HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: Graphene, HC 159

Tuesday 13 September 2016

Ordered by the House of Commons to be published on 13 September 2016.

Watch the meeting

Members present: Dr Tania Mathias (Chair); Victoria Borwick; Chris Green; Carol Monaghan; Matt Warman

Questions 112-161

Witnesses

I: Baroness Neville-Rolfe DBE CMG, Minister for Energy and Intellectual Property, Department for Business, Energy and Industrial Strategy, Dr Sharon Ellis, Director, Business Innovation, Department for Business, Energy and Industrial Strategy, and Paul Mason, Director of Emerging and Enabling Technologies, Innovate UK.

Written evidence from witnesses:

- Department for Business, Innovation and Skills
- Innovate UK

Examination of witnesses

Baroness Neville-Rolfe DBE CMG, Dr Sharon Ellis and Paul Mason.

Q112 **Chair:** Welcome to the Science and Technology Committee hearing about the commercialisation of graphene. Might I ask you to introduce yourselves and your expertise relating to the topic of commercialisation of graphene, in under a minute, starting with Mr Mason?

Paul Mason: Good afternoon, everyone. My name is Paul Mason. I am the director of emerging and enabling technologies at Innovate UK. Innovate UK is the UK innovation agency. We help companies to develop new i-products and services. I am responsible for early-stage programmes and cross-cutting technology programmes. Graphene is within the remit of the programmes we fund that I am responsible for.

Baroness Neville-Rolfe: I am Lucy Neville-Rolfe, the Minister for Intellectual Property at the new Department for Business, Energy and Industrial Policy. The Science and Universities Minister, as you probably know, is taking the Higher Education and Research Bill through Parliament, but I know you are keen to progress the inquiry. We have obviously applied a lot of funding—£120 million—for research and innovation in graphene, which we are looking forward to talking to you about. It is early days but we are beginning to see applications and products coming through—some exciting products. We also have a world-leading intellectual property system in the UK, which is a strong driver for innovation, as can be seen from the global innovation index.

Dr Ellis: I am Sharon Ellis, a director at the Department for Business, Energy and Industrial Strategy. My responsibilities cover business innovation, and thus sponsorship of Innovate UK, our delivery body, which is here today. I also have experience of science funding, and EPSRC—the Engineering and Physical Sciences Research Council—has been a very key funder of research into graphene. I am here to answer questions around science funding and science policy.

Q113 **Chair:** Thank you. I hope we will get all the information we need, but if there is something afterwards, I hope you will be generous with written requests from the Committee. Baroness Neville-Rolfe, could you tell us what the main driver was behind the Government's decision to invest in the National Graphene Institute and the Graphene Engineering Innovation Centre, and why money went to them rather than other research areas?

Baroness Neville-Rolfe: I am sure you all know that we try to invest in excellent research, to build opportunity and capacity in academic and business collaboration, to commercialise research and to raise awareness. Graphene is a brilliant British breakthrough. It is also a disruptive technology, so we saw the need to invest in both research and institutes to bring the research and in-product development and demonstration. That is the driver behind the £120 million in graphene. I could take you through the key areas, if you would find it helpful. Would that be helpful?

Chair: Please do.

Baroness Neville-Rolfe: You mentioned the National Graphene Institute at Manchester. That was £38 million to harness world-leading R and D, which would be from technological readiness levels 1 to 5. Then there is a complementary £20 million on the Graphene Engineering Innovation Centre, which will not open until 2018, but that will help to commercialise in levels 3 to 6, leveraging £40 million funding, because collaboration is important, through the research partnership investment fund. You mentioned the other things, but it is important that we also mention £15 million at the graphene application centre in Sedgefield, part of the Centre for Process Innovation, which I had the pleasure of visiting recently. Then we have money for doctoral training, and around £33 million for competitions in graphene R and D supported by EPSRC, in turn, co-funding joint feasibility studies with Innovate UK.

Q114 **Chair:** What was the EP?

Baroness Neville-Rolfe: EPSRC.

Dr Ellis: It is the Engineering and Physical Sciences Research Council.

Baroness Neville-Rolfe: I thought it was helpful to bring these things together because you might ask what we are doing in all these areas. To complete the picture, we have the National Physical Laboratory, which is also important, because it is making measurements and setting standards. It is part of an EU joint endeavour on graphene.

Q115 **Chair:** You are giving to the NPL—the National Physical Laboratory.

Baroness Neville-Rolfe: The National Physical Laboratory is principally funded through Horizon 2020—

Dr Ellis: There is an element.

Baroness Neville-Rolfe: The graphene work.

Dr Ellis: The standards work that the NPL is doing in relation to graphene is funded as part of an EU flagship programme.

Q116 **Chair:** Will that carry on?

Baroness Neville-Rolfe: Thanks to Philip Hammond's timely announcement, we have a little more security than when you started your deliberations.

Q117 **Chair:** Are there any terms or conditions on the investment for the National Graphene Institute and the innovation centre?

Baroness Neville-Rolfe: You probably know the system in universities better than I do. The research contracts are set up on the basis of business cases.

Q118 **Chair:** Those are the only terms and conditions.

Baroness Neville-Rolfe: They would be, yes. They are proposals, the sort of standard contract terms and conditions. There is not a special arrangement. On the research side you have to have research outputs, publications, those kind of things—

Chair: Standard.

Baroness Neville-Rolfe: Standard things. On the GEIC side, which is starting in 2018, we will do more of the sort of monitoring that we like in the Catapult area, where you get quite detailed monitoring coming in, at least quarterly, sometimes monthly, explaining what they are doing on projects and how they are moving forward. I am not sure whether that answers your question, madam Chairman.

Q119 **Chair:** Yes. What are the Government doing to encourage investment from the private sector?

Baroness Neville-Rolfe: There is quite a substantial amount of private sector involvement.

Q120 **Chair:** Are the Government doing anything to try to encourage it?

Baroness Neville-Rolfe: The institutes encourage it, and we are encouraging it because our model of research and development is to be collaborative. In the institutes, £61 million of investment has levered 69 partners, and 85% of the projects are working with 28 SMEs, 20 of which have a UK manufacturing base. That is the institutes. We have also invested in other universities—Cambridge, for example. Innovate UK has done a lot of work raising awareness among businesses of the opportunities of graphene, and in awareness-raising of the technology we have also tried to demonstrate the feasibility of using the product. We were discussing that this morning: 35 graphene projects covering aerospace, automotive, energy, batteries and electronics.

Q121 **Chair:** You are bringing in the private sector.

Baroness Neville-Rolfe: We are bringing in the private sector in these joint ventures, which is very much what Innovate UK is about, and which our new industrial strategy I hope will pick up. Of course, graphene is a bit like some of the other areas I deal with—intellectual property and energy; it very much has cross-cutting potential, so we will try to move it into lots of different areas.

Q122 **Chair:** Absolutely. Thank you. There was a report about BGT Materials and the relationship with the University of Manchester. Were the Government concerned by the role of BGT and did the Government intervene at all in the controversy?

Dr Ellis: In terms of the engagement Manchester had with the company BGTM—the UK-based, Taiwanese-owned company—we saw that very much as part of what our universities do. They are open to collaborate. They use their excellent research to work with people who are interested in working with them—

Q123 **Chair:** The Government were not concerned by that relationship.

Dr Ellis: It is quite natural for universities to collaborate with a wide range of—

Q124 **Chair:** We understand that, but on this specific case were you at all concerned?

Dr Ellis: We certainly had conversations with Manchester to understand the—

Q125 **Chair:** So you were concerned.

Dr Ellis: We weren't concerned. Because we have invested—

Q126 **Chair:** What kind of conversations were you having?

Dr Ellis: We invested in Manchester as part of the National Graphene Institute, and our delivery body, which is the Engineering and Physical Sciences Research Council, had regular engagements to check how the project was going. The conversations were along the lines of how things were going, what occupancy at the institute was like and, as part of those conversations, clearly they talked about the businesses that they were working with. We did not have any concerns on the back of those conversations. It was felt to be part of the natural progression of a technology, and working with companies who are interested in working with UK universities and businesses.

Q127 **Chair:** You were not involved with the newspaper story and trying to intervene on that.

Dr Ellis: I certainly was not involved in that and I am not aware of Government involvement.

Q128 **Chair:** Were the Government involved at all in trying to intervene there?

Baroness Neville-Rolfe: Not that I am aware of, but I cannot answer for every press inquiry. What I would say is that the international attractiveness of UK research is one of our real strengths. It brings big opportunities to leverage overseas investment—

Chair: Sure, yes.

Baroness Neville-Rolfe: And exchange of knowledge. The actual graphene discovery was by two Russian scientists working at Manchester. What you need to do—

Q129 **Chair:** We have had submissions from them.

Baroness Neville-Rolfe: I have read some of the evidence that they gave, and they felt comfortable and I am comfortable about it.

Q130 **Chair:** The Committee has been lucky to interview them as well, but we wanted the Government angle, and that is fine. I have a clear answer.

Q131 **Chris Green:** Mr Mason, from our previous session in April, it appears

that the relationship between academia and industry innovators has not fully matured. What can be done to improve relationships between universities and businesses in commercialising graphene research?

Paul Mason: It is in a typical place for an early stage technology. When something is just emerging from the science base, many companies will not know what it is. They will not know how they can use it in their own particular end uses and applications, so one of the things you have to do is raise awareness of the opportunity and then help companies to explore the particular properties that a thing might have—in this case graphene, but it could be quantum technologies or machine learning, or lots of different things—in their own application and market areas. In the early stages, when companies are trying to work out which properties they care about, which centres of excellence are the places they should really go for a particular end-use application, how it will change their supply chain and which other companies they need to collaborate with, the relationships between companies and universities, in particular, are inevitably going to be embryonic rather than deep, rich and embedded in the way they might be in the case of a more mature technology.

Q132 **Chris Green:** Has anything in particular been done, or is it just a natural, growing process?

Paul Mason: It is typical of an early-stage technology and we see it in lots of things. It is probably slightly similar to the case in quantum technologies at the moment, for example. I do not think there is anything to be alarmed about. We see our role as helping companies and universities to overcome the inevitable barriers when you do not know what you do not know. One of the things we have done in the area of graphene is to start a special interest group, which is a way of raising the profile, putting on events, getting think pieces together and creating the opportunity for people to meet who might have expertise on the science side or expertise on the use side. That now has over 350 members and we have run lots of collaboration building workshops, where companies come together with academics. Companies say what they care about, academics might say what expertise they have and then we fund it jointly with EPSRC. As Baroness Neville-Rolfe was saying, there are some 35 or 40 projects to help companies take the early steps in working out what the technology can do for them. The relationships are at an early stage, but putting aside the slight adverse press coverage earlier in the year, if you were to talk to Haydale, Thomas Swan or Sharp Labs, or any one of a number of 30 companies, some of whom are collaborating with the universities, which might be Cambridge, Manchester, Nottingham Trent, Warwick, Bath or Queen Mary, they would say that they are working together on how to unpack the opportunities.[1]

There is a particular challenge, if I may make this point, on the question of graphene, in that graphene is not graphene is not graphene.

[1] The witness later clarified that, the other Universities involved are Bradford, Sheffield, Strathclyde, Surrey and UCL.

Depending on how you make it and characterise it, it is very different. That means that when you try to use it, you get quite different effects. If you are running a business and you want to sell a product, you have to know that it will behave the same day after day and batch after batch, so that you can warranty the performance and you know what your costs will be, so that you can control your costs and know what your price will be. You have to work out how that works out through the supply chain. One particular problem with graphene has been characterising it so that you know that one source is the same as another, and that has been a challenge. This is the reason why the National Physical Laboratory has been so important—the point that was made earlier. There has been really good progress made in the last two or three years in the UK with EPSRC and ourselves, but the work was primarily done at NPL to take that forward. It is a slightly long answer, but—

Chair: I have to declare that the National Physical Laboratory is in my constituency. I didn't plant any of that.

Paul Mason: They are extremely good. I saw some of their progress recently.

Q133 **Chris Green:** So the previous criticisms of the University of Manchester not being able to support businesses' commercialisation proposals are in part early-stage problems that are being overcome. Is there any particular support or advice that has been given to the University of Manchester or other universities, anything in particular that has been done?

Paul Mason: Not by us. I am not sure that we would see it as our place to advise people on how they should behave. They are independent bodies and they know more about graphene than we do, certainly about the science. Our job is to broker relationships, to introduce the right academics to the right companies and raise with companies the excitement and the opportunity that comes from new technologies. Where it is difficult to justify the costs, because it is quite expensive to do this work and you are not quite sure there is something in it for you, do you really want to spend your money on it? That is quite an important thing that the public sector can do when it thinks there is a significant opportunity. Other countries around the world are doing exactly that, so it is about making sure that the UK capitalises on its great discovery.

Q134 **Chris Green:** Surely—perhaps Dr Ellis and the Minister may want to comment—with the Government now having an industrial strategy, we should be picking winners, shouldn't we?

Baroness Neville-Rolfe: I would put the question the other way round: what can we do to support the universities to gather and exploit the commercial opportunity? I have three or four thoughts that I think may be helpful to the Committee. Of course we are thinking about just this in the industrial strategy, so in a sense your discussions and the ones you are going to have more broadly in your next inquiry will be extremely

helpful. I should perhaps declare an interest, because I come from business, but quite a long time ago.

I think companies are critical, because they are going to have to develop the individual products or the individual services and register the IP. That is one reason why we have worked with the universities and business to develop a tool called the Lambert toolkit, which is a set of specimen agreements that allow university and business to move forward on collaborative R and D projects, and that helps the tech-transfer teams, which you will see in a number of universities, engaged in trying to move things across. That is important.

Q135 **Chris Green:** Often, large companies are quite cautious about investing in a novel technology, especially if there are all kinds of consistency concerns, as you were discussing before, and it is really unknown, with no commercial products out there at the moment. How do you incentivise large companies to invest and commercialise?

Baroness Neville-Rolfe: R and D and innovation is a key part of many of our most successful companies, and of course companies abroad as well. IP and innovation can be a very significant part of the value of a company, so they have an incentive. What we, the Government, can do is set the right framework, which is one of the reasons why we have set up nine, now 10, Catapults, to help with the valley of death between research and innovation. We are supporting interactions through knowledge transfer partnerships and Catalyst funds, as well as some enterprise zones, higher education innovation funding, impact acceleration accounts and incubators and science parks. There is the Innovate UK work, which you have already had an introduction to, and we have explained how in graphene in particular it has produced 35 innovative projects. The University of Manchester, where we started, has attracted external income, including the BGTM income that you mentioned, and elsewhere. It has already spun out two companies—Graphene Lighting and 2-DTech—so it is quite an interesting case study, and one that I am sure we will be looking at as we work up the industrial strategy. I would be at pains to add that it is one example and that we have first-class universities in the UK and a determination by this Government to see how that can be reflected in development, good products and sales around the world, because innovation is absolutely key to growth.

Q136 **Chair:** May I go back to what the Government want in return for their investment in the graphene institute?

Dr Ellis: In terms of the value we take from investment in R and D in particular—

Q137 **Chair:** What measurables are there for the money invested? Are there any?

Dr Ellis: The money invested for the National Graphene Institute was for capital investments, so the value is in the creation of the building and the

kit that enables researchers to collaborate with business. The measure is there.

Q138 **Chair:** There is no output—nothing measurable.

Dr Ellis: Not a tangible output, beyond the building, the kit and the environment for the people. The broader framework for how we value R and D outputs—

Q139 **Chair:** It is more on the graphene R and D. That is what we are interested in.

Dr Ellis: In the original business case for the investment in the National Graphene Institute, there were some measurable outcomes in terms of a small number of collaborations with business. There were a small number of expectations that there would be new knowledge generated, and I think from our evidence in terms of numbers of businesses that they are collaborating with, people wanting to come and invest and joint patents that have been put together between Manchester and BGTM, those were the sorts of things that were suggested in the business case. They are a relatively small number, but those are the things that we are seeing coming from that original investment.

Paul Mason: In terms of the outputs from an economic point of view, we have supported 7,600 companies since our inauguration, and that has added about £13 billion to GVA and created 35,000 new jobs—

Q140 **Chris Green:** Innovate UK?

Paul Mason: Innovate UK overall in all parts of the economy. With very early-stage technologies, you do not know which are going to be the ones that grow into the huge thing. Google came out of a Stanford patent 20 years ago. At some point things grow really large, and if something gets you a Nobel prize, it is pretty significant. We do not yet know which of the various things that we invest in, one of which is graphene, will be the things that really turn big results. You cannot necessarily map an investment choice in an early-stage technology to a guaranteed return, but if you invest in enough of them, you know some of them will win.

Q141 **Chris Green:** What you are saying is bigger than graphene. You invest in a whole range of areas and graphene is one of them. Graphene may not turn out very well, but those other areas might, and that is where the returns on the investment will be. But it might well be graphene.

Paul Mason: It could easily be graphene. It might be 15 years before you really see it, and it is quite likely to be in something you did not necessarily anticipate when you started.

Q142 **Chris Green:** There has been a huge investment at the moment in institutes, the National Graphene Institute and the soon to be opened Graphene Engineering Innovation Centre, but often organisations need ongoing investment for management and for upkeep. What funding streams are available for that?

Paul Mason: On the innovation side, we have structured our investment into supporting business-led innovation in one of the four sector groups. Manufacturing and materials is one, health and life sciences is another, and infrastructure systems and emerging and enabling technology—the one I look after—and then we have a catch-all open-scope programme that says that if you have world-class ideas and world-class companies you do not necessarily have to sit in a world-class sector, like the healthcare sector in the UK. People who want to develop graphene-based products or services could apply for funding through any of those competitions that are relevant. If you were manufacturing graphene or working out how to use graphene in a composite material or something, you could apply to the manufacturing competition, or you could apply to the emerging technologies one if you were trying to do work on some particular aspects of how you commercialise or make graphene. In our area, it is definitely in the scope of the competitions that we have going forward. Of course, we have those 35 projects under way at the moment, some of which only started earlier in 2016. Over the next six or 12 months, they will start to come to the end of their projects, their feasibility studies. We will learn which of the avenues of exploration companies worked on prove to be fruitful, which ones are cul-de-sacs and which ones the companies want to take further forward. Then our subsequent funding streams will be available for them as they want to take those next steps forward.

Q143 **Chris Green:** I think what you are saying is outrageous: you are almost telling a politician that science and innovation take a very long time and we have to be patient and wait for the outcomes. Dr Ellis.

Dr Ellis: My colleague has talked about innovation funding. In terms of research funding, EPSRC have identified materials and graphene as a key area of investment and they have made available over the period the institutes have been around £33 million of resource funding. Again, it is a competitive system. The process is that calls go out, bids come in, they are peer-reviewed and excellence is then funded from that, so the opportunities for Manchester to gain resource funding out of that £33 million were there.

Q144 **Chris Green:** At the moment, is it too early to say when we are going to get a hard return for the investment? Could you say what is going to be the first blockbuster product from graphene?

Paul Mason: It is quite difficult to predict that. If you are asking me to say what industries I think they might be, the UK is very good at taking technologies and putting them into high-end materials or applications, so you can see them in motor sports, aerospace or high-end sports equipment. Look at how well we have done in the Olympics on the basis of a lot of technology being used in training, nutrition and the design of apparel. You could see it in industries such as aerospace or maybe even pharmaceuticals, and some of the stuff around electronics that we do not make here but we own quite a lot of the IP. There are things such as

high-end capacitors that have satellite applications and that kind of thing, but probably not bulk capacitors for radios.

Baroness Neville-Rolfe: The thing about graphene, which is why it is so brilliant, is that it is so strong and it has conductivity. Therefore, you have the early-stage successes, such as the tennis rackets, hockey sticks and fishing rods—the things that people have seen graphene being used for—but we are beginning to see it being used for things like the strengthening of drones or electronic vehicles, and, not only in the UK, you will see that coming through.

Paul Mason: If the prices of indium and tin go up, graphene will be much more attractive for liquid crystal displays. If the prices of indium and tin stay as they are, it is perhaps not so important to develop it. External influences will create demand in the marketplace to pull certain products forward. It is hard to foresee.

Baroness Neville-Rolfe: It is very long term. I dealt with digital in my previous job. The digital camera was produced in 1975, and it was not until 2003 that it became the way that everybody started to take photographs. The mouse was invented in the 1970s and did not really get going until the 1990s. I imagine that graphene could potentially have some slow-burn applications.

Chair: Or not.

Baroness Neville-Rolfe: Or not. We have also had failures where a technology has been applied.

Q145 **Chris Green:** Moving on to the patents and the intellectual property side, what you have just said, Minister, highlights the importance perhaps of having control of the intellectual property. Just as we saw in the Olympics recently that we were ahead of China in the medal table, now it seems that in terms of patents we are way behind China. Is it that we have the gold medals and they are collecting all the bronzes or is it something else?

Baroness Neville-Rolfe: On patents, the numbers—this point may have been made to you already—are much less important than the quality of the patent.

Q146 **Chair:** How can we be sure?

Baroness Neville-Rolfe: That is a good question about life.

Chair: Just for graphene now.

Baroness Neville-Rolfe: If you talk to business people and academics, they want to make sure that they have registered the key patents, in this case graphene, and it is very interesting how usually relatively few patents create big value. At Stanford, of 10,000 patents, a mere three patents created 67% of all licence revenue. That is the Stanford office.

That is what we have seen in the digital area. We believe that universities should patent the things that they think are right. We have a very strong framework for supporting companies on patents, in terms of both the legal framework and enforcement, and our IP is well respected around the world, if you look at the individual indices. That seems to be a reason why people want to come to develop things in the UK and operate in our market. In markets overseas, our support on IP is very important, which is why we have IP attachés, for example, in key export markets.

Q147 **Chair:** If I might just ask a supplementary, Baroness, do you think that is going to be influenced at all by the EU?

Baroness Neville-Rolfe: The narrow question on patents is that the European Patent Office is not an EU institution.

Chair: So it should not.

Baroness Neville-Rolfe: That will continue. There are some aspects of IP where certainly we have highlighted the importance of getting the IP right. IP has increasingly international standards. Its protection is an international endeavour because it does not have borders in quite the same way as a specific product.

Q148 **Chris Green:** In an environment with limited resources, is it about £50,000 to maintain a patent over its lifetime? It is an expensive process. Essentially, we are looking to scientists, to people, to use their judgment. We can either spend the money on patents—10,000 is quite a large number of patents to be maintaining—or we can invest that same money in research, and perhaps commercialisation. We have to trust the scientists to get the judgment right. Do you think we are broadly getting it right at the moment?

Paul Mason: My personal view is this. The filing of the patent in the early days, in the first few years of cover, is relatively less expensive. The fees to keep a patent in force become much higher as the patent becomes older, on the grounds that if you are commercially successful you will have made money out of the monopoly that the patent gives you and therefore you should be able to pay to cover the costs of the enforcement infrastructure. Getting the patent filed is not as expensive as £50,000 overall, and it is why we think that getting companies collaborating with academics in the very early stages is key to securing the right kind of IP claims. The whole thing hinges on what is in the claims; you have to have an inventive step and it has to be novel. Each time you discover something new by collaborating, you discover something novel because you are talking to a new person about a new problem that never occurred to you before, so now you have something that you can claim and on which you can file a patent. Quality is absolutely key. Quantity creates problems where you end up with patent thickets. It can get difficult if people are filing a lot of things around you, because the sheer effort to understand what your freedom to operate is can get hard.

There is a challenge for all of us in that, and graphene is not unique in that area. We need to look quite carefully to the future, but it is more than just a numbers game. As these new technologies, new applications, new infrastructures and new intellectual property relationships come forward, they might give you the inventive steps that allow you to create unique IP that was not there previously. You now have the patent where the money is, because you have been working as a company, and as the academic excellence, to create that invention. There is plenty to do. Most of the patents are in force only in China anyway, so they would not apply in the UK unless somebody applied them here. I cannot remember the percentage off-hand.

Dr Ellis: Going back to your point about "trust the scientist", that is possibly not truly representative of what goes on in universities. Academics do what academics do—they research. There is quite an infrastructure around the university system to help front-line researchers understand the opportunities of the work that they are doing. There are things that we can do to improve. I know you have another investigation into IP commercialisations in universities, and there may well be things that we can learn from that, but I do not think it is just trust the scientists. There is an infrastructure in universities to support and help, but if there are more things we could do, we would be very happy to understand them.

Baroness Neville-Rolfe: I think the Intellectual Property Office has a role to play through business advice to universities on how they optimise their IP and how they make the sort of judgments that you are talking about. It is £230 for a low-cost patent application, but there are also legal costs involved, quite apart from the repeat fees. You want to make sure you are investing in the right intellectual property. We can really help. In fact, we have a Law Commission Bill going through my House on unjustified threats, which will stop too much needless fighting over patents. We are trying to improve the regime as part of our general manifesto commitment to make Britain a really good place to do business and to patent. I spend a lot of time talking to the Americans and the Chinese about patents. You will know that the Chinese have targets—they have numbers in their five-year plan—which has the effect of producing large numbers of patents. We debate how you make sure you get the quality of patent that is going to lead to innovation and development and winning industries for the future.

Q149 **Chris Green:** Are there countries around the world that have role-model behaviours in terms of patents and intellectual property? What countries would you say we ought to learn from, and are we learning from them?

Baroness Neville-Rolfe: You have a conversation with the big countries, and the United States features well on the scores, but it has the problem of patent trolls and thickets that you were mentioning, which we would not want.

Chair: What was that—patent?

Baroness Neville-Rolfe: Patent thickets, where people—

Chair: What was the first one?

Baroness Neville-Rolfe: Patent trolls. In your next inquiry, you will learn about patent trolls, which is when other people speculatively register patents that a company can then get rid of through legal action. That is not a good use of public or private resources. Some of the smaller countries, Switzerland, for example, where the World Intellectual Property Organisation is located, have good practice. We could certainly send you, perhaps for your next inquiry, some information on the different strengths and weaknesses of different countries, if you think that would be useful. It is always good to look at international comparisons.

Q150 **Chris Green:** Finally, it is incredibly important to safeguard our intellectual property, especially when we have partnerships with universities and businesses abroad. How do we safeguard our intellectual property when we have relationships with foreign organisations?

Dr Ellis: Specifically going back to graphene, the background IP, in the invention and the systems they have used to create it, is owned by Manchester. That is theirs; they patented it and it is a valuable resource for them. In terms of opening up ideas and thinking, that is very much the conversation that we would expect the universities to have with individual partners. The relationships would be different. The natural instinct of universities, probably just due to proximity, is to work with local companies and industries if they can, but they have to work with people who are interested, and I look at that as an opportunity to do joint patenting, for example. There is a joint patent between Manchester and BGTM, which will, downstream, create some revenue. In terms of protection, think about what the deal is, think about what the opportunities are and try to gain value from that, as Manchester have done, certainly in the patent they have with BGTM.

Paul Mason: Commercialising IP is a strategic business decision, so you can protect it and patent it. You could publish it and put it out in the open domain and nobody else can patent it because it is no longer new, and then you have freedom to operate because nobody can stop you. That is a very valid policy. Another thing you can do is to practise in secret, if you do not think other people can work out what it is, and then your protection is your contracts with your employees, the way you operate and how you retain that know-how inside the organisation. You have to think through, when you are thinking about how you commercialise something, what your strategy is going to be to realise the value from the IP that you are creating. One of your tools is patenting, but even if you decide to patent, which territories, what exact claims and how you are going to enforce them is quite a complex area. For our own part, the way we ensure that the value accrues in the UK is, as I said before, that we fund a lot of collaborative projects with people who have problems and solutions or opportunities and someone else who might just take it a bit

further downstream. In each of those projects, we have a contract with the people that allows us to pay them the grant—a legal contract with them. We will not allow them to start their projects and we will not reimburse them any money until they have an agreement in place between the consortium collaborators as to how IP will be managed. If they do not have a signed contract—"This is how the IP is going to be managed for things created during the project"—we do not let them start and we will not give them any taxpayers' money. We really drive that point home. That is 7,600 companies and 7,600 agreements about how the IP will be owned and managed going forward as the projects progress.

Baroness Neville-Rolfe: As Intellectual Property Minister, I am passionate about having the right regime and making sure that in these sorts of circumstances the opportunity is taken, but innovation is also about enterprise and getting on. I come from business, where speed of change is important. It is possible to create innovative businesses that do not necessarily focus a huge amount on IP; you might register the trade mark and the design and not bother with a patent. You can have different models. The key thing is to make sure that we maintain our free flow of innovation in this country and have good protection for it where that is right from the company's or the university's perspective, and that we have the sort of enterprising culture that allows change, including small changes. I used to work in retail where you would have innovations on packaging, systems and computers that you did not necessarily register as IP or seek to get an R and D credit on, because they were changes to the business, but they were very innovative. It is a broader point about encouraging business.

Chair: That is good. I am conscious of the time.

Q151 **Victoria Borwick:** I want to take us back to the universities and their technology transfer offices, which we shall now colloquially call TTOs, but I used it in its full form at the beginning. They have these TTOs to develop their products and services. How do the Government liaise with them? Do you finance them or do you do that for research spending? How do you liaise with the universities on that?

Dr Ellis: We have HEFCE, the higher education funding agency, which is the arm of Government that liaises with the higher education institutes. They are the people who are liaising with TTOs in general.

Q152 **Victoria Borwick:** Fine. Does the decision made on how to fund them, or how much to fund them, come from HEFCE? Is there a balance between the research money that we allocate and HEFCE?

Dr Ellis: There are conversations. Commercialising research from R and D is an important aim for the Government. We want to do more of it, so there is a conversation with HEFCE as you go through allocating money around what are the right investments to make.

Q153 **Victoria Borwick:** Can HEFCE allocate directly research money for undertaking technology transfer? Can they put money in directly?

Dr Ellis: It is part of the settlement that goes to universities.

Baroness Neville-Rolfe: Typically, the tech transfer people are self-funding. In my experience, I have had friends who have been tech-transfer officers and they are often ex-strategy directors. They set up within the university, and have a look at what needs to be patented, sold or developed. They arrange partnerships and they tend to be self-funding in some models rather than being the recipient of a grant as such.

Q154 **Victoria Borwick:** They are not eating into research grants. That is what we are trying to establish.

Baroness Neville-Rolfe: I think we need to check.

Dr Ellis: A small amount of money is provided for technology transfer as part of the dual funding of research.

Q155 **Victoria Borwick:** It is the same budget.

Dr Ellis: It is the same budget that is used for a number of purposes, but as the Baroness said—

Paul Mason: If I remember the numbers—they may not be absolutely right—there is some data from HEFCE applicable to 2013, I think, so it is not brand new data, saying that the licensing income from all UK universities accounted for about £120 million per annum, or it did in that year. The cost to maintain the patent portfolio was something like £80 million, and therefore they cleared £50 million profit overall.[23] It is something like that. I am sure the numbers can be provided for you, but it is something like that, which, as a percentage of a £6 billion R and D investment, is not a very good return. Regaining the investment in the science base should not be sought through licensing to the TTOs but through the use of the patents through companies further downstream.

Q156 **Victoria Borwick:** What lessons were learned from our previous experience with things like silicon that we could use for graphene or any

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[2] The witness later clarified that the licensing income from all UK universities accounted for about £82 million per annum, or it did in that year and that the direct cost to maintain the patent portfolio was something like £34 million, and therefore they cleared £50 million overall.

[3] It would be incorrect to infer that this is a surplus as (1) this figure does not cover all overhead costs, (2) net licensing revenue is split between the academics and the university (typically 50:50 or 33:33:33 between academics, their department and the university central admin) and (3) the distribution is very uneven with most universities receiving very little in IP licensing income. Consequently the great majority of university of tech transfer functions operate at a net cost to the institution and are primarily managed to deliver public benefit from the research (through ensuring the exploitation of research by others). This was confirmed by Prof Trevor McMillan's report.

other new products?

Dr Ellis: We have been saying fairly consistently that there is no one standard model for commercialisation of a product. Our policy has been to ensure that we are investing in research, pull-through into commercialisation and innovation, and, as Paul said, investing in a broad range of opportunities, be it aerospace, energy, or whatever.

Q157 **Chair:** The graphene story is unique.

Dr Ellis: If I was to draw you a road map from discovery through to, "Here are the products," I do not believe I could.

Paul Mason: I do not know anything about silicon. Well, I know that if you have an X-ray spectrometer you should not use furniture polish in your laboratory or PDMS gets everywhere. That is pretty much where my knowledge finishes. The really interesting thing about early-stage technologies is what you can learn from other technologies. There was some great work done by the Institute for Manufacturing in Cambridge University under their emerging industries programme, which Professor Sir Mike Gregory ran. They did historical road-mapping of a couple of dozen disruptive technologies. We look forward on to road maps. That is what we are doing with the graphene road map from the graphene flagship. It is projected forward to 2025 or something. That programme looked back over the last 50 years, or even longer, for a couple of dozen technologies, such as the silicon chip, CAT scanners, mobile phones and digital cameras, to try to find the patterns that emerge as early-stage industries grow, to see what the learnings were.

Q158 **Victoria Borwick:** That is right and it is why we are asking. We want to highlight where there are efficiencies.

Paul Mason: It is an incredibly invaluable piece of work and it informs our strategy for emerging technologies. One key thing that accelerates things is investment in demonstrators, and that is why we spend a lot of our effort with companies to try to create demonstrators that prove different points to internal investors, to shareholders, to outside investors or to customers about how a technology will work. That is the thing that gets technology moving faster, and it is generally applicable. It is probably true of silicon, but I do not know the particular details.

Q159 **Victoria Borwick:** My final quick question is on the balance between graphene research and applications or manufacturing, because it has been commented to us that we spend more on the research than we do on the applications. Do you have a view? Have the Government got the balance right between research and innovation in supporting graphene?

Baroness Neville-Rolfe: My own feeling is that you need to spend a chunky sum of money on research, and that is why we had the commitment of £6 billion, and you need to add on development money, but of course, a lot of the development effort is being made by companies and is not counted in the same way. What you can do is

complement the sort of thing that we have been talking about with help for small businesses to start up.

Chair: So you think the banks—

Baroness Neville-Rolfe: The British Business Bank, for example, has been making about £3 billion available over recent years.

Q160 **Chair:** But the balance is right, from your point of view.

Baroness Neville-Rolfe: It is obviously something we are going to be looking at as part of the industrial strategy.

Q161 **Victoria Borwick:** Would you say it was continually under review?

Baroness Neville-Rolfe: We will look at the question again. I think we should, but this country has had a lot of success over 200 or 300 years from having a very strong research base, and I feel passionately that the research base needs to be supported and we have to find clever ways of developing. To suddenly move the budgets out of the universities into the demonstrators would not necessarily be where I was coming from today.

Victoria Borwick: Okay. That is sensible, thank you.

Chair: Thank you. The Committee is glad it is going to be under review. We appreciate your time and your clarity about the Government investment and there have been some especially good, clear answers on patents—very useful for us. If we email you for further information, I hope you will bear with us, but for now the meeting is adjourned.