to improve public health". However, we believe that significant further investment is required to make this a reality. Collection and analysis of real-world data by expert groups (potentially in hubs across the UK) will be key. For example, the STAR METRICS US initiative documents a return in investment in science funding. A focus on recruitment of patients and clear messaging about value to patients will also underpin success.

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57 Royal College of Physicians of London, Consultant physicians working with patients: The duties, responsibilities, and practice of physicians in medicine, 2013. Available online at: http://www.rcplondon.ac.uk/sites/default/files/consultant_physicians_revised_5th_ed_full_text_final.pdf (accessed 12 April 2017.

58 PricewaterhouseCoopers (commissioned by the British Pharmacological Society) Clinical Pharmacology and Therapeutics: The case for savings in the NHS, 2016. Available online at: https://www.bps.ac.uk/BPSMemberPortal/media/BPSWebsite/Assets/CPT-case-for-savings-in-the-NHS.pdf (accessed 12 April 2017).

Antimicrobial resistance

67. The Society is a member of the Learned Society Partnership on Antimicrobial Resistance (LeSPAR). LeSPAR also includes the Royal Society of Chemistry, the Royal Society of Biology, the Biochemical Society, the British Society for Antimicrobial Chemotherapy, the Society for Applied Microbiology and the Microbiology Society. LeSPAR is an advisory group that recognises the global challenge of antimicrobial resistance which requires a commitment to working in partnership across organisations and disciplines by:

- Supporting researchers in creating, sharing and applying knowledge
- Organising focused events to enable networking and knowledge exchange, and to promote effective collaborations across disciplines and sectors
- Engaging with government and other funders to achieve policy and funding support for the antimicrobial research community and connecting expertise from our membership to policy makers
- Assembling information on relevant resources and meetings.

68. LeSPAR supports the recommendations of the O'Neill Report,[59] in particular the recommendation to support development of rapid new diagnostics and a global innovation fund would be well-suited to the ICSF.

Emerging technologies

69. The Society believes that the industrial strategy must consider the impact of emerging technologies such as advanced genomics which have the potential to reshape the world. As such, business and policy leaders must be aware of these and start to prepare for the impact, with an understanding of which emerging technologies will be of significance to them. Disruptive Technologies: Advances that will transform life, business and the global economy[60] identifies 12 technologies as being capable to drive significant economic transformations and disruptions. Examples of these outlined are advanced robotics and next generation genomics. The report notes that the potential benefits of the technologies discussed in the report are extremely high but it is essential to consider the challenges of preparing for this impact. If government waits until the technologies are exerting their full influence on the economy, it will clearly be too late to capture the benefits and react to the consequences. The Society notes the article on Disruptive technologies, which says that "Business leaders should keep their organizational strategies updated in the face of continually evolving technologies, ensure that their organizations continue to look ahead, and use technologies to improve internal performance."[61] In regards to employee skills, it will also be essential to ensure that employee skills are kept up to date in relation to these emerging technologies.

70. Further, we note that disruptive innovation is linked to academic freedom. That is, without allowing academics the room to experiment, many innovations may not happen. As part of our analysis of REF impact case studies, we note a case study from Newcastle University, which states:

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59 Tacking Drug-resistant technologies globally: Final report and recommendation, May 2016, https://amr-review.org/sites/default/files/160525_Final%20paper_with%20cover.pdf (accessed 11 April 2017).

60 McKinsey Global Institute, Disruptive Technologies: Advances that will transform life, business and the global economy http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies (accessed 11 April 2017).

61 McKinsey Global Institute, Disruptive Technologies: Advances that will transform life, business and the global economy http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies (accessed 11 April 2017).

"When the project was first established, PARP was not considered a viable target, particularly by the pharmaceutical industry, but the Newcastle team championed it and drove the project to clinical proof-of-principle. PARP has now been adopted as a key cancer drug target by the global pharmaceutical industry, and has reached cancer patients across Europe, the Americas, Australasia and Asia, with eight PARP inhibitors currently in clinical trial development worldwide and at least eight cancer types being treated through clinical trials"

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

71. We have touched on critical environment factors throughout our response. Please see below for a brief summary and reference to the question where we have given a more detailed response:

- Increasing visibility of partnerships will support a collaborative environment. Please see our references to 'Gateway to Research' and Konfer.Online[62] (an online platform for accessing research partners) in Question 1. Development of the digital brokering tool is supported by the House of Commons Science and Technology Select Committee.[63]
- Coordination of funding mechanisms is also essential. Please see our detailed response to this in Question 5.
- Building strong and trusted relationships through facilitating collaboration across the sector and through investing in clusters is a key recommendation of ours. Please see our responses to Questions 1, 5 and below.

There are several examples of successful clusters in the UK, for instance:

- Alzheimer's Research Drug Discovery Institutes
- University of Dundee Drug Discovery Unit
- Northern Health Science Alliance
- Manchester Collaborative Centre for Inflammation research (MCCIR)

72. In addition, the Francis Crick Institute applies the logic of clusters by providing a single space within which to concentrate expertise across disciplines. We would like to reiterate our recommendation that clusters based on academic excellence by therapeutic area would raise the visibility of UK academic excellence as a collaboration point with industry and, importantly for translation of research, the NHS. The Society believes that creating Therapeutic Centres of Excellence is positive for internationally competitive drug discovery in the UK. This would mean embedding academic researchers alongside drug discovery scientists. It is also essential for there to be a focus on training in such centres to ensure that there will be a future generation of drug discovery scientists. This approach could help build on regional expertise, but the granularity of targeting centres by therapeutic area means that those with relevant knowledge and expertise are connected in a sustainable way.

73. A UKRI that is committed to the vision set out by Paul Nurse and the government in its white paper[64] has huge potential to deliver here. It is extremely important that

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62 National Centre for Universities and Business, http://www.ncub.co.uk/konfer-online.html (accessed 11 April 2017).

63 House of Commons, Science and Technology Committee, Managing Intellectual Property and Technology transfer, Tenth Report of Session 2016-17, (paragraph 28) https://www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/755/755.pdf (accessed 11 April 2017).

64 Higher Education: Success as a knowledge economy-white paper,16 May 2016, https://www.gov.uk/government/publications/higher-education-success-as-a-knowledge-economy-white-paper (accessed 10 April 2017).

research councils work with government to fully leverage their investment in research (£6 billion) alongside the government's committed funding of £4.7 billion. The aim is to continue to improve and develop and as Sir Mark Walport notes, '*We need a system that is agile, flexible and able to respond strategically to future challenges and that can support the best researchers and innovators.'* He notes that a particular issue is the difficulties in collaborating and working closely together which when not done successfully results in separation. Sir Mark Walport noted the importance of engaging with people across research and innovation and the business landscape and creating a strategic picture. Overall, there is a need for constant communication. In the next 10 years we need to illustrate that we are taking advantage of our research leadership, which includes the entire research landscape as business development is increasingly dependent on all of these. Ensuring the physical sciences and humanities are able to work together for example, is central to such a collaboration and to success. Sir Mark Walport notes that it is critical that government has the scientific, engineering and social science expertise that it needs and part of this will be ensuring continuing professional development for government scientists and engineers.

74. UKRI aims to use public engagement to establish a narrative between schools that illustrates the importance of STEM subjects. Working with other organisations such as the DfE and Higher Education sector is essential for this.

Leveraging the full sector

75. Organisations such as learned societies and biotechnology support groups such as OneNucleus and BioNow can support clusters by offering networking opportunities, brokering relationships and offering support for education and training. For example, the Society jointly funded a researcher mobility workshop to bring together individuals in industry and academia. The event provided mentoring, an opportunity to work together on a challenge and access to funding to support a placement or training opportunity in the sector. Feedback was hugely positive, with representative feedback from delegates discussing a new appreciation for mobility and collaboration: *"the need for academia to collaborate continuously and closely with industry so that academic research is purposeful and addresses contemporary problems faced by industry. However, for collaboration to be successful, mutual trust is paramount".*

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

76. The Society believes that supporting the next generation of research leaders and entrepreneurs should focus on two main elements:

1. Embedding awareness of what is involved in these careers from an early stage and giving opportunities to embody these behaviours
2. Ensuring that these behaviours are rewarded

77. In terms of supporting development of these behaviours at an early stage, the Society supports gold-standard approaches to embed autonomous, research led learning at a school level e.g. the British Science Association's CREST Awards, the Institute for Research in Schools and Nuffield Research placements as discussed in our response to Question 1.

78. The Society believes that embedding Entrepreneurial Awareness into education and continuing professional development in order to teach the process of turning research into commercialisation would be of real value.

79. Collaborative behaviour is central to leadership in research and entrepreneurship and it is important that such behaviours are supported and rewarded. Providing individuals with mentors and experts ('knowledge intermediaries') who are likely to be able to note potential collaboration opportunities and facilitate partnerships is essential. We would like to reiterate our support for Konfer.Online as discussed in our responses to Questions 1 and 7.

80. Possible barriers to collaboration in industry are the lack of mobility of staff, a lack of time to engage in networking and therefore being aware of such opportunities and in some cases, the lack of awareness of the relevance of the academic sector to industry. Reluctance on the part of academia may be due to factors such as being protective over ideas, funding not being available for such activities and a lack of role models to illustrate the utility of collaborations. Overall, it is essential that both academia and industry are encouraged and provided with incentives to engage in such collaborations and that both consider this to be mutually beneficial. The perceptions academics have of the potential barriers can be found in the Accounting for Impact at Imperial College London[65] report which notes that faculty members as opposed to research staff have a tendency to report higher barriers to collaboration. Specific barriers noted by faculty members include difficulty finding appropriate partners, lack of suitable government funding programmes for research with partners and lack of continuity in partners' research. Unsurprisingly, senior members of staff appear to experience higher barriers to collaboration and the Society believes that this therefore needs focus because these are the individuals who are in the position to change things. The results of this research indicate that engagement may improve matters and the Society therefore suggests a concerted effort to focus, acknowledge and address such perceptions. In addition to this, the Society suggests creating a range of case studies of successful partnerships to provide examples and advice.

81. The Society supports development of a well-rounded culture within academia. In our response to the House of Commons Science and Technology Committee inquiry on Research Integrity[66], the Society noted:

> *"Researchers in the early years of their independent careers in particular are vulnerable to the perception that they must publish papers in journals with high impact factors, if they are to be eligible for fellowships and permanent positions. Universities foster this by encouraging publication in such journals. Rather than rewarding the results of experiments, promotion and progression should also factor in the quality of the scientist at hand: their rigour, productivity and commitment to nurturing the next generation of scientists. Ultimately, it is a question of long-term investment over potentially short-term gains.*
>
> *A shift in the reward and recognition culture in academia will be fundamental. Moves to open access publication, the responsible use of bibliometrics, the value placed on non-research activities and drivers enforced at institutional and group levels will be key to achieving this. High quality research outputs are clearly important, but other contributions should be included in hiring and promotion criteria. Clearly rewarding broad contributions to teaching, administration, public engagement and a commitment to the next generation*

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65 Accounting for Impact at Imperial College London , March 2015 https://workspace.imperial.ac.uk/business-school/Public/research/I_Egroup/MP%20-%20Web%20Docs/TRIC%20report%2024.pdf (accessed 11 April 2017).

66 Research Integrity Inquiry, Science and Technology Committee (House of Commons), March 2017, https://www.parliament.uk/business/committees/committees-a-z/commons-select/science-and-technology-committee/inquiries/parliament-2015/inquiry6/ (accessed 11 April 2017).

in addition to research outputs would help drive a more rounded academic culture."

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?

82. As noted in our response to Question 1, we strongly support efforts to improve basic numeracy and literacy as fundamental to increasing both opportunity for individuals and UK productivity as identified by a recent OECD[67] report.

83. We are supportive of the Royal Society's Vision[68] for science and mathematics education:

> *"Science and mathematics are at the heart of modern life. They are essential to understanding the world and provide the foundations for economic prosperity.*
>
> *Being educated in science and mathematics enables people to make informed choices about their life and work, empowers them to shape scientific and technological developments, and equips them to prosper in today's rapidly-changing, knowledge-focused economies"*

84. Mathematical and statistical skills must be a focus throughout the education system. Computer programmes which enable students to learn about statistics are also suggested as particularly useful though this would likely suit older pupils. The ABPI *Bridging the skills gap in the biopharmaceutical industry*[69] details the need to focus on big data and bioinformatics skills. These are new fields and this is therefore a major challenge for the sector and needs focused investment. In parallel, to fully exploit big data, learning must encourage the development of critical thinking, creativity and problem solving. Similarly, these skills should be built into continuing professional development and adult-learning and on-the-job training to build on workforce investment and enhance retention.

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

85. The Society agrees that there is a significant issue with how technical education is perceived and this extends into the opportunities offered. Technical education must be seen to offer opportunities with parity of esteem to academic routes rather than being seen as the 'inferior' route.

86. Enabling better flexibility for young people to choose between these routes is also necessary as expecting an individual to know the exact career they wish to pursue, aged 16, dismisses the impact of cultural capital and prior knowledge individuals may have. As the government wishes to focus on widening participation and equal access, the Society believes that this is a significant area to be considered to ensure equality across a diverse group of individuals and regions. The Society agrees that the path to undertaking technical education is not clear and that there needs to be a focus on this in order to promote technical education.

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[67] OECD, Building Skills for all: A review of England (2016), https://www.oecd.org/unitedkingdom/building-skills-for-all-review-of-england.pdf (accessed 11 April 2017).
[68] The Royal Society, https://royalsociety.org/topics-policy/education-skills/topic/ (accessed 11 April 2017).
[69] ABPI, *Bridging the skills gap in the biopharmaceutical industry, November 2015.* http://www.abpi.org.uk/our-work/library/industry/documents/skills_gap_industry.pdf (accessed 11 April 2017).

87. In principle, the Society welcomes the introduction of 'T-levels' as a way of offering clear technical career pathways and a means through which to develop people with the skills to allow themselves and the economy to flourish. However, it is imperative that technical training be implemented in a way that ensures parity with academic routes and is also mindful of the stereotypes that may put young women off such a pathway.

88. The Society believes that training and upskill initiatives both at technical and academic level are best based regionally but that a national UK infrastructure is necessary. National infrastructure with City & Guilds, vocational education and apprenticeships (229 NVQ's in 2014) have all been tried and tested but need a higher level of government funding and support. For example, the City and Guilds Tech Bac initiative in 2014, baccalaureate-style (age 16-19) is considered transferrable across borders.

89. In the US, it is more commercially driven with CfPIE (The Center for Professional Innovation and Education). CfPIE provides technical training for pharmaceutical, biotech, medical devices, skin/cosmetic certification programmes (classroom, on-site, virtual), allowing upskill vocational training. The Society would support exploration of how City and Guilds could work with the pharmaceutical industry to improve vocational training and opportunity on a national level.

90. In addition to this, further education is generally seen to lack funding. If it is to be seen to possess equal weighting to HE, this must change and funding must be reviewed. To further illustrate this, London Economics noted that funding for sixteen to nineteen-year-old students in FE was the equivalent to merely 42% of HE funding. Funding for sixteen to nineteen year old non-apprentices was equivalent to 54% of the funding per full-time undergraduate student from England studying in England in 2013/14.[70] The Society therefore advises Government to clearly consider how to change the current funding situation for FE and it believes that increasing funding will aid with technical education being viewed in a similar way to HE.

91. The Society supports investment in STEM ambassadors as a mechanism for building science capital for teachers and students, through equipping them with resources and training that supports real world learning. Currently, the scheme is focused on academic routes but there is opportunity to expand it to include technical routes. Unless advice is offered through the same channels wherever possible there is a risk that a 'two-tier' system will remain. Similarly, work experience and placement opportunities should be considered as an integral part of investment in technical training.

92. In addition to the development of new and clearer technical routes, it is necessary to ensure that technical professionals are well-supported in their careers. The Society supports professional registration, for example via the scheme offered by the Science Council[71], which offers four awards:

- RSciTech (Registered Science Technician)
- RSci (Registered Scientist)
- CSci (Chartered Scientist)
- CSciTeach (Chartered Science Teacher)

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70 London Economics, Mind the Gap: Comparing public funding in Higher and Further Education, November 2015, 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 (accessed 11 April 2017).

71 Science Council http://sciencecouncil.org/scientists-science-technicians/ (accessed 11 April 2017).

93. The Society is also aware that Higher Education Institutions are considering the use of CSciTeach among their education staff. The award is intended to serve all science educators, regardless of level.

94. There are opportunities to work with the learned societies and wider professional bodies to develop a programme of continuing professional development that is recognised across these routes. It would be helpful if such training opportunities increased exposure of people working in a range of disciplines and across the sector to facilitate interdisciplinary and cross-sector working. Professional registration also has advantages of facilitating permeability of the sector, enabling employers to have a clear view of the training and skills of technical staff. We are keen that messaging around professional registration should be focused on building and supporting a successful career.

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

95. The Society agrees that it is essential that the processes for applying to FE colleges and apprenticeships are made clearer to a diverse audience with clear career path options outlined to encourage individuals to consider following these routes.

96. The idea of constructing a service similar to UCAS to find technical courses may make paths to technical routes clearer and therefore more accessible. It is also necessary to consider prerequisites and how selection may be undertaken to ensure equal opportunities.

97. The Science Industry Partnership (SIP) has developed an innovative skills programme such as the SMART apprenticeships and a Modular Masters in Formulation science both of which have been found to be particularly impactful on vocational training. SIP anticipates that 37,000 apprenticeships are needed from now until 2025.

98. In regards to the ABPI, the Society wishes to draw attention to the apprenticeships levy and how the money is likely to be used. It appears that ABPI aim to ensure that flexibility is introduced into the levy to ensure that employers are not prevented from using the levy to address the highest priority skills and training requirements. The Society agrees with ABPI that there must be a focus on the quality of apprenticeships rather than a focus on quantity.[72] It is also essential that apprenticeships are seen as a good basis for access to top university courses if people take this route. The outcomes must be well explained in terms of how an individual could progress/where they could go to ensure that a clear path is possible. It is therefore essential for schools and careers advisors to be aware of apprenticeship opportunities, particularly in deprived areas. As government's aim is to ensure that all regions are considered in regards to the industrial strategy, the Society would like to emphasise the need to ensure opportunities are accessible to those around the UK which will in turn have the potential to produce young people equipped with industry skills.

99. Initial research by the Society indicates that apprenticeship provision related to pharmacology (and likely the broader life sciences) needs significant development. We believe that in addition to clear, supportive and accessible pathways, a cultural change is required within an academic and industry setting regarding rationalisation of where

72 ABPI response to committee on Education, Skills and the Economy http://www.abpi.org.uk/our-work/policy-parliamentary/Documents/Apprenticeship%20Inquiry%20ABPI%20response%20March%202016.pdf (accessed 11 April 2017).

graduate/postgraduate skills are needed and where investment in technical pathways may have a significant positive impact on skills retention.

100. It is also essential to consider how the new proposed Trailblazer apprenticeships will function and enable young people to develop their skills and construct clearer paths for them as a result of this. The Society suggests that government ensures that processes are established which will enable industry and educators to continue to communicate smoothly in order to ensure that the apprenticeships are successfully developing the skills required. There is a huge opportunity to leverage apprenticeships for delivery of high-level skills in the Life Sciences. The Society would support the exploration of degree apprenticeships as part of this approach. In addition, research by the Society suggests that the routes that are currently available are not very visible to applicants, so it will be important that communications about these career opportunities are delivered on a par with academic and graduate routes.

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?

101. Please see our response to Question 5 regarding skills needs in clinical pharmacology and the in vivo sciences.

102. The Society believes that the work undertaken by the SIP on skills strategy is vital to government considerations and suggests consulting closely with the group. SIP is a highly successful partnership of employers from across the UK science industries and they have collaborated to develop a list of skills needed to compete in a global market. The aim of this group is to produce talent which meets the needs of skills demand and ensures innovation and flexibility throughout the sector. There is a need to promote science careers and vocational education and ensure that anyone entering through this route is well-trained.

103. The Society agrees with SIP's suggestions that there is a need for a variety of skills across the science sector, including the following:

- Big Data skills/quantitative are essential, especially for those with scientific and healthcare knowledge and statistical and analytical competence.
- Formulation skills are essential
- Interdisciplinary skills are essential to ensure collaboration is undertaken. An example is the need for computational skills
- Practical computer skills

104. The Society believes that it is important to consider regional differences and adapting to these rather than creating a 'one size fits all' approach. The Society also believes that it is essential to ensure that the skills shortage directly correlates to specific job shortage in order to be valuable.

105. Specifically with regard to drug discovery, the Society would like to note the need for big data and analytical skills e.g. for the handling of real world patient data. We support ideas that would focus/enhance training and practice in local hubs.

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?

106. Clear career and progression pathways are central to the retention of skills within the sector. Such pathways must include opportunities for existing employees to gain new skills and to build on investments in training. This should be combined with a system

that facilitates movement and permeability, allowing churn in the system to highlight good practice and the exchange of ideas and approaches. As outlined in our response to Question 13, the Society supports the recommendations of the Science Industry Partnership with regard to core skills needs in statistics and data handling.

107. Within academia, the loss of highly-skilled postdoctoral scientists is a known problem. This is partly because there is not provision to convert from an academic track (whereby the individual goes on to secure grant funding on an independent basis) to a technical track. The Society would recommend central HEI funding for core technical skills within an institution, as separate from posts funded from grants. Such people represent an under-used resource: it is much more efficient to upskill someone who already has specialised technical knowledge, rather than training from the bottom again. Someone who already has a depth of knowledge and skills will be primed to take advantage of disruptive innovation more quickly.

108. Currently, there are financial incentives to do this: it is cheaper to hire a PhD student than it is to keep paying a more expensive postdoctoral scientist. If the time and resource put into training these individuals were valued and continued through academic and technical routes through professional registration, they would represent a resource across the sector. In its report, "The scientific century: securing our future prosperity", the Royal Society cites data showing that of those with a scientific PhD only 3.5% will gain a permanent research contract and only 0.45% will go on to become a professor. Just over half of those leave academia following their PhD. The Society's own research indicates that around a third of those with a pharmacology degree go on to work outside the academia and the pharmaceutical industry. That scientific education is producing individuals valued in other sectors and across the economy shows the value of this training. However, there is a balance to be struck between flow between and across sectors through choice and churn - and those who reach a ceiling and have nowhere to progress to. It is this latter point that is of concern to the Society, both in terms of supporting individuals but also in terms of wasted investment in the sector. We would strongly recommend the development of new career tracks that enable talented and skilled individuals to remain employed and contribute their skills to UK life sciences within the academic setting.

109. This logic also applies to those who leave the track for various reasons e.g. caring responsibilities. Women are more likely to take a career break and enabling their return is likely to support aims for gender equality in the sector. Opportunities for retraining and upskilling should be proactively offered to these people, ideally before they take a career break to help embed this in the culture.

110. Access to people in different parts of the sector is another mechanism for keeping approaches and skills up to date. For example, the Alzheimer's Research UK's Drug Discovery Alliance worked with Eric Karran as their Director of Research Strategy due to his background at GSK, Pfizer and Lilly. This is true for specific challenges but also advances in drug discovery across the board. For example, whilst small molecules will continue to be important, it is clear that a shift to biologics and stratification/personalisation is in process. Ensuring that drug discovery in an academic setting is able to operate at the highest level will require access to industry expertise. Valuing partnerships like this at all levels will help the transfer of knowledge, supporting collaborative working and commercialisation of 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?

111. We would like to reiterate our response to Question 1 on this point:

112. Foreign Direct Investment: Drug discovery is a global business and the UK is already attracting FDI in this area. However, the Society's own research has indicated that FDI from non UK-based multi-national corporations and particularly NTBFs appears underdeveloped. As the UK seeks to forge new international trade links, we would welcome new opportunities which emerge from this.

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?

113. Please see our response to Question 32.

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

114. A concern with a life sciences sectoral deal is the extent to which it focuses on a UK sectoral context. As the University of Sussex Science Policy & Research Unit has argued[73], sectoral and technology-focused industrial strategies tend to increase the risk of capture by vested interests, and limit the potential for spill over by failing to involve other sectors. As an alternative to this approach which mitigates against these pitfalls, they suggest a mission-based approach which focuses on complex societal problems. Using this as an approach, the Society's research on drug discovery and development REF case studies has identified a concentration of research effort directed towards non-communicable diseases (78% of drug indications listed, of which cancers constitute 42%). This raises the question of what constitutes a desirable distribution of research effort between non-communicable diseases and, for example, infectious diseases, mental health or reproductive health, at a point where the UK must actively seek international trade opportunities.

115. A second issue identified in the Society's research on drug discovery and development REF case studies is an underdeveloped global network of FDI channels. There are three points to make concerning this issue. First, while we have found evidence of US-based MNCs investing in UK research, these are predominantly East Coast or Midwest-based. This suggests that there may be untapped potential for investment among West Coast-based MNCs. Second, a number of NTBFs based in the Boston, MA and Southern California life sciences ecosystems have invested in UK research. Isolated examples exist elsewhere globally, suggesting that this is an underdeveloped funding channel for UK research. While it must be remembered that FDI from NTBFs is likely to be limited in size, it is possible that such links may also be related to more disruptive technological innovation, therefore these links should be encouraged. On a related point, we find virtually no evidence of European NTBFs investing in UK research outside EU framework programmes. Depending on the terms of the UK's exit from the EU, these links may have to be built in another way. Our third point is low number of instances of drug discovery FDI outside the US and EU. We suggest that the Department of International Trade be engaged to identify opportunities in this context.

73 Response to BIS Committee Inquiry: Industrial Strategy http://www.progressiveeconomy.eu/sites/default/files/Industrial%20Strategy%20Inquiry%2027Sept16%20-%20SPRU.pdf (accessed 11 April 2017).