HOUSE OF COMMONS

Science and Technology Select Committee

Oral evidence: Industrial Strategy: science, research and innovation, HC 991

Wednesday 22 February 2017

Ordered by the House of Commons to be published on 22 February 2017.

Watch the meeting

Members present: Stephen Metcalfe (Chair); Victoria Borwick; Jim Dowd; Chris Green; Dr Tania Mathias; Carol Monaghan; Derek Thomas; Matt Warman.

Questions 1 - 70

Witnesses

I: Professor Alex Halliday, Vice President, The Royal Society; Professor Quintin McKellar CBE, Vice-Chancellor, University of Hertfordshire, and Chair, Innovation and Growth Policy Network, Universities UK; and Professor Paul Nightingale, Deputy Director, Science Policy Research Unit (SPRU), University of Sussex.

II: Steve Bates OBE, Chief Executive, BioIndustry Association; Jen Rae, Head of Policy, Nesta; and Allan E Cook CBE FREng, Vice President, Royal Academy of Engineering.

Examination of witnesses

Witnesses: Professor Alex Halliday, Professor Quintin McKellar CBE and Professor Paul Nightingale.

Q1 **Chair:** Good morning, welcome and thank you for joining us today. This is the first of two panels in which we will be looking at the recently published industrial strategy and is our contribution to the consultation. For the record, could you state who you are and who you are representing today?

Professor McKellar: I am Quintin McKellar. I am from the University of Hertfordshire and am representing Universities UK, which is the collection of university vice-chancellors.

Professor Nightingale: I am Paul Nightingale from the University of Sussex, representing myself.

Professor Halliday: I am Alex Halliday. I am vice-president and physical secretary of the Royal Society. I am a professor at the University of Oxford.

Q2 **Chair:** Thank you very much. Again, welcome. To start with, I have a relatively straightforward question. What do you make of the proposed industrial strategy?

Professor McKellar: Thank you for the opportunity to comment on it. I have to say we are hugely pleased to see the potential substantive investment that is going to be made in research and innovation as a consequence of the industrial strategy. We are particularly pleased to see the emphasis that you have placed on HEIF—higher education innovation funding—and the knowledge transfer partnerships, which we think will contribute in a very substantial way, together with the patient funding that you are talking about, to finance and support follow-on success of spin-out companies.

We very much support the ambition with regard to technical education but would suggest that that should be at both degree and sub-degree level. We support the ambition for lifelong learning, particularly part-time and short courses and how they might contribute to retraining and upskilling individuals in society.

We hope that the strategy can embrace educational cohesion. We thought, perhaps, reading it, that the one thing that was missing was a cohesion between school, further education and higher education, and we hope that that can be embraced as you develop your thinking.

Clearly, we think universities can contribute in a very major way, in particular both to supporting productivity in London and in the regions as anchor institutions. We think universities have a major part to play in that.

Finally, we are hugely encouraged that this might have elements of long-termism in it, and we think that that long-term approach to developing and enhancing productivity is important for the country.

Professor Nightingale: I would agree with all those points. It is a very impressive document; some very intelligent thinking has gone into it. In general, I think it is very good. The emphasis on place shows some very innovative approaches to important problems. The focus on productivity has identified a key problem, and I am very pleased to see there is a very clear focus on productivity.

I have a few concerns about it, but they should not go against my overall view that this is positive. I am concerned about the model of innovation that is present in it. I think that is a misleading and dated model of innovation. I have concerns about capacity; it is an interesting strategy, but can it be implemented effectively? I have a shared concern about the cohesion and whether the various pillars can be made to work together to deliver outputs more than the sum of their parts, but overall I am impressed with the document.

Professor Halliday: The Royal Society welcomes the industrial strategy. It is a wonderful piece of work highlighting a number of the key things we need to think about for the future. We think there is a particularly useful focus on both science and the importance of science and innovation in fuelling new areas. We want the UK to be not just the No. 1 place for science but the No. 1 place for ideas, and the fuelling of those new ideas, with funding that allows them to turn into innovative new products.

We see creating that ecosystem as fundamentally important. A key part of that has to be around skills and infrastructure, the importance of which, again, the document recognises, and, as others have picked up, the importance of place has a key part in that. The UK has been—I do not want to say slow relative to other countries—slow in recognising the importance of place in terms of the opportunities as well as the threats of ignoring place.

We see the UK, if all goes well, as an international hub for innovation. It is already seen as a very innovative country with a very different mentality in some ways from other countries. We also see it as a country that can be opportunistic in this environment and we welcome that.

There are concerns, but at the same time we welcome the opportunities around regulation in particular, because we do not know how that is going to play out. We have to be quite careful about how we handle regulation in terms of the new opportunities we might get.

The other big thing we need to think about is the idea of the challenge fund, which we think is brilliant, great and fantastic. If you talk to people in the United States about it, it is quite clear that DARPA-like structures sometimes work extremely well and sometimes seem to struggle. We think there needs to be some quite critical thinking about it generally and

in particular applying such a system of funding ideas in such an unconstrained way to a country like the UK versus the United States.

The last thing I would say is that we think technical education and the skills agenda are hugely important for the UK, an area where again we have lagged behind relative to other countries and we need to up our game dramatically, both in further education, as my colleagues have mentioned, and in broadening education. As we move forward, in the future we are going to have more robotic delivery of products. We need people to be able to reskill in new ways as that takes hold. We need people to get a broad education so they can move from one area to another, both because they are going to have to deal with the fact that their employment may change and from the point of view that we need experts with breadth. For climate change, we need people who have a degree in chemical engineering and a degree in law—those kinds of people. That is the kind of thinking we need to have around the education and skills agenda.

Q3 **Chair:** Thank you. I certainly get the sense from all three of you that it is broadly welcomed and a very positive step. However, there must be things that, having read through the document, you felt were missing. I am not particularly asking you to pick holes in it, but is there anything else that you would have liked to have seen added to it or you felt has not been given the attention it should have?

Professor McKellar: If you will allow me to kick off, it is not so much something that is missing; it is just a little more clarity in some of the issues. In particular, it talks both in terms of the research and innovation agenda and the technical education agenda about establishing new institutes. Could I insert a couple of words of warning, in that by adding institutes—using capital to develop institutes—you potentially dilute the future recurrent funding for the institutes you have currently? If you look at the research institutes across the UK that currently exist, we have been spending the last 30 years trying to merge and unify them with the universities simply because they do not have the critical mass that is required and the overheads when you establish a new institute in terms of car parks, refectories and libraries. All these sorts of things are very substantial.

If I could insert a word of caution, if you are creating new institutes, try to embrace them within the organisations that you currently have, whether those are higher education, further education or indeed business, because some of them may well be appropriate for embracing within businesses, but do it in such a way that they add and subsequently do not dilute the future recurrent funding that will be required to ensure that these institutes run effectively.

Professor Nightingale: The big gap is in relation to innovation. The focus on innovation is very much about the commercialisation of university research. High-tech, R&D-based innovation is about 3% of the UK economy. There is another 97% to think of. Even within that 3%, the

majority of high-tech innovation that goes on in the UK does not involve university research, so there is a big world of innovation out there that it is not focusing on, and that needs to be addressed. If we focus only on that small bit, we may distort the system and not fund and support bits of the UK innovation system that are very successful. We need to be realistic about how innovation takes place. It is not just university spin-outs and commercialisation, and that is not necessarily the big problem with the UK economy. The focus should go back to productivity again.

I would like to have seen more detail about the financing. There are a lot of big projects that have been announced. The concern in academia is that these are Christmas toys without the batteries, which is the phrase that is used. You announce a big building, but who is going to pay the salaries, where is that money going to come from and what is going to be cut to pay for that? That needs a little more work. Then there is strategic capability. How are you going to align everything and make it work well? A little more detail on that would have been useful, but, overall, as I said, it is a very good document.

Professor Halliday: There are some things where you could say we would like to know more; we would like to understand more. Part of the problem is that we are dealing with a moving target because we have Brexit plus the development of UKRI within the UK, both of which are exciting and come with a certain stress associated with them as to how they are going to work and all the rest of it. I feel as though, to some extent, there is a certain amount of uncertainty as to how this will play out, although I know we are going to talk about that later.

There are some dangers with setting things up in this strongly sectoral way that has been talked about within the paper. Having different sectors sometimes misses some of the most important aspects of innovation around interdisciplinarity. If you look at areas such as machine learning, which is an incredibly important area that is going to transform a lot of what we do in the future and links to other areas such as robotics and artificial intelligence, machine learning is going to have a phenomenal impact on everything to do with the workforce pretty much as well as the workplace. We need to think quite hard about how that is going to happen. It is going to happen across a lot of different areas, so I do not think you can fit it into any of these sectors very easily. The Government health warning around the packet, if you like, is to think about those cross-disciplinary areas that could end up being ignored because you have siloed everything into sectors.

Q4 **Chair:** Thank you for that. Before I pass on to Chris Green, who is going to explore the Brexit aspect of this a little more, it is going to be important for us—you and the Government—to measure how well the strategy is working and how it is delivered. How do you think that should be done? What metrics should we use to assess the strategy against?

Professor McKellar: Simply and obviously it is productivity, in the sense that you demonstrate very clearly at the outset in the document how we have begun to slip against some of our major competitors, and clearly if the strategy works—and my emphasis is on long-termism because I am not sure you will see this instantly—we would hope to see increased productivity across the country.

Professor Nightingale: I would agree with that completely. It is very important with something this ambitious that we have very clear evaluation built in from the start, which is something the Government have pushed in a very good way. We need very clear performance indicators, we need to be clear about what our baselines are and we need to be very clear about the methodologies we are using to look at counterfactuals. This needs to be built in from the start.

In some areas of the Green Paper I was impressed by the links to academic research. There were other areas where I thought it was a bit gimmicky, and, given that, we need to stress that we want to see some robust evaluations and good quality evidence coming out of what is being proposed.

Professor Halliday: I do not disagree with any of this at all—it is spot on—but I would look to see what we have done about place and in particular certain disenfranchised communities across the UK, which in previous years were part of our industrial strategy and they have been left behind. We have to focus on that, such as to what extent the industrial strategy applies to Cornwall or what it does to north-east England, and so on. Having grown up in Cornwall, I have a conflict of interest. They have been building a dual carriageway across Cornwall since I was a kid at the age of 10. They are still building a dual carriageway just to provide access to Cornwall, and this is barking mad. If you had an industrial strategy for the country that considered place, you would, as a country, take ownership of this problem and think about what we are going to do for these different parts of the country. That is the bit that in the past we have somehow lost and need to think about quite clearly, because Brexit is a bit of a wake-up call to all of us, including academics and scientists, who are busy writing their papers and so on.

Chair: Thank you very much. That is a good point to hand over to Chris Green.

Q5 **Chris Green:** Thank you. Pretty much everything seems to be seen through the prism of Brexit these days, no matter what the subject is. The industrial strategy Green Paper came out near enough at the same time as the Brexit White Paper, only a few days apart. How well do you think they complement one another? Do you have a view on that?

Professor McKellar: Clearly, the industrial strategy is hugely helpful, but there will be tensions with what is happening in Brexit. We do not know how and whether we are going to be able to retain our links

through things such as Horizon 2020 as to the funding programmes. It is very clear to everybody that it is unlikely that the European Union will want to give us back more money than we put in to whatever system we develop, and even if we repatriate the money that we are currently investing in research in Europe, we would hope, as a sector, to see as much of that coming back to invest in research over and above what is being promised here in the Green Paper. There is a little tension there that we would want to tease out.

The other thing is about the movement of people. In universities, we attract very many students from the European Union and we would wish to continue to do so. They enrich our educational programmes and—it would be unfair of me not to mention it—they bring finance to the universities, and that is important as well.

The other issue—and one that I have to tell you staff within our university are currently very concerned about—relates to the staff themselves. More than 15% of our staff are European Union citizens and they are concerned about their futures. The sooner that can be teased out and we can get reassurances for them that their citizenship in the UK will be maintained is deeply important. For the future, it was really helpful that the Prime Minister mentioned continuing to attract the brightest and the best. I hope it is beyond that, but certainly that is a reassuring statement, which I think we would all support. We would wish to continue to attract the brightest and the best into our universities and businesses to support this industrial strategy because that is critical.

Q6 **Chris Green:** So there is no necessary clash between the Brexit White Paper and the industrial strategy Green Paper, perhaps, or is there anything—

Professor McKellar: I do not think there is a clash. Perhaps the two are supportive. Certainly, the industrial strategy is supportive and could be supportive of us leaving the European Union and helping maintain that productivity as we leave.

Professor Nightingale: There is huge uncertainty around Brexit. We do not know what Brexit will bring. I agree 100% with everything that has been said here. There are a couple of issues we should keep an eye on. One is international students, who in a sense subsidise the university system and are a big source of income. If we were to lose that, there would be a cost. There is too much focus on commercialisation and spin-outs of university research. A large amount of innovation that drives productivity in the UK relates to supply chains; it relates to activities where components are moved around the country, Europe and the world, and they are improved and moved back and forth. If there is a constraint on the movement of those at borders, that may increase costs and reduce the flow of technology to the UK.

If you are a German company and you want to reduce costs, you may push some of that innovation activity out to the UK, and that is a really

important source of productivity growth for the UK. So, it is really important that we do not have barriers to that at borders. The consequences of that will be very significant in the long term because there will be a compound interest effect on productivity. Over 40 years that would be a very significant cost. The negotiations to ensure that that does not happen are going to be very important.

Q7 **Chris Green:** This is going to be quite interesting in the two years of the negotiations. At the beginning, because the formal process has not started, no negotiations can, in a formal sense, be engaged in. No matter what our negotiating position is, we cannot make any progress, or certainly we cannot announce any progress, so an early win for the negotiation process perhaps would be recognition of travel and EU residency for EU citizens here and UK citizens in Europe.

Professor Nightingale: It is more about the harmonisation of non-tariff barriers. That would be a big concern. This is sector specific. It is a really big issue in aerospace and the automotive industry. It is less important in other sectors, but non-tariff barriers, which will constrain the movement of components around—because we no longer trade German cars for English planes; it is bits moving around—are the key thing.

Q8 **Chris Green:** The industrial strategy hopes could be derailed, to some extent, by Brexit, but it depends so much upon the nature of the negotiation.

Professor Halliday: I have just been over in Berlin for a couple of days talking to different groups from across Europe about what we are trying to do in terms of the area of science but also the creative industries more broadly, including education as well. Once you get past the dire state of people's concerns, which I think we have moved on from a little in Britain, you realise there is a lot of interest in potentially trying to keep Europe strong even though we may be pulling out of the EU. We are incredibly strong within Europe. The second strongest country is Germany in many respects in terms of science and our role in Horizon 2020. We have phenomenal influence. Germany feels this and does not want to be left as the strong country in Europe. We have to recognise that and keep working with these countries individually as we develop this industrial strategy.

Mobility is absolutely key. It is more important in many respects than the money issue from the point of view of the science agenda. It is also something that is key to the business agenda as well. We have very strong partnerships with the CBI, and so on, discussing these issues, as they are going to be rolled out, and we see this as something that will be fantastically important for the UK. I have to say that we are well below the OECD average for R&D in terms of Government investment, and the Government's announcement of extra money in the autumn statement has made a significant difference to that and we are moving towards the OECD average. That is a great thing to be able to talk about abroad right now, and people seeing this as a place to be doing research and

innovation is something we want to make a big deal out of in the Brexit negotiations and making sure that is accessible.

The one bit of Brexit I am most worried about, as I mentioned before, in that I do not know what we should be doing, is regulation. I see that we have both advantages and disadvantages with being tied into Europe. The advantage is that Europe is a big market, so if you have the same regulation, to some extent, it matters hugely for your products. On the other hand, there are some things where deregulation of certain things, or new regulations that we put in place in the UK, could give the UK a competitive advantage in certain areas. We have to think quite carefully about how we do that.

Q9 **Carol Monaghan:** Could I go back slightly before I start on what I was planning to ask you? First, you will be aware that this Committee published a report asking for immediate guarantees to be given to EU nationals in science and research, and that was something we felt came across very strongly from the witnesses from whom we took evidence. You mentioned EU students and the financial contribution they make. Is there any sense of concern about what jurisdiction or what fee structure will be in place for EU students post Brexit, and is that, potentially, going to impact your university income if they are classed as international students?

Professor McKellar: Yes and yes. There clearly is concern. Currently, EU students have access in England to the Student Loans Company loans. Consequently, they have embraced those energetically and we have had a very buoyant number of EU students coming to the UK. It seems to me to be highly unlikely, but I would certainly encourage you to look at maintaining the opportunity for EU students to have access to student loans. That would be, from a university perspective, a very positive thing, but it seems, I would suggest, unlikely in the fullness of time. Consequently, we will be considering EU students in exactly the same way that we consider other overseas students. That means that we will probably be charging them more. They currently get the same rate as our UK students, which is £9,000. Most universities charge overseas students slightly more than that. For some universities, it works out roughly the same. If you add the Government subsidy on to the tuition fees, it works out at roughly the same. Some universities charge substantially more, but it is likely that we will be charging our EU students more as overseas students. For them, that is the downside.

The upside is that the pound is much weaker, and, consequently, not only for them but for all overseas students, the UK has become a more attractive potential place to go to get education. I am probably not allowed to go too far down this track, but if you look at what is happening in the United States, which is currently the biggest single attractor of overseas students, as they become less, if you like, welcoming, it is likely that we will embrace some of the students who are going there. This all depends, at a higher level, on what the Home Office does in allowing us

continued access to overseas students, and you are aware that our sector is particularly concerned about that. This is not the time to debate it, but it is certainly an issue that you should keep on your radars.

Carol Monaghan: Rather than asking the other two panel members, if you are broadly in agreement, I will move on to the questions I was supposed to be asking, Chair.

Professor Halliday: The only thing I would add is that a lot of our overseas students are absolutely fantastic, at Oxford certainly. They are superb and a brilliant asset to the UK in terms of our knowledge base and we should not think of them as just a cash cow. They are a phenomenal asset to our education and research.

Professor Nightingale: I would agree 100% with both.

Q10 **Carol Monaghan:** Thank you. The industrial strategy Green Paper reminds us of the decision to increase science spending by £2 billion per annum by 2021, which is in response to our international competitors' spending. To what extent will this increased budget in itself make the industrial strategy deliverable?

Professor McKellar: I seem to be going first every time.

Professor Halliday: You are the wisest of the three of us.

Professor McKellar: If only. Fundamentally, it will make a substantial difference. There is no doubt about that. Simply increasing the quantum of research and innovation, which is happening within the whole community, is going to have a positive impact. We know that if we look across at all the correlations in different industrialised countries. We know that, if you increase the amount that you invest in research and innovation, you get an increase in productivity. That has to be a good thing.

The question is how you invest it in such a way to get the best return on your investment. I mentioned at the outset the higher education innovation fund, which has been hugely supportive. You get about a 9:1 ratio return on investment for that, which is fabulous. It is the same with knowledge transfer partnerships, and they have the additional benefit that they bring universities very much closer to businesses and they support businesses, both through that initial set-up phase but also as the businesses develop and follow on with their growth. That is hugely important.

I would not for a minute suggest that you should not also be thinking about investing in the basic research, because that is critically important as well. You have to have that basic research in order to spin out the ideas that can subsequently be developed through innovation. All of it is important.

One very interesting graph in your paper is the Frascati Manual, which shows the relative—and it is on a percentage basis—amounts of basic applied and experimental development work done in different countries. You can see that in the big developing nations—in particular, China—they are putting huge proportions into that experimental development. You need to think quite carefully about the proportions. In this country, we are not bad in terms of the relative proportions. We have worked hard at it through both our research councils and through the QR, which is the funding that comes to us through, as it has been, HEFCE—the Higher Education Funding Council. That has worked really well for universities.

You might also, though, consider how you incentivise business to invest more in research, because as a country we are pretty poor. Whether you give tax breaks or what you do, I do not know, but you certainly should not miss the business part in terms of the research infrastructure.

Q11 **Carol Monaghan:** Part of the Green Paper seems to suggest that increasing public spending will drive up private investment. Do you think that is realistic?

Professor McKellar: Yes.

Professor Nightingale: Yes, I do. The evidence is that the crowding-out effect that people were worried about is not actually the case and that there are very substantial spillovers. One way to think about funding academic research is that it is not just supply; it is not just spin-out; it is the creation of demand in industry. You develop skilled researchers who go out into industry, and, because they are clever and can solve technical problems, it reduces the cost of innovation and makes it more attractive to industry to invest in. It is not, "We do research; you spin it out." It is, "We do research and then we generate people who go into industry, improve innovation there and make the country more competitive in that way." It will have an effect.

Specifically on your question, "Is this essential?", "Yes." The key message that the research community is getting is that we need to be thinking about aligning the research that we are doing better with the needs of industry and the needs of society. That is coming through very clearly to academia. Without this money, the sorts of interdisciplinary research that is needed, and the point made by Alex about the vital nature of funding interdisciplinary research in these areas, would not happen. Interdisciplinary research gets murdered in peer review, and a lot of interdisciplinary researchers would like to do these sorts of activities of engaging industry, doing fun, exciting work, but they think that they would not get that funded. Now, with the resource coming through that is directed towards this, people are much happier.

Professor Halliday: I left the UK in the mid-1980s to go to America because it was quite clear the funding for science was much better there. The key thing that one of my friends at Woods Hole told me was that, if you have a good idea, you will find the money for it here. That was

actually true and I repeatedly got funded. I did not always get exactly what I asked for, but there was this incredible incentivising system for allowing you to have ideas, get money behind them and then take these to the next stage. That should be the thing we really go for where there is extra funding. We have had several years of flat cash settlements for research councils. We have seen Innovate UK underfunded; roughly half the good ideas they would like to fund are not being funded. The net result is that we are not doing enough to put money behind those good ideas, and there is also demand management in the research councils that to some extent means universities are somewhat more conservative about which proposals they submit. They want to make sure they do not put any in that are too risky in case they do not get funded. There are a number of things right now that need addressing with this extra funding, just to do with getting those good ideas and making people feel that the UK Government really want to get money behind your ideas and help you succeed. That is a hugely important part of this extra funding.

Mobility, not just in terms of people moving around but between sectors in terms of expertise, is hugely important as well. We need to think about that. That is brought out a little in what has been said already.

As to the whole issue around building the interaction between businesses and universities, we have been talking about this for years; there have been many reports on it, and Ann Dowling's report was just a couple of years ago. We get it and we understand it. We are still rather weak in terms of SMEs, in particular. Universities tend to go and get money from Rolls-Royce and other big companies. We do not think about the many smaller companies that we could be working with more effectively, so there could be quite a lot of work done in that area in particular.

Also, the key thing with all of this is to think about how we can make the UK the most interesting, exciting and dynamic place to come to if you really want to and attract people from all over the world to come here. Right now, with what is happening in America, we are seeing at Oxford a significant jump in the number of Americans wanting to come to be employed at Oxford University. That is good news for us, and it is quite important to maintain that momentum, as we go through Brexit in particular, that this is the place to come to for doing top-class research and for building businesses and innovation. I have talked too much.

Q12 **Carol Monaghan:** Could I ask one final quick question, and I would appreciate quick answers because I know the Chair will get upset otherwise? Does it matter that the industrial strategy challenge fund will have to come out of the £2 billion per annum increase? Is this likely to muddy the waters on the science budget ring fence?

Professor Halliday: Basically, the answer is that it has to come from somewhere, and the key thing is that a DARPA-like or challenge-fund type thing is a good idea. While, as I said, it needs to be treated carefully, the basic idea is a good one. From all my conversations with John Kingman and others, and there has been Paul Nurse, and so on,

there is concern to make sure that that increase in funding focuses also on discovery-led science and not just around stuff that is about commercial ideas. It is quite important to strengthen both of these arms and there is probably a certain amount of cynicism in the community about what the £2 billion is for. Achieving clarity through UKRI will be a really good thing, with a new chief executive in place. Getting some clear ideas of where we are going with this would be very helpful in the near future. Most people would recognise that the challenge fund is a good idea, but you also have to focus on fundamental discovery science.

Carol Monaghan: Rather than asking the other panel members, I will pass to the Chair.

Chair: Thank you. Dr Tania Mathias.

Q13 **Dr Mathias:** Thank you. Could I ask Professor Halliday a quick question? When you said in the 1980s you were in America and any idea could be funded, did that come from Government money, private money, or both?

Professor Halliday: It was not "any idea;" it was "any good idea." It has to be a good idea.

Dr Mathias: A good point.

Professor Halliday: Yes. It was Government money; it was National Science Foundation, then the Department of Energy and then NASA. I got funding from a variety of sources. Halfway through, after about five years, I got the opportunity to take a look at a new instrument that was being developed in Manchester in the UK, and raised the money in America to get the first of these instruments because there was no money in Britain to buy one. America was the first. We got the first and we went to all these different funding agencies, the universities, of course, as well, and it was highly successful. It transformed my career and my research field—just actually being the first.

Q14 **Dr Mathias:** It was dependent on Government money really.

Professor Halliday: Yes, but people there are prepared to give good ideas a go, which is very important.

Professor Nightingale: Can I come in on that point? An important feature of the US system that is often overlooked is the plurality of funding. It is not just one funder with lots of money. There are lots of different institutions that give out research money. There is co-operation but there is also competition between them. If someone has a good idea and it is rejected in one place, that may be a good reason for someone else to grab it. This is important because it helps drive something that the US is particularly good at in its research system, which is developing interdisciplinary research. Something that is rejected by a rather conservative funder because it cuts across disciplines may be picked up by someone else and funded, and that goes forward.

Q15 **Dr Mathias:** Again, it is another Government institution.

Professor Nightingale: This is Government funding, yes.

Q16 **Dr Mathias:** On the Green Paper where they talk about the priority areas for the challenge fund, Professor Halliday, do you think these areas are giving a different focus to the previous eight great technologies that the Government had?

Professor Halliday: Basically, I think these areas are fine. I have no major problems with them, but we need to look into what some of these areas, as defined, really mean. I was discussing outside where the agritech part of this is, for example.

Q17 **Dr Mathias:** Where is the what?

Professor Halliday: Agritech. We are doing satellites and we are doing fantastic new stuff—

Q18 **Dr Mathias:** Whereas that was spelt out more, before, with the eight great technologies.

Professor Halliday: Yes, so the question is, how does that fit in? Is it part of the biotech strategy or is it something else? Understanding that and where we are in terms of other opportunities, particularly in the creative area of the arts and where we have lots of opportunities to work very closely, and getting at the detail of what they are thinking of doing in these particular areas would be very helpful for the future.

Q19 **Dr Mathias:** Professor Nightingale, would you agree?

Professor Nightingale: Yes. I am probably a bit more concerned about this focus on eight great technologies because, as an academic, I can be very flexible in what my research is about and I can make pretty much anything fit with eight great technologies.

Q20 **Dr Mathias:** Are you happy with that?

Professor Nightingale: I would prefer that it was not so technology focused. There are elements of this I like. I like the emphasis on engaging with industry, on addressing important topics—

Q21 **Dr Mathias:** Do you prefer the current priorities to the previous focus?

Professor Nightingale: I can see why they are chosen, but you have creative industries and there are whole loads of other areas that are really important that may get lost. The process of doing something that is going to have some external impact is very important, and that I really agree with, but I do not think we need to be hung up with technologies. As to the technologies that we are picking on now and saying they are great, it is very difficult to predict what will be important in the future; 100 years ago we said steam engines. We need to support not just the incumbents, which is highlighted in the Green Paper. We need to be driving innovation and be opening up to disruptive change. In that

regard, it is the process rather than what they pick that is the important thing.

Q22 **Dr Mathias:** Professor McKellar, would you agree?

Professor McKellar: I pretty much agree with what has been said. The topics that have been picked in the paper are clearly sensible topics. Please do not go away thinking they are not; they absolutely are. The issue is what is left out. The issue is predicting the future. By its nature, what you are trying to do there is predict what is going to be important in the future and that is not necessarily what is going to be important in the future. Picking winners is a difficult issue, in particular within an industrial strategy. I totally support the comments about the creative industries. We must not miss that out. We are very strong in the creative industries in the UK and we should not let them drop off the perch.

Q23 **Dr Mathias:** We need a sector that has no name almost.

Professor Nightingale: Or drop the sectors—drop the sector focus.

Dr Mathias: Okay.

Victoria Borwick: That is brave.

Q24 **Dr Mathias:** Professor Holliday, do you think the criteria for projects getting the challenge fund are the right ones?

Professor Halliday: Yes. The exciting thing about what they have done in DARPA is to some extent to allow Government money to be hugely unconstrained in how it is spent and give people phenomenal autonomy to go ahead and crash and burn or be hugely successful. That is the idea. You should see mostly crash and burns, but there will be hugely successful things that reap big rewards. That might be the right way of doing things. We certainly need to move in that direction.

We need to look at some of the technologies, some of the ideas that have come out of the UK in the past that have gone abroad to be commercialised, and some of them are struggling to get back, such as quantum technologies. Quantum computing and all that stuff was largely coming out of the UK originally, but we are talking about 20 years ago, and 20 years later we have now made it a priority in this country as part of our industrial strategy, and you wonder what happened in between.

What happened in between was that the Canadians, Americans, Australians and Japanese got on to this and jumped on it hugely, and we are now waking up and saying we should be good at this, and we are, or we used to be. Recognising those amazing, innovative ideas that buck all the trends that could be totally transformative and nurturing those through decades of work to develop is the bit we need to get right if we want to be hugely influential in the future.

Professor Nightingale: I am very sceptical about transferring the DARPA model to the UK. I have said that some of the Green Paper is

research based and some of it is very gimmicky. This strikes me as very gimmicky. We need to be much more realistic about the successes and failures of DARPA. In a recent review of DARPA in *Foreign Affairs*, Lawrence D. Freedman, who is a very distinguished professor, said the most important thing for historians of DARPA is to not be mocking.

DARPA, as you have pointed out, has had lots of crashes and burns. Often it tries to find technological solutions to political problems. I do not think the UK is in a position where we have enough resource that we can just throw money around and expect to have lots of failures. We are not a rich enough country to do that. Our science system is not big enough to do that. We have to be much more rigorous, much more concerned about the risks and make sure that we really are driving success. DARPA is not an organisation that you can just transfer to the UK and expect it to work. We need to be very critical about just transferring institutions across—very critical.

Q25 **Dr Mathias:** But we have heard that crash and burn is part of the process of allowing those unknown successes to emerge.

Professor Nightingale: If you are going to fail, you want to fail early and fail cheaply. You do not want to have a huge big investment that gets more and more money, and then just ends up being a white elephant. There needs to be early focus on, "Is this commercially viable?", moving away from vanity projects, such as, "This is the new geeky thing; this is high-tech." Is it going to generate jobs? Is it going to improve productivity? These are the questions we should be focused on. In the UK, when you look at what Innovate UK does, there is a lot for DARPA to learn from them in their focus on whether this is going to generate jobs and productivity improvements.

Q26 **Dr Mathias:** Professor McKellar, do you want to comment?

Professor McKellar: I am going to sit somewhere between my two colleagues in the sense that I think there is a place for having some of that far-out, high-risk funding, because there are clearly ideas, some of which will be hugely successful and some of which will not. I would suggest you really want to think about ensuring that the pipeline of young—I should not be ageist, but, generally speaking—early career PhD-type individuals are funded adequately, because that is absolutely critical, both to the research community but also, ultimately, I would suggest, to an industrial strategy that improves productivity. The people whom we train at PhD level are the ones who will go into industry and drive industry forward, and drive our education system forward. I would be suggesting, yes, some DARPA—a bit of risk, why not? because that is critical—but also make sure you have that pipeline adequately resourced.

Professor Nightingale: The point about a portfolio is a good one. It is not just high risk; it is high risk and high return. You do not want to have high risk and low return. Have a portfolio and be thinking about managing that portfolio of research so that it is aligned with the needs of

the UK, in the short, the medium and the long term, and include—I agree—some high-risk, high-return investments, which you should expect will not always pay off. But we do not want just to have a focus on the high-risk stuff, and we certainly do not want high-risk, low return.

Q27 **Dr Mathias:** Do you think the challenge fund money, going back to Professor McKellar, will go to the same areas that get sector deals?

Professor McKellar: I do not know where the challenge fund will go. That is one of the beauties of the potential model you are talking about. It will be really sparky ideas that will attract, presumably, the funders. I am very confident that in the UK we will have—through our current research councils, but, ultimately, through UKRI—and retain a very robust system of peer review, of selecting good projects to fund. I am confident in that system and I am confident that the change to UKRI, assuming the higher education Bill goes through, will be, relatively speaking, a good thing for the UK. I am quite comfortable with that.

Professor Halliday: The pros of the DARPA are that it is quite different in the way it looks at peer review and things like that, so it is not clear to me that the research councils could do a job like this to provide the right framework for this. I also want to say quickly that I agree with Paul entirely about the need for caution and we are going to be throwing money at things that are going to be going down the drain. So, the question is whether you think the *Daily Mail* and the UK have the stomach for that in terms of Government money being driven in that way. It may be different in America from here.

Q28 **Dr Mathias:** We need a bit more Beckett: "Fail again. Fail better." Sir Mark Walport told us that there were public meetings with research councils, industry and academics. Professor Halliday, were you or was your organisation involved in any of those meetings?

Professor Halliday: No.

Professor Nightingale: I attended a meeting. I thought it was well run. That kind of engagement is good.

Q29 **Dr Mathias:** Was that you as yourself or representing—

Professor Nightingale: Me as myself. I thought it was a good idea. My concern about the process that it involved is that the structure has built-in biases. It has built-in biases towards gee-whiz, high-tech solutions, and it is biased against the low-tech but important things that are needed for innovation. We need to pay attention to the potential biases there. Not all research that is important for innovation is cutting edge. Some of it is quite pedestrian and dull. Getting more industry involvement is a good thing and that could be pushed more. The most important thing for me would be, rather than thinking just, "This is a cool, geeky technology; it is a new widget; it creates lots of value," how does the UK capture that value? It is too science push and not enough

economics, management, commercialisation, making money, driving productivity and creating jobs.

Q30 **Dr Mathias:** Professor McKellar, were you involved in any of those meetings?

Professor McKellar: I am not sure of the meetings you are referring to, but we invited Professor Walport to come to speak to us, which he did. I was hugely reassured by what he said since his appointment. He clearly indicated to us that the evolution of UKRI would be evolution and not revolution, and that Innovate UK would still continue to fund, as it has done in a very appropriate way, as would the research councils, and that any changes would be done with consultation, over a period of time and not instantly. I was quite reassured by what he told us.

Q31 **Derek Thomas:** Professor Halliday, you might be pleased to know I am the MP for West Cornwall, so I know exactly what you mean by the A30. I notice you come from Penzance, but we do have more properties connected directly through fibre than any other town in the country, so that is maybe the industrial strategy working ahead of time. We do not have the roads, though.

In the Green Paper, on the UK, there is a reference to the heavier focus on basic research than on applied or experimental research compared with other countries. Do you think the Government's agenda is to shift the balance towards a model similar to Singapore or Japan, and, if that is the case, are you fairly comfortable with that focus?

Professor Halliday: Basically, I do not think there is such a thing as pure and applied research, or basic and applied research, or fundamental research versus other things. There is discovery research, which is all about figuring out things and all the rest of it, and people, hopefully, having the awareness to think about applications that might be useful. That is the environment that we need to create and that is much more the kind of way in which people think today.

I know we talk about the Haldane principle and how everything is bottom-up in this country, but the reality is that the Government do have a way of helping universities think about doing things differently. A good example of that is the introduction of impact into the REF, where the universities had to demonstrate the impact of the work they do. Initially, there was huge push-back by the community, including mathematicians at Oxford in particular, but then they came out No. 1 for impact in the REF and thought this was quite good because they were demonstrating talking about what it is they do for the UK more broadly, or the world more broadly. People think entirely that way now. Universities are very enthusiastic and relaxed about it.

As to the division between what you call basic, applied or between, if you like, discovery mode and other kinds of science, there will be a need to make sure we are still doing cutting-edge discovery research and that some of the great ideas in cutting-edge research, which is quite

fundamental in nature, whether it is to do with particle physics, black holes or whatever, will still need to be funded and we need to make sure we are doing well internationally.

It is, I think, quite important to recognise that a lot of this basic science, or fundamental science, or discovery-mode science, in the end makes your cell phone work, means satellite technologies can work, GPS and so on, and, if we had not made those discoveries many years ago, this country would not be able to use these technologies today.

Professor Nightingale: That was the section of the Green Paper I was concerned about. We need to be very careful in looking at that data and understanding what it means. The distribution between early-stage, basic and applied is very influenced by industrial structure, so if countries have different industrial structures that is going to be different, and it is very influenced by the level of development. If you are looking at China, it is going to have more later-stage activity, in part because labour costs are so much less. We should not try to replicate China because we will not be able to compete on labour costs. The policy focus should be: if you look at global value chains, what are the parts of those global value chains where the UK is good, and how can we upgrade to increased productivity, higher-wage jobs and more jobs within those? That should be the focus, not relative positions of upstream or downstream. That is a much more useful way of looking at things.

We should be thinking of ARM. It does very sophisticated design of chips; it may not produce those chips, but there are very high-wage jobs in the UK. There is Ricardo. It produces very high-end McLaren engines, but 80% of the activity it does is in services, and that is high-value jobs. The fact that we are not doing the metal bashing is not necessarily a bad thing. We have to remember again that we are a service economy; 80% of the economy is in services and only 3% of it is in high-tech manufacturing. We need to have an innovation system that supports the UK economy and is realistic about how we can improve rather than trying to copy, on the one hand, the United States or, on the other hand, China.

Q32 **Derek Thomas:** That probably picks up my next point. How important will UK Research and Innovation's role be in any adjustment in public expenditure between research and innovation? Does the creation of UKRI make the adjustment more or less likely? This is about where money goes. What is the balance? Is it innovation or is it research?

Professor McKellar: We are really rehearsing again the answers you have just heard. The only thing I would say is that you want to try as much as possible to encourage also innovation—indeed, research and innovation— from the private sector, because what this does in the industrial strategy is pump prime from the public sector research end. At the same time, you also need to encourage the private sector industry and business to invest much more in research, because, as a country, we are very poor at that. I do not know how you are going do it—perhaps through tax breaks, or whatever—but certainly think of that very deeply.

Q33 **Derek Thomas:** That is good. Finally, do you think that UKRI's lead role in managing the industrial strategy challenge fund will be a positive one? Are you in support of that?

Professor Nightingale: There is a danger that we need to be cognisant of, which is that the focus is very much on spinning out innovations from universities—too much—and there is a lot of innovation going on that is not like that. We should be concerned that Innovate UK does not take on a Cinderella role. If we look at the amount of money that is spent on innovation, it roughly divides up one third on research and two thirds on development. If you look at the spend, in terms of support, we are nowhere near that.

You could make an argument that Innovate UK should have more resources, but then it comes back to the question we have been raising about what you cut. There is not any fat to cut. We need to make sure that it is an organisation that is properly supported and is allowed to do what industry needs, and is not confined to doing something that is not the most important thing for the UK necessarily.

Q34 **Matt Warman:** You have touched on both these topics already but I want to talk a little more about commercialisation and STEM skills. The Green Paper is very complimentary about the UK's record on basic research and very uncomplimentary, by implication, about our ability to commercialise. Ultimately, is Britain's record in commercialisation largely a problem with universities, which is what the Green Paper seems to imply? If it is, what action could be taken to encourage universities to change their culture and practice?

Professor Nightingale: Can I lead on this? This is a bugbear of mine. The diagnosis here is false. I think they have made an incorrect diagnosis of the problems of the UK. I do not think that there is a massive issue with commercialisation in the UK. It could be improved. One way we could improve it is to look at the organisations that are best in the world on this, such as the University of California, and copy what they do, which is to push out research as much as they can to generate jobs in California and try not to have silly IP agreements and make it complicated for firms to access technology. Our IP should be there to protect technology so that firms can make money from it and create jobs. We should be open about that and that is what we should be doing.

Q35 **Matt Warman:** That is an open-source approach, effectively.

Professor Nightingale: You should get people in from industry and ask them what they want from the UK system and they will probably tell you that the current TTOs—technology transfer organisations—are not working as they would like. There are some people who will give you a very harsh view of them. I do not think the issue is commercialisation. We should be getting skilled people out and getting research back and forth. Often, innovation is not just universities spinning out research; it is industry having problems and getting universities to help with them. It is

that two-way interaction. The diagnosis is misleading and that is the big flaw for me in the Green Paper.

Q36 **Matt Warman:** I am keen for others to come in, but if the Government disagree with you and think commercialisation is a big problem, do you think there is stuff that Government could be doing to try to influence the culture of universities that would encourage more of the commercialisation that they say they seek?

Professor McKellar: If you will allow me to interject here, setting up regional IP offices is probably not the answer. Universities virtually across the country all have their own IP offices. I do not think that is going to make any difference whatsoever. The way you are describing it and talking about culture is a much more important thing, but, if I am allowed to suggest this to you, I think the culture has changed and is changing. You cannot change these things overnight, but there has been a gradual change and, as a nation, within our higher education sector we are becoming much better. We briefly mentioned earlier the research excellence framework and the introduction of impact into that. It is not just financial impact, but impact in a whole raft of ways, and that has encouraged and enthused the sector. It was hugely concerned about that when it was introduced. It is now, I think, largely comfortable with it, and that cultural change is what you are hoping for. I think it is coming, but you need to be a little patient.

Professor Nightingale: Can I add an important point? If you wanted to improve it, I would shift away from thinking the best way to commercialise technology is in new firms. New firms are often the worst organisations to commercialise technology. Established firms have resources, money, links to markets and are often much better.

Even worse than start-ups are academic start-ups. Academics do not have the skills and do not have an understanding of the markets. There is a very famous British venture capitalist who said, "For the firm to grow, the academic must go." The focus we have on academic spin-outs is a really bad focus. The evidence is very clear that they are a bad way to commercialise. We should be thinking not that academics have some special skills in starting firms—they don't—and we should be thinking about what is the best way to drive up productivity in the UK.

Look at what the University of California is doing; their focus is on generating jobs in California and generating productivity improvements in California. Keep academics, apart from a few exceptional people, doing what they are good at; do not make them do things that, by disposition and training, they are bad at.

Professor Halliday: I slightly disagree with this. I was the dean of science and engineering at Oxford before I became vice-president of the Royal Society. One thing we did was focus heavily on commercialisation and the development of IP, and getting people to think about it. We had to deal with different models of IP and how you handle those, and of

course there are different versions in Cambridge and Oxford, just like there are different versions in Stanford and Michigan.

The key thing is that you want to get people to invest in the ideas, and we have built a fund in Oxford Sciences Innovation from an initial £300 million to over £600 million, I think it is now, which has brought people from all over the world to invest in Oxford University's spin-outs. It is not just the university. We are also including the Harwell campus space cluster being built down there. So, we are very keen to see universities become hubs for innovation and new ideas, and we see this as an important opportunity.

We find huge opportunities for entrepreneurship in the university, both the undergraduate and the graduate sectors, and there are stronger links now between the business school at Oxford certainly and many other parts of academia, including the humanities. We see this as part of something everybody wants to talk about. Roughly, we are going to expect that, if we provide courses that are non-compulsory, voluntary courses, options you might want to take in entrepreneurship at the undergraduate level, you would probably get something like a 10% take-up, I would guess. That is a lot of people, skilled entrepreneurs, coming out of Oxford University if we do that. There are big opportunities and big wins.

Of course, there is another issue with all of this, which relates to the IP structure, and that is that universities have been struggling with their bottom line and sometimes it is because of the way the university is structured. Oxford has a structure I would not recommend to other people. But, at the same time, there are ways in which trying to rebuild the campus and put money into it can be linked to IP deals, and that is how we put up our new chemistry building in 2005, which has been hugely successful and transformative. Getting investment into universities that is linked to IP and linked to commercialisation is something that seems to work, certainly pretty well at Oxford.

Q37 **Matt Warman:** For what it is worth, personally, what Professor Nightingale said about measuring the number of companies as not necessarily being a very good metric probably seems right. I wonder if measuring the number of patents, as the Green Paper seeks to do, is a much better way or not.

Professor McKellar: I tried to do both and I looked at it in several ways. My calculations are based on published data but they are probably not hugely accurate, so don't go away quoting them. In essence, the UK produces about three spin-outs per $1 billion spent on HE. The US only produces 0.4, so that just gives you an idea. When it comes to patents, though, the UK produces about 28 per $1 billion spent, whereas the US produces 106 per $1 billion spent. There is quite an interesting difference there.

Stand back a minute and embrace what Paul just told you. Neither of those are particularly good metrics necessarily, but they are nevertheless metrics and they do tell you something. They tell us something about the different ways that we engage with and try to develop our research outcome. I would hugely support what Alex said earlier. Paul says that university academics are not necessarily the best people to commercialise things, but nor are they necessarily the worst.

Professor Nightingale: That is true.

Professor McKellar: Just be aware and give them the chance.

Q38 **Matt Warman:** Is it not the reality that generalising on this stuff is pretty pointless?

Professor McKellar: Absolutely.

Professor Nightingale: Yes. The metric of spin-outs is a terrible metric. It is very easy to start a company. I teach an entrepreneurship course and I pick up the phone and start a company over the phone. It is very simple, so, as an academic, if I am going to be rewarded for that, I will produce you as many spin-outs as you want; they will all be useless. Over half of all the start-ups are going to die within three years, so it is rapidly a misleading statistic. Then, if you look at the skew of the distribution about where the growth comes from, it is a tiny percentage. We should not be focusing on quantity; we should be focusing on quality. That is a key message to get across.

Q39 **Matt Warman:** Although when it comes to changing the culture, which is what a lot of the Green Paper seems to seek to do, one way you said earlier that you might measure success is a willingness to fail fast. Therefore, the fact that those companies die within three years would be a measure of cultural success.

Professor Nightingale: Three years after starting a company is failing late and expensively. We are talking about lots of resource that would be wasted there. It would be much better if we were failing within weeks or months without much money being spent.

On the patents, that is also a terrible metric. The evidence is that most patents are valueless, and on the ones that are valuable it is highly skewed, so we should be thinking about the quality, not the quantity, and often in the process of developing new innovations it is not just one bit of technology we need; we need lots of bits of technology to come together. If we create a messy patent system involving universities, that is going to make it more difficult, not easier, to commercialise. I do not think that the technology transfer offices are set up in the right way to drive commercialisation of university technology. Universities on their own are expected to cover a very broad front of technological activity, and that means they cannot have that specialised knowledge. This is something we need to rethink.

Professor Halliday: I totally agree with Paul about the fact that academics cannot run companies. That is something we have seen repeatedly at Oxford. The thing that we need to think about, in terms of the industrial strategy, is the kind of education and training that provides us with good CEOs and good management people who can turn a spin-out into a successful company, because that is the bit on which we quite often fail.

Matt Warman: I am conscious of time.

Chair: Yes. Time is our enemy.

Q40 **Matt Warman:** Very briefly on the industrial strategy and STEM skills—and I do not want to reduce it quite to yes or no—do you think the measures in the Green Paper will help STEM skills across the various different areas where there are deficits, including the lifelong training aspect of this stuff?

Professor McKellar: If you do not mind, there are a couple of things there. First, they will help but they certainly will not address it. Setting up a few more free schools that focus on STEM is not going to cut the mustard, I am afraid. You need a much longer-term, much deeper level of investment. If I go back to something Alex said at the beginning, be careful because what we need now are people who have a range of skills and a range of backgrounds, not simply focused on one specific area. The paper emphasises too much sub-degree-level technical skills. Be aware now that many universities in the country have business people on their advisory boards; they are teaching in experiential environments; they are using simulations and actually training people. Many of them have students going out doing placements, so the technical skills are now being married with the intellectual skills within universities. That is what will really drive it.

Even if you look in your own Green Paper, all the evidence that you quote in relation to skills relates to degree-level skills and those uplifting our productivity, not sub-degree. That is not to say that you should not also think about sub-degree-level skills, and of course I personally think you should support further education colleges more effectively in a much deeper way because they are currently starved of resource. The reason you are being critical of them, in a sense, in the paper is not because they are not good but because they simply do not have the resource to do what you would like them to do more effectively.

Professor Halliday: I want to say that the further education situation is critical. We are dire at that. It is great that we have lots of good hairdressers and all the rest of it, but the fact is we need to think hard about the skills base we need for the future, think about courses that will deliver that and incentivise further education teaching along those lines, in particular to retrain and reskill people. There is lots we could do that other countries are doing and we are not. In our meetings with entrepreneurs—we have had dinners with them—this comes out as the

biggest problem with the UK. It is not actually Brexit; it is the skill base within the UK, which may be affected by our inability to bring people in from abroad.

Q41 **Matt Warman:** That is not something that the industrial strategy is solely looking at, to be fair. It is a multifaceted problem.

Professor Nightingale: This is a very complicated issue. The relationship between skills, productivity and place is very complicated. It is a step in the right direction. I would echo the point that we should not just think of skills as degree level and we should not just think they end when you leave university or further education. They continue over people's lives, and that upgrading of skills over people's working lives is really important. That is something all educational institutions could do a lot more about. When universities are good, they are very good at that, and FE colleges, when they do it, are very good at that, and that is something we should support. I would share your view that perhaps FE has been the Cinderella and perhaps should be given a trip to the ball.

Chair: As I said, time is unfortunately our enemy and I am sure we could have carried on exploring some of these things for a lot longer, but I am going to have to draw this session to a close. Thank you very much indeed for your full and candid answers. We will move straight on to the second session. Thank you very much.

Examination of witnesses

Witnesses: Steve Bates OBE, Jen Rae and Allan E Cook CBE FREng.

Q42 **Chair:** Welcome. Thank you for joining us for the second panel looking at our response to the proposed industrial strategy. We are grateful for your time this morning. Before I ask you to introduce yourselves and state where you are from, we are running a little behind time. I do not want to shut down the debate, but if we can keep the questioning and the answers tight, that would be excellent. We will start with you, Allan.

Allan Cook: I am Allan Cook. I am vice-president of the Royal Academy of Engineering. I am also chairman of Atkins engineering consultancy and chairman of SEMTA, which is the sector skills council to do with engineering and advanced manufacturing.

Jen Rae: I am Jen Rae. I am head of policy at Nesta, which is the UK's innovation charity. We focus on how innovation and the creation of good ideas contributes to the development of the UK economy, which is my own particular interest. But we also look much wider at public service provision, new ideas and how Government can deliver services.

Steve Bates: Good morning. I am Steve Bates. I am the chief executive of the BioIndustry Association. We are the trade association for UK life sciences companies, everything from start-up, scaling and established

businesses operating closely from the UK life science base, multinationals, all the way down to one-man bands.

Q43 **Chair:** Thank you. I will start with the same question as I started with the first panel, which is basically, what is your take on the Green Paper published last month? Does it contain everything you wanted it to? What is missing? How could it be improved? It is just a general question.

Allan Cook: From an engineering point of view, we are hugely supportive of the Green Paper. It is a massive step in the right direction. Under the previous Administration, Vince Cable, the then Secretary of State for the Department for Business, Innovation and Skills, was very clear about his desire to drive a strategy within the UK. This Green Paper—out for consultation, of course—is taking a step further, incorporating a lot of things that we recommended. It is all-encompassing, so it covers the whole of the UK. It talks a lot about prosperity and productivity; it talks a lot about places; it talks a lot, obviously, about skills, and the 10 pillars are a clear indication of the direction of travel, but it is out for consultation.

Is there anything it could do better? There are a number of things that we are referring to as part of our consultation, but the one thing that sticks out from a Royal Academy point of view—and I would suggest even from an industrial point of view too—is the lack of focus on diversity and inclusion overall. There is quite a lot of conversation in the paper about skills and the development of skills, but not enough, in our mind, about diversity and inclusion, particularly because from our point of view we do have an issue in engineering and advanced manufacturing, as you know, and we would like to have seen a little bit more focus on that particular area. But, overall, we are hugely supportive; I think it is a massive step in the right direction.

Jen Rae: Yes, similarly, we are very supportive of the document and the approach. It builds on the programmes of previous Governments, so there is a sense of continuity in there such that the word "new" in front of it probably belies the history of industrial strategy over the last 10 years. It recognises there is a real value in putting a narrative over those programmes in setting out what we are trying to achieve as a country within the industrial strategy. Nesta would welcome a strong focus on innovation and the contribution of innovation to productivity, and for the first time in a long time this is backed up by some serious investment. The additional £4.7 billion that is in there, which is out for consultation as to what it could be spent on, is a real strength of the strategy. Not only are we saying that as a country we are going to be doing and promoting more innovation, but we actually have some resources to do it.

For me, also, there is a clear indication of a cross-Government approach. The 10 pillars go across various Government Departments and, to me, it felt like there was a consultation process within Government that gave it a real strength when you read it through.

Finally, the questions asked at the end of each section are really good questions. There is a sense of genuine consultation. They are asking for responses back from the wider community as to what should be invested in and why. It is a well-written and clearly set out document. I have read quite a few Government documents over the years and this one felt like I understood where it had come from and what it was trying to do, while also asking good questions about what it should do next.

There were a few areas for next steps and big questions, which you will probably want to go on to, given the questions you asked in the previous session. The industrial strategy challenge fund is a huge opportunity, but there are questions over the process by which that would be run and what that money would be spent on.

The skills section, which I know you are not looking directly at, is related across the first pillar—the innovation pillar. That is a welcome look at technical skills, but there is an opportunity here to be much more ambitious about skills provision and looking at the future of the workforce, not just in the next five years but also over a much longer term.

Finally, there is something in the Government's interaction with businesses and which businesses it talks to. The sector deals are a very interesting initiative, but, for me, the process by which Government talk to businesses, not just in the sectors that they have previously prioritised but in new emerging sectors, needs to be right.

Steve Bates: It is a hugely welcome document. It identifies the correct challenges. I highlight the particular ones around the lack of scale-up capital and the challenge of management expertise. It is right to recognise our strengths in science, as we have heard in the last hour, and especially life science. The sector deals are a great way of engaging with industry. It is a consultation paper, so there are some interesting ideas, but they are really only at the review stage, particularly the stuff about what we do around patient capital, how the FCA is going to manage that and how we will operate technology transfer, which you also touched on earlier.

Q44 **Chair:** Thank you. There are a number of practical measures that are highlighted in the proposed strategy. Do you think they go far enough, that they are appropriate suggestions, or would you like to have seen it go further in any particular direction?

Allan Cook: As it is a consultation document, it is quite difficult to be completely articulate about just exactly what the practical implications are. It tries to have a balanced approach. Like Steve, I am hugely supportive of the fact that this covers all Departments. It really is driven by the Prime Minister, although Greg Clark has the responsibility as part of his portfolio, but it is clearly across all Government Departments.

All Government Departments have specific areas of requirement and needs. It will be different in the health service compared with transportation. There has to be a balance in what is the art of the doable in the overall scheme of things. The danger is to try to boil the ocean where you are trying to do everything and be all things to all men, and that is very difficult to do. But as a consultation document, in the right stage, it strikes a balance between a positive message—this is what we are trying to do for the UK—and the overall practicalities of implementation. The proof of the pudding is going to be in the eating in how we can take those practical examples forward.

Q45 **Chair:** Does anyone want to add anything in particular to that?

Jen Rae: There is a real strength in rounding up what is already going on, and this document does that; so, the sections on what the Government have already committed to, and then the consultation on what they might do in addition, are equally important as new practical measures. It is a taking-stock document and then the next stages will be really clear. I guess there is a question for me over what the next stage in the process is: if it is a Green Paper, is there a White Paper? Then, are we looking at delving into each of those individual pillars and working out a plan for each of them?

Chair: It is a good question, which we are not here to answer at the moment.

Steve Bates: I hope that life science, as it has been engaged in industrial strategies over the last 20 years with Governments of all colours—the coalition Government, the Conservative Government and previous Labour Governments—may have some lessons to share with other sectors as a result of that. There are some examples of policies recently that have delivered on some of the objectives here, crowding in private sector investment through the Biomedical Catalyst and through Innovate UK, which may be able to be built on.

Q46 **Chair:** Very briefly, before I pass over to Chris Green, we talked in the previous session about metrics that we might use to measure the success of the strategy. There is obviously the broad one, which is an increase in productivity and general economic growth. Is there anything specific that anyone can add to that that they think is something that would and could be used to measure the success of the strategy?

Allan Cook: The two things you mentioned there cover it for us in terms of productivity and the economic growth that we would see coming out of the UK. The UK, for an island and a relatively small economy, is incredibly resourceful. We have a fantastic track record over decades—indeed, centuries—on how innovative we are and can be, but we certainly have over the last 10, 20 and even probably 30 years slipped back in our productivity. We have probably balanced that—certainly recently—against full employment. That sometimes detracts from productivity, so we need to be careful that we are not doing that. In terms of the western

economies, we are lagging behind some of them. As to some of the countries we are lagging behind, it is quite remarkable, so productivity and prosperity have to be a key metric, and, because it is a UK and a UK Government approach, it has to be economic growth.

Steve Bates: I would do it through companies to scale: can we grow some UK companies to global scale? You are aware of the big ones we see in the US. Could we do it in the UK? There is no reason why we could not do so off the science base that we have.

Jen Rae: There needs to be a long-term approach taken here, but the ambition within the document is beyond the scope of five years and the metrics should reflect that. We do not have much evidence of what works in outcome or evaluations. If we are trying new things in this industrial strategy, we should make sure we evaluate them and add to that evidence base.

Q47 **Chris Green:** Everything gets seen at the moment through the prism of Brexit. How do you think the industrial strategy Green Paper and the Government's White Paper complement one another?

Jen Rae: As to the industrial strategy, there is a lot of stuff in there we needed to do anyway whether or not we were leaving the EU. It is important to remember that this builds on programmes and policy that the Government have had in place for a number of years. Leaving the EU adds a different slant to that, but this industrial strategy is important anyway.

There are clearly big questions. In the last session, you covered some of those in terms of the uncertainty around our access to international talent, particularly for businesses and also universities, and our access to funding. The cross-Government, cross-departmental approach that seems to have been taken in the industrial strategy is something that you would hope to see as we start to get more certainty on our approach to leaving the EU. It provides a good indication that, as a Government, those Departments are beginning to work together to address some of these issues.

Allan Cook: From a Royal Academy point of view, in October we published a paper. Basically, we brought together 38 professional engineering institutes and produced a paper on the impact of Brexit to engineering. We would go back to that. Doing an industrial strategy for the UK is a huge challenge. It is a great challenge to have. Doing that in the context of Brexit—and the implication of Brexit—is adding more complexity and more challenge. The engineering community has an incredible record of working very closely with various economies, and that includes a lot of work that we have been doing with the European Union. We see that continuing. Very succinctly, the industrial strategy is a big challenge, and adding to it the complexity of Brexit makes it an even bigger challenge.

Steve Bates: The three things that the industrial strategy does not touch on that are vital for our sector in the context of Brexit are regulation, immigration and funding.

On regulation, research and medicines regulation are a key Brexit issue. It is being addressed by the Government in a different format, but we have had the European Medicines Agency here—we have had an integrated system—for many years. How we operate in a new process is vitally important to the success of our sector, so that is a key issue.

Q48 **Chris Green:** Does the Green Paper deal adequately with that issue?

Steve Bates: It only mentions regulation three times in the Green Paper and they all refer to saving businesses money through reducing red tape. It is not really the prism through which life science businesses would see the challenge of regulation in terms of Brexit.

On immigration, you have heard a lot this morning about the importance of skilled people being able to be part of the science base. It is equally important for businesses particularly being able to attract, retain and develop people. I will not go further on that.

On funding, the European Investment Bank is a significant funder of UK innovation, and we do quite well out of that coming into SMEs and venture capital in the UK. If we are no longer able to participate in that format, some of our venture capital will lose cornerstones, which will then have an impact on innovation, which makes it even more important for the innovation and Innovate UK part of this to be got right.

Q49 **Chris Green:** In that sense, as to the money we would not be putting into the EU, you would want to see replication to some extent of the resources we get back in the new framework.

Steve Bates: I am afraid it is worse than that. We get oversized amounts of money coming from the EU in the direction of the UK through the European Investment Bank into UK businesses partly because we are profitable and do it well. They like investing in the UK and we are oversize for their investment mechanism. If we are unable to attract that, we would have to replicate from the UK more than we get at present from Europe to get the same quantum of cash.

Q50 **Chris Green:** The negotiations may go wonderfully smoothly, and the nation states and the Commission work together to get the best deal that suits everyone. It could also be quite terrible. You could almost get an extreme position where to deter any other country from leaving the EU you get a really bad deal, which would be quite damaging for everyone. If we go for more of the worst outcome in terms of the negotiations, to what extent will the hopes of the industrial strategy be derailed, delayed or more difficult than expected to deliver?

Allan Cook: Certainly, the UK has always played an important part in the European Commission in terms of regulations. Steve's point about the

biomedical industry and the pharmaceutical areas is absolutely right. It is a similar situation in engineering. Thinking about aerospace and green-sky policies, the work that we do jointly with the European Union and the Commission is hugely important to many industries within the UK. I would not like to think towards the negative side as to how terrible this could be. Of course, it could be catastrophic; it could be really bad; but I would like to think that the communities that are looking at the benefits of investing in the UK would continue to look favourably on us because we add value to what they do, we add value to their thinking, and we add value to the way that they implement some of these regulations. I still believe that we will have a voice post Brexit and that the UK will also continue to benefit from the interface between what is a very important trading nation or community from a UK point of view.

I am much more optimistic about the practicalities of it. I do not think we should underestimate the challenge, but I would hate to start thinking about what the terrible impact could be, because it could be really catastrophic.

Q51 **Chris Green:** How useful over the course of negotiations would it be to have an indication as we go along what things have been agreed or near enough agreed to give us that certainty?

Steve Bates: Clarity and certainty are what businesses want. In a sense, if it is good news or bad news, either is news and certainty is helpful. The biomedical community in the UK is entrepreneurial. This is a globalised business and it is a global opportunity driven by global trends—an ageing population, the development of science and opportunity there. People will still continue to build businesses and look to export and engage in these things. It is a question of scale and pace. If the barriers become extremely difficult, then entrepreneurs are able to move people and jobs around the globe in this sector, and that is more likely to happen than there not to be the development of these technologies.

Q52 **Chris Green:** I have a final, quick point. We can often look at the negative sides of the challenges that Brexit poses, but perhaps the Green Paper did not quite capture the opportunities of Brexit. It might be a bit of a challenge, but could you each give perhaps an opportunity that Brexit presents that the Green Paper does not suggest?

Steve Bates: It is clear that the development of genetically modified foods and agribusinesses has been stymied in Europe as a whole for a generation. I am not able to say that we have in membership of the BioIndustry Association significant players in that space. Agriculture is going to change significantly with this and potentially the adaption of some of the more modern techniques that are available is something in which the UK has the opportunity to lead. There is a societal debate as to whether that is something that we want do, but if we are going to have plant food that sustains eight billion people on the globe and live in cities that need to feed people in an intensive fashion, there is the opportunity and there is also opportunity for diversity of that across the UK.

Chris Green: Unless you are desperate to get in with another point, that is a good one to—

Allan Cook: If I can come in on this one, I think we touched on regulation, skills and on funding. Certainly, we did not see too many impacts on red tape, but everybody recognises that the European Union and the European Commission are hugely inefficient. From a positive point of view, in not being part of the European Commission and having more freedom to do some of the things that we feel impact the UK from an engineering and advanced manufacturing point of view, we should seize that with both hands and try to make the best use of the funding that would normally have gone to the Commission into the UK in terms of innovation, research, investment and, of course, the development of our industries.

Q53 **Dr Mathias:** Steve Bates, the Green Paper points out the sector deals that are already in prospect, such as the life sciences and ultra-low emission vehicles. Looking at the challenge fund criteria, do you think there is going to be an overlap with those deals, and does it matter?

Steve Bates: I hope there is some overlap and I do not think it matters. It is right that Innovate UK develops its thinking around areas; I know it is looking at the future of healthcare and it would be right for it to do that. It is also looking at the bioeconomy, and some of those areas are linked to and cross over with the life science sector. There is a good working relationship between the people at Innovate UK and the people who are looking at the sector deal. Sir John Bell is the Government's champion for life sciences. That is working quite effectively.

Q54 **Dr Mathias:** Would you agree?

Jen Rae: There could well be some overlap, but I would see the industrial strategy challenge fund as a funding mechanism particularly for potential new ideas, and we could talk a little more about that. The sector deals themselves seem to me to be a mechanism by which Government are saying to business, "If you want to talk to us, come together and tell us what your sector needs." That potentially is funding, but it is also a conversation about regulation and about how different sectors interact with Government in different ways. For me, the opportunity for those sector deals is that they are less defined in emerging sectors that have not necessarily in the past had the capacity or opportunity to talk to Government about their needs. These deals could provide them a way in, in a way that Government structures in the past around sector councils has not allowed them to do. For example, the creative industries have a council, but it is formed slightly differently than some of the more established industries such as aerospace and automotive. These sector deals provide that mechanism for a conversation rather than just funding.

Allan Cook: I had the benefit of working with a number of the sectors in the previous Administration under BIS—aerospace, automotive, defence and cyber—and they were hugely successful in each of their own ways.

We should be building on that sector. I know there was a fair amount of criticism across Government about why we were prioritising these 11 or 12 sectors. Part of the strategy is about prioritisation, so you really do need drivers of industrial growth and economic growth to be there; but we should be doing exactly what Jen says, which is using where we have the overlaps, and there were huge amounts of overlap in aerospace, automotive, cyber and defence, where you have dual-use technologies that can be applied across three out of four of those sectors.

We have lifted the industrial strategy up and said this is now going to be across Government Departments, which has broadened it out, saying this is an opportunity for us to develop what has been done successfully, and to look at what has not worked so well and apply it. Every sector has been given the opportunity under Greg Clark to provide input into what worked well, what did not work quite so well and whether we could apply it to the Green Paper. That will be part of the consultation that will go forward. I think there will be overlaps, but we should be using them to our advantage.

Steve Bates: If I may talk about the life science sector—which I hope is included in the creative industries, because the idea that people who do science are not creative is a misnomer—the life science sector is disrupting itself with the technologies that sit on the edges or outside it. If you look at cell and gene therapy, engineered biology or other areas, these are not monolithic and they are dynamic sectors that are being disrupted by new technology. Equally, the sectors have different engagements with Government in terms of the public sector as a customer. The NHS is a vitally important component for things around genomics and a number of areas, so there is a real opportunity for partnership in the industrial strategy.

Q55 **Dr Mathias:** Sir Mark Walport told us that Innovate UK and the research councils were having public meetings. Allan Cook, were you involved in any of those?

Allan Cook: Yes, I was.

Jen Rae: I was as well.

Steve Bates: I have seen John Kingman and Mark Walport at a number of events. Innovate UK's role in the future of UKRI is absolutely crucial. Innovate has a slightly different objective in terms of building businesses and we are very keen to make sure that that objective remains strong and the focus within UKRI. I am confident from conversations with John Kingman and Mark Walport that that is going to be maintained.

Q56 **Dr Mathias:** You had those meetings. Were you part of the public meetings as well?

Steve Bates: There have been so many meetings; I am not sure.

Dr Mathias: That is fair enough. Thank you.

Q57 **Matt Warman:** Briefly, is the number of patents produced a useful barometer of innovation?

Steve Bates: No.

Q58 **Matt Warman:** Anyone else?

Allan Cook: Adding a caveat, it is a measure. You asked about metrics. I do not think so, certainly not from an engineering point of view. Is it ever used in anger as to how well or badly we are doing in terms of patents? We are notoriously poor at developing patents and making the most of them if you compare us with the likes of Japan or the USA in the way that we do that. We are less litigious, so that is obviously a factor of it, but we tend to share. In general—and I think it is a generalisation—where previously people reflected on the fact that knowledge is power, now people reflect on the fact that the sharing of knowledge is where the real power is. Because we are talking about much more collaboration—not just within the UK, not just within sectors, not just within the industry side of it—with the nations that we deal with, we trade with and interface with, sharing of that knowledge is really important and therefore patents are less influential.

Q59 **Matt Warman:** It is a leading question, but is the Dowling review on commercialisation of university IP likely? It sounds as if you are suggesting that sharing would be the single biggest cultural change that could be encouraged, but is there anything else? Am I being fair?

Allan Cook: Ann Dowling's report was absolutely right on collaboration and what we needed to do on co-operation, and I hope that we will see that incorporated into the work that is going on. We certainly will be reflecting on that when we respond to the Green Paper.

Steve Bates: You asked about the number of patents. Much of the value in early-stage and even scaling life science companies resides in a patent position. Patents are crucial for the future, and perhaps there is some opportunity post Brexit for the UK to look at its patent position. We are supportive of the Dowling position. Our companies share the frustrations of the experience, but I think that experience is moving with regard to TTOs, and the Dowling proposals are very helpful.

Jen Rae: You had some excellent comments from Paul Nightingale in the last session on this, and, although it is one measure, there are others. In terms of innovation within businesses, there are other things we should be focusing on, and businesses make the most contribution to UK innovation. Within businesses, R&D and IP are just one small fraction of that, so things around process innovation, service innovation and skills training are all more important to businesses than R&D and IP.

Q60 **Matt Warman:** The university enterprise zones could also help. They are not in the Green Paper. Do any of you have any thoughts on whether that is a pilot that should be expanded or could help in this area—that sort of stuff?

Allan Cook: It is a mistake that the university enterprise zones are not in there. When you think about what is in there with regard to the desire to be less south-east-centric and move expertise, knowledge and, therefore, economic power around the UK, it is an omission that needs to be reflected. Within a number of areas in the south-west, Scotland, the north-west and the north-east, there is a tremendous amount of interface and co-operation with the universities from an industrial point of view. It varies, of course, and it is difficult to make a complete generalisation, but the university enterprise zones could have a real impetus in getting the best out of the regions overall, and we will certainly be reflecting that.

Q61 **Matt Warman:** Finally, on the subject of things that could have an impact, do you think that the proposals in the paper to change the small business research initiative are the right proposals? Are they helpful?

Allan Cook: Small businesses—SMEs—are such a huge part of our supply chain in engineering. I always refer to the statistic that, if you look at engineering in advanced manufacturing, we have round about 145,000 companies in the UK. Of those, probably over 90% of the companies employ 10 people or less. The small and medium enterprise is an important part of that. Anything we can do to make it easier for these organisations to participate and add value has to have a huge impact.

Q62 **Matt Warman:** Do you have anything specific in mind?

Allan Cook: We have always recognised the supply chain. The difficulty is that some of these small companies are start-up companies, and we know how notoriously difficult it is when you have five or six people; you normally have the same people who are involved in the research, development and manufacture, the shipping and the gathering in of the cash. It is very difficult to get their engagement, basically, at forums like this.

Steve Bates: In terms of the Government as a purchaser of innovation and a validation in the market, SBRI is a crucial element to this. It depends on your sector. It is quite hard to do that if you are an early-stage drug developer, but perhaps if you have a med-tech device it can be important, and the challenge in the NHS is adoption and uptake. Quite often you can do that with a hospital, but then getting every hospital to adopt it is a challenge for small businesses. So, we welcome it, it is useful in certain places, and particularly it may be important if we can link it to processes post Brexit that give validation, which enables it to be sold to overseas markets.

Q63 **Derek Thomas:** We have heard several times on this Committee that there is a heavier focus towards basic research than the actual end result—commercialisation. I know we have touched on it briefly, but do you think the Green Paper addresses or corrects, if it needs correcting, the emphasis on research rather than commercialisation?

Steve Bates: I have heard the comments in the last hour and I would agree with them, but, in a sense, the D is a significantly longer and more

difficult journey in some respects than the R in the R&D. Therefore, if you are going to build businesses to scale, it is very important that there is a full understanding of the support mechanisms that our businesses face when they see what they can do in other countries. In America, there is lots of support for businesses to scale. Therefore, if we are going to build businesses and have a great place to grow and build businesses here rather than elsewhere, we need to do quite a lot of this. Innovate UK is the right mechanism to do that and that is reflected in the paper.

Jen Rae: I share some of Paul Nightingale's concern over the model that is used within here. It feels quite linear in that the inputs go in at the research science base and then towards the end of it you get businesses that do some more innovation. But I think it has moved on, and the section on supporting businesses to scale and grow, which is a different pillar but is interlinked, is a slightly weaker section than the R&D one and investment in innovation. There are some big questions posed there about how you do support businesses to invest in innovation and then turn that into growth.

For UKRI, this is going to be a big challenge as to its set-up and the balance of the relationship between the research councils and Innovate UK. As Paul said, we need to make sure there is not a Cinderella relationship going on there as to where they sit within it. We could always spend more on the D of R&D, and I would like to make sure that the additional £4.7 billion is prioritised towards that D.

Allan Cook: We also support Innovate UK. It has been a huge influence and continues to be. Getting the balance right between the R and the D is really important.

I do not agree with what Paul said previously about the lack of success coming out of universities and the role that academics play in that, because when you look at some of the successes that we have had in Cambridge—the Cambridge Angels—and the work that goes on in Heriot Watt and Oxford, it is hugely supportive and we could not do that without the support and the involvement from the academics. I think you are getting the balance right, and it varies in what it is you are trying to do the research on that leads to the development. Of course, not every research paper or involvement is going to lead to a development, a product or a business, but front-end innovation is really important and I think we do it rather well in this country.

Q64 **Derek Thomas:** We have heard about the extra £2 billion for the science budget in the Green Paper. Very briefly, what would your priorities be for that money? Where do you want to see that money go, if you have any ideas? Do not feel you have to answer.

Steve Bates: The Biomedical Catalyst is an Innovate UK scheme that has been very effective at crowding in private sector money, and we should look at things that amplify what you can get from the public purse. There are some good models that may work for other sectors as

well. There may be some opportunity in my space around the novel ways in which manufacturing may happen within life sciences, particularly around cell and gene therapy, viral vectors and others, where some help to get that going might anchor the manufacturing businesses of the future here rather than in other places. There is an opportunity there.

Jen Rae: As part of that, the industrial strategy challenge fund, which is in that £2 billion, is a real opportunity to do things differently. I would like to see a chunk of that money put towards not just funding the same programmes that Innovate UK and the research councils have funded in the past but looking at new ways of supporting innovation. This challenge-led approach that is set out in the document, which will develop over time, is an exciting way of looking at how you could get new ideas and innovation focused on achieving a particular outcome and whether that is a benefit for society or looking at new opportunities for the economy, building on UK strengths. To me, that feels like a good opportunity to do the different things that we might want to do.

Allan Cook: I would say industrial digitalisation, artificial intelligence, robotics and—because with our demographics and the skills gap that we already have, which is going to get worse—moving towards a more productive, more innovative way of building our businesses, developing our organisations, developing the technologies that we have, and we will be working towards industrial digitalisation. The other fourth industrial revolution is absolutely crucial, not least because other economies are doing exactly that and we have to compete on this because it is a global economy now.

Q65 **Dr Mathias:** On other economies, could you say who is leading on the fourth industrial revolution?

Allan Cook: Germany is doing fantastically well, but they have been at this for a number of years—decades—and America, if you look at the amount of investment that is being made by Government and industry together. This is part of the sectoral approach, because this is not just a Government approach; this is a joint collaboration between Government and industry, so it is basically using the expertise and the knowledge to do that. It is the USA and Germany.

Q66 **Carol Monaghan:** I will be as brief as I can. I want to ask a couple of questions about skills. The Green Paper attempts to tackle the skills shortages through institutes of technology. How confident are you that this is going to help with STEM skill shortages?

Allan Cook: It is far too early to say. We do not really know. We have been asked to give our ideas about what the institutes of technology are going to be around, so we have a number of things that we are focusing on, UTCs being one of them and more investment in STEM subjects another. As to what these institutes are going to be all about, the devil will be in the detail. It is too early at this stage to make any reference about that. All I do know is that we would strongly urge the Government

in the industrial strategy to focus more on younger children. I believe that, from an engineering point of view, we have to get the message across much earlier than 11, 12 and 13-year-olds. Their decisions and their mindset have already been formed long before then. We have to invest.

Q67 **Carol Monaghan:** I do not think you will find many arguing with that here. Jen, did you want to come in?

Jen Rae: Yes; I agree with Allan. It is very early to tell. We are long overdue a shake-up in vocational and technical skills delivery, particularly at local level in terms of linking up the supply chain, what businesses want from the local workforce, through to what skills are being provided in the training. That works over a shorter period of time, but it is most important that we get the longer pipeline right, and getting in much earlier in terms of the education system is going to be key to that.

I would also make a plea, which was something that Steve mentioned earlier, that creative skills are very important here as well, and it is the combination of scientific and technical skills with creative skills, and looking at digital skills and analysing data, that is going to be important for those jobs that we will want people leaving the education system now to do. It is making sure we combine those together.

Q68 **Carol Monaghan:** I remember somebody once telling me that physics was not a creative subject, and I said, "Tell that to Einstein, Newton or Feynman, or any of these guys." Steve, do you have anything to add?

Steve Bates: As to the institutes of technology, it is too early to give a substantive comment. In terms of skills, in the Science Industry Partnership we are looking for bioinformaticians, health informaticians, computational scientists, health economists, formulation scientists, control and instrumentation engineers, process safety engineers, the technician workforce, toxicology, pathology and systems biology, especially immunologists, QPs to do release and vet physiology and pathology.

I would draw this Committee's attention to the apprenticeship levy and its impact on how this might work in the life science sector. We estimate around 15% of our members are going to be caught by the levy, and another 15% think they might be. At the moment in life sciences, apprenticeships tend to be in the higher category of skills, and if there is a drive to a number doing the lower end of the apprenticeships, this means it will forcibly drive the sector to do things that are not helpful and skill up people in ways that will not really work for us. We think there should be some flexibility to enable levy-paying companies to share the funds in their digital account with their collaboration partners and companies in their supply chain so that they can get those people into SMEs. Let the big guys put them into SMEs and grow the base that way round.

Allan Cook: I have a final point, Carol. I feel very strongly about this. The Institute for Apprenticeships and the apprenticeship levy are going to be governed out of the Department for Education—the DFE. It is in the wrong place. My concern is this. From an industrial point of view, further education, higher education and education itself are absolutely crucial to what we are talking about, but the interface between developing the right skills that Steve, Jen and we need to drive our industry is dependent upon the interface between industry and the organisations involved. Having it in education, I am sorry, is not going to get it the right level of attention that it needs. We need to look at that. I do not know how we do that. Before, it was in BIS. It is no longer in BIS. It is now in the DFE, and, because of the challenges that the DFE faces, I do not think it will get the attention that it absolutely needs. Apprenticeships are the lifeblood of what we do within our organisations.

Q69 **Carol Monaghan:** That is on the record now. If I could ask one final question, Chair, in the industrial strategy there is also a focus on increasing skills through teaching in schools and universities. It talks about training 2,500 specialist maths and science teachers and upskilling 15,000 non-specialist teachers. Are you confident that they will be able to achieve this ambition?

Allan Cook: Historically, they have not done well and we are seeing the impact of that now, certainly from an engineering point of view in the amount of pupils who choose engineering or associated subjects, because of a lack of specialist skills in terms of maths. That has improved, but physics, chemistry, and design and technology have not improved. Historically, we have not achieved what we have set out to achieve in developing the right sort of specialist skills, but I am hoping that the work that is going to go on and the consultation that is absolutely critical to this will help us to shape what we are trying to do in that particular area and put the focus of attention into those specialist skills that we need. But it is not only maths and physics, of course. There are general skills that we need across the board.

Steve Bates: I do not know whether it is going to be successful. I know we are committed to working with Sherry Coutu, who does the Scale-Up Institute, to ensure that members from the BIA's community who are working in bioscience are going to make themselves available to schools to share what they do, how they do it, why they needed their maths, physics and chemistry as part of an inspiration, hopefully before people make their choices this year, to encourage people to see what that means, what that decision is, particularly if you do not have anybody in your family who has experience of either working in industry or in a science-based skill. So, we are trying to help.

Q70 **Chair:** Thank you very much. Can I pick up on that point? How many schools are you hoping to be able to get into?

Steve Bates: If we could work with you, perhaps we could improve the number. I was going to talk to you about that later.

Chair: Fine. Thank you very much indeed for your attendance this morning and for your very helpful contribution. I am sure you will look forward to seeing our report as part of the consultation process. I am sure you will all be taking part individually as well in that process. Thank you very much indeed for your attendance.