



Select Committee on Science and Technology

Corrected oral evidence: Life Sciences and the Industrial Strategy

Tuesday 14 November 2017

10.10 am

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Members present: Lord Patel (The Chairman); Lord Borwick; Lord Fox; Lord Griffiths of Fforestfach; Lord Mair; Lord Maxton; Baroness Morgan of Huyton; Baroness Neville-Jones; Lord Oxburgh; Lord Renfrew of Kaimsthorn; Lord Vallance of Tummel.

Evidence Session No. 14

Heard in Public

Questions 110 - 126

Witnesses

Professor Jonathan Elliott, Vice-Principal, Research and Innovation, Royal Veterinary College; Dr David Hughes, Head of Global R&D Technology Scouting, Syngenta; Professor Angela Karp, Director for Science Innovation, Engagement and Partnerships, Rothamsted Research.

USE OF THE TRANSCRIPT

This is a corrected transcript of evidence taken in public and webcast on www.parliamentlive.tv.

Examination of witnesses

Professor Jonathan Elliott, Dr David Hughes and Professor Angela Karp.

Q110 **The Chairman:** Good morning. Thank you all for coming today to help us with this inquiry on the life sciences industrial strategy, which Sir John Bell published a document on. Although that is the focus of our inquiry, it has come to our attention that the title refers to life sciences but the inquiry is more about biomedical sciences. We would like to hear your views about the life sciences industrial strategy as published, and we would particularly like to hear, through answers to our questions, whether you feel there is a missed opportunity with other life sciences. If you do not mind, please start by introducing yourselves. If you want to make any initial comments, please do so. Otherwise, we will proceed to the questions.

Dr David Hughes: I work for Syngenta, which is a global multinational agricultural technology corporation based in Switzerland. We provide some of the inputs that farmers use to produce food, most notably crop protection chemicals and seeds. I have a couple of quick points to make about Syngenta. First of all, we are an innovation-driven organisation. Every year we spend well over \$1 billion globally on agricultural technology research and development.

Secondly, as many of you probably know, we can trace our ancestry back through to ICI, which means that we have a disproportionately large number of assets in the UK. By assets I mean sites, people, infrastructure and so on. That makes the UK a particularly important country from Syngenta's point of view. The industrial strategy in the UK is therefore particularly important to us.

I have been working in agricultural sciences for 22 years now at the Jealott's Hill research station in Berkshire for Syngenta and at previous companies. My current role is as global head of technology scouting for the corporation worldwide. That is all about creating and maintaining relationships with key scientists and scientific institutions in the outside world, with a view to leveraging those relationships to create mutual value somehow, most often by co-creating collaborative research programmes that can be run more effectively and efficiently in partnership than either partner could do by themselves.

Professor Angela Karp: I am the director for science, innovation, engagement and partnerships at Rothamsted Research. Rothamsted is one of the longest running agricultural research institutes globally. We do integrated strategic science. At the moment, we have strategic funding from the Biotechnology and Biological Sciences Research Council—BBSRC—for four challenge-led strategic programmes that are solving agricultural research problems.

Our fifth programme is funded from the industrial strategy challenge fund. We have a lot of interest in the industrial strategy, are obviously behind it and require that it has success. We are also founding partners of three of the four agricultural innovation centres, which are often called

agritech centres. Rothamsted works very much in the space of research, innovation and translation for the benefit of the agricultural sector.

Professor Jonathan Elliott: I am vice-principal for research and innovation at the Royal Veterinary College, which is part of the University of London and is a small specialist college focusing on animal science and veterinary science. We train veterinary graduates to go into veterinary practice and research into veterinary science. We also train animal scientists in our biological scientist programmes, who understand how animals function at the whole-animal level and are therefore very important to both veterinary and biomedical science. There is an overlap between the two; in fact, the preclinical sciences for animal health research are identical to the preclinical sciences for medical research, and there is a lot of cross-play between the two.

You have probably come across the term “one health”, which recognises that we are sharing the environment that we live in with our companion animals and the animals that we use to produce food. We very much feel that animal health research should feature in the life sciences strategy alongside human medical research, because the interplay and the synergies between the two. The Royal Veterinary College founded the first innovation centre in London, the London BioScience Innovation Centre, which is based on our Camden campus. It has 60 client companies at the moment, and we work very closely with industry across the biomedical and veterinary sciences area, so our graduates are very well versed in that interplay between human medicine and veterinary medicine.

The number of pet animals in this country is increasing. There are now 8.5 million dogs and 8 million cats, which are suffering from the same problems that humans are. They are living longer because we are controlling the infectious diseases that they have, and they are developing degenerative diseases at a faster rate than people are. Studying those animals and looking at how we can help them will also give us clues for human medicine and give us a different angle on this than some of the laboratory animal models that have been used for a long time.

Q111 **The Chairman:** Thank you very much indeed. To go back to my initial comment, what are your comments on my question about the life sciences industrial strategy, which, although it is called the life sciences industrial strategy, focuses on biomedical science—as, it appeared, did the Green Paper? Do you think not involving other life sciences is a missed opportunity?

Professor Angela Karp: Absolutely. I think we all agree that it is a huge missed opportunity. We can elaborate on that, if you would like.

The Chairman: We would like to hear from you why you think it is a missed opportunity. Can you not convince us but inform us, so that we can say in our report that the competitive strength of other life sciences is similar to that of biomedical sciences?

Professor Angela Karp: One massive gap is that having healthy people starts with healthy food, but the provision of healthy, affordable food is completely missing from this strategy. Linked to that is the fact that our natural capital is very important for health and well-being. There is no mention of the importance of our natural capital in all its forms. For us and for me, life science is about all living organisms and the contribution they make to our health and well-being. The life sciences strategy focuses on one rather narrow area.

Dr David Hughes: Focusing on the agrisciences, the situation was beautifully expressed in Sir John Beddington's report back in 2011, which made the very clear and compelling case for further investment in agriscience. The opportunity space is huge. We can be absolutely assured that the demand for healthy food is going to increase in the medium term. It is just a matter of simple demographics. On the flipside, the opportunities for technical intervention in how we produce our food are huge and getting bigger. That is a delicious prospect for an innovations system: that you have increasing demand and increasing means of intervention at the same time. That would be fantastic.

The threat is also becoming more acute. What if you get this wrong? For example, we are seeing increasing volatility in our food systems. We had a taste of that in 2007 and again in 2011, when we had riots on the streets because of food price spikes, for example. We are seeing volatility in our climate and weather systems, which have a profound impact. We also have volatility in our economic systems. The impact of agriculture on the wider environment is getting worse, not better. The opportunity and the need to intervene and make our agricultural systems more sustainable are quite clear there.

This is very important for the UK, too. The UK is particularly well placed to be able to take advantage of this because of our science base. We have some of the world's best agricultural scientists at some of the world's best agricultural institutes, such as Rothamsted, John Innes and James Hutton. We also have strength in our traditional universities, such as Oxford, Cambridge, Nottingham and Exeter. There is a long list of world-class universities in this particular field.

We are also vulnerable in the UK. British farming can only produce half the amount of food that UK consumers eat. We are particularly vulnerable to global trade and the world commodity markets, too. All these points are very well made in John Beddington's report and are, if anything, more acute today than when that report was written a few years ago.

Professor Jonathan Elliott: My colleagues have made the points on the food side. Clearly veterinary science is really important for food safety and for working in combination with medical sciences on many of the zoonotic diseases that are emerging today and causing major outbreaks of disease. We really need to get veterinary and human medical science working well together with industry to solve some of those problems, to develop the technical solutions for those problems and to develop the early warning systems that those diseases are occurring.

As I mentioned earlier, the same biomedical science is the foundation for applied veterinary science as it is for applied medical sciences. Why would we not also be leading in that area? The Royal Veterinary College is ranked third in the world on the QS rankings for veterinary medicine. The other veterinary schools in the UK are not far behind. We are leading in Europe. The two schools ahead of us are both American schools, Cornell and Davis. Our aspiration is to catch those schools up in the quality of our academic science.

The Chairman: Did you make representations and submit evidence to the consultation on the Government's Green Paper on industrial strategy?

Professor Angela Karp: We did not submit evidence, although we have been in peripheral discussions with other bodies that did. The industrial strategy as it is written is quite generic. Many of us are missing clarity of detail in it that you can get your teeth into to respond easily to. We have submitted evidence now, but it is difficult to do that in such a top-level document.

The Chairman: The consultation was called for pretty widely. Anybody could have sent submissions.

Professor Angela Karp: It is true, and we have made a submission this Committee's review of the life sciences strategy, which has more relevance to our sector.

The Chairman: You have submitted evidence to John Bell's document.

Professor Angela Karp: We have to this Committee's review of the life sciences one, yes.

The Chairman: Since it was published.

Professor Angela Karp: Correct.

The Chairman: Would you mind sending us a copy of that?

Professor Angela Karp: We sent a copy in. I would like to pick up a point from my colleagues. David has already made the point that there is a lot of activity around the agricultural sector at the moment, a lot of work on big data, sensors, robotics, satellites and so on. All these technologies are active around this space. We can see a massive opportunity for growth in this area, but it requires really strong cross-sectoral connections to be forged. One of our concerns is that Bell's life sciences strategy does not really connect with these other sectors. We are not saying that the Bell strategy is wrong in itself, but we would like to see much more cross-sectoral connection that captures some of this opportunity.

- Q112 **Lord Fox:** You focused on the benefits to health, well-being or whatever of what you are doing. An industrial strategy looks at the financial and commercial opportunity. Without downscaling those benefits, can we focus on those a little? Can you comment on the scale of the opportunity for the United Kingdom to transition the science and these things into innovative business? Can you comment on whether the Bell approach makes it harder for the non-human health part of the bio-sector to realise

those opportunities, because it focuses all the attention away from what you are doing to somewhere else? What is the scale of the opportunity, and does Bell make that harder because of the change in focus?

Dr Hughes: Agricultural in the 10-to-20-year time horizon is likely to be considerably different from what it is today. The pace of change and the introduction of new technologies are making a big impact. We can see that happening right now. The question is: does the UK want to be part of that, or is the UK happy to sit back and reap the benefits that are being developed elsewhere?

Lord Fox: The question is, "Can it be?", not "Does it want to be?".

Dr David Hughes: It can if it wants to be. It requires investment in the right areas at the right time, of course. That is a strategic decision for the Government to make. If we do not do it, others will, but we are well placed to do that if we decide to act.

On the sectoral approach, my concern about setting up strong sectors in our industrial strategy and investing in those sectors is that, although that makes incremental benefits in those sectors more likely, it makes disruptive developments at the interface of those sectors much less likely because the focus will be much more internal.

Again, if the Government want to do that, that is fine, but there is an opportunity cost in strengthening the sectors at the expense of the interface between sectors, which is where much of the magic tends to happen in scientific innovation. There is a global convergence phenomenon whereby the blurring of scientific boundaries is increasing rather than decreasing the rates of innovation. In an increasingly convergent world, that would seem to be a bigger opportunity.

Baroness Neville-Jones: Following what you have just said, I want to ask a method question. The biomedical strategy has been written, but would you see an advantage, despite the delay, in having a similar adjunct strategy written for wider life sciences, with a wider definition of life sciences? Would that be a valuable thing to try to do, even if it comes later than Sir John Bell?

Professor Angela Karp: It would be an incredibly important thing to do, because otherwise we will miss this opportunity. Whether you call it an overarching life sciences strategy or a bio-economy strategy, which would bring all those sectors in, it is very important that we do not miss those interfaces.

To come back to the question, SMEs are changing farming today, in addition to the impact of companies such as Syngenta. There is a lot of movement in this space. What is missing is more translational science to make sure that science and innovation is really pushed out into the places that will pick it up, scale it up and use it in practice. That is what will get us there.

Baroness Neville-Jones: Do you all agree?

Professor Jonathan Elliott: We do.

Dr David Hughes: Definitely.

The Chairman: That was a good question. You would much rather have a separate strategy than become a small part of a bigger strategy.

Baroness Neville-Jones: That is the way it has fallen out, is it not?

Q113 **Lord Maxton:** My question has been answered to some extent by you, Professor Karp, when you talked about further technologies. The fact is, of course, that even "life sciences" is arguably not the correct term, because you are using a lot of technology that is not a life science in the work that you do. Is that true, and to what extent do you therefore use computers and technology as part of your work?

Professor Angela Karp: That is massively important. Sometimes people feel that they cannot see growth in jobs, for example, in the farming sector, but one has to realise that there is a growth of jobs but they are just different types of jobs. We are creating huge amounts of data. This data needs to be analysed, integrated and sent back to inform decisions on the farm. That is a whole new area that is working. For this we need robotics, sensors, and devices, and it is the same in the veterinary area. We need all these devices to collect the data, and we need integrational computational sciences to synthesise and assimilate it and make informed decisions. This space is moving very fast at the moment.

Q114 **Lord Oxburgh:** It was part of John Bell's objective to make the UK the best place in the world to invest in life sciences, effectively attracting investment here. You have partly answered this question, but to what extent do you think that aim has been achieved? What more needs to be done to change that around as far as your sector is concerned? Again, you have perhaps touched on that previously.

Dr David Hughes: His report may very well go a long way to making it the best place in the world to invest in biomedical sciences, because that is the focus of the report. It does not speak at all about agricultural sciences, animal health sciences or industrial biotechnology. Even synthetic biology gets barely a mention, even though that was one of the eight great technologies in the previous strategy. As far as it goes, it is good, but it misses huge chunks of life sciences. If you truly want to have a holistic life sciences strategy, there are big gaps.

Lord Oxburgh: To pursue that, what would need to be done to attract foreign or domestic investment to this sector? This is what this question is about.

Professor Angela Karp: We need to re-examine our innovation model and move away from a linear model of innovation, which initially focuses on excellent knowledge and science, and have a much more dynamic innovation model where engagement with users and partners takes place much earlier and is leaner and more agile. At the same time, we need to develop a nurturing structure. We need clear mechanisms. We need mentorship and training for all those involved in the new system in order to create an attractive place for companies to come. We need to make

the regulations simpler. Our mechanism is very bureaucratic at the moment.

Lord Oxburgh: How would you change the present system to achieve that?

Professor Angela Karp: I would propose that in addition to the normal research model system, which is of course excellent in the UK—we just heard about the excellence of our science—we consider having innovation hubs, where we couple to that excellent research base (physical) areas where there is much more dynamic research innovation going on, which will attract companies in and allow you to do shorter high-risk projects that are supported by the environment, where there are investors in that space and where much more agile thinking is allowed to take place. It is not about replacing the system that we have but about thinking about adding a much more dynamic ecosystem to that system that would attract companies to invest in us.

Professor Jonathan Elliott: I agree with what has been said. With the animal health research that I have been talking about, there is a lot of interface with human medicine. If we approach it just from the medical side, we are missing a trick from the animal welfare side and in the productivity aspects of producing good, nutritious food, which is essentially what the agricultural industry is all about.

Lord Oxburgh: Looking at your CV, I concluded that animal livers and kidneys work in much the same way as humans’.

Professor Jonathan Elliott: Yes. We can lead on the companion animal veterinary health side, and we certainly do that. The companion animal and equine industries themselves are worth a lot of money to the UK. Making the most of that research to benefit human kind as well is about asking where the comparisons are. What can we learn from medicine, and what can we give to human medicine from the problems we are looking at and trying to solve in veterinary medicine, with the partnerships we have with the animal health industry?

Dr David Hughes: We can be a little hard on ourselves here in the UK. Bearing in mind that I represent a multinational organisation on developing collaborative research programmes, we can work right around the world with anyone, and indeed we do. At the moment we have over 500 R&D collaborations with external partners globally, but over 30% of those are in the UK. It is by far the single most important country for collaborative research. The United States is number two, at about 25%. China is around about 15%, at number three. From our point of view, the numbers would suggest that the UK is already one of the best places in the world to do collaborative research in agricultural technologies. Maybe we should not be quite so hard on ourselves. The situation is actually reasonably good.

Q115 **Baroness Morgan of Huyton:** My question follows on from something that Dr Hughes said, which I was very struck by. You have all said it to an extent. You talked about the best innovations being at the boundaries. I wonder whether there are any lessons for us in relation to future

research strategy. In a previous report we looked at the establishment of UKRI, and the argument for that was all about it enabling us to have research across the boundaries better. Just listening to you, is it fair to say that the way the life sciences strategy is currently laid out it has rather missed the opportunity to cross the boundaries? Are there lessons in that for the future research strategy for the new organisation?

Dr David Hughes: I think so. That comes back to my point about convergence. This is happening, it has already happened, and people are reaping the opportunities of blurring the boundaries between different traditional scientific disciplines. Biology has been a case in point. How many different types of biology are there? There are hundreds, if you put it into Wikipedia. Creating artificial silos that form the foundation of a strategy is counter to that megatrend.

Professor Jonathan Elliott: I can give you an example from animal science. We are very interested in what constrains how animals move: the size of them and the speed with which they move. We study that in a computer modelling system and get real data from live animals moving freely. That is of interest to companies that are interested in designing robots, so bio-inspired robotics. We work quite closely with those companies, particularly on animal flight and the sensing mechanisms that insects have to control their flight and how that feedback system works. That is incredibly interesting to the aerospace industry.

Professor Angela Karp: At Rothamsted, we are considering soil. We need a theory of everything for soils. The connections that take place in soils are more complex than those that take place in our brains, which means that by learning from how they are studying brains we can learn how to study some of the connections that take place in soils. It is those sorts of gaps that we can close and where we can be even more at the front of our science, because we have such excellence science in all these areas.

Q116 **Lord Griffiths of Fforestfach:** Professor Karp, you said that, on the question of a framework for innovation, at present there is too much emphasis on a linear framework, which ultimately I took as rather static. You contrasted that with a dynamic framework. Could you expand a little on that? Am I right in thinking that in academic terms the dynamic approach is much more applied, with much less emphasis on fundamental research or not?

Professor Angela Karp: No, that is not what I meant. In a linear model there is a lot of focus on making sure that the knowledge is right and on building that knowledge. When you are sure it is right, you share it and see whether people have applications of it. In a dynamic model, you share that knowledge much earlier to check the relevance of the science and to check much earlier on that your assumptions about its usefulness are correct. By doing that, you can refocus your efforts and improve what you are building in your research. That is an example of a dynamic model.

It is the basis of how lean approaches are used in start-ups, for example. They share early, they build again, they focus again and re-build again. There is more reiterative sharing and engagement, rather than focusing on the knowledge and hoping that somebody else will come and translate it. We need much closer connections between our excellent science and innovation and the translation and scale-up of it going outwards. That is best done in dynamic models growing it all together. Does that explain the question better?

Q117 **Lord Griffiths of Fforestfach:** That is terrific. The next question is to do with the Government's response to Sir John Bell's report. If we take the shortcomings of that report—let us assume that it was not broad enough—if you simply look at biomedical sciences, what would be your evaluation of the Government's response? If you felt the Government could do more, what do you think that should be in practical terms?

Professor Angela Karp: What we really need is clarity about the mechanisms by which we are going to make this happen. The aspirations are good, but we need to understand what we are going to do that is going to incentivise this to take place. That includes making sure we have enough research and innovation and enough translation and are attractive to companies to come and work with us. A bit more attention needs to be paid to those mechanisms.

Lord Griffiths of Fforestfach: Is that mainly funding?

Professor Angela Karp: It is also about how we are going to do it. For example, if we are to set up innovation hubs or if we are to have such a model, what do we expect to see? What would success would like? What would a successful cluster look like? We need to look around, look at models that have worked elsewhere, see what would work well for Britain and explore those models. It is about the models and an investment that is comparable to our competitors. Our investment in the sector has gone down in the UK. We need to revitalise that.

Dr David Hughes: If the Government warmly welcome investment in science and technology, that is to be welcomed generally. The narrow focus of Sir John Bell's report is fine, and I can see a compelling case for decent return on investment in biomedical sciences. Some of the points that Sir John makes in his report are generic and are to be warmly supported, such as on incentivising industrial R&D in the UK and incentivising manufacturing and concerns about the movement of people—those sorts of things.

Some of the more interesting ideas, though, are very sector-specific. The HARP idea of a DARPA equivalent is particularly motivating and interesting from my point of view. What we are missing are relevant sector-specific ideas that could be operational in agriculture, for example. That would be very interesting. We have the Agri-food Technology Leadership Council, which I suggest may be charged with leading thinking in this particular area. That would be a good place to start.

Q118 **Lord Oxburgh:** Which, if any, of your organisations take responsibility

for the biomes of soils?

Professor Angela Karp: We do a huge amount of work on soils.

Lord Oxburgh: Is that your responsibility?

Professor Angela Karp: We are one of the organisations that are working on soils, for sure.

Lord Oxburgh: What about the other two?

Dr David Hughes: I am not sure about taking responsibility. We fully acknowledge the complexity of the plant-soil interface and the impacts that can have on plant health. My company is about intervening by somehow using the understanding of that interface to improve crop growth, health or whatever.

Lord Oxburgh: Should soils come into this? That is really my question.

Dr David Hughes: It is an emerging opportunity but it is massively complex, as Angela said.

On the question of whether there is that fundamental level of understanding in order to be able to devise intervention strategies that can make agriculture better, we are not quite there yet. I see it as a growth area in the future.

Professor Angela Karp: Absolutely. One of our programmes is on source to nutrition. I would like to make the Committee aware, if you are not already, that the composition and nutritional value of our crops has gone down. I am talking about our staple foods. When it comes to things like selenium and zinc, for example, the nutritional value has gone down. We see similar trends in fruit and vegetables. I come back to the fact that having healthy people starts with healthy food. We have to understand what is happening with our soils and what is happening when we cultivate things or graze animals on the top of them. We have to understand the chain that goes from soil to either crop or grazing land to animal or crop that we eat in order to improve what we are doing.

Lord Oxburgh: What do you mean by less healthy vegetables?

Professor Angela Karp: There is less nutritional value in what we are eating at the moment in terms of the elements in particular. They are still not quite clear why that is.

Baroness Neville-Jones: Is it because soils are being depleted?

Professor Angela Karp: Some soils are being depleted, but it is not always the soils. There is recent evidence that climate change, for example, is exasperating a drop-in selenium. There are many factors involved, but it needs more research.

The Chairman: When you go to a supermarket and buy most vegetables, they have a label on and they come from all over the world. Is it our soil or their soil?

Professor Angela Karp: It is an issue in the UK and globally.

The Chairman: How do we influence the soil in Kenya?

Professor Angela Karp: We have programmes now and new technologies. Again, we come back to innovations; we have innovative technologies that enable us to profile soils much more precisely, so that you can take samples of soils and see the whole elemental composition. This enables us to direct the fertilisation of those areas of soil. The soils in Africa are being studied in this way. You can say, “These soils are zinc-deficient. These soils are selenium-deficient. In these areas, we need to supplement what we are fertilising”. That is how we can intervene so that the people who are eating the food that comes off those soils have a better composition in the food they are eating.

Dr David Hughes: As an interesting aside, some soils are now becoming sulphur-depleted since we have solved the problem of acid rain. When we had acid rain, there was plenty of sulphur in the soil. Now it is more of a challenge.

Professor Jonathan Elliott: The quality of the soil is going to influence the animals that are grazing on the pasture and producing the milk and meat that we eat. Also, the environmental sciences aspects of things like antimicrobial resistance seem to be an area that is quite neglected. We are studying the interface between animal health and human health and food that we are eating, but not what we are putting into the environment from the animal production that is influencing the whole microbiome in soil and perpetuating the resistance genes in the bacteria that live there. Bringing all those sciences together is really important for solving those big issues.

Professor Angela Karp: Rothamsted is leading on the Africa Soil Information Service, which is funded by Bill and Melinda Gates. We are leading on that programme, which is looking at soils in Africa to understand and to profile.

Q119 **Lord Mair:** What are your views on urban farming, which we are now seeing in places like Shanghai, where getting produce from the countryside into very large megacities is very complicated? There are now buildings that are entirely designed for farming.

Dr David Hughes: It is a very interesting trend. There are two key questions. First, can it scale adequately to become significant? The second challenge is the amount of energy that those systems tend to use. They tend to be efficient in some respects—for example, water use and chemical use can sometimes be cycled into these kinds of systems—but they tend to use quite a lot of energy. There are pros and cons. It is an emerging, embryonic stage of technology. Quite where it will go in the future, I am not so sure.

Professor Angela Karp: I would echo that and add that it is a very important trend in understanding the importance of food, because when you have urban farming you reconnect people in the cities with food production. That is really, really important. One of the problems is people understanding the value of food and food production. Bringing it back into cities reconnects them with that, which is a social plus, in addition to what David has just said.

Q120 Baroness Neville-Jones: One of the things that has been emerging from the evidence that we have taken is the extreme importance of implementation. You can have all the strategies in the world, but if you do not get really good implementation they are not worth a great deal. Let us take the hypothesis that you are involved in strategic implementation. How would you want to see implementation of this strategy set about and started? Where do you think the key accountabilities would lie? It would be good to hear from all of you on that.

Dr David Hughes: I find that question quite difficult to answer, because most of what is being proposed is not specific to our sector.

Baroness Neville-Jones: I am asking you to include the hypothesis that you would be involved.

The Chairman: In any strategy, what would be important for implementation and who would be accountable?

Dr David Hughes: It really rather depends on exactly what is being proposed. I find it quite difficult to get my head around this as a hypothetical question. There are some measures in which it seems the Government would have to take the lead, such as increasing levels of investment and tax incentives for R&D, all these sorts of things, which are policy tools that you hope will nudge business and industry into the sorts of behaviours you wish them to exhibit.

For the more specific tools, such as the HARP idea, if there was some kind of equivalent in our sector, who would be involved in those? What role would industry play? I would like to think that we would engage and play some kind of role, but it all depends on the specifics of what is being proposed. I struggle with this question in a hypothetical sense, I must admit.

Professor Angela Karp: I come back to the point that science changes societies by excellent science being coupled with excellent translational pathways. That has to be fundamental at the top. If you have that at the top, you can then say, "What are our priorities?" That does not mean, "What are our sectors?" but "What are the challenges that we really want to go for, that we want Britain to be competitive in?" Against those priorities, what are the key mechanisms that we need to work? I talked about some of those in the innovation space. What are the key things that need to happen to do that?

Baroness Neville-Jones: Can you identify some of those?

Professor Angela Karp: Yes, for example thinking about building clusters where you have critical mass and an environment around you to do excellent science but where there are also companies and investors around you so that you can pick up that science, translate it and co-develop it, working a lot more with companies and engaging closely with them. That would be one example. Clusters is one example. It is not the only solution.

The other things are the investment that is going to mobilise that to happen, and training and mentorship. I do not just mean skilling up the next generation of scientists through students. We need to make sure that our post-graduates, researchers and companies have access to business, mentorship and enterprise training in order to be able to move that science faster down that pathway. There needs to be an environment that nurtures the right kind of ecosystem.

Baroness Neville-Jones: Many more centres for doctoral training. Is that the kind of thing you mean?

Professor Angela Karp: Yes, that would be one, but we also need to have training that enables SMEs and start-ups to get going. Many start-ups fail because they do not know how to build business plans. We need to provide that good environment.

The last thing is cross-sectoral linkages. After all, we are not a massive continent. We connect well. Britain does really well in its science when we have these cross-disciplinary initiatives. We can exploit that.

Professor Jonathan Elliott: I do not have much more to add to that. The idea of bringing people together within these strategic hubs that are from different areas of the life science sector, particularly in animal health, plant health and microbes, together with human health, would be very effective.

Q121 **The Chairman:** We have heard before that UK science is good. The UK is regarded as one of the top places to be a biomedical scientist, but we are poor in biomedical sciences—we are not as good at innovation as Germany, the United States and Japan, for example, and are even worse in taking innovation to commercialisation. How does that relate to the agrisciences and animal sciences sectors? Are you better, worse or the same?

Professor Angela Karp: We might be slightly better, but there is a missing bit in the middle, which is the translational piece. We have an excellent science base and we have innovations that make it to industry, but there is a big gap in the middle that needs to be filled. That is my view. Do you agree?

Dr David Hughes: Yes. It is quite a dynamic landscape. We have certain technology sectors, such as crop protection chemistry and biotechnology in seeds, that are highly regulated. That means that only the big corporations can afford to play in those areas. There are some technology innovations that are coming through that involve, say, digital sciences and that are essentially unregulated, which means that small companies can innovate in that space and get things to the market quickly. We are seeing a thriving venture capital funded emerging environment there. The UK does pretty well there, compared to places such as France and Germany. It is not the same as the United States, of course, or China. These are culturally different places. Going back to what I said earlier, we should not beat ourselves up too badly here. It seems to be functioning. There is always more you can do, but the situation really is not that bad.

Lord Vallance of Tummel: If I can come back to the gap in the middle, some of what you have been talking about is structural and organisational. It is a gearbox that perhaps does not exist. There might also be a cultural and motivational aspect coming to all this. If you are looking at a strategy, you are looking at its economic impact, and the focus needs to be on its economic impact. If you are a scientist, your focus may very well not be economic impact at all. In fact, you are motivated by how many reviews you get in journals and this, that and the other. Equally, on the finance side of the business, our finance culture is very short-termist. That is the nature of the beast. It seems to me that if you are going to get the gap in the middle right, a culture change needs to come about. Am I making any sense?

Professor Angela Karp: You are absolutely right.

Professor Jonathan Elliott: The culture change has started and is being driven by the impact aspect of the REF and by the way in which research councils have changed their emphasis and want to see pathways to impact and impact summaries in applications. Many of our academics are driven by wanting to make a difference—to the practice, to animal health and to people's lives in developing countries. Part of that is that they want to make an economic difference to the UK, but they find it hard to get from that basic science discovery to its translation, to get the funding to do that and get the companies that are interested in investing.

Lord Vallance of Tummel: And to get the motivation.

Professor Jonathan Elliott: They are motivated to do that because they would like to make a difference. They would like to see their science make a difference.

Lord Vallance of Tummel: An industrial strategy is to do with economic difference. You are using changing lifestyles and so on as examples, which is great stuff, but it is the economic endgame that I am interested in, and how you get the culture so that the science base is interested in producing an economic output.

Professor Angela Karp: I agree with John, but there are two missing pieces there. Again, I come back to mentorship in business and entrepreneurial thinking. That needs to be ingrained a bit. On top of that, we need to have incentives and rewards for scientists who have an economic impact. Although impact is recognised in the excellence framework, we need to have special incentives for people who are moving in that direction in order to encourage that. They are there ready to go, but it is harder for them, if they take that route, to get promoted through our normal system. We need to have incentives that recognise that and that people want to do.

Dr David Hughes: This push towards impact has made a noticeable difference. Academics and scientists in the UK science base seem to be very willing to talk to us now, whereas in the past the industrial application of the science that they were developing was not so interesting and they would rather develop something new. It has made a difference. Compare that to engagement with university professors

elsewhere in the world where that can still be a significant issue. In the UK, the situation is much better.

Q122 Baroness Neville-Jones: My question follows on from what you have just been saying. One of the things that preoccupies the Government is what they have chosen to call place: that is, the uneven distribution of science and technology capability in the country and therefore future wealth creation. Do you see an opportunity, in the particular sciences you are involved in, of more clusters and centres not sacrificing excellence but being able to combine excellence with new scientific and economic activity, partly because of the nature of the sciences that you are dealing with? They seem to me to have a stronger link with rural areas and parts of the country that are not necessarily associated with big activity. Is there an opportunity there for benefitting not only science and technology but the communities in which you sit, more broadly than the existing centres of excellence?

Professor Angela Karp: There is a huge opportunity, because for many areas that are rural-based the farming industry is key. The sectors that we are talking about, such as digital, are interfacing with those rural areas. That is a way of bringing technology and innovation into those places. We are quite different in many parts of the UK, so to recognise those differences and regional challenges would be very important to creating the right kinds of innovations that will elevate the economies of those specific regions. We cannot have a one-fix-all, because we are in the UK. We need to think about challenges that are specific for specific areas, and help to grow the economies through those opportunities there.

Baroness Neville-Jones: Is there anything to be done in the pipeline of how science and technology is funded in this country, which is largely, though not exclusively, through the research councils, which at the moment is not being done?

Professor Angela Karp: We have opportunities for regional funding, for example through the ERDF and working with the local enterprise partnership, but you need to have a strong will to manage the ERDF. It is a very long process to get those funds. Local enterprise partnerships are hugely helpful in supporting scientists like us in even trying for that sort of fund.

Baroness Neville-Jones: They would naturally become more important after Brexit.

Professor Angela Karp: They could be much more important. The process needs to be much simpler, because companies lose interest when you start talking about something that takes 19 months to prepare.

Q123 Lord Fox: I have the inevitable Brexit question about what the challenges and opportunities are.

Dr David Hughes: Yes, there are. The free movement of people and qualified people is important for maintaining diversity in our science base and our companies to avoid the formation of monocultures, for want of a better word. Diverse teams are more effective than single teams. Support

for the science base is also important, although the Government's injection of cash there is very welcome. We have to recognise, though, that we still may end up being excluded from some of the big mega projects in Europe, such as the Human Brain Project and quantum technologies project, which are simply too big for single nation states to support by themselves. It could be that our scientists no longer get invited to those kinds of parties. Support for British farmers is going to be crucial for us, as will indications of how willing they are to spend money on new technologies. How that ends up is quite important up.

The final point is about how these technologies are regulated in the market. That will also be very important for us.

Lord Fox: Looking in particular at you and GMO issues, we have heard evidence in previous inquiries that the European Union handled GMO in an entirely sclerotic way because political decisions overtook science ones. Do you see any opportunity post Brexit, assuming there is one, to benefit from that?

Dr David Hughes: Yes, but it all depends on how the UK Government decide to regulate that technology. What Michael Gove said over the weekend signalled, if anything, an intensification in the regulatory environment for agriculture. This is going out to consultation, and we will certainly engage with that wholeheartedly, but it all depends.

Q124 **Lord Griffiths of Fforestfach:** Syngenta is a very well-known, large international company at the cutting edge of science and research that is based in Switzerland, which is not a member of the European Union. To what extent do you feel that not being a member of the European Union is a handicap?

Dr David Hughes: Not at all. We have operations in many countries around the world. The fact that we are headquartered in Switzerland is largely irrelevant. You probably know that we were taken over by a new Chinese chemical corporation in the summer. That seems to make little difference either. Operations still continue as they were before. It is not particularly relevant.

Q125 **Baroness Neville-Jones:** I heard rather different evidence from one of your other colleagues in a different inquiry about the access to European funding. Perhaps you consider that to be at the margin of Syngenta's activities.

Dr David Hughes: Do you mean things like Horizon 2020?

Baroness Neville-Jones: Yes.

Dr David Hughes: The rules for engagement in Horizon 2020 all depend on where you are doing your operations. Because we have R&D sites in European countries, our view is that we would still probably be eligible if we based the scientific activities in those R&D sites. However, we have never really leveraged Horizon 2020. It is not a great funding mechanism for several reasons. The IP requirements are beyond where our red lines would be in terms of exploiting the output for those sorts of projects. The

red tape associated with getting funding from Horizon 2020 is not worth the hassle. There are better funding mechanisms from the research councils, for example. We have never really made that much use of Horizon 2020 as a funding tool.

The Chairman: In terms of commercialisation, who are your big competitors?

Dr David Hughes: This time last year there were six big companies in the space: Syngenta, Bayer and BASF in Europe, and Dow, DuPont and Monsanto in the United States. Dow and DuPont are merging. Bayer are taking over Monsanto and Syngenta has been taken over by ChemChina. BASF are picking up some of the assets from the Monsanto-Bayer merger. We are going to go from a big six to a mega four, probably by this time next year.

The Chairman: There is no UK-based company.

Dr David Hughes: No, though as I mentioned we can trace our heritage back to Zeneca/ICI. We are no longer based in the UK but we have many assets here.

Baroness Neville-Jones: What is the likely effect of oligopoly? We are getting very near that.

Dr David Hughes: It is too early to say. It is all happening right now.

Professor Angela Karp: One simple thing from our perspective is that for many of these projects—bearing in mind that Innovate UK and other means that we have of working with companies require match funding of some sort—the number of partners we can go to is quite small. That is a limitation for us.

Baroness Neville-Jones: Is that because there is nothing much between the very big and the really quite small?

Professor Angela Karp: It is partly that, but it is also because those in between often do not have much cash to invest, which comes back to the point about giving them more flexibility, looking at the mechanisms and being more flexible in how those co-operations take place. Very small companies struggle to find the cash to match a big research innovation project. That needs a bit of examining.

Professor Jonathan Elliott: The same is true of the animal health pharma companies.

Q126 **Baroness Morgan of Huyton:** You have been really clear and, interestingly, largely in the same place. Could you summarise, if you were to give one recommendation for us to put in our report to the relevant Ministers, what it would be? You have given us very clear responses, but you have given us quite a lot. What would be top of your list?

Professor Angela Karp: If it is about economic growth, we need to have excellence science coupled with excellent translational pathways. We need to make sure that that connection is there and that it is

cross-sectoral. We should not try to prescribe where the innovations may be.

Dr David Hughes: The agrifood sector is the UK's biggest single manufacturing sector, I believe. It is a little strange that it does not get a mention in either the life science strategy or the Green Paper.

Baroness Neville-Jones: Therefore put it in?

Dr David Hughes: Yes. There should a strategic emphasis based on the arguments made in Sir John Beddington's report. As I said before, they are very strong.

The Chairman: Earlier on, you commented to Baroness Neville-Jones question, which I thought was good, that what is required is a separate strategy that addresses agri and animal science, and that identifies the strengths and weaknesses that could be developed into an effective industrial strategy for other life sciences.

Professor Angela Karp: That would be an excellent recommendation that we would all be behind.

Professor Jonathan Elliott: We should make use of our excellent biomedical sciences, our basic bioscience, for the benefit of agriculture and animal health research.

Lord Oxburgh: Does Innovate UK appear on any of your horizons?

Dr David Hughes: Yes. We certainly work with Innovate UK.

Professor Angela Karp: Yes, we work with Innovate UK.

The Chairman: That is good. Thank you very much indeed. It has been challenging, but we needed to explore all the nuances with you. Thank you very much for coming today.