IOP Institute of Physics

Submission to the Department for Business, Energy and Industrial Strategy's consultation on the Government's R&D Roadmap

1. **How can we best increase knowledge and understanding through research, including by achieving bigger breakthroughs?**

We are on the cusp of a new industrial era, powered by science, technology and engineering. Governments all over the world recognise the potential of these developments to shape the social and economic futures of their countries and this is driving investment in education, skills, research and innovation. Globally, our competitors such as Germany, Israel, South Korea and Japan already invest more than 3% of their GDP in research and development.

To make sure the UK can realise the full societal and economic benefits of this scientifically inspired revolution, our STEM community needs to be world-leading. That means strengthening our research and innovation ecosystem and building more productive ties between universities, research institutes, businesses and government.

The IOP welcomes the Government's commitment to increase investment in R&D to 2.4% of GDP and the associated upscaling of public investment in R&D. These commitments reflect the importance of science and innovation in boosting productivity and long-term economic growth more than a decade after the global financial crisis and have become all-the-more significant as we prepare for the long-term economic and social impacts of COVID-19.

Over the past decade, the UK's total R&D intensity – public and private – has remained consistent at approximately 1.7% of GDP, one of the lowest levels in the G7. This low level of R&D limits the UK's ability to develop and build on scientific discoveries and innovations. The ratio for public to private investment in R&D has, for many years, been 1:2. Roughly one third of total R&D investment comes from public sources and two thirds from private sources. Increasing public R&D investment to £22 billion per year by 2024-25 will take direct support for R&D to 0.8% of GDP, ahead of the USA, Japan, France and China in the OECD R&D league. To meet (and surpass) the 2.4% target, more focus is needed on unlocking the potential of increased private sector investment including investment from overseas.

The UK STEM community has the talent, skills and knowledge to capitalise on these investments and fuel far-reaching scientific, technological, social and economic change. The UK boasts world-class institutions, a reputation for excellence in science and engineering and a track record of ground-breaking discoveries.

However, the UK needs a coherent long-term plan to build our position as the global hub for new world-leading technologies, to draw on our strengths across multiple disciplines, to attract talent from around the world and to promote British entrepreneurship. This long-term plan must couple a clear investment roadmap with fresh thinking about the balance, distribution, sources and scale of funding and how to identify prospects with genuine potential for scientific, economic or societal transformation.

Historically low levels of investment have contributed to a patchy distribution of funding across the spectrum of R&D. For example, by international standards, the UK invests relatively little at the more developmental end of the spectrum, with support at intermediate

TRL levels lacking. Funding for large-scale R&D projects, which place significant focus on technology demonstration could fill an important gap in the UK research and innovation ecosystem.

Over the past decade, public investment in fundamental research has fallen proportionally as public investment in applied research and experimental development has increased. If the full benefits of investment in R&D are to be realised, the impacts of fundamental research on the research and innovation ecosystem and on society, culture and the economy must be better understood and this evidence used to underpin appropriate levels of funding.

Some steps have already been taken to bring more coherence to the UK's research and innovation ecosystem. We support the proposal for a new funding agency, based on the US 'ARPA' model, in which funding is allocated by programme managers, which is largely absent from the existing UK funding system.

In recent years, the Research Councils' flat cash budgets have diminished their scope for funding genuine blue skies and high-risk research, so the establishment of a new funding agency focused on 'blue skies' and 'high-risk, high-reward' research is welcomed (with the proviso that its remit and funding should remain distinct from the Research Councils and Innovate UK).

The UK ARPA should not fund purely theoretical advancements in knowledge or incremental innovation, but should target truly disruptive research, with the aim of achieving step changes in technological capability and solving difficult challenges that require a critical mass of cross-disciplinary researchers and innovators.

ARPA may contribute to (and benefit from) stronger and more strategic horizon scanning capabilities. A more co-ordinated and coherent approach to identifying areas with the potential for growth and large scale economic and social returns will help guide investment and support competitive international leadership in areas relevant to our HEIs and physics-based and engineering businesses.

For our part, we are exploring new ways of working with our community (including the business community) to identify and highlight opportunities and challenges associated with increasing R&D intensity in the physical sciences and engineering. This includes scanning the horizons of physics to identify new and emerging research areas and improving our understanding of research and innovation priorities, critical underpinning capabilities and areas of potential growth (including those fields or technologies which are vital enablers for other sectors or technologies but which are presently unrecognised or undervalued).

2. How can we maximise the economic, environmental and societal impact of research through effective application of new knowledge?

Physics is a recognised engine for discovery and innovation and a significant contributor to our economy and we are committed to ensuring that physics (and the physical sciences and engineering more broadly) delivers on its exceptional potential to benefit society.

To better understand the factors which drive or inhibit innovation in the physics community and to support robust and innovative links between large businesses, SMEs and universities we will be mining national innovation data and undertaking a detailed survey of physics based businesses.

We have started the preparations for this work by convening small scale discussions with representatives of physics businesses. Some of our members have identified short-term funding as a challenge for larger or more technical projects. In such cases, problems can arise when short-term funding runs out with the research still incomplete. Longer-term funding may benefit projects in certain fields (particularly those which promise significant returns and growth). For example, quantum technology may need twenty-year funding, rather than ten, to get it to the point of commercialisation.

Our members have also identified firm size as a potential constraint on collaboration or accessing business and innovation support from government. A supportive economic and regulatory framework is beneficial for all firms, but arguably more so for SMEs who drive a lot of growth and innovation.

This has been borne out by successive reviews of business support and innovation and there remains a strong case for enterprise or innovation support which is tailored for micro businesses and SMEs who are often at the cutting edge of new technologies and innovations but who lack the time, resources or know how to access support. These (and other) constraints appear to impact SMEs' ability to access and benefit from the R&D tax credit.[1] We are currently consulting members on this topic and will respond to HM Treasury's consultation in due course.

There is a decades-long history of initiatives to boost collaboration and knowledge exchange between universities and industry. For example, the Higher Education Innovation Fund (HEIF) is very well regarded and has been shown to provide a good return on investment, with £9.30 generated for every £1 of funding according to Research England.[2] Despite this, the Fund is still a relatively modest £213 million.

Some other, more recent initiatives to fund research at the interface between industry and academia have also met with success. For example, Innovate UK was instrumental in facilitating collaborations in respect of robots in extreme environments, which resulted in various applications in computer science and engineering, the energy sector, and in both civil and military defence.

One lesson from decades of reviews is that instruments or support that have been shown to work in one area do not necessarily translate to others. Rather, relevance, coherence and matching support to specific, identified needs are more important considerations. Targeted or even bespoke approaches have a place alongside blanket availability of instruments or schemes. For example, quantum technologies have benefited from a coherent programme of support orchestrated by EPSRC and Innovate UK.

There have been very many independent reviews and strategies aimed at increasing business-university collaboration, and nearly all have highlighted the impact of the misalignment or absence of incentives for business-university collaboration. The 2015 Dowling Review of Business-University Research Collaborations[3] noted that 'There is a strong sense that, despite progress made, the academic environment does not yet sufficiently support, incentivise or reward collaborative work with businesses.'

Other reports have noted the impacts of poor understanding of innovation processes and the impact of disconnects between those undertaking research and those who may apply the fruits of their work. For example, a 2009 report[4] from the Royal Society on the role of science

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[1] Quoting OECD data, the CBI estimated that tax incentives accounted for 61% of government support for business R&D in the UK in 2015 (Untapped Investment, the importance of the UK's R&D tax incentive regime in meeting the UK's R&D target, CBI, August 2019)

[2] https://re.ukri.org/knowledge-exchange/the-higher-education-innovation-fund-heif/

[3] https://www.raeng.org.uk/publications/reports/the-dowling-review-of-business-university-research

[4] Hidden Wealth, Royal Society, 2009

in service sector innovation noted 'a degree of confusion about the difference between knowledge exchange and innovation' and said that 'many people working inside universities appear to equate knowledge exchange with innovation itself.'

There is a wealth of literature on business-university collaboration, yet successive editions of the UK Innovation Survey[5] show that innovation active firms are more likely to have (and to value) collaborative partnerships with other businesses (including competitors) than they are to collaborate with universities. So, while business-university collaboration must remain an important focal point for policymakers, more attention needs to be paid to understanding and unlocking the value of business to business collaboration (including within the supply chain), especially given the importance of driving up private sector R&D investment.

Innovation surveys have shown us over many years that innovative companies, even successful ones, can find it challenging to access the skills needed to undertake or integrate high quality R&D within successful, competitive businesses.

Our physics and economy reports show that there are more than 2 million people working in physics based industries across 80 or so economic sectors in the UK, contributing around 10% of GDP[6]. However, we also know that employers across the UK and Ireland report difficulties with recruiting people with the right skills including critical STEM skills.

The scale of this skills shortage has been illustrated by the Social Market Foundation, which found that despite recent increases, there remains a shortfall of around 40,000 STEM graduates in the UK each year[7]. Our own work showed that 89% of STEM businesses struggled to recruit people with the right skills in the year 2017-18. This equates to a skills shortage of 173,000 workers, an average of 10 unfilled roles per business. In turn, this costs £1.5 billion a year as companies are forced to inflate salaries, recruit from overseas or simply leave posts vacant.

Other recently published reports have highlighted a skills shortage in the UK, with employers reporting that 106,000 vacancies at professional level are considered hard to fill[8]. 79,000 of these vacancies were due specifically to a low number of applicants with the required skills, with many in technical roles, such as the physical sciences, engineering, teaching (including science), and IT. It was also noted that SMEs experienced greater and wider shortages of graduates than larger employers.

Aside from the acute financial and opportunity costs of these shortages and gaps there is a further fundamental drawback. Without sufficient numbers of skilled STEM workers we cannot realise the benefits of additional financial investment in R&D. So, alongside the R&D roadmap and UKRI's talent strategy, the Government should review the National Skills Strategy.

To help inform the national debate about skills and future skills policy, the IOP is undertaking its own study into workforce skills to understand:

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[5] See UK Innovation Survey 2019 Headline Findings: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/873740/UKIS_2019_Headlines_Findings.pdf

[6] Institute of Physics (2016); The role of physics in driving UK economic growth and prosperity: http://www.iop.org/publications/iop/2017/file_70263.pdf

[7] Social Market Foundation (2013); In the Balance: The STEM human capital crunch: http://www.smf.co.uk/wp-content/uploads/2013/03/Publication-In-The-Balance-The-STEM-human-capital-crunch.pdf

[8] HECSU (2020); Skills shortages in the UK 2019-20: Insight into occupational shortages in the UK Labour market: https://graduatemarkettrends.cdn.prismic.io/graduatemarkettrends/f90f52ec-a7ed-45bc-a9b8-1873c0da2c41_skills-shortages-in-the-uk-201920.pdf

- which physics skills are valued and needed by employers;
- whether the current supply of physics skills and knowledge meets the needs of employers today;
- how the demand for physics-related skills might change in future;
- and how the sector might adapt to meet these changing needs.

The IOP also recognises the role of open science in increasing access to knowledge and knowledge exchange. We are a strong supporter of open science and open access to scientific research and endorse the principles of ensuring the widest possible dissemination of scholarly work.

We are committed to working with UKRI to help achieve the vision of widely disseminated and re-usable research outputs and, at the same time, to supporting our research communities to publish their work in an appropriate manner and in the appropriate places. We believe that the best way to realise this vision is to permit and encourage a plurality of pathways that allow disciplines with different scholarly traditions to embrace approaches that best work for them. More detail about the opportunities and challenges associated with open access publishing are contained in our response to the consultation on UKRI's Open Access review.[9]

3. How can we encourage innovation and ensure it is used to greatest effect, not just in our cutting-edge industries, but right across the economy and throughout our public services?

The drive for innovation (and efficiency) in public services is unsurprising given the scale of public spending. The Office for Budget Responsibility estimated that public spending would amount to £840 billion or approximately 38% of national income in 2019-20. The Institute for Government estimated total public procurement to be in the order of £300 billion in 2017/18.

As with business-university collaboration, innovation in the public sector has been the subject of very many reviews and reports including notable work from the CBI, National Audit Office and NESTA. A 2009 report from the Royal Society[10] included a chapter on the role of STEM in innovation in the public sector. It noted that 'the public sector has traditionally viewed innovation as an ‘optional extra’ or even an added burden, rather than a core activity that is both necessary and of significant value. This is in contrast to the private sector, where innovation is perceived as vitally important in increasing profits and reducing costs, and even to survival itself.'

Many of the factors that constrain business-university collaboration have also been identified as constraints on public service innovation. These include the absence or misalignment of incentives, the prevalence of short-termism and a tension between policy priorities and pressure to keep costs low. In view of this, it may be advantageous to extend existing incentives for business-university collaboration to public services (or to repurpose them if necessary). For example, additional incentives could be offered to recipients of HEIF funding to work with public service partners and more secondments (or Knowledge Transfer Partnerships) could be offered to allow people to move between public services, private companies and academic research groups or PSREs.

[9] https://www.iop.org/policy/consultations/file_73999.pdf
[10] Royal Society (2009); Hidden Wealth, the contribution of science to service sector innovation: https://royalsociety.org/-/media/Royal_Society_Content/policy/publications/2009/7863.pdf

As noted by many commentators and reviewers, public procurement is a potentially powerful tool for embedding innovation in public services and, simultaneously, for driving innovation in supply chains (especially with SMEs). The idea that contracts are more valuable than grants is not new but, despite the success of the Small Business Research Initiative (SBRI), the UK has still not fully harnessed the power of procurement to drive or deepen innovation in public services or in value chains. Extending SBRI would help to stimulate UK-based start-ups and scale-ups but commissioning guidelines, the norms governing public accountability and time horizons all need to be adjusted if we are too see a more radical shift in mainstream procurement culture. For example, large-scale infrastructure projects (such as HS2) could be primed for innovation by embedding the requirement for new or prototype technologies and construction techniques. There have been some notable attempts to do this with defence procurement but, outside of the NHS, this has been less common in civil procurement.

With the advent of ARPA, and the scale and long-term nature of the challenges it is likely to tackle, there is an opportunity to more directly and purposefully link R&D, innovative collaborations and procurement. A combination of an extension to SBRI, the advent of ARPA and a more innovative culture in public procurement could offer stepping stones to SMEs in innovative supply chains to win contracts and grow their businesses which, in turn, may provide the basis for the growth of internationally significant value chains in the UK. These international value chains offer strong commercial routes to take UK-developed technologies and services to the global market, with significant scientific and economic benefits for the UK.

4. How can we attract, retain and develop talented and diverse people to R&D roles? How can we make R&D for everyone?

It is important to begin early in promoting the benefits and enjoyment of a career in R&D, as well as reducing the barriers to those who may not have considered this as a career. There needs to be a widening of the pool of people considering, applying and studying for subjects, to include more people in underrepresented groups in terms of colour, sexual identity, disability, social and economic backgrounds. Government should work with organisations in the R&D sector to engage with these groups to showcase the many and varied career options available to them. In addition, new resources should be developed to highlight the various educational routes, training and career opportunities available in the R&D sector. The objective should not only be to highlight the number of interesting career choices within the R&D sector, but to ensure more people – particularly those from underrepresented groups – see such careers as genuinely open and available to them.

Engaging with such underrepresented groups must be addressed early on and in a sustained manner – for example, by ensuring that every secondary school pupil in the UK has access to a specialist physics teacher, rather than teachers who have been trained in biology or chemistry to cover these lessons. In addition, steps should be taken to encourage girls and young people from black and minority ethnic and lower socio-economic backgrounds to consider careers in science. Particular encouragement should be made for girls to study physics beyond the age of 16, given the ongoing underrepresentation in the numbers of pupils studying physics for A-level (22% in both 2019 and 2018) or AS level (26% in 2019, 25% in 2018)[11]. Science teachers who are specialists in their subjects are beneficial for pupils in discussing careers in their respective STEM field. This is particularly true for girls studying under a female science teacher, as this provides a professional role model to aspire to, as well as someone who can help explore potential career options.

[11] Joint Council for Qualifications (2019); GCE A Level & GCE AS Level Results Summer 2019: https://www.jcq.org.uk/wp-content/uploads/2019/08/A-Level-and-AS-Results-Summer-2019.pdf

By encouraging more pupils to study science subjects at school, this will both help to address the current disparities in uptake of subjects such as physics, increase the numbers applying and studying these subjects at university and forms of other Higher and Further Education. With trained graduates, technicians and apprentices entering the workplace, this will increase the number of people going into R&D roles.

In addition to encouraging more pupils to study STEM subjects, it is also important to consider the environment in which those who move into the R&D sector work and operate. For example, there is currently a disparity in the success rates of female, disabled and ethnic minority applicants in securing funding for research (particularly that provided by UKRI) compared to their white, male, non-disabled counterparts. The Government must ensure a level of detail and and disaggregation to enable the development and implementation of evidence-based interventions to reform our research funding ecosystem. It should also work with science organisations (including the Institute of Physics) to ensure that academic researchers have an equal opportunity to publish the results of their work. In addressing such disparities, the Government should consider current initiatives such as the IOP's Project Juno, which recognises and rewards departments and schools of physics, institutes and organisations that are able to demonstrate that they have taken action to address gender equality in physics and to encourage better practice for all staff. The Jocelyn Bell Burnell medal, which is awarded annually to exceptional early-career contributions by early career female physicists, should also be noted by Government as a means of engaging talented researchers in an underrepresented group. Similar projects aimed at supporting other underrepresented groups, such as the Inclusion Matters initiative led by the EPSRC to further equality, diversity and inclusion in engineering and physical sciences research, should also be considered as part of a future strategy to engage such underrepresented groups around careers in R&D.

Finally, the professional conduct of research should also be considered, building on the requirement by UKRI for organisations in receipt of funding to adopt ACAS good practice guidance on bullying and harassment.

5. How should we ensure that R&D plays its fullest role in levelling up all over the UK?

Early in 2020, the IOP's Executive Team visited the Atomic Weapons Establishment in Berkshire, the Daresbury Laboratory in Cheshire and Sellafield in Cumbria to learn more about the impact of large-scale science and engineering facilities on national, regional and local economies. Such science and engineering clusters are vitally important to their local economies but they also have a magnetic effect in the wider region and beyond (sometimes nationally and internationally), drawing in people, skills, suppliers, innovators and investment.

The importance of Sellafield as an employer in the local and regional community is stark. Of the company's 11,000 employees, 85% are based at the site we visited. Although Daresbury employs only around 300 staff, it is also a science and innovation campus and is home to approximately 150 hi-tech, high growth companies (many of which are microbusinesses). This is the Government's place agenda - its strategy for levelling up and addressing regional inequality - brought to life.

A recurring theme on our visits was the importance of people and skills. It was very clear that skills is not 'a one size fits all' issue. We heard a lot about the breadth and depth of skills that are needed in the workforce. Each of the three organisations had established apprenticeship schemes and they rely on and greatly value the apprentices who have come through their schemes, with all three enjoying high retention rates.

At Daresbury, we heard about the direct impact of skills shortages on hi-tech businesses. There is an annual survey of the companies on the site and, in recent years, the survey results have revealed just how much these high growth businesses depend on finding appropriately skilled individuals. In 2016, 26% of the companies said their growth was constrained by a lack of available skills. In 2017, that figure had grown to 30% and by 2018 it was 33%. Although they are hi-tech firms, the skills they need are not just scientific. The areas of greatest need include software and IT, engineering, leadership, management, project management, commercial and customer service skills.

These examples highlight the importance of actively planning and building key infrastructure across the regions e.g. putting in place policies to support local skills development, supply chains and building application infrastructure (such as catapults and innovation centres) around centres, facilities and clusters. For our part, the IOP is committed to working with our community to build the first network connecting physics based innovation centres and facilities in the UK and Ireland.

The study for UKRI's Strength in Places Fund has already highlighted many of the UK's key areas of research strength, and where significant economic impact can be achieved. The Government should conduct such reviews on a regular basis to identify new and developing areas of scientific excellence, map supply chains and regional skills and knowledge. Key to the success of such studies is recognition that excellent research is taking place in unexpected institutions and supporting it accordingly.

This audit based approach may help to identify prospects or opportunities but, to achieve real change, overt commitments to developing institutions, networks and capabilities outside the South East are needed. Government could actively solicit proposals for initiatives, facilities, networks or centres of excellence outside the Golden Triangle. For example, a commitment could be made to siting ARPA somewhere other than London or the South.

6. How should we strengthen our research infrastructure and institutions in support of our vision?

To maintain and where necessary, strengthen our research infrastructure, the UK needs a comprehensive, coherent, strategic and long-range approach to planning, maintenance and investment. This must be a comprehensive system approach, encompassing skills, supply chains and other important dependencies that should contribute to the productivity and levelling up agendas.

The UK has a richly diverse research and innovation landscape with national and international facilities and institutions and infrastructure spanning the public, private and not for profit sectors.

The UK is home to several world-leading research facilities, such as the ISIS Neutron and Muon Source and the Diamond Light Source. However, it is notable that the UK has fewer Public Sector Research Establishments (PSREs), large scale development and/or demonstrator laboratories and facilities than many other developed nations.

Such large-scale facilities not only attract research talent from the UK and abroad, but also draw investment from philanthropic, industrial and overseas sectors. They also contribute to greater public understanding and appreciation of science.

Given the scientific and economic benefits of such facilities, the Government should consider new opportunities to invest in, renew and expand the UK's research infrastructure, particularly in areas that could underpin major scientific advances, help to address global challenges and stimulate economic activity on a large scale. For example, the IOP is aware of a proposal to Government to support and build the next generation X-ray Free Electron Laser (XFEL) in the UK. A UK XFEL could support multidisciplinary applications in fields such as structural biology and biochemistry (including research into the structure and development of the COVID virus), pharmaceuticals, engineering, fusion research, and clean energy.

The advantages offered by national facilities include retaining full control over science and technology programmes, retaining all intellectual property rights, including those necessary for commercial application, and the ability to safeguard future capabilities for industry and defence. Such facilities can support UK business and attract international commercial customers from across the globe, contributing to economic recovery and growth. The short-term benefits of building such facilities include construction, service and employment opportunities as well as opportunities for scientific and engineering innovation associated with the design and commissioning of facilities.

In terms of other existing infrastructure, developing and further rolling out across the country schemes such as the 'Analysis for Innovators' initiative, which was largely funded by grants, would be welcomed. The use of 'Catapults' could make these more accessible and also encourage collaboration.

7. How should we most effectively and safely collaborate with partners and networks around the globe?

Our community is closely intertwined with international networks, infrastructures, facilities and investment streams so, to stay at the forefront of scientific discovery and innovation, we must ensure that we maintain a strong presence in international networks, partnerships and programmes and that we remain open and attractive to talented researchers and innovators.

The physics community in the UK is enriched by talented people from all over the world. In 2017, 27% of academic staff in UK physics departments were from non-UK EU countries and 18% were from non-EU countries. More than half of physics postdoctoral researchers were from outside of the UK.[12] Openness to talent and ideas has allowed us to build strong international ties, valuable and productive research collaborations and world-class shared infrastructure. It is vital that the Government sends a clear message to domestic and international investors that the UK is open for business and ready to embrace the opportunities of a changing world.

A comprehensive, cross-government international science and innovation strategy is needed alongside the R&D roadmap. In the past, such strategies have been framed narrowly and have not fully acknowledged or encompassed the richness and diversity of the UK research and innovation landscape. Many of the UK's research institutions and facilities (including PSREs) have significant world standing but not all have benefitted from previous strategies. A rounded and coherent - and genuinely cross departmental - international strategy could make an important contribution to increasing and maintaining the foreign direct investment in R&D, which will be vital in reaching the Government's 2.4% target.

Engaging with EU science and innovation programmes strengthens UK science. The benefits to UK physics are not only financial: the exchange of ideas, people and technologies that the programmes facilitate are central to the strength of UK physics.

[12] https://www.iop.org/policy/consultations/file_72542.pdf, IOP, December 2018

While the Government's pledge to meet any shortfall in funding in the event of the UK's non-participation in the upcoming Framework Programme is welcome, we urge the Government to take steps to secure as close a relationship with the European science community as possible. The UK should ensure that full membership of the next Framework Programme, Horizon Europe, should be a minimum requirement for negotiations for a future UK-EU trade deal and we should seek to play a full role in ESFRI and other joint programmes that support physics.

Looking beyond Europe, international collaborations and partnerships are likely to play an even greater part in finding solutions to the biggest challenges faced by society, such as those identified in the Government's Industrial Strategy. In facilitating such collaborations, the Government should consider utilising the networks and specialisms of non-governmental organisations to broker and facilitate cross-border partnerships to bring together scientists and researchers from across the globe to work on projects that fuel discovery and innovation.

The IOP is focused on strengthening relationships in key countries including China, Japan, India, the USA and Canada and works to broker collaborations and foster dialogue and exchanges. For example, the IOP worked with UK and Canadian funders to help support investment in research between the UK and Canada (in quantum technologies), following an agreement between the two countries' Prime Ministers in 2017 to collaborate in several scientific areas.

IOP Publishing works with researchers and institutions from around the world. Our approach to publishing supports a vibrant and collaborative international community and allows high quality research to be published in high quality journals no matter where that research is carried out. We will continue to use our scientific publishing, and the international relationships it supports, to help increase our global reach.

8. How can we harness excitement about this vision, listen to a wider range of voices to ensure R&D is delivering for society, and inspire a whole new generation of scientists, researchers, technicians, engineers, and innovators?

In a mature and healthy democracy, every person in the country, from every walk of life, should be able to participate in well-informed discussion and dialogue about the choices and challenges that affect us all.

Such dialogue must be genuinely two-way – in other words, there must be a focus not just on imparting the value of science, research and innovation but on listening to people from all parts of society and learning about their lives, expectations and questions. The IOP is committed to making sure that people can participate in informed debates about public funding and policy issues such as new treatments and diagnostics in healthcare; decarbonising our economies; and cybersecurity and recognising the important role that physics will play in these. In this way we will help to amplify the public voice in discussions about science and society.

One of the ways we will do this is to enable public-led discussions and conversations by asking questions and sharing knowledge about the role and value of physics in all our lives.
We are organising a series of public meetings (alongside other scientific organisations) to better understand the issues which people are concerned about or interested in, with particular emphasis on climate, weather, artificial intelligence, big data, health and energy. Equipped with a better understanding of people's priorities, preferences or questions we can then communicate the benefits offered by physics in our everyday lives, detailing the journey

from research, through innovation to social impact and making physics and the solutions it offers accessible, real, tangible and easy to understand.

We will also demonstrate the diversity of the physics community, showing that this is a profession open to everyone in society now and in the future, for example, by showing how future jobs will offer opportunities to people from all backgrounds, including those who may not have considered physics as a career.

Central to this work are efforts to remove barriers to participation (for example those that negatively influence young people's subject choices and attitudes to subjects that will be vital to the R&D of the future) and to create opportunities for people of all backgrounds and ages to engage with physics and its connection to the world around us.

Initiatives such as these will be key to inspiring a new generation of scientists, researchers and other future STEM professionals, particularly those from groups which are currently underrepresented in R&D.