HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: Budget 2020: research and innovation spending, HC 257

Wednesday 18 March 2020

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Watch the meeting

Members present: Greg Clark (Chair); Aaron Bell; Mark Logan; Graham Stringer; Zarah Sultana.

Questions 1 - 66

Witnesses

I: Harriet Wallace, Director, International Research and Innovation, Department for Business, Energy and Industrial Strategy; Alexandra Jones, Director, Science, Research and Innovation, Department for Business, Energy and Industrial Strategy; Professor Sir Mark Walport, Chief Executive, UK Research and Innovation; and Sir John Kingman, Chair, UK Research and Innovation.

II: Dr Rupert Lewis, Chief Science Policy Officer, Royal Society; and Tim Figures, Director, Technology, Sustainability and Innovation, Make UK.

Examination of witnesses

Witnesses: Harriet Wallace, Alexandra Jones, Professor Sir Mark Walport and Sir John Kingman.

Q1 **Chair:** I am very grateful to the witnesses for coming today to give evidence on the Budget. There is a lot going on in the world of science and research, but the Budget settlement is very important, not least for that. We are very grateful to you for the flexibility you have shown in giving evidence to the Committee today.

May I ask the witnesses—two from BEIS and two from UKRI—to introduce themselves and to make any brief opening remarks that they care to make?

Alexandra Jones: I am director of science, research and innovation at BEIS. Shall I make some opening remarks once we have all introduced ourselves?

Harriet Wallace: I am director of international research and innovation at BEIS.

Professor Sir Mark Walport: I am chief executive of UK Research and Innovation. I will make a few remarks after Alex has spoken.

Sir John Kingman: I am the non-executive chair of UKRI.

Alexandra Jones: I will make a few remarks. I am pleased to be here to talk about such an important issue. The Government are firmly committed to becoming a global science superpower and continuing to collaborate internationally on scientific research.

That commitment was firmly demonstrated just a week ago by the Budget, in which we saw the largest and fastest-ever increase in public funding for R&D—a commitment to £22 billion in 2024-25, very much putting the UK on track to reach 2.4% of GDP being spent on R&D across the economy by 2027.

What has also been striking in recent months is conversations about how we make the most of that investment. We are keen to talk about not just the international dimensions of that—the Budget includes funding for continued participation in EU science programmes—but the place strategy for R&D, a commitment to ensure that we are investing in people and are very open to talent from around the world, and a commitment to make sure that we are really making the most of our huge strengths in world-class research. We are looking at a new funding agency for high-risk, high-reward research, while absolutely making the most of UKRI, which is not quite two years old, and the fantastic opportunities that it is bringing, and continues to bring, for the UK.

I am very pleased to be here to talk through more details of the Budget settlement and the wider work that the Government are doing on the UK as a science superpower.

Q2 **Chair:** Thank you very much, Alex. I turn to Sir Mark.

Professor Sir Mark Walport: I really want to contextualise my remarks in the present, in relation to the coronavirus. The truth is that the UK is a science superpower. You can see that in the science advice that is coming to Government from many of the researchers—researchers generally, because the social scientists are important as well. Of course, there is a great deal of increasing investment in research and innovation around the world. We are going through an industrial revolution and face a series of global challenges, both in economic competition and in the environmental consequences of having 7.5 billion people on the planet.

If ever you wanted a justification for the importance of discovery research, it is the coronavirus pandemic. I will cite three long-standing Medical Research Council investments: in Glasgow, in the MRC virology unit, which has a long and distinguished history; in Oxford, in the Human Immunology Unit, where one of the vaccine candidates is being progressed and funded by CEPI, the Coalition for Epidemic Preparedness Innovations; and at Imperial College, in the Department of Infectious Disease Epidemiology, where the infectious disease modellers are absolutely critical to providing the advice to Government. That is based on foundations of mathematical biology. The fact that the coronavirus was sequenced within days of the infection being identified in China came from discoveries in the UK going right back to 1953—in particular, the discovery of the methods for sequencing DNA and RNA. All that work was done by people who wanted to understand the molecular structures of life.

I come to the present. There is no doubt that it is good news that the Government have a clear commitment to research and innovation. That has to be the right thing to do. John and I believe that UK Research and Innovation is the organisation that the UK needs. You can see already that integration and working across disciplines are critical to tackling not only the present issue, but also the big global challenges that I have outlined very briefly. We bring together all the research disciplines, but we also incorporate the UK's innovation agency. That is important in supporting some of the biotechnology firms that are developing products, for example.

It is very good news that the Government have an ambitious vision for research and development. UKRI has a very ambitious vision for the next five years. We want to ensure that the UK is a science superpower. We are looking forward very much to working with Government to make that happen.

Q3 **Chair:** Thank you, Sir Mark. Perhaps we may use you, as the chief executive of our principal funding agency for science and research

generally and as a former Government chief scientific adviser—a very distinguished one—as a conduit to put on record our thanks and gratitude for both the work of the science community historically and the intense work that we know is going on now. It is absolutely vital, not just to the future of this country, but to the world. We are very proud of what has been achieved and very proud of the work that is being done at the moment.

I turn to the present. We will look first at the Budget and then broaden out into some wider questions.

Alex, reflecting on the Budget announcement, clearly you would consider it to be a good announcement in terms of what you were hoping for. Tell me what it means in practical terms for UK science and research.

Alexandra Jones: I think that it means several things. First, this is a very significant and long-term commitment. The Government have said, "We will invest £22 billion by 2024-25." That gives the science community certainty about the increases ahead. It also puts us firmly on track for the 2.4% target. We can come back to some more of the detail of that.

That commitment, and the investment behind it, is a very significant signal to the community, both within the UK and internationally, of the seriousness with which the Government are taking their ambition. I agree with Sir Mark that we are already a science superpower, but we need to make sure that we are making the most of that.

That is the first point. In the long term, we are on track for 2.4%. The Budget also includes a series of measures that support our world-leading research, for example. We have support for world-leading research in all regions and nations of the UK. Within that—talking about bureaucracy—there is some support for innovation programmes for business. It talks about £400 million for infrastructure, equipment and world-class research, which also supports levelling up.

There are a series of specific measures for the next year. The key things are the long-term commitment, the clear commitments in the Budget to back businesses to invest and innovate—R&D tax credits are part of that—the commitments to world-leading research and the commitments to make sure that we are doing this right across the UK and beyond.

Q4 **Chair:** We have the £22 billion by 2024-25, with a 15% increase for next year. To be clear, next year is the next financial year.

Alexandra Jones: It is.

Q5 **Chair:** So it is actually next month.

Alexandra Jones: Yes—it is next month.

Q6 **Chair:** It begins in April. We know what the overall budget for R&D is going to be for the first year of that. What is the trajectory thereafter?

What is the increase year by year until 2025? Is it front-loaded, or is it linear?

Alexandra Jones: The precise allocations are being decided as part of the spending review. We are looking at that and are working with the Treasury and UKRI to take into account the capacity of the system, to make sure that we are scaling up at the right level to get the right talent in place and to make the most of the infrastructure. We are investing in schemes. The plan is to increase that, but we are talking about that at the spending review. Detailed allocations will come out at the spending review, which is due to happen in July, subject to everything.

Q7 **Chair:** Based on your experience, what is optimal? Is it to have a steady increase, is it to front-load it or is it to back-load it? You must have some reflections on what you would like to see going into that spending review.

Alexandra Jones: We are working very closely with UKRI, which is delivering this on the ground. There are some programmes that are already in place and that can increase funding fairly quickly. That provides certainty. There are some programmes, such as infrastructure programmes, where you need a long-term commitment, but it may take a bit of time to get the spend in place. It does vary. One of the benefits of having the long-term commitment is that you have certainty for businesses and others about where this is going, but it varies depending on the different programmes. Mark and John may have some reflections on some of the detail of that. With infrastructure, you would expect it to scale up a bit. With the existing talent programmes, you can increase it reasonably quickly. I know that UKRI is oversubscribed with high-quality proposals. There are opportunities, potentially, to make the most of those. We are going through that in detail.

Q8 **Chair:** I will come on to Sir John and Sir Mark in a second. Everyone would agree that one of the great advantages of a commitment that goes out to 2024-25 is the prospective certainty that it provides, but that becomes actual certainty only if it is translated into budgets that can then allow funding rounds to take place. If the envelope is there, but the money is not committed to particular programmes, the benefit of that certainty is lost. You would agree with that, I assume.

Alexandra Jones: We are certainly working at pace, with UKRI and other partners, during the spending review to finalise what that will look like and what the programmes will look like. That will be part of the spending review.

Q9 **Chair:** You expect to do that in the spending review, which was intended to be this summer.

Alexandra Jones: It is intended to be in July.

Q10 **Chair:** Let me ask some questions about the 2.4% target, and beyond. It was a very important statement in the Budget that it remains the Government's policy to attain 2.4%, which has been the OECD average

for R&D funding. As you will remember from a previous role, that was the foundational policy of the industrial strategy. It is good to see that continuing. The industrial strategy also committed the Government to move beyond 2.4% to a longer-term—not necessarily a long-term—ambition of 3%. Does that remain Government policy?

Alexandra Jones: Certainly, the Government have talked about that previously. What is most striking about the Budget is the speed with which we are moving towards 2.4%. If we invest £22 billion by 2024-25, we will be at 0.8% of GDP then, based on OBR predictions. That puts us on track to get to 2.4% by 2027, certainly—potentially sooner. We know from looking at private investment that that can also stimulate further private investment. What the Government are doing is putting in the investment to move faster, if anything, towards the 2.4% target. The ambitions to be a science superpower speak for themselves about where the Government are hoping to go in the longer term.

Q11 **Chair:** Clearly, it would be good to get there faster. I hope you agree that to get there faster, and stay there, is not consistent with moving beyond the average and being one of the world's more research-intensive countries. Is it your ambition to record that longer-term ambition when it comes to the spending review?

Alexandra Jones: Ministers will certainly talk about that in the spending review, as we look at the allocations over the five-year period and beyond. I think that the ambition to be a science superpower—to get to 2.4% and to do that more quickly, if anything—is very clear. I am sure that there will be further conversations about that during the spending review, as we talk about where that money will go and which programmes it will be invested in.

Q12 **Chair:** Sir John and Sir Mark, you represent the principal research body in the UK. Although new, you draw on a heritage of success. The system of research funding in the UK is one of the things that mark out our excellence. It is founded on challenge and peer review, not on passing fashion, so we have a very important institutional inheritance. I am sure that you welcome the increased commitment to science funding and the longer-term certainty that it brings. Perhaps I will start with that. What was your reaction to the overall Budget settlement?

Professor Sir Mark Walport: Our reaction to the overall Budget is extremely positive. This is a major commitment. As Alex has just said, it takes us on a trajectory that is compatible with the 2.4% target—although, as we know, the 2.4% target depends on having roughly one part of public and two parts of private investment.

It is worth looking at the profile of funding going back to 2010. The funding for discovery research has remained largely flat since then, with increases in some areas. The big uplifts have been, first, in the development of ODA funding, which has been extremely welcome and has enabled us to create programmes like the global challenges research

fund, and, secondly, in the extremely welcome funding that has come with the national productivity investment fund. That has enabled us to do more work around the development side of the research and development or research and innovation targets.

It is important to say that one of the things that we have done in the first two years of our existence is build the capacity of the system through the introduction of a series of what are becoming increasingly well-tried systems for funding research and innovation. For example, we are looking at the pace at which we can get money out the door and spend the taxpayer's money wisely and well.

People underpin the whole system. They include the graduate students whom we train, some of whom will do research and many of whom will go into business and other walks of life. They are really important people: at the end of the day, science and innovation is a people game.

Then, of course, there is the infrastructure. We have future leaders fellowships, which are new leadership programmes. They provide much longer funding, traditionally. They are a very important direction of travel, and we can scale them up quite rapidly.

We are looking at working with innovation scholarship. One of the issues for the UK is the permeability between the academic and the business sector. We can scale all that quite quickly. We have created new centres for doctoral training in AI, which is obviously an important technological area.

Our strategic priorities fund has enabled us to fund a whole series of programmes that could not typically have been funded by a classic small or medium-sized grant route, tackling everything from air quality right through to advanced quantum science. It is a very flexible programme. Basically, it is built on encouraging people to have big ideas and supporting those. Again, we can do those quite quickly. They are typically grants of between £10 million and £40 million, so they are not trivial.

One good example at the moment is the productivity research institute. This is a critical issue. We have some of the best brains in economics and the relevant social sciences in the world, and this will give them an opportunity. There is a competition to choose that, which is near completion.

There is the strength in places fund. We will come back to place, but in the first round we found that there was an enormous demand. We are therefore confident that this mechanism can be used more extensively.

The industrial strategy challenge fund is very much the largest of all these funds and is where industrial leverage is the strongest. It is addressing a range of issues that are extremely important when it comes to tackling the net zero target, for example, which is extremely relevant to the UK's bid to decarbonise industrial clusters. It is looking at how the

hydrogen economy might develop and at energy systems in general, but it is also working on issues such as plastics.

I believe that we have a suite of schemes that is absolutely fit for purpose. I echo Alex's point that there is a range of timescales. In the last year, Mark Thomson, who is the executive chair of the Science and Technology Facilities Council, has published an infrastructure strategy going out to 2030. That provides a menu that needs to be prioritised and discussed with Government and the community. Of course, that will take much longer to bring on. One of the things in the industrial strategy is around medicines manufacturing, which is a critical issue. We believe that we have the range of programmes that the nation needs and that will provide the best value for money for the taxpayer. We are ambitious to move forward.

Q13 **Chair:** The structures and the capacity are there. Thinking about next year, I am sure that the 15% increase in research funding is welcome to you. What is your new baseline funding for the next financial year, which begins in a couple of weeks?

Professor Sir Mark Walport: The answer is that I do not know yet what our funding envelope for the coming year is. We are in active discussion with BEIS. Obviously, we are keen to know the answer to that.

Q14 **Chair:** It is rather surprising to discover that you do not know what the funding is for a financial year that begins in two weeks. Are you able to make commitments to scientists to continue research programmes if you have not had your budget? Can you anticipate it?

Professor Sir Mark Walport: I am confident that we will have a budget. I am very optimistic, given the 15% uplift, that we will have enough to continue our trajectory. Obviously, it would be nice for me, as an accounting officer, to have a bit more certainty.

Q15 **Chair:** Sir John, you are the chair of UKRI. Presumably you cast an eye over the prudence of decisions that are made. Has your council had any discussions or concerns about the budgetary situation for the year that is about to start?

Sir John Kingman: We are holding a board meeting today after this hearing. I am sure that this will be an important topic. To be clear, we are operating within the context of a Government who have said to us very clearly that they want to grow research and innovation spending. I do not think that anything is currently held up by the lack of a budget for the next financial year. We are operating on the basis of an assumption, which allows us to take the decisions that we need to take at the moment. We will need to have a budget, for sure. I expect that we will get one.

Q16 **Chair:** Harriet and Alex, perhaps you can help us—and help Sir John and Sir Mark—as regards when they might know how much money they will have for next year.

Alexandra Jones: We have been working very closely over recent months to make sure that we are giving as much comfort as possible to UKRI in making commitments to scientists and projects. As you know, it takes a little time after a formal Budget settlement to make the allocations. We are working at pace. It has been a week. The Budget was announced a week ago. We are working very much together, and rapidly, with the aim of ensuring that there is that certainty. Given the Government's commitment to making the UK a science superpower and the increases in budgets, we have been able to work closely with UKRI to provide that support for projects and scientists in the future. We are working at pace on the detail of that—the specific numbers, which UKRI needs, of course—and hope to be able to give it in the coming days.

Q17 **Chair:** You are confident that UKRI can maintain its previous commitments. It is a question of how the extra 15% translates into programmes.

Alexandra Jones: We have been working really closely with UKRI to ensure that, as a result of lack of certainty about the exact figures for next year, nothing stops that should not stop. Of course, UKRI takes decisions all the time about projects that are good and not good. We have been exchanging letters and are working very closely to ensure that the fact that the Budget was quite close to the start of the new financial year—for all kinds of reasons, and unavoidably—does not mean that anything stops that should not stop. We are working together very closely. We have been doing that since the end of last year, and we continue to work together closely. I am very hopeful that we will have the detailed budget out in the coming days.

Professor Sir Mark Walport: I should specifically reassure you that we are making new commitments in the context of the coronavirus pandemic. I will take the accounting officer risk of continuing to do that.

Chair: That is very important. I am sure that everyone would be reassured if that risk were covered and endorsed by the Government.

Q18 **Graham Stringer:** May I follow up on Sir Mark's opening remarks, which were interesting? We had the leader of the Oxford vaccine team here last week. I was certainly impressed; I think that the rest of the Committee was, too. There are at least four teams around the world looking for a vaccine at the moment, aren't there?

Professor Sir Mark Walport: There are many more than that. There are many teams around the world looking for one.

Q19 **Graham Stringer:** How are the Government approaching co-ordinating or using the best results from the different teams that are working on this?

Professor Sir Mark Walport: The first thing to say is that we are co-ordinated across Government. The grants that we are making at the moment are in partnership with NIHR. The chief medical officer is

involved and understands the decisions, as does the Government chief scientific adviser. We are joined up at that level.

Secondly, without going into enormous detail, I note that the specific vaccine to which you refer is one of those that are supported by CEPI, which I talked about before. The Oxford team is also actively involved in grant requests to us at the moment. Although this has not been announced formally, I think that it will be getting some more money. The team is also working with the Bioindustry Association on some initial scale-up manufacturing so that trials can be done.

It is worth saying that, on vaccines, there are many very good ideas being explored around the world. This is an area where there is open global collaboration. The challenge is the clinical trials, which take time and where choices have to be made. The UK cannot support all of them, but we will support what we judge to be the most significant opportunities for vaccine research. The witness you spoke to last week is in a very good team at the Human Immunology Unit in Oxford, which I talked about.

Q20 **Graham Stringer:** Are we going to get into the classic situation of UK science—that we make a breakthrough in vaccines but do not have the capacity to manufacture the vaccine? How are you approaching that problem of manufacturing capacity?

Professor Sir Mark Walport: I think that there is a dramatic change in the way in which new vaccines will be made. When Patrick Vallance spoke to you yesterday, he made the point that, whereas just a few years ago a new vaccine would have taken 20 years to develop, they can now be developed much faster. The rate-limiting step, ultimately, is making sure that they are safe and efficacious and do not cause adverse effects. Vaccines based on nucleic acids or on protein synthesis in the laboratory can be scaled up much faster. It is the distribution that becomes the issue, rather than the actual manufacturing.

Q21 **Graham Stringer:** So you think that we could manufacture in this country 30 million—

Professor Sir Mark Walport: To be honest, the commercial manufacturing of vaccines is not part of UK Research and Innovation's day-to-day responsibility, so I do not think that I am really the right person to answer that question. What I can tell you is that, when they are shown to be safe, nucleic acid vaccines can be manufactured at volume extremely quickly.

Q22 **Graham Stringer:** May I raise a final and very obvious point about the metric of how much money goes into research and innovation? In normal times, 3% or 2.4% of GDP makes sense. I do not think that you need to have a crystal ball to see that our GDP is going to shrink quite dramatically over the next 12 months or so. Have you thought through what the request will be? Will you want to keep the amount of increased

funding, so that it becomes a larger percentage of GDP?

Professor Sir Mark Walport: That is a very good question. When I talk about percentages, I always make the point that it is the denominator that matters, as you know. There are some quite fast ways of changing a percentage that is a percentage of GDP. That is not a trivial point. Obviously, this is a global shock that will reset economies around the world.

The other important thing to say in relation to your figure is that some sectors of the economy are much more R&D intensive than others. Of course, the pharma industry is traditionally one of the most R&D intensive industries. If there was ever a good illustration of why that is, it is now. A lot of the early research and development will go into vaccines that ultimately turn out to be dead ends. At the end of the day, the world does not need 15 different vaccines—it needs one or, maybe, two that really work effectively and can be distributed. Then we get into the technicalities of coronavirus—the question of what happens in future years, where there are some uncertainties. However, that is a question that is more for Patrick and Chris to answer, rather than me.

Sir John Kingman: It is important not to overstate that concern. To get from where we are to 2.4%, whatever happens to the economy as a result of the virus, will be an enormous increase in the R&D intensity of the British economy. It is an achievable goal. A number of countries have achieved similar shifts in their R&D intensity. The thing that is incredibly good about the 2.4% figure is that it is a whole-economy target. That shapes the way in which UKRI thinks, and I think that it shapes Government policy, too. We are thinking not just about how we can shovel money out of the door to the best public science, but about how we can spend money in a way that catalyses private sector activity, which is two thirds of R&D in the economy. That is really important.

Q23 **Graham Stringer:** I do not want to labour the point, but we might reach 3% of GDP this year, because the denominator shrinks.

Sir John Kingman: But only if the British economy were to halve in size. The thing that will be affected by the virus is the rate of growth in GDP, not the level of GDP.

Q24 **Aaron Bell:** On the coronavirus, a vaccine is an immediate challenge, but so is ventilation. We are looking at manufacturing a sufficient number of ventilators. Can the directors from BEIS update us on that and on whether anything is being done in the innovation space? I have seen suggestions that you might be able to use one ventilator for multiple patients. Is there any research in that space? Do the directors from BEIS have any information about the projects? If it is not their area, please say so.

Alexandra Jones: UKRI is looking at detailed projects. Certainly, we are working with it and supporting it to do things. For example, Innovate UK has a call-out for manufacturers who might be able to turn what they are

doing now into manufacturing ventilators. We are supporting and helping to co-ordinate that across Government.

We are also working with the Department for Education, UKRI and others to think about what impact this might have on a whole range of different sectors, including universities but also some manufacturing sectors. Are there ways in which we can make the most of the capacity around the country to support this effort? UKRI would be working on very detailed projects, which I think is more what you are asking about.

Professor Sir Mark Walport: I do not have a lot to add to that. Innovate UK is talking to people. I know the Department of Health is very actively speaking to a large variety of manufacturers to source ventilators, but another critical issue is the people who run the ventilators. This is largely a health service issue. If we can, we will help to identify innovative manufacturers, but the Department itself is working very hard on this. I am a clinician. The last time I worked in a respiratory hospital was in the early 1980s and I think the technology has improved.

Q25 **Aaron Bell:** That was all I wanted to ask about coronavirus. More generally, I want to ask about the £800 million for a British ARPA—a new funding agency. What advice would the panel give on setting it up? What would be distinctive about it? Should its focus be in broad areas or should it be mission based?

Alexandra Jones: BEIS is very much leading on this and working very closely with UKRI and others. What has been announced is the creation of a new funding agency specialising in high-risk, high-reward projects. We are very much in the design phase, looking at what we can learn from around the world and how to ensure it is a complementary part of the system, of which UKRI is such an important component. The conversations are very much inspired by US ARPA and particular interest in the early phases of that. The lessons from that are the importance of brilliant people being able to investigate quite high-risk and potentially high-reward projects in all kinds of areas—lots of breakthroughs came from that. We are trying to understand what that might look like in the UK context.

We are looking at international comparisons to see what might be relevant. For example, Canada has an agency called CIFAR, which we are talking to. We are talking to those involved in the various ARPAs—there are multiple different ARPAs in the United States at the moment—to understand what works there, and we are talking to UKRI academics and industry to think about where the gap is. It will be looking at new funding approaches, high-risk, high-reward projects, and trying to understand what is most effective.

On your question about missions, DARPA looks much more at specific missions. ARPA is much more about investing in people and allowing them to make discoveries more serendipitously, but with some focus. That is very much a live discussion at the moment.

We are also looking, if it is high-risk, high-reward—there is £800 million of public money in it—at how to make sure it allows risks to be taken but manages public money effectively. It is very much at the design stage. We are talking about a great deal of people, but that focus on the high-risk side and testing funding approaches, where we can look at what might be most effective and understand what works best, is very much there.

It is also interesting to look at organisations like the British Heart Foundation or the Wellcome Trust, where, interestingly, in their funding portfolio they are putting aside a pot of money to fund high-risk, high-reward projects and thinking about who they bring in to do that.

The key is people; those we bring in will be critical. We are very much talking to people about how we design this and answer questions about how tight or broad a focus it should have, and we are very keen to make sure we engage with people by holding a whole range of sessions to ensure that it complements the great work UKRI is doing. It does fund many bold, risky projects itself. We are keen to ensure we use this opportunity to do something that is slightly different that complements it.

Professor Sir Mark Walport: I want to make the point that UK Research and Innovation funds high-risk, high-reward projects. We have a long, distinguished history of doing so through our constituent organisations. You only have to look at the Laboratory of Molecular Biology in Cambridge to see that. If you want examples of high-risk, high-reward projects, at the moment it is developing vaccines for coronavirus. There is no question but that that is a significant and important part of our portfolio. Indeed, one of the best ways you can support high-risk, high-reward projects is to fund talented people who have bold ideas and are prepared to take the risks associated with them.

Having said that, we welcome the establishment of an ARPA-like agency. ARPA has been a number of different things over the years. Of course, it started as ARPA and became DARPA. It was created as a rather specific US response to the launch of Sputnik I, and its long-term effect in the United States has been to create the doctrine that the US wants to be ahead in every area of technology. We think there is plenty of room for an organisation complementary to us, and we are working closely with BEIS and others. I directed the Wellcome Trust for 10 years, so I am very familiar with some of the high-risk, high-reward strategies. Indeed, I worked with CIFAR, the Canadian body, and other North American organisations over the years. I do think there is an opportunity for a parallel organisation.

If you look at the history of ARPA, you see that one of the critical features is that its strengths and weaknesses have depended very much on the strengths and weaknesses of the leadership. You need visionary people. ARPA historically was led very strongly by engineers, who are good at tackling system-level projects, such as how you get a person to the

moon. The difficult thing about sending a person to the moon is getting them back again.

Sir John Kingman: It is worth adding that it is not at all unusual for us to work alongside other funding agencies. Alex mentioned the Wellcome Trust, which is a massive funder of work in the UK, or the NIHR. The Department of Health funds £1 billion a year of research, often alongside us. It is not unheard of that we collaborate with other major funders in the system. The amount of money that the Government are proposing to invest in ARPA is in the context of a much, much bigger investment across the board in science, and that also helps hugely.

The important thing to us is clarity about what ARPA is there to do—what the Government expect of it and what the leadership wants to do.

Q26 **Aaron Bell:** Obviously, it would be high-risk, high-reward, so there is a question about how we measure success and the tolerance for things not working. Secondly, there is a question of place, to which we have already alluded. What does the panel think of the prospects of managing to locate this ARPA somewhere outside London, the south-east and east, and putting it in the midlands or the north? Are there any thoughts on that?

Alexandra Jones: Location is one of the big issues under discussion, and there are different models for this kind of ARPA. Would you have it as an institution where you put lots of people in the same place, or would you have it as a hub-and-spoke model? Ministers would need to decide that, but I think there would be real enthusiasm to have that in the midlands, the north or other parts of the UK, although it would work with institutes potentially right round the country.

As Sir Mark and Sir John have said, the big lesson from all of these agencies around the world is that it is about people: the brilliant researchers and scientists, but also programme managers and those who make this happen. Many of them may well be right around the UK; there are lots of them around the UK, so we are open to thinking about what that would look like. That is very much part of the discussions they have at the moment.

Q27 **Chair:** Given the stress you have placed on high-risk, high-reward projects and the statement by Sir Mark that the current research system takes on such projects, in the Government's mind what is the specific problem to which ARPA is the answer? Is it that the appetite for risk is insufficient in the present system and is constrained in some ways? You mentioned people. Is it that we need to have a new set of people who are not containable or would not want to work within the present arrangements and institutions? Is it about the agility and commentary on some of the bureaucracy that goes with existing research institutions? What is the problem to which this is the solution?

Alexandra Jones: UKRI certainly does fund some bold high-risk, high-reward projects, but it is challenging to have some of the perhaps higher

rates of failure that you might get in some of these ARPA-like organisations. For example, one of the challenges faced by ARPA-E in the 10 years of its existence is that lots of the things it is doing are not working, but when do you measure success? For UKRI, given the money it has had, one of the questions Government will ask is about success rates. It does fund high-risk, high-reward, but that is among a portfolio of projects.

An organisation that is all about high-risk, high-reward means it can have a higher appetite for risk. It is about the people and having that mechanism for funding individuals to investigate their interests and not have to demonstrate impact.

We are looking at bureaucracy and other things. I know that in the wider system we are also looking at tackling some of the bureaucracy, but I think it is about that level of risk and potential failures because you are taking particularly high risks.

The final issue we are trying to investigate—we are looking at this and talking to people about it—is whether there are areas of research that are perhaps where quantum computing was 30 years ago that can be more challenging, because it is very, very vague at the moment to invest in them. UKRI will invest in some of that. I think that having some dedicated funding to do that is regarded as an opportunity to ensure we are able to fund the very speculative that could lead to all sorts of serendipitous outcomes, such as the internet or GPS.

Q28 **Chair:** Given those concerns and ambitions, one of the things it might be appropriate to do is reflect on whether the reforms of existing institutions might be able to apply those insights on perhaps an even broader canvas than the £800 million for ARPA. The Committee may want to help the thinking on this embryonic institution to make sure it accords to our best traditions and best international practice.

Professor Sir Mark Walport: One of the important drivers around ARPA has been bureaucracy. In that sense, it is rather helpful to UK Research and Innovation because we have inherited quite a bureaucratic system, and we are working very hard to tackle that. We are doing some experiments with rather stripped-down forms. I think it is a slight myth that ARPA itself was not bureaucratic. Its early years—it came out of defence—were dominated to some extent by arguments about whether the generals or engineers controlled it, but, leaving aside the history, I do think there is an opportunity for us to become much nimbler, and having another organisation that is pushing down on bureaucracy will help us.

The other important point is tolerance of failure. I think that over time we should be much tougher over closing down things when they do not work. At the moment there is still a slight culture that people are frightened of closing things down because acknowledgment of failure is seen as carrying a certain stigma.

There are some real opportunities here. We have an industrial strategy challenge. Not every challenge is as successful as others. That is not surprising. They are all tackling quite high-risk things. I do think that UK Research and Innovation is taking the bureaucracy agenda very seriously.

It is about making our awards better, not simply about making grants shorter. If you are talking about a piece of research or innovation, the key questions in determining whether to fund are: what is the question you are trying to tackle, be it an innovation or research question? Why is it interesting or important? Let us have some indication of the ability to tackle the question, and are you in an environment that enables that to happen? Then you need to know roughly what the resources are at the time you ask the question. You do not need to know it to the last pound, but you need to know it within 10%. If it looks like that should be funded, you can go into more of the details, which we ask of almost everyone.

Answering those questions well on four or five sides of paper is rather harder than filling out a 50-page form that has a whole lot of other stuff on it.

Sir John Kingman: Chair, I think your point is absolutely correct. Another good example would be the industrial strategy challenge fund, which is at least as big an intervention as ARPA. We have already employed a set of challenge directors for each challenge, which was very consciously modelled on what DARPA/ARPA had done in the United States and is proving rather successful. It is completely different from the way in which the research councils have traditionally operated.

If it is clear that ARPA is able to have a set of freedoms that allows it to employ really talented people, which we might not be able to do because of the traditional constraints within which we have operated, we would want to argue for the lessons of that to be learned.

Chair: There is more to follow up in the weeks and months ahead, and I hope that the Government will have an appetite for motivated members of this Committee and its expert witnesses being able to guide that so we can make the most of an important opportunity, with significant funding attached to it, but also learn any lessons from doing that and apply them to existing organisations.

Q29 **Zarah Sultana:** Alex, you touched on increasing R&D tax credits to leverage private investment. What evidence is there that increasing the rate of tax credit will mean research being undertaken that would not otherwise have taken place, rather than companies using it as tax relief for research they would have done anyway?

Alexandra Jones: I would normally be very happy to answer that, but, as Sir John is an expert on this, having done it in the Treasury for some years, I would like to pass that to him.

Sir John Kingman: I am not sure I can claim to be an expert, but I do know some experts. I was involved in the creation of R&D tax credits in the late '90s and their development over subsequent Budgets. They are a massive intervention; they cost the Government a lot of money. I think the total spend is about £3 billion a year, so this is very serious spending by the Government. They have been exhaustively studied both in the UK and internationally. It is interesting that the Institute for Fiscal Studies, which is institutionally very sceptical about any form of tax subsidy, has published a lot of work on R&D tax credits that I read to be very positive about their impact.

It is also very important to bear in mind that we operate in a world in which essentially every developed country has an R&D tax credit. A large part of the purpose of an R&D tax credit is to ensure that the UK is a competitive place in which mobile R&D will occur.

We know that R&D tax credits make a significant difference to that. They also make a big difference to the cash flow of smaller firms. That is why the SME tax credit was always payable even to loss-making firms that were at an early stage and not yet making profits.

Q30 **Mark Logan:** Sir Mark, earlier you touched on the UK being a science superpower. In relation to DARPA and ARPA, do you see that as the silver bullet, or what other things should we be thinking of outside this new idea of ARPA in the UK?

Professor Sir Mark Walport: I am not quite sure I understand the question in terms of a silver bullet.

Q31 **Mark Logan:** To maintain our leadership role as a science superpower.

Professor Sir Mark Walport: Obviously, to maintain that leadership role does require resources. We are behind the growth of other countries. As Sir John has said, this is a massive intervention. It is interesting that other countries have shown they can absorb that sort of increase in R&D over a similar timescale. Korea is a very notable example of one that has succeeded in doing that. At the end of the day, the trick is to build the human capacity; that is going to be the really important thing.

One thing that has not been mentioned and has been an extremely important intervention in the past couple of months is the global talent visa. That is really important. One of the aspects of leading in research and innovation globally is that you have a global workforce. The global talent visas, on which we have worked with BEIS, the Home Office and No. 10, are an important intervention, because researchers and innovators on grants funded by UKRI and other similar organisations here and around the world will be able to come here and very easily bring their families with them.

That is a very important part of the silver bullet, to use that nomenclature, but they will come as long as the environment is present. It comes back to the environment and infrastructure, which will be critical

to do their work. Therefore, maintaining that infrastructure, which is a much longer-term project, is going to be absolutely critical. We do have world-leading infrastructure; we also participate in global infrastructures—for example, our subscription to CERN. While CERN is most famous recently for the Higgs boson, it has also developed technology particularly in the handling of large data and the invention of the worldwide web by Sir Tim Berners-Lee. That has been absolutely critical. It is about being global in attracting people but also being global in our outlook and global partnerships.

Harriet Wallace: All the endorsing bodies that are now part of that visa scheme are starting to get applications. Early indications are that it is starting to attract people.

Alexandra Jones: On your "silver bullet", the way we are thinking about it is that the UK is a science superpower. Of course, we have world-leading research and ARPA is a part of that. As Sir Mark and Sir John have made very clear, a great deal of fantastic research is already happening. How do we build on what is already happening and make the most of this opportunity? How do we invest in and attract people from around the world and remain attractive for them and those already here? How do we maintain the infrastructure but also invest in new infrastructure where the UKRI's map of opportunities and international relationships will be incredibly valuable? Given coronavirus, it is also about thinking how to make the most of Government's capacity in research to respond to situations like this, but also how we leverage in private investment, which, going back to the 2.4%, will be critical to reaching that in the years ahead, whatever happens to the denominator.

Professor Sir Mark Walport: To return to something Sir John said earlier, business—industry—is an absolutely critical part of this. What is the goal of being a science superpower? It is the prosperity of all of us as citizens. That depends on our economy, health and all sorts of things.

Success has to be measured by the state of the economy and whether we have the innovative businesses in a world that is changing dramatically. One of the big challenge areas is the service sector, because approximately 80% of our economy is the service sector. We see innovative businesses in many respects, but a lot needs to be done on R&D there, and there are also issues of diffusion of technology, which are very important.

Q32 **Mark Logan:** In terms of levelling up, earlier you mentioned the strength in places fund. Are there plans to increase that fund?

Professor Sir Mark Walport: That is part of our discussion with BEIS and Ministers over the next short period. What I can tell you is that the demand through the strength in places fund is large.

Sir John Kingman: It is high-quality demand.

Alexandra Jones: BEIS is developing a place strategy, working incredibly closely with UKRI but also looking at some of the work going on across governance on levelling up. A key part of that will be looking at how we make the most of excellence around the UK. Innovation and jobs around the UK are also a big part of being a science superpower, as Sir Mark has said.

Q33 **Chair:** Do you have a published strategy, or will you have one, to address the levelling-up principle and reconcile that with the funding excellence principle?

Professor Sir Mark Walport: We do not have a published strategy at the moment. We will be discussing this at the board in a few minutes' time, so we are working very hard on it. Obviously, we would work with BEIS on that because Ministers ultimately need to agree the different approaches we are taking.

We have very ambitious plans in terms of levelling up. We talk about strength in places, but that is only one vehicle. We are working increasingly closely with the British Business Bank. There is a huge number of opportunities. It is worth remembering that excellence is distributed very widely around the country. There are not very many places that do not have major universities somewhere nearby, so I think there are plenty of opportunities.

Alexandra Jones: BEIS has committed to publishing a place strategy in the summer, subject to everything that is going on at the moment, so that should respond to that point. We are also very much ensuring that we make the most of work going on in other Departments. We will be working with DIT on investment and infrastructure, so there are opportunities to make the most of multiple things as we think about how we are to make the most of R&D right across the UK.

Q34 **Graham Stringer:** We have some of the best universities in the world: Oxford, Cambridge, UCL and Imperial. Our other universities are very good by any international comparison. Would you, Sir Mark, think that a reasonable criterion for whether we have succeeded in levelling up is whether Newcastle, Manchester, Liverpool or another university got up to the level of Oxford and Cambridge?

Professor Sir Mark Walport: We need all our universities to be as good as they possibly can be. There is a tendency to take a somewhat holistic view of universities. I have had the privilege of travelling around UK universities going back to 2003. Every university you go to shows huge areas of strengths. Sometimes they are in narrower areas than others. Even in the greatest universities, not every department is as good as the best in the world.

We have to build on strength. I can give you many examples. If you look at the clusters that are developing—I think that is quite an interesting way of looking at it—you see a strong cluster around semiconductors

building in the Bristol-Cardiff area, with extremely strong universities. In Dundee there is a world-class life sciences cluster built on an extraordinary department of biochemistry. You look around Surrey and the satellite sector where you can see very important spin-outs.

On a more local scale, you can look at the partnership at Lincoln between Siemens and its gas turbine business and the university, where it has created a new engineering department.

One of the tricks of local economic development is going to be identifying where the real strengths are—you need some kind of kindling—and building around that. That is typically about more than one university producing the academic research; you need the technical skills and apprenticeships. You see industrial strength, corresponding university strength and local government commitment.

Another important factor is that in many cases you can see the clear effect of local leadership. It is difficult to underestimate the importance of leadership. What we have to do is work to identify local leadership to help places to grow, but not all levers are in the hands of BEIS or UK Research and Innovation. Transport is very important as well, so local transport policy will matter. This is a systems engineering challenge that we will have to work on right across both the broad public sector and Government and local government.

What is going to be important—this is another area where UK Research and Innovation can contribute—is that this needs detailed microeconomic analysis to work out the individual situation in different places. No two places are exactly the same. We need to work with places across the UK. It is not just for UK Research and Innovation. We have to work with others to identify the local opportunities. I think the strength in places fund is a very good example of how that is starting to work. As Sir John has said, there seems to be very good demand, but the other issue is diffusion. How do you deal with the quite large tail of businesses that are not using the current state of technology?

Q35 **Graham Stringer:** I think that is a fair description of the strength of our universities, which is very considerable, but I do not think that Sheffield, Manchester or Newcastle Universities and what they do in any international ranking is at the same level as Oxford, Cambridge or Caltech. It is about getting those universities, on the basis of the strengths they have, to that level. That is what I am really asking about. Would that be part of any strategy that you envisage?

Professor Sir Mark Walport: Our strategy will be to build on the strengths. With respect, it is easy to be a bit tough. We are in the extraordinary position of having a number of universities in the top 10 in the world. If you look in the top 200, you see that many of our universities are present. Would we like all of them to be in the top 20? Of course we would, but the fact that there are any, in the context of what has happened in the US over many years and the extraordinary growth of

universities in China, shows that this is becoming a much more competitive marketplace for education, research and innovation.

It goes back to where we started, which is why it is so important to continue to raise our game and not simply say, "We are a scientific superpower, so we do not need to do anything." I do not believe Government is doing that.

Q36 **Graham Stringer:** May I take you back to the answers on ARPA? You went very concisely through a list of criteria to check potential research projects. You did not mention assessment of the impact of research, which has always been a difficult thing. Was it an omission, or has it been dropped?

Professor Sir Mark Walport: Clearly, we have to be able to provide the best justification ultimately to taxpayers that their money is wisely spent. One of the difficult challenges is to come up with a concise description of a discovery portfolio of research. If you say that the field-weighted citation index is four times the global average, that is not a very satisfying statistic. It does tell you that your research is cited a lot, so the question is how we adequately describe the product of what we are trying to achieve, which is discovery. I think that will require narrative at least as much as numbers. We can tell you about numbers of papers; we can tell you the quality, but at the moment, on coronavirus, it comes back to narrative and what discoveries are made, recognising that we do fund high-risk, high-reward research and not every research project yields important discoveries, nor should they.

Q37 **Graham Stringer:** When UK Research and Innovation was set up, it followed a long period when the percentage of funding to each research council had ossified. I think your challenge was to make decisions so that history did not determine where the research money went. Have you made progress on that? If so, what is it?

Professor Sir Mark Walport: It is work in progress. To put some numbers on the point you have made, the money in the traditional research ring fence declined by 15% in real terms between 2010-11 and 2019-20. That has been by some measure compensated by the fact that there has been an increase in funding through ODA, which is important, and also through the national productivity investment fund, but it emphasises that we need to make sure we have a broadly balanced portfolio. To head off what perhaps is the next question on what the right answer should be between research and innovation, there is not really a right answer.

Graham Stringer: I understand that.

Q38 **Chair:** I am sure the Committee will return to that subject. I know that all members of the Committee have a great interest in the regional excellence agenda, to which we will return.

We talked at the beginning about budgets for UKRI and other bodies

coming out of the overall budget. There was a commitment to publish a road map to the 2.4% target both by the Government and UKRI by December. That has not happened. When might we expect that?

Alexandra Jones: The spending review would be a good opportunity because we will have a much better sense of it. Reference was made earlier to certainty around allocation of the programme, so following that spending review would be a good opportunity to set it out.

Q39 **Chair:** Sir Mark or Sir John, is that your intention as UKRI?

Professor Sir Mark Walport: We are working in lockstep with our parent Department.

Q40 **Chair:** On Zarah's question about R&D tax credits, the 2.4% refers to public and private and will need to inquire into the efficacy of what drives up private sector investment. Sir John referred to some IFS research. What we do know is that such evidence as there is suggests it is the small and medium-sized enterprise R&D tax credits that have had the principal effect, and most claims have been made for that. That was not the focus of the Budget. Do you think it should have been?

Sir John Kingman: The SME credit and large company credit have broadly different purposes and are both necessary. The large company credit is relevant mainly to mobile R&D internationally. The SME credit is particularly important from a cash-flow perspective for small and growing firms. A good approach is one that embraces both. The competitiveness of the large company credit had fallen behind, as it were, the international pack. It is very welcome that the Government have increased somewhat the value of the large company credit. It is not my reading of the evidence that the SME credit is dramatically more impactful than the large company credit; its purpose is different. You need both.

Q41 **Chair:** We have been talking a lot about science, but everyone here today is responsible for UK research, which includes the arts and humanities and social sciences. Alex, you confirmed that all the Budget announcements are in scope and there is no decision or implication that these other disciplines in which the UK is very strong and excellent are excluded.

Alexandra Jones: There certainly is not. We are talking about the allocations and where they will go. UKRI includes AHRC and ESRC. One of the things UKRI has created is the multidisciplinary opportunities. If you look at the industrial strategy challenge fund, it is striking that it is not just about engineering but the required behavioural changes. That is about bringing things together. The strategic priorities fund is explicitly multidisciplinary about bringing things together.

Certainly, UKRI will be looking at some of that detailed work in partnership, but in making those allocations it includes those councils. There is no decision made about the detail, but the strategic priorities

fund and industrial strategy challenge fund are just two examples where a slightly different approach to funding, for which UKRI has created the opportunity, brings those disciplines together and makes sure we have got those advances and they are actually used and adopted by companies.

Q42 **Chair:** Sir John and Sir Mark, was not one of the founding purposes of UKRI to bring together what might have been siloed research councils?

Professor Sir Mark Walport: Absolutely. Thank you for that question. We have talked a fair amount about the social sciences, but the arts and humanities in a broader sense are absolutely critical at a time of modern plague in understanding the history and literature of previous plagues, because this was a much commoner experience in the past. It is the arts and humanities that contribute to the culture, be it sport or the arts, and make life worth living for many people. This is enormously important. We see it as being absolutely critical that we are responsible for that very broad portfolio. It is science in the sense of the renaissance and enlightenment as much as anything. Therefore, when we talk about the sciences, we talk about all of them.

Q43 **Chair:** Finally, to return to the current context, Graham asked questions about the development of manufacturing capability. Obviously, currently the lessons from scientists across the world need to be applied at a very rapid rate so that we can make the earliest possible advances in the science in which the UK is so strong. Would you just reassure the Committee that the agility of funding mechanisms for research in UKRI is adequate to the urgency? Perhaps you might say whether there are any changes you are making so that prospective lines of inquiry can be pursued more quickly than might otherwise be tolerable.

Professor Sir Mark Walport: I will make two points, if I may. Your point about manufacturing is important. It is one example where, if you look at the distribution of the high-value manufacturing catapult and its different components, there are very strong bases around the UK—for example, in the west midlands.

On your specific point, at the moment we are running two very fast call responses for research programmes relevant to the coronavirus pandemic, including the social sciences. A panel met yesterday, and decisions will be made rather quickly after that. We will make available further money. The issue is where infrastructure is involved. There, the limiting effect is not the speed of the decision but the speed of implementation.

Chair: I thank our witnesses for coming today at an important time. The Budget was a very important one for science and research generally. I am sure the Committee will want to keep a close eye on it. Having had this good news about a boost in research funding, it is very important that we do not snatch defeat from the jaws of victory by not deploying it as quickly as possible through any uncertainty in budgets.

The very important innovation in policy of establishing this new research agency is a very exciting opportunity. I am sure the Committee will want to help the Government and science in learning the best lessons from history and what happens around the world, including applying those to some of our existing institutions.

The importance of place in the settlement and in future science strategy will be very important. We look forward to the publication of the place strategies that were mentioned, which I anticipate will be reflected in the road maps—the 2.4%—as well.

We are very grateful for this session and look forward to meeting in the months ahead. Thank you very much.

Examination of witnesses

Witnesses: Dr Rupert Lewis and Tim Figures.

Q44 **Chair:** I thank Tim Figures and Rupert Lewis for joining us today. We have just taken evidence, which I think you have seen, from UKRI and from BEIS, the Department with the budget for science and innovation. You will have seen our pleasure at the fact that there is an increasing trajectory for the science and research budget, both for the next few years and a longer-term trajectory to get to 2.4% of research and development spending across the economy.

We would be grateful for your guidance on the most important priorities for that. Will you introduce yourselves and, if you want to make some introductory remarks, you are welcome to do so? Let us start with Dr Lewis.

Dr Lewis: First, I offer apologies from Professor Richard Catlow, the foreign secretary, who was due to be here this morning. Unfortunately, he is unwell, so I am his replacement.

We welcome the commitment to 2.4% and the very strong financial commitment made in the Budget of £22 billion. As some Committee members have mentioned, this is a great announcement and a great signal, particularly to the investment community. We look forward to the plans—the detail of how it will pan out—and to helping the Government.

We are interested in their policies with respect to basic research versus innovation. Given the 2:1 private-public investment ratio, we are particularly interested in what their plans might be for attracting private sector investment, here and overseas.

With the place agenda, a number of our fellows have advised on ARPA, which is interesting if not yet completely formulated. Again, we look forward to helping the Government with that as best we can, although, having said that, it is a small part of a much bigger innovation ecosystem—so how that fits in is interesting.

Across the science agenda, in terms of what is important at the moment, we welcome the doubling of investment in energy innovation and the net zero agenda, the R&D tax credit increase and the private investment perspective, and the Nature4Climate fund and natural environment impact fund. Our conclusion is that this is a really welcome financial commitment, but we look forward to seeing what the actual plans are.

Tim Figures: I am the director of technology, sustainability and innovation at Make UK, the national membership organisation representing around 20,000 manufacturers of all shapes and sizes across the UK.

Like others, we very much welcome this increase in expenditure, because it is of the order of magnitude needed to give a realistic chance of hitting the 2.4% GDP target. As an organisation representing the people who will have to significantly increase their own contributions to make the numbers add up, we are very interested in how this funding will flow through and how our members, which currently represent as a sector around two thirds of all private sector research and development, will be incentivised and supported to come up with the additional private sector cash that will be needed to make the numbers add up across the board.

Q45 **Chair:** Thank you, Mr Figures. Perhaps I may start with you, on the basis that the money is for research and development. This country has quite well-established structures of peer review inherited from the research councils, which on the pure science and research side are well embedded. It is fair to say that, on the applied side, particularly in technology and innovation, the same institutions are not there, so your guidance on the important priorities will be particularly key. I would be interested to know how you shape the funding agenda of the institutions and whether you have a view, on behalf of your members, about what the priorities should be within the new settlement.

Tim Figures: Absolutely. Two thirds of all expenditure is in manufacturing, which in turn is comprised of four sectors: pharmaceuticals, aerospace, automotive and electronics. Other sectors that might be critical, or probably would be critical to a levelling-up agenda, such as metals or food and drink, currently have very low research and development intensity. While we would want to build on the good work done in those four key sectors, we think that spreading innovation more broadly across manufacturing as a whole is important.

One thing that in our experience does not work quite so well as it could is encouraging existing manufacturing businesses, many of which are very well established and are in parts of the country where the levelling-up agenda is particularly relevant, to adopt and embrace digital manufacturing techniques. While organisations such as the High Value Manufacturing Catapult are very good at research into those techniques, support for the adoption or diffusion of those technologies into manufacturers is not yet where it should be.

Q46 **Chair:** Given the concentration on the sectors that you describe, is that a reflection of the funding priorities of official bodies—of Government Departments and their agencies—or a reflection of the research culture in those industries?

Tim Figures: It is probably a bit of both, because one has probably followed the other over time, as people investing public money have wanted to attract the greatest possible private sector match funding for those investments.

Q47 **Chair:** Given that the implication of that is that some of these sectors have not had the voice, or at least a successful voice, in Government and their related agencies, how can that be corrected?

Tim Figures: You are rightly focusing on the £22 billion and the research and development aspects, but Make UK's members, particularly smaller and medium-sized manufacturers, are participating in a range of schemes that might be termed regional economic development. Looking at how decisions work elsewhere in the Budget—around the shared prosperity fund, for example—is also critical. At the moment, we are seeing a lot of universities and catapults helping manufacturers to digitise and improve productivity that are actually using funding sources like the European regional development fund to fund that kind of activity, because they are not finding it as easy as they would like to get funds from Innovate UK to do that kind of thing.

Q48 **Chair:** Does it concern you and your members that, if they have had recourse to those funds because the domestic sources have not proved successful in reliably funding them, the end of access to those funds is going to compound the situation?

Tim Figures: Absolutely. Decisions that have yet to be taken about how the shared prosperity fund will work, and, in particular, who can bid for it and what they can spend those funds on, will be critical. If that fund's criteria end up being drawn too tightly, we could see a funding gap in this area open up, which would point things in the wrong direction.

Q49 **Chair:** Obviously, part of the totality of the funding settlement is for research and development more broadly. There is sometimes perceived to be a tension between blue-skies research, as it is sometimes called, or discovery research, and applications, including the diffusion of technology already invented but not taken up. Do you have any view on the current balance of funding in the inherited settlement between those two?

Tim Figures: Again, it is important that both things are financed and supported. In our view, whatever the funding route, whether it is via Innovate UK or other budget lines, having more support for diffusion and adoption of whatever technologies are invented, whether new or existing, is critical.

Q50 **Chair:** Are there particular schemes that have proved successful in that?

Tim Figures: You will be familiar with the work of the Made Smarter commission of a few years ago, which looked at this critical issue of digitalising manufacturing. That commission made a number of recommendations, which have been partially implemented; one which has been very successful was an integrated pilot scheme that operates in the north-west at the moment but not in other parts of the country. One thing we have called for very strongly is for that scheme to be rolled out across the country to help manufacturers modernise and digitalise.

Q51 **Chair:** Have you had any response to that call?

Tim Figures: It was put into our submission ahead of the Budget, and the Budget did not make any specific announcements on that, but we are aware that decisions are yet to be taken on the detailed allocation of these funds through the comprehensive spending review. We are actually engaged at the moment in an exercise of gathering evidence across the country about the effectiveness of these measures. I should have been in the north-west today, engaging with stakeholders, but for obvious reasons I am unable to travel. But we will gather together that evidence and produce it before the comprehensive spending review, and hope that the Government take it on board.

Q52 **Chair:** We are glad to have the benefit of your wisdom today, as you cannot make it to the north-west.

You will have heard in the previous session, exactly as you said, that some of the specific funding allocations have not yet been made for the financial year ahead. Do you happen to know from talking to your members whether that applies to ongoing schemes such as Made Smarter?

Tim Figures: As we understand it, funding is there for the Made Smarter pilot scheme, and, actually, there is the possibility under the industrial strategy challenge fund for stakeholders in other parts of the country to bid for schemes that will do similar things to Made Smarter, but we have not received any detailed feedback from Government about exactly what funding will be available for what from later in the year.

Q53 **Chair:** Dr Lewis, you obviously welcomed the settlement that has been made. Do you have any reflections, as one of the most august bodies representing practising scientists across the country, on how priorities should be set for the use of this money?

Dr Lewis: Yes—and reflecting on some of the questions from the previous session—we see the dichotomy that is sometimes expressed between basic research and innovation and near-market innovation as two sides of the same coin. It would be good to regard them as an ecosystem: today's basic research is tomorrow's innovation. Many world-changing innovations, such as antibiotics, lasers, X-rays and so on, started out as basic research in areas that were not anticipated to have such effects. We are looking to the Government to consider this as a

healthy ecosystem and think about how they can use the increased budget to increase the health of that ecosystem.

If you look at the data—you referred in your previous question to the manufacturing side—the Royal Society's mission is to promote excellent science for the benefit of humanity. The benefit of humanity aspect of it is how you go from a research paper to the actual effect to the economy and society, in health, environment and so on. How does one improve the nature of that journey or translation? The innovation pathway is one of those ways, and the UK historically has had not a very large budget. The innovation ecosystem is quite young; catapults are not that old, as an institution. So I guess we would be looking for progress in those areas.

Signals of long-term intent would be really useful, again, particularly from the point of view of the 2:1 private-public ratio. How does one send signals that the private sector is aware of what the UK's framework looks like, has an awareness of what the innovation ecosystem looks like and has some reasonable certainty that it will persist in its current form or evolve in a recognisable form over a reasonable period of time? So we are looking for a long-term agenda.

On place, again, as Sir Mark mentioned, there is excellence all around the country. There is excellence as academics would recognise it, in the sense of publication rates, field-weighted citation indices, and so on, but the Royal Society also has a view that it is about the whole system. It is not just about the higher education sector—it is also about the further education sector; an excellent ecosystem needs brilliant technicians as well as great academics. There is much innovation that is near market that would never feature in an academic publication. In terms of the benefit to humanity, we take a holistic and system view, and we look to the Government to take a similar perspective.

Chair: Thank you. Aaron Bell had some questions on ARPA in the last session, and you indicated some thoughts and views on that. I shall hand over to Aaron.

Q54 **Aaron Bell:** You mentioned how often science in the past has been driven by serendipity, and innovation has gone into areas that you would not necessarily expect. First, to both of you, what is your initial response to the proposal of £800 million going into a British version of ARPA?

Dr Lewis: From the perspective of the Royal Society, it is really important for innovation ecosystems to adapt and evolve, and, as an experiment, it is a really welcome one. There is evidence from overseas, particularly the US, on some of the benefits of investing in the high-risk, high-reward science. It is fair to say that it is not easy to pin down exactly how to do an evaluation of that evidence. There is a lot of speculation about how to do it well, and there is debate about whether it should be mission led or not, and about whether it is about basic research or particular challenge-based research. Many of our fellows who have

some experience in this area have been personally advising the Government on this.

In broad terms, we welcome the experiment. It would be useful to hear how this big experiment will fit in with the wider innovation ecosystem; we have not heard much about that yet. We would agree with some of the generic points from other experiences, such as having a high tolerance for failure and a reasonable timescale for evaluation, recruiting really good leaders and giving them a fair level of autonomy; that is what the evidence appears to indicate. Our general view is that it is an interesting experiment, although it is not huge, which is probably a good thing in that, as an experiment goes, it is not taking too much risk, and we broadly welcome it.

Tim Figures: We think it is a very interesting experiment, and it is good to see the Government investing in that. I am probably less qualified to say whether this or that structure might or might not work. From the perspective of manufacturers, I guess we will judge it on the results, what eventually emerges, and whether it is useful and commercialisable for them.

Q55 **Aaron Bell:** Relatedly, I suppose—and this ties into the levelling-up agenda—it is a question of place. We had some discussion in the first session about what the model would be, whether it would be hub and spoke or a big institute or whatever. Based on what you said about how science has developed in the past, what would your thoughts be about the risks or rewards of locating an ARPA somewhere other than in the golden triangle that has been so effective in lots of other areas?

Dr Lewis: It is hard for us to have a view at the moment, because we have not seen a clear conceptualisation of exactly what the Government plans are yet for ARPA—whether it is, as Alex Jones suggested, to have a hub-and-spoke model, or whether elements are near market or driven by a particular challenge, with near-market research locating quite close to the manufacturers that might be involved, which would seem a useful thing to do. It might be about high-risk and basic research, in which case location is perhaps less important. We do not have a strong view on this, because we have not yet seen very clear plans from the Government for their conceptualisation of it.

Q56 **Aaron Bell:** I go back to something you said, Mr Figures, about low R&D intensity in sectors that could help with the levelling-up agenda. A number of members of this Committee are very interested in that, in some of the areas that we represent. Could we get a culture change out of all the work that the Government are doing? Could that promote a culture change within some of these sectors, and some of the SMEs within those sectors? Can we drive the culture forward as well as the funding?

Tim Figures: Yes, I hope very much that we can, and, as an organisation, Make UK is certainly committed to doing that with our

members and our sector. But it takes a lot of effort—working with SMEs, many of which, even before the current coronavirus issues, are dealing with a whole range of challenges. It can be tricky and it is resource intensive.

One lesson that we have learned from the Made Smarter pilot that I mentioned earlier in the north-west is that you need four co-ordinated things going on at the same time: trusted advisers who know what they are talking about going around and searching out SMEs to work with them; some financial support for investments, because often some upfront investment in technology or training is required; strengthened links with universities; and, interestingly, and, perhaps most importantly, support for cultural change, and how you get existing SMEs that might have done things in a particular way for a very long time to embrace change.

Those four things are needed together to crack this, as well as a challenge culture, if you like. If you say, "Fill out a form and send it into Innovate UK, and you'll hear in two months whether you have been successful or not," it is difficult to engage those sorts of businesses with that kind of culture.

Q57 **Graham Stringer:** Dr Lewis, you gave the example of the laser, which is now in virtually everybody's living room, and that is an excellent one, because it was based on highly theoretical research; then somebody came along and created a physical one, and then it was created industrially. I was rather disappointed in Sir Mark's answers on the question of impact, because he was basically saying that, even if you applied to ARPA, you still had to produce some sense of impact. When we interviewed people in this Committee's predecessor, we talked to people who were assessing papers and people putting in papers, and they often told us that they did not know how to do it. Do you think that is fair? I do not want you to criticise Sir Mark, but do you think that there is a better answer than that you have to have impact?

Dr Lewis: That is an interesting question. I suppose in terms of impact assessment frameworks of various kinds, as they have evolved through the years, whatever system you create creates unintended consequences. One issue with something like pathways to impact is that it takes a basic researcher and asks them to guess what might happen to their work, and creates some sort of hypothetical path. The societal impact is not necessarily what you are immediately looking for from someone doing basic research. You are asking them to do it really well, break new ground and discover new things without necessarily knowing where the impact is going to lie.

So it is useful to take a more sophisticated approach and let basic researchers do their basic research, promoting the idea of excellence and quality. Clearly, as you go up the innovation TRL levels, you are expecting more specific and direct impacts from your work, so it would be

more reasonable to ask for them in those circumstances, and to ask people to describe those direct impacts.

I agree with you that, at a basic research level, there is an artificiality about asking people what societal effect they might have in their research.

Q58 **Graham Stringer:** May I ask the question in a different way, and I hope get a different slant on the answer? How would you define blue-skies research, which is what ARPA says it is going to fund?

Dr Lewis: There are many definitions of blue-skies research, but I suppose, fundamentally, it is research for the purpose of curiosity and interest, without necessarily any specific societal end goals in mind. I could keep it as straightforward as that; it is probably the most useful thing.

The previous discussion brings to mind research into hot spring bacteria in Iceland, thermophilus aquaticus. They discovered an enzyme that works that is really hot, which then generated the polymerase chain reaction, which is now the basis of almost all kinds of DNA fingerprinting, rapid diagnostics and so on. Again, that reinforces the point about pursuing an interest and curiosity at scale, as a nation—that serendipity works, if one does it at scale.

Q59 **Graham Stringer:** I have just one final question along the same lines. Sir Mark was looking for positive results. I think that the largest experiment in the world at the moment is CERN funded. Had they not found the Higgs boson, that would have been possibly more fundamentally interesting than finding it—so you cannot even define the success of research as having a positive result, can you?

Dr Lewis: Well, you could describe it as having positive results, but not necessarily in the area that you are immediately looking for. Again, fusion research is a very good example of that. There has been so much fascinating and useful science to come out of such research without yet having viable working fusion. As Sir Mark mentioned, there is the slightly unexpected outcome of the invention of the internet, with something similar to APRA generating such an outcome. So there are positive outcomes, but not necessarily the ones you were looking for and expecting.

Q60 **Graham Stringer:** Mr Figures, you talked about applying to the ERDF for funding, when you failed to get funding in the UK. It is often said that Britain is a net beneficiary from the EU in terms of science, which of course is true when it comes to the pure science side of it, but it is not true when you look at the regional development funds, where we are net contributor. When you add them together, we are a net contributor. Have you had discussions with Government to try to secure what should be extra funding for science to ensure that, if you cannot apply for ERDF funding now that we have left the EU, there will be an equivalent pot?

Tim Figures: That is what the shared prosperity fund is designed, in part, to do. Right now, under the terms of the withdrawal agreement with the EU, existing European-funded programmes will continue to their conclusion, so there is another 18 months to two years of funding, as those wind down. New European programmes, if Brexit had not happened, would normally be starting from next year, so decisions need to be made by the Government about the shared prosperity fund—who will get it, how much they will get, what the distribution will be and what it can be spent on. What we are very strongly saying to the Government is that it needs to be, in terms of what it can be spent on, very similar to what regional authorities can spend ERDF on at the moment; otherwise there is a risk that the gaps that I mentioned start opening up.

Q61 **Graham Stringer:** I think I am asking a slightly different question, although not very well. There should be more money in the fund, because we are a net contributor to the two science budgets. Have you managed to discuss that with Government, and what have the Government said? Have they said that there will be more money in those pots?

Tim Figures: We have not had indications about the quantum of money that will be made available. From the perspective of people in the regions, there are funds that they can access at the moment; I am sure that, if additional funding were made available, they would find that very welcome, but our focus has been on continuity for the moment rather than significant expansion.

Q62 **Zarah Sultana:** With the increase in R&D investment, we are going to need to expand the workforce. Do you think that the doctoral training partnerships in UK universities are enough, and, if not, what more needs to be done to encourage more people from across the world?

Dr Lewis: You have hit on an incredibly important issue. A lot of the benefit of science funding is that people come out of it with skills that are widely deployable. On whether the doctoral training centres are enough, Alex Jones mentioned a 2.4% road map. We would like to see skills being a really important part of that. There is a very significant uplift in the number of skilled people that is implied by the 2.4% uplift and, if the Government go beyond that to three, even more so. We would like to see specific plans about how the Government intend to handle the skills part of that.

Q63 **Mark Logan:** A perennial problem in the UK is the ability to leverage private investment from public investment in R&D. I think you touched on this earlier, Dr Lewis, but what steps should the Government and other partners be taking to increase the leverage we are getting?

Dr Lewis: From the Budget numbers, it appears that the Government are anticipating the same level of leverage as they currently get, which is roughly 2:1, because they have committed to 0.8%. The implication is that the private sector will then raise up to 1.6%.

The Budget itself does not mention much about this yet, but the Government may be asking themselves what works for private sector investment, what it likes and what it seeks. Half of private investment is foreign direct investment, so what are the Government's intentions with respect to identifying overseas investors? What is the strategy, what countries will they go to, what particular sectors will they go to, and which R&D-intensive companies or sectors might they go to? Those are the sorts of things we would expect to see.

To come back to the innovation ecosystem, at national level the catapults were founded on an analogous model to the Fraunhofer institutes in Germany. Everyone knows about the Fraunhofer institutes, because they have been around a long time. What do the Government intend to do with respect to marketing their science innovation ecosystem overseas to attract the foreign direct investment that we need? How will the Business Department work with the Trade Department to make that happen? Those are the sorts of questions that we will be asking.

Tim Figures: While we would agree with all of that, as I mentioned earlier, current experience and that leverage rate have resulted in R&D expenditure being concentrated in four sectors. There is, perhaps, a bit of a tension between that and maintaining those levels of leverage with this degree of expenditure and a levelling-up agenda that suggests that what we might also need to do is to concentrate on other sectors and smaller businesses, where, as I said, more effort might be needed, and you might have to spend more public money to get a return from private sector investment.

Q64 **Mark Logan:** On that point about FDI, I know in some academic debates in recent years there has been scepticism about how useful it is for technological investment, because there is a problem with diffusion. Academically, to what extent do you see that as an issue? What steps should we be taking to make sure that we benefit—the place and society?

Dr Lewis: I am thinking of the two elements, if you like—the basic research and the innovation, which I guess the private sector is more interested in. What are we doing at basic research level to continually reinvest and drive the excellence that ultimately flows into the economy? We have visibility, because having four out of the top 20 universities in the world is a strong international signal. Foreign investors come to places like Imperial College, UCL, Oxford and Cambridge and others. At the basic research level, how do we continually invest and promote the idea that we are the best in the areas that we are the best in, and stay at the cutting edge?

At the more near-market level, where you would expect more of the FDI to come, what are we doing to attract those people? What is it that they come here for? Touching on one of the Member's points on IP, if a foreign investor invests in small companies in the UK, what would it take for such investors to leave those companies in the UK, because our science innovation ecosystem is so strong that it is in their interests to do so.

Those are the searching questions that would be interesting and would be the sorts of analysis that we would expect the Government to take.

Q65 **Chair:** Thank you, Mark. On private investment, it is striking that, in the communications around the Budget, the big increase in publicly funded R&D was promoted, I am sure correctly, as putting us in the top quartile in the world for publicly funded R&D. But given that we are so far behind the OECD average for R&D in general, this exposes the fact that we are particularly poor at private sector research and development. While steps are being taken and strides are being made towards improving the public-funded side, we seem to start from a position of much greater weakness than people would assume, when it comes to private sector R&D, in that the excellence of our research institutions has not translated into the level of private investment that perhaps one might expect. Do you recognise that, Mr Figures, and do you have any views on how private industry can best be galvanised to participate in this national endeavour to improve our research intensity?

Tim Figures: Absolutely. That is correct—and that is what the figures suggest. The 2.4% target requires a very significant increase in effort by the private sector as well. There are a number of things there about driving forward a culture of R&D and collaborating well with universities, catapults and other people engaged in this kind of research, in every part of the country and every sector. While it is not directly my responsibility, today I was interested to hear the point that Sir Mark Walport made about a lack of innovation by the services sector. Given that it is 80% of the economy, as he said, and the fact that manufacturing is currently shouldering a disproportionate contribution to the R&D effort, that is notable. Maybe the uptake of technologies such as artificial intelligence, which can be widely used in sectors such as law and audit, might help to rebalance.

Then it is about ensuring the right support, in terms of fiscal incentives—so the increase in the research and development tax credit is welcome, but more work could be done to simplify how that tax credit system works, and the kind of financial support that we have been talking about today. All those things together should, I hope, encourage the private sector to improve its game.

Q66 **Chair:** Thank you. Finally, to Dr Lewis, given the disparity that we have in this country between our publicly funded research and the low level of private industry research, do you have any reflections on whether your fellowship is perhaps less engaged with industry than perhaps its equivalent bodies in other countries?

Dr Lewis: That is a really interesting question. I suppose it depends on the historical view that one might take. One of the first publications from the Royal Society was a practical manual on how to grow trees around the country to cope with the new fleet required in the 1660s. So the Royal Society has waxed and waned in its engagement with industry over

the centuries. The fellows of the Royal Society exist in an ecosystem created by a lot of policy, both nationally and in the sector.

One area that Tim Figures mentioned is, I think, changing. If you were a fellow years ago and you were doing basic research that one day might be relevant to medicine, it might take many years for your research ultimately to reach fruition, and a huge amount of investment. With those members of the fellowship who are absolute world-leading experts at the basic research for data AI, data science and so on, their research might be relevant tomorrow to the private sector. I think it is no longer a case that there is a linear model of a long journey; the world has changed, particularly in data and AI, and there is often a much shorter path from basic research to societal impact.

Clearly, the fellowship is varied; there are 1,600 members, and many are in areas that are probably not very close to industry. Many are in areas that are directly engaged with industry, depending on their sector, particularly new areas of science; there is a much more permeable and more rapid innovation pathway than in the past.

Chair: Thank you. I know many of your fellows and know of their engagement with industry, so I hope that this is a period of waxing rather than waning in their connections with industry.

We are very grateful for your attendance here. This Committee believes in experts, and it is important that we should have had advice from representatives of manufacturing industry, in particular, and the Royal Society today. We will take evidence from a wide range of other bodies during the weeks and months ahead. We are very grateful to you for coming today.