



HOUSE OF LORDS

Science and Technology Committee

Corrected oral evidence: Engineering biology

Tuesday 23 April 2024

10.15 am

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Members present: Baroness Brown of Cambridge (The Chair); Lord Berkeley; Lord Borwick; Lord Drayson; Lord Lucas; Baroness Neville-Jones; Baroness Northover; Lord Rees of Ludlow; Viscount Stansgate; Lord Strasburger; Lord Wei; Baroness Willis of Summertown.

Evidence Session No. 3

Heard in Public

Questions 17 – 34

Witnesses

[I](#): Dr Jim Ajioka, Chief Scientific Officer, Colorifix; Will Milligan, Chief Executive Officer, Extracellular; Rosemary Sinclair Dokos, Senior Vice-President, Oxford Nanopore Technologies.

USE OF THE TRANSCRIPT

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

Examination of witnesses

Dr Jim Ajioka, Will Milligan and Rosemary Sinclair Dokos.

Q17 The Chair: I would like to welcome the witnesses to our third evidence session on our inquiry into engineering biology. The witnesses today are Dr Jim Ajioka, the chief scientific officer of Colorifix; Will Milligan, the chief executive officer of Extracellular; and Rosemary Sinclair Dokos, senior vice-president of Oxford Nanopore Technologies. Thank you all very much for joining us this morning. The session is being broadcast on parliamentlive.tv and a transcript will be sent to you shortly after this session for you to make any minor corrections. If there is anything you do not have a chance to say or data that you think we might find useful to have, we would be very pleased to receive that as formal evidence after the session.

Let me kick off gently by asking you each to briefly set out what your company does and what the business model for your company is.

Rosemary Sinclair Dokos: Thank you and good morning, everyone. Oxford Nanopore Technologies is a company that was established in 2005, a spin-out of Oxford. We develop a sensing platform, the first applications for which are DNA and RNA sequencing. We have created a slew of products, some being handheld DNA sequencers that have been used around the world. We ship our products to over 120 countries, and they are used for anything from infectious disease monitoring to human health, cancer, oncology, biopharma, food authenticity and security, so they have a broad application. At the heart of our company is a nanopore, which is a biological protein that we put inside our devices and that is why we are one of the companies that does biological engineering in the UK.

The Chair: Can you give me an indication of the size of your company, just ballpark figures for turnover or numbers of employees?

Rosemary Sinclair Dokos: We are 1,300 people, most of them in the UK, with a very strong element of R&D and manufacturing in the UK. Of course, our commercial organisation is a global one.

The Chair: In terms of the companies we have been talking to, you are quite a large organisation. Jim, please introduce your company.

Dr Jim Ajioka: Our company is essentially addressing the question of how we can drop chemical synthesis in favour of a biological

process. We design organisms, in this case microbes, to generate, deposit, and fix small molecules on to surfaces, focusing on textiles, so we make pigments that we can put on to textiles.

Our business model is complicated in the sense that it is a commodity chemical space, so there are very tight margins. We have a licensing model where we build the organisms to make different colours and pair those colours with different fabrics because, as you probably know, not all colours show the same spectrum of reflectance on different fabrics. You might have one thing on polyester and one thing on cotton but they do not look the same, so we have to pair the pigment with the fabric, and then we licence that recipe to a dye house or a mill. We also charge a royalty on top of that to increase our own margins.

The other side of the business is that we build our own bioreactors, which will go anywhere from 30 to 300 to 3,000 litres. That is good enough to at least service European-style dye houses at this point. We recently dyed 1.5 tonnes of polyester, which is about 10 kilometres of fabric end-to-end, so it is starting to get to real scale.

Biology is always a genotype-environment interaction, meaning that you have to control both the genetics and the environment. We have to build, as well as sell, our own bioreactors, because we have to have the same environment to put the organisms into. We also make our own food, because you have to feed them the same things all the time to have a recipe that works. We sell the food and bioreactors as part of the business model. It is sort of an inkjet printer model of trying to increase revenue.

The Chair: What is the scale of Colorifix at the moment?

Dr Jim Ajioka: We have onboarded three mills, or dye houses, in Portugal. We are starting things up in Sri Lanka and India and we are continuing to work in Europe, because it is a place where you can get exposure due to its work with high fashion.

The Chair: And how many of you are there?

Dr Jim Ajioka: 100 employees.

The Chair: Thank you. It is helpful for us to have a feel of the scale. And finally, Will.

Will Milligan: Thank you for having me here today to speak to the committee. Extracellular is a scale-up partner for engineering biology companies with a specific focus on the alternative foods and biomaterials space. We help companies develop their

manufacturing processes and scale up. With our support they can reduce their costs and get to market faster.

In terms of our business model, we sell our services to other start-ups and large corporates around the world. We have a number of customers that come to us for our expertise in scale-up and development of these products. Much was said in the committee last week about the challenges of scaling up. We are dedicated solely to supporting that sector of the future bioeconomy.

As for size of business, we are currently 15 people. I started it two years ago, so we are relatively young and relatively small, but we are growing quite quickly.

The Chair: Thank you.

Q18 **Lord Borwick:** What are the key areas of science involved, and how are you hoping to innovate on existing processes or products using engineering biology?

Rosemary Sinclair Dokos: At Nanopore, we have many scientific elements, because we have hardware, software and all the rest. Around the protein engineering element of our company, some exciting advancements that have come in over the last two to three years have been the onboarding of things like machine learning and AI towards the engineering and design of proteins. We have to be incredibly targeted with the proteins we design. They are reading DNA, and they have to read it at 99% accuracy, so any tiny mutation we make can change the performance of our system. That part of the technology has been really interesting and exciting.

With that, we have onboarded things like higher throughput screening methods, which have classically been used in pharma, in order to screen through these mutations that machine learning and AI can hit. Of course, as soon as we scale up we encounter something that we will all hear from the committee members, which is how you support British biotech companies through that. The invention side is actually quite healthy in the UK, but machine learning and AI will create an enormous backlog of demand for higher process and higher scalability. It will be interesting to see how the UK Government can support companies coming through with all these new inventions to scale those up through production, execution and commercialisation over the next few years.

The Chair: Can I ask you a really stupid question? How do you keep these proteins alive in a handheld device? Do you have to supply proteins fresh to be put in every time people use it?

Rosemary Sinclair Dokos: I have a device with me, which you can pass around, if you like. We have a consumable cartridge, and the proteins live in this little window for a year before someone adds a sample. They are quite happy in there. They will be quite happy in the fridge, but they do not like freezers; they get too cold.

The Chair: Thank you. Sorry to interrupt. I was just intrigued.

Lord Borwick: And Jim, what are the key areas and how are you hoping to innovate on existing processes or products?

Dr Jim Ajioka: What we do comes back to a lot of what has been discussed previously. We use molecular biology and microbiology at the core, trying to create a build-test-learn cycle that is fast. We have been able to take our designs, which we design computationally from databases, and then build them by DNA synthesis and DNA assembly. The DNA assembly part of it is something they do at foundries. We had to do one in-house because we needed to do it faster than can be done at a foundry.

Our first test is essentially just whether it made colour. It is not a complicated downstream process. Also, does it go on to fabrics or not? Do we have the analytical tools to tell us about the process, and does it meet industry standards? We use analytical chemistry to test to make sure that we are putting on what we think we are putting on. Then we use other things, such as AI, to try to develop better processes with regard to the enzymes that are doing the job and how to get better fixation on to the fabrics themselves.

Lord Borwick: Mr Mulligan, the same question to you.

Will Mulligan: We focus on applying process understanding from traditional biopharmaceutical products for non-health biotech applications. A lot of the understanding of how engineering biology products are produced is based in healthcare, but a lot of the non-health biotech applications need to be produced much more cost effectively. We really focus on trying to make these processes cost effective, so we innovate on the application of existing technologies in a fit-for-purpose manner. To put that into context, if you are producing a biopharmaceutical, you need a large-scale bioproduction facility with very high-quality standards, which will have very high operating costs. We work more closely to microbrewery, which produces beer at a relatively low cost. We make that transition from biopharmaceutical production to non-health biotech production.

Q19 **Baroness Willis of Summertown:** I used a nanopore in the field of plant sciences a long time ago and it was fantastic. You have all

developed these fantastic new technologies. A question arises. What are the major barriers in scaling up from being in the lab or the new processes to becoming a global product?

Rosemary Sinclair Dokos: These are challenges that are character building, and we have already gone through a lot of character-building processes at Oxford Nanopore. One particularly interesting time—it must have been around 2018 or 2019—was when we were going from the phase where we could cobble things together in academic-style laboratories but could see that the demand was coming.

We needed to build a factory to get things to a decent scale. As a loss-making company, it was incredibly difficult to get Innovate UK funding. We spent ages going through all the applications, and then, three or four months after that process started, someone said, “Oh, there’s a clause at the back here that says you’re a loss-making company, so you don’t qualify for this”.

That was a particularly challenging time and one that we overcame because our leadership team have built a phenomenal funding base around the company. That is what you need in order to get these technologies out the door. If we did not have that, we would have struggled to break through from something that had around £20 million or £30 million in annual revenue to where we are today and where we want to be as a business.

That will continue to be a challenge the next time we want to duplicate the footprint of our factory and say, “Right, let’s go out and double the size”. What funding cycles will be available for companies that want to really make it in the UK?

The Chair: Who would you go to for funding for a factory in the UK?

Rosemary Sinclair Dokos: I believe we went to the UK innovation committee, but I will need to look at my notes.

Baroness Neville-Jones: Innovate UK?

Rosemary Sinclair Dokos: Innovate UK, yes.

The Chair: You would not go to the UK Infrastructure Bank.

Rosemary Sinclair Dokos: At the time, we raised the money ourselves through private equity funding. Now, we are a public company, so we have floated and that is where we would go for funding.

Baroness Willis of Summertown: Jim, could you address that

question?

Dr Jim Ajioka: You have to understand our business model to understand the scaling. In order for our process to work, we have to be able to grow the organisms in the dye house, which requires us having bioreactors that are not made for GMP facilities but are made for dirty environments, so we had to make our own machines. Therefore, we also manufacture hardware, which for an engineering biology company is not normal. That was a major challenge, and we had to do it on the sly so that our investors did not really know we were doing it. We knew enough about how bioreactors worked to be able to say, "This is the way we want to design it". We worked with a small company to cobble together what we wanted and now we can scale the manufacturing of it as well.

It is about trying to scale fermentation. We now have machines functioning that do 3,000 litres, and we can turn them around fast too. That is the other thing: if you are going to do dyeing, you have to have your machines make a colour, strip it down, clean it, and start over again. We can do that in about two hours, which is lightning fast compared to most traditional bioreactors. Also, our machines are plug and play, so you can unload them off a dock, put them together, and in a couple of days to a couple of weeks you can have a complete running system. It is all engineered to be shipped in containers. We can ship anywhere, lock them down and plug them in. With our 300-litre bioreactor, we took it off a skid, put it in Cambridge, and three days later it was running.

Baroness Willis of Summertown: Would you say then that one of the challenges is the narrowness of the funding portfolio, which is why you had to do it on the sly rather than being able to apply openly for the funding?

Dr Jim Ajioka: Yes, but that is because we realised that it had to be done. We had limited funding, so we did not engage a third party to help us develop them. We knew we could do it ourselves. It is not really that complicated. It is not like astrophysics or something.

Baroness Willis of Summertown: No, but the point you make is a really good one. You get money for engineering biology and then you need money for the development of other technologies, which does not necessarily come under that umbrella.

Dr Jim Ajioka: No, but you just figure out how you are going to design it yourself.

Baroness Willis of Summertown: I understand that. Will?

Will Milligan: We support a number of companies that are developing engineering biology products in biofoundries, for instance. They have a deep understanding of their product and their cell line, but they might not necessarily have that understanding of how to scale those products. In order to build that capability, you need to invest millions of pounds of capex, build the right kind of team and have the right kind of facilities. We focus on centralising those production capabilities so that we can support a number of companies with the same kind of capabilities. Quite often, they are first-of-a-kind facilities for first-of-a-kind products, and that is the challenging thing to raise financing for.

Baroness Willis of Summertown: Is that a challenge for your company, then?

Will Milligan: Yes. Our business model does not necessarily allow us to make a profit because of the challenges in fundraising for biomanufacturing facilities. So we need to look at the business model and say, "Well, a company needs a certain amount of product or a certain access to capabilities, so how much does it cost to install? How much can we sell it for? How does it help them?" It is the win-win that we try to deliver across the board to help these products to scale.

Q20 **Lord Lucas:** You have all mentioned difficulties in raising finance. Looking particularly at what the Government might influence, what could we do to make it better and easier to raise finance in the UK, both private finance and in the interaction with Innovate UK and the government structures? What needs to change, particularly given that a lot more will be coming through, as you said Jim?

Dr Jim Ajioka: This is the American side of me coming out. You need DARPA. You need deep pockets where the money is coming from something where you can make a contract rather than just a straight-up grant. There are metrics that you have to meet, but it has deep pockets. DARPA comes from the US Department of Defense, which has huge, huge cash reserves. In the UK, you do not have the scale of money to do it. That is the problem. We have used Innovate UK very effectively for developing some of our stuff, do not get me wrong, but if you want to do this right, you have to find deep pockets.

Rosemary Sinclair Dokos: Yes, it is a matter of scale. As a technology company for instance, Nanopore competes with US-based and China-based competitors. In China, they can set up a factory with 1,000 people tomorrow and try to replicate what we

are doing. It is the same in the States. As was just said, there is an immense amount of funding available there.

However, there are a lot of things that the UK does brilliantly, particularly at the very onset of that R&D phase, the early phases of companies and early phases of spin-outs from universities. We excel at that in the UK, but there needs to be more careful guidance for when companies are making that leap from the 100, 200, 300 personnel size to beyond that, which is the area where companies are at the biggest risk of failure. It is often really unclear how you can get that support, be it from the Office for Life Sciences or Innovate UK. I do not know how much attention gets paid to companies at the 200 or 300 people size that are trying to make it big, and that is one of the most challenging parts of the business.

Dr Jim Ajioka: Yes, and you have to figure out how to make your route to market fast. For us, the fashion industry's attention span is pretty close to zero, so you have to do it really, really fast, but you also have to think about how you are going to make money fast. So for us it is about trying not to worry too much about where our next funding tranche is, although we are still having to do that, but figuring out how we are going to make money fast enough to start supporting ourselves. You have to take that on board if you are going to start a company.

Will Milligan: Yes, and it is key to make sure that this capability and value stays in the UK. UK companies need capital incentive schemes for engineering biology products, and there is precedence for that from the OLS. In healthcare manufacturing, more than £600 million in total is available for healthcare manufacturing to be in the UK, for private companies to make sure that capacity is built here, and to build long-term value for businesses that may otherwise relocate.

There are challenges, particularly in the food space, with some products being drawn to other nations for their large-scale production. There is a company in Scotland called ENOUGH, which secured €70 million from EU grants and set up its large-scale production in the Netherlands. There are other grants that are available for companies specifically in the Netherlands to see large-scale manufacturing, and we need the same kind of capital incentive schemes to make sure that these capabilities are built here.

Lord Lucas: Rosemary, did you say something about loss-making companies not qualifying for support? Where is that coming from? I mean, how long did it take Amazon to make money, for goodness

sake?

Rosemary Sinclair Dokos: Oh, it took Amazon ages to make money. We applied for the Innovate UK funding to set up our factory back in 2018 and everything was fine until literally the last week, when we were all expecting to get the funding, and then, "No, here's this clause. You're a loss-making company. You can't have that."

That is part of the challenge, because how can the Government figure out which companies will and will not make it big in order to make informed decisions? It is not an easy judgment to make, for sure, but it is the nature of biotech; it passes through a very long phase as a loss-making company, and the right ones, when they make it, really make it.

The predecessor company to Nanopore was a Cambridge company called Solexa. I do not know how many of you are familiar with Solexa. It was sold for about \$650 million back in 2007 to Illumina, an American company. It was sold when the Solexa product was just hitting the market. They were establishing themselves, they were finding it difficult to scale up, and in came this American company, which did a fabulous job post 2007 to scale it. At its height, that American company was worth \$30 billion off the back of an invention that came from Cambridge and which we could have had in the UK. That is an example of the innovation that comes from the UK and the execution that then happens in the US.

Baroness Neville-Jones: I want to probe you a little further on the question of being loss making and the consequences. Are you saying that it is an Innovate UK rule that it will not finance something that is loss making, or that it was a judgment it made about your company that you were not going to make it or whatever?

Rosemary Sinclair Dokos: No, it was a written rule at the time when we applied.

The Chair: Do you know if it still a rule?

Rosemary Sinclair Dokos: I am not sure. We have not applied since. We got our factories.

Baroness Neville-Jones: We will check that one out. It is interesting.

Q21 **Lord Drayson:** We are having an inquiry into engineering biology partly because it is one of the few areas of technology that the Government have identified can make a significant difference to UK

economic growth. My question builds on some of the points you have already made about the challenges of taking a promising business and scaling it to the point where it makes a meaningful difference to the UK economy. Oxford Nanopore is the closest to that. As a company, you decided to float on the London stock market. How is that going?

Rosemary Sinclair Dokos: Oh, fun. For us, it was a fantastic achievement and a brilliant part of our journey. Lots of macroeconomic things have happened since we IPO-ed, but for us it has been brilliant. It is generally recognised that it is a bit harder to get liquidity in London than in other markets, but we are very proud to have done what we did and IPO-ed in London.

Lord Drayson: So you are a rare UK unicorn listed on the London stock market. How easy is it for you to raise additional capital now, given the flow of funds out of the UK market and the performance of your share price since IPO?

Rosemary Sinclair Dokos: It is never easy, including pre IPO, to raise the amounts of money we have had to raise in order to achieve what we have. We do, however, have a particularly compelling business and a particularly compelling platform, and we are lucky to work with partners who can see beyond where the product is today to what it could be doing in five, 10, 15 years' time. We have been able to raise additional capital through partnerships. We did one with bioMérieux last year and raised a further \$70 million. So it is possible, but it takes an enormous amount of energy and you have to deliver, but that is why we do it.

Q22 **Lord Drayson:** One of the concerns is that UK companies get harvested by foreign companies. You mentioned Solexa, and there is—not in your sector—DeepMind, now Google DeepMind. What is seen by the industry as an effective strategy to continue your journey, building jobs, making profits, paying taxes in the UK, and not getting taken out?

Rosemary Sinclair Dokos: In order to take a company from an interesting technical innovation to a global powerhouse, you need people with high experience in manufacturing, but not manufacturing in small stages, which is what we have a lot of in the UK. The UK is an interesting place: we have a lot of small, mid-sized biotech companies, and we have enormous pharma companies. You do not have this lovely thing in the middle, which is where we fit: we are not quite a diagnostic product—we are almost a diagnostic product—but we fit in that space. We do not need the controls and the regimented approach that pharma needs. If we try to apply the skills and talents that we have in the UK to

the industry sector that we want to go into, they bring across an enormous amount of quality control, procedures and processes, which actually slow innovation down, because you need all those processes to be safe in pharma.

If you go to other places in Europe, such as Germany, they have a much healthier diagnostic industry and scale up size, so you start getting quite a lot of good talent and people who can run manufacturing processes from there. In the US as well, you have a lot of mid to large-size diagnostic companies making and manufacturing things every day of the week. In the UK, because we have created this environment where we are brilliant at innovation and then fail at scale-up, we start having a skill shortage at roughly the size we are now.

Lord Drayson: This is the phase I am particularly interested in: getting from 1,300, where you are now, to 20,000 people. As you say, huge amounts have been done to improve the spin-outs from university. The venture capital market is all pretty terrific. Where it is not terrific is in this 200, 300 people size going to thousands of people. Do you see a role for government—a Government of any colour—in actively intervening in the market to support and enable companies to continue to grow?

Rosemary Sinclair Dokos: One of the interesting challenges we have had more recently is that if we are missing skills, we may find those skills in Europe, for instance, and in roles that can be done remotely; people who could be consultants for us whilst happily living in their countries. Under current Brexit rules, they are allowed to come to the UK for only eight, maybe 12, working days a year. We are fine for people who want to relocate and move here, but for people who want to do hybrid working it is a bit difficult. So in this particular phase we have a skill gap in the UK and it is a little difficult to pull that skill gap in.

Lord Drayson: So the skills issue is one thing. Is there anything else where you think there is a role for government to intervene?

Dr Jim Ajioka: We face similar employment issues because we work in India and Portugal and we have visa issues all the time, which slows us down. Trying to get people from one place to another is not always easy. There are also some regulatory issues—we will probably get to that later in the questioning—that could probably be worked on a little too.

Coming back to funding, a lot of it will come down to trying to figure out how you are going to fund this, and how government can intervene to do that is really a good question. There will be a point

at which we will have to expand our ability to manufacture bioreactors, for example.

Lord Drayson: So is there a role. Would it be appropriate for government to invest in funding such facilities?

Dr Jim Ajioka: I think so, because if you look at pretty much any other place on the globe, Governments interact quite a bit with businesses to make sure that they have advantages. I do not think that happens very much here.

Q23 **Lord Drayson:** Finally, how much of a risk is it that these innovations coming out of UK research will lead to a start-up that ends up being commercialised somewhere else? What is the reality in 2024?

Will Milligan: Maybe I can speak to that. We are an early-stage company focused on biomanufacturing food products. We have a number of investors from around the world, from the US to Asia and Europe, and they want us to be elsewhere rather than in the UK.

Lord Drayson: Why?

Will Milligan: In the innovative food space, it is easier for companies to bring products to market in the US and Singapore, for instance. They are the two leading markets for that sector. Our customers want us to be elsewhere, in relevant geographies where the regulatory pathway is more streamlined and efficient and they have a better line of sight of the regulatory process. Our investors want us to be there too.

Incentives from government are also more significant there. If we were to set up in Singapore, for example, we would have funding for the training and development of individuals there and the salaries and facilities would be subsidised. So there are significant incentives for us to move abroad, and as we think about growing our business it is an important consideration for us.

Lord Drayson: It sounds like the UK is one of the most difficult places to do this.

Will Milligan: Yes, but we have built our business because of the great foundations of biotechnology in this country.

Lord Drayson: That is typically what happens: people start here and then leave.

Will Milligan: Exactly, and I am keen to make sure that we are growing the UK bioeconomy more than anything else, but it is a

challenge. The companies we support are from east-coast and west-coast US and from Europe and Asia. They come here because of the great R&D capabilities that we have, and they expect us to make sure that we have the manufacturing capability elsewhere for them to commercialise those products.

Lord Drayson: If there was one thing a new Government could do to stop you leaving, what would it be?

Will Milligan: Based on what our customers are telling us, it is line of sight in getting these products approved and on the market. The FSA is the main regulator they would have to interact with. It is underfunded and has quite a high backlog post Brexit that it has to process. Singapore, on the other hand, has a very clear framework for the approval process in bringing products to market, and the recommended timelines are about half what they are in the UK. If we can fund regulators appropriately, I would love to see the UK being one of the leading countries in the world to bring these products in and make sure they come to market. They have great benefits; they are safer for people and the environment.

Dr Jim Ajioka: One thing you can do to try to mitigate that a little, which we have done, is to have subsidiaries.

The Chair: Can we leave regulatory for a moment? Lord Berkeley's question is about that.

Q24 **Lord Berkeley:** Who are the main regulators in your sector of engineering biology? To use your question about regulators, are they sufficiently resourced and knowledgeable? From what you have been talking about, is there a lack of ability to recruit people to work with you? I may know the answer, but I would like to hear yours. We have covered other European states, Singapore, the US and other places. How does what the regulatory landscape does and the timescale you mentioned compare with other countries?

Dr Jim Ajioka: I can give lots of answers to that. For us, although our product is not a GM product, our process is, so whoever uses it has to have a GM licence. In the UK, it is pretty straightforward and the HSE is really good at it. We have had contained-use regulations for a long time, and they work really well. Most of Europe is similarly good, because the EU harmonised that a while ago, but going into other countries is a little different. We have had to have laws changed in a couple of places to actually start up, so it is a bigger problem globally because everybody has a different way of doing it.

A lot of products in the textile industry are very textile industry specific, so they will not apply to a lot of other places, but you have

regulations about what it is possible to put on to products and what it is not. Largely, they are not done by Governments but by other types of industry standards companies. We work with one called Ekotex that is recognised globally through the textile and fashion industry. If you comply with it, you have a better chance of getting your stuff into market. We are helping it set standards for the stuff that we are doing now.

Rosemary Sinclair Dokos: We do not have an enormous number of regulators that we deal with regularly. We get all our ISO standards from the BSA, et cetera. The ones that we will obviously start dealing with more once we get our product into clinic are the Medical Standards Agency, the FDA, and all the guys in Europe.

Q25 **Lord Berkeley:** A further question for Will. Are there any problems with these regulators across the world working together? You need to get approval from regulators in many different countries. Are there problems with timescale, what they want, or how they achieve it?

Will Milligan: Yes. For us, and a lot of the customers we work with, we have to look at the requirements of different regulators globally. There is a sense that many regulators around the world are strapped for resources and capabilities, and some are looking at harmonisation more quickly than other industries have previously. There are examples of Governments—Israel, for instance—looking at approved products in other geographies and adopting them, or adopting the approval process of other regulators, to streamline their approval processes, heavily relying on the FDA, the USDA, and the Singapore Food Agency.

Lord Berkeley: You say they are short of resources. Is that because they are not allowed to recruit, they do not have enough money to recruit, or there is not enough knowledge in the industry generally to get the right people?

Will Milligan: For the UK, it is the novel food regulations that these products have to pass through. It is a rigorous scientific process, as it should be, but sufficient resources are needed in order to be able to review these products as they come through approval, to engage with the companies for any additional questions, to make sure that those questions are addressed in a timely manner and, ultimately, to progress these to approval.

Q26 **Baroness Willis of Summertown:** Moving on from regulation to facilities, particularly publicly funded facilities, have any of your companies used publicly funded facilities like the biofoundries or the Centre for Process Innovation? If not, or even if they have, are

there other facilities that you would like to see publicly funded that would really help in moving your companies on?

Rosemary Sinclair Dokos: I do not believe we have used the UK funded ones. We collaborate with the University of Oxford and use a lot of its specialised equipment, things that we might not necessarily have. Over the years, we have built up all our capex and internal R&D capabilities, so we do that less and less, but if there is a piece of equipment or technology that we do not have in-house that is available at one of our collaborating universities, we will go there and use that equipment.

Dr Jim Ajioka: Our experience is similar. Some foundries that have been discussed before, like SimbiCity, were not running when we started up, so we had to build an in-house foundry. This was important for us, because we have to turn over our R&D really fast; our products are colour, and you have to make loads of them, so we cannot sit around and wait to do that.

It comes down to what other places do. I was in Singapore on a British high commission junket talking about engineering biology, and its food stuff was amazing. It has put together a couple of different food sites which basically are wholly about food security. It wants to be able to innovate the food area fast, so it has concentrated on focused institutes on food. That is something we should think about here: to be very focused. It is nice to have a foundry, but it is not focused. It may be better to have a more generalised area where you could not only do the molecular biology in terms of the design-build-test cycle but widen it out so that you have space for doing hardware development and downstream processing. We also had to spend money on mass spec machines and HPLCs, all the analytical tools, and that is expensive. You could have something that is theme-built, like the food agencies.

Baroness Willis of Summertown: Just to follow up on that, though, Rosemary, you are saying that you can use your university collaborations to use their equipment. But presumably that equipment has other uses and has been purchased on a grant for another project. Do you find that a barrier to being able to access the right facilities?

Rosemary Sinclair Dokos: It is normally one to two days of, "Quick. Check this. Is it actually working?" Then we move out. It is all for very early-stage research, so we do not normally—

Baroness Willis of Summertown: It is that next bit where there still seems to be that—

Rosemary Sinclair Dokos: Whenever we have tried to outsource it, those outsourcing partners have to be able to comply with a lot of different customers. Because we are purifying proteins to such an insane degree, when we come in and demand incredibly different processes from everyone else, a learning cycle is required before the product comes out correctly. If there are staff changes and they have not been correctly trained, that might impact our quality of product. We have certain things that are nice and stable that we outsource, but a lot of the other things we use in-house because it is so custom.

Baroness Willis of Summertown: Am I hearing that you think that the Government's foundries and government-funded facilities need to be more specific and more focused on particulars? Again, going back to you your Singapore example, it is on a particular branch of engineering biology. Is that correct?

Dr Jim Ajioka: Yes, I think so. As Rosemary pointed out, sometimes you have different regulations for different kinds of things, even though the product you are trying to make is a protein. They do not all get regulated the same way.

Baroness Willis of Summertown: Will, do you have anything to add?

Will Milligan: Government facilities are really useful for early-stage start-ups, where they need a huge amount of capex and quite simply do not have the time or resources to be able to build them. First-of-a-kind facilities are exactly where government resources should be. Where they span multiple products is where they would be most cost effective. For centres like the CPI, we set out to help early-stage start-ups—like Jim and Rosemary were saying—to be quicker, at a larger scale, and cheaper than traditional facilities. It is what we have built our business model on, because a lot of the—

Baroness Willis of Summertown: Sorry to interrupt, but does that mean you fund facilities then?

Will Milligan: We build our own facilities. Our capabilities are about facilities, and the feedback that a lot of companies come to us with is that they need things quickly, at a high quality, at a low cost, and at a larger scale. That is the demand in the market, so that is what we try to deliver.

Lord Berkeley: Is that why you are in Bristol? Is it better, low-cost, more facilities, or is it just coincidence?

Will Milligan: Bristol is a fantastic place to build a business.

Lord Berkeley: I agree.

Will Milligan: For us, the advantages of being in Bristol are great universities, so it is a great source of talent. There is not a lot of biotech; it is outside the golden triangle, so it removes us from the competitive landscape to try to get talent. We do not see a lot of people moving around. People love living in Bristol, our team loves it there, and it is really well connected. For us, it is a fantastic place to build a business.

Q27 **Lord Rees of Ludlow:** Following the last remark, I would like to ask all three witnesses about the issue of getting skilled people on the staff, all the way from the university-funded down to the apprentice level, et cetera. Are any of you having real problems, and which is the most difficult level of staff to recruit?

Will Milligan: For the biomanufacturing side of things, we need people with more of an engineering mindset. We do not necessarily need a lot of PhD graduates for what we do. We do not do deep research; we do applied engineering and try to solve manufacturing problems. It is not the same kind of skill challenges that deep engineering biology companies need, but it is still a challenge for us. We have to invest a lot in training internally to make sure that we are upskilling the people that we have.

With the growth plans that we have, we hope to be 100 people or more in the next two years, and we are looking at where these employees are going to come from. We need to access better training, or develop better training ourselves, to make sure that we can grow. Also, as I said, we should be expanding globally, so it is about exporting that talent as well to make sure that we can support production elsewhere. So we are thinking outwardly more than inwardly.

Lord Rees of Ludlow: Do you have foreign talent in your Bristol operation?

Will Milligan: Yes, about 50% of our team is from abroad. Most were here already, and we support a number of visas as well. It is a really international team that we have.

Dr Jim Ajioka: We run the range. We have everything from supporting PhD students, to using the BA or BSc apprenticeship programme, to using school leavers. School leavers we train ourselves, which is great, because a lot of them can do very good jobs; they can do BTEC level work without too much trouble. The apprenticeship programme is great. I think we should expand that, actually, because we can train somebody to do a job while they are learning the fundamentals of that job at university level. We need

to have more of that. Supporting PhD students is just because it is interesting for me, mostly. Being in Cambridge and Norwich, it is not a problem to attract anybody. That is just the way it is.

Will Milligan: But it is expensive.

Dr Jim Ajioka: Well, no. That is one of the reasons why we are in Norwich. It does not cost us as much to rent lab space, and it is a fantastic place, because the John Innes Centre, the Earlham Institute, and UEA are there. You have huge talent just sitting there in Norfolk. It is great.

Lord Rees of Ludlow: Dr Dokos, before you answer, I would like to respond to what you said about Solexa and Illumina, which is a real scar on Cambridge in my opinion. I knew the people involved very much and it was a big disaster for Cambridge and for the UK. Could I ask you the same question I asked the other two, although you are operating on a slightly bigger scale?

Rosemary Sinclair Dokos: Yes. I started when we were 200, so I remember what it is like to be much smaller. Internships are fantastic, and getting young talent has been brilliant. We will always say that attracting the right talent for us is difficult, because we have so many STEM subjects, not just production engineering, as you have been saying. Production engineering is an art, but when someone thinks about what degree they should do at university, it is probably not very high up on the list of ambitions. Mechanical engineering, algorithm development, machine learning, AI—all those skill sets are needed. What was really interesting was that when we launched our internship application process this year, we got over 1,000 applicants for machine learning and AI, which was just crazy considering that our machine learning team is far smaller than that.

We have to recruit skills and talent from all over the world. There are very bright minds, and we want the best. Oxford is a great place to come, and obviously since becoming international, since developing an international footprint, if there are particular talents out in the US or APAC who want to stay put, we can also employ them there.

Lord Rees of Ludlow: So just being in the Oxford ecosystem, as it were, is a big plus, or does it lead to greater competition for staff?

Rosemary Sinclair Dokos: There is competition, but we have a very strong vision and entity as a company. I remember thinking that this was it, we had made it, when I jumped into a taxi at Oxford train station and asked them to take me to Oxford

Nanopore, and the guy knew where it was. It was great. We have established a great reputation in Oxford, which helps, so we do attract people.

- Q28 **Lord Lucas:** About 10 years ago, the computer games industry commissioned a report on next gen, which looked at the training available for computer games and said that about 85% of it was rubbish. That was really good for the 15%, and they were able to build reputations, reach out and improve the recruitment pattern as a whole. Do you think there is scope for that in engineering biology: to really use your experience to focus on where the quality is, and then spread that knowledge out around people who might be looking for careers?

Will Milligan: That is one of the strengths of the UK. We have a great understanding of biomanufacturing, and that is something that we can leverage globally to bring companies here, to bring processes and products here, and then to expand our businesses globally but from a base in the UK.

Baroness Northover: Following up on skills, you mentioned the Immigration Rules and you also obliquely mentioned Brexit. Presumably you have been drawing on people, say from Europe, who were already here, but that has become, I would have thought, more difficult. Do you have any recommendations for any new Government on what would improve things as far as you were concerned?

Dr Jim Ajioka: Speed up visas.

Will Milligan: Lowering the salary threshold for people coming to the country would make a huge difference.

Rosemary Sinclair Dokos: Both of those, but also looking at the hybrid working rules. If you have people who could happily be employed in a country in Europe, thinking about how often they are allowed to come out and spend time with the team so they can get embedded and integrated would be really valuable.

- Q29 **Viscount Stansgate:** As you know, the Government have identified engineering biology as one of the five key technologies and set out their own vision in the *National Vision for Engineering Biology*. What would you recommend the Government do, given that they have indicated a spend of about £2 billion over the next 10 years? Let us just assume, for the sake of argument, that it is new money, what type of use should be made of that? What would you recommend the Government do to help make this a success story for engineering biology and for Britain?

Will Milligan: We need to see that investment directed towards skills, which we just talked about, training the next generation of people who will be working in biomanufacturing and engineering biology—as well as in AI, for us—or at least in data management. We generate a huge amount of data and we do not leverage it effectively—we are process engineers and some biologists—and making sure that that is part of the skill set that is coming through is useful.

I would also recommend capital incentive schemes to make sure that we are building infrastructure here—once it is here, it stays here and is an asset that we can leverage for the next 10 to 20 years to make sure that we are building a foundation for the future bioeconomy—and regulatory reform to make sure that we are significantly funding the regulators to make sure that we can bring more of these products to market.

Dr Jim Ajioka: Yes, education is an obvious thing, but there needs to be more government investment, private investment, co-investment of some sort, because every other country that is good at doing manufacturing, or whatever, does that. I do not think we do it well enough here.

Rosemary Sinclair Dokos: Particularly now with the acceleration of all the discoveries that are potentially there due to the ML/AI revolution, it probably brings down the barrier to entry for companies to make the next big breakthrough, so actually there is a risk for the UK in terms of its innovation power. We have been a fantastic innovation power because we have the best universities, the best minds, and fantastic facilities in those universities. If that barrier to breakthrough is reduced with machine learning and AI, you might find that other countries will now be able to catch up on that innovation end.

We have to play to our strengths. The capabilities that we have in universities are fantastic. The massive powerhouses that we have in industry, such as GSK, are brilliant. We do not have a BioNTech, but we have others. It is really about how UK government strategy can pull those two levers together, pull the educational lever with the powerhouses of the UK, so that we can be really well engaged with all the upstarts and new biotech companies to execute on the innovation, because we are going to be in a much more competitive environment for innovation over the next 10 to 15 years.

Viscount Stansgate: I would like to follow up by asking you what you think other countries are doing better than we are.

Rosemary Sinclair Dokos: Jim has opinions about this.

Dr Jim Ajioka: Again, if you look at Singapore, it is doing a lot because it does a lot of government/university/private integration. It does it well and we could learn from that.

Coming back to the model of having topic or food-specific innovation centres would be useful, because there is a very good focus on what you are trying to do, so there is a focus on regulation and all the other things that are involved.

People discount the fact that this country is really good at quirky fun. I am not kidding. I have spent time in the states as well, and people in America are really gung-ho; they just go at it with a sledgehammer effect. We do not have as many resources here, so people have to think a little more. We need to encourage that. That is what this country is really good at: sitting back, thinking, having quirky ideas and developing them. How you put that into business is harder, but that is what we are good at.

Viscount Stansgate: One of you—I forget who—mentioned that China could build a factory tomorrow with 1,000 people just like that. What is going on in China which might prove a formidable competitor in the future in this area?

Rosemary Sinclair Dokos: It has had a lot of investment in academia. The relationship between government, academia and industry is incredibly tight. It can choose strategic areas to focus on and really go for it.

Q30 **Viscount Stansgate:** My last question is entirely different, and it may be irrelevant. To what extent do developments in engineering biology depend on having very high-level computing power?

Dr Jim Ajioka: A lot.

Rosemary Sinclair Dokos: Yes. It is massively accelerated by it. You could have a massive breakthrough in mathematics that would then require less computing power for all biological engineering. It is a vast amount. We work very closely with NVIDIA, which is the leader of the pack in its GPU capability. Things that it has tried to do in the UK, like Cambridge One, may have floundered a little, but certainly building better industry relations with computing superpowers is important.

Dr Jim Ajioka: For us, it is like collaborating with university people who do AI and trying to build different mathematical models that might be more suited to purpose.

Q31 **Baroness Willis of Summertown:** I was struck by one of the things you said: that the priority area should be in education. I was

also struck by the statements you have made where you say internships and apprenticeships are really important and you do not necessarily need the higher-level PhDs. Where would you focus that funding in education, and what sort of education are you talking about?

Will Milligan: I would say the apprentice's side of things, for us anyway.

Baroness Willis of Summertown: Presumably, you need to have people coming through from the school system for apprenticeships. I do not know how much engineering biology is currently focused on in schools.

Dr Jim Ajioka: Yes, but there are also university schemes that should be expanded. We have a student now from UEA who is doing a project with us. He spends part of his time at UEA doing his university studies, and quite a bit of time with us in the company, and it works very well.

Baroness Willis of Summertown: Thank you. I was trying for some clarity. Rosemary, do you have any thoughts on that?

Rosemary Sinclair Dokos: Yes. There is education, there is experience. I do not know whether UEA does, but University of Warwick has manufacturing degrees or apprenticeships that you can do alongside, so it is good to see some of those subjects coming out. It is quite easy for someone to think that they will go to university and do a bachelor in science, but it is quite nice to have one and two-year courses that can move alongside someone's work life to develop different skills. I do not think we are going to get manufacturing engineers out of university knowing exactly what to do. It is always experience plus knowledge.

Q32 **Lord Drayson:** Rosemary, you mentioned the importance of large powerhouses like GSK. To what extent are the large companies in the industries that are going to be disrupted by engineering biology, food, chemicals and pharmaceuticals investing in the scale-up companies through venture arms and so forth, or are they not active, effectively?

Rosemary Sinclair Dokos: I do not know the landscape well enough to offer a factual opinion. I would get a little worried that they are so focused on making sure that their daily business is delivering that they do not worry about whether they are going to get disrupted. If they are going to get disrupted, are they going to get disrupted by a UK company or an external company because we are not really bringing them into the fold here? They do invest

in start-ups, and they have fantastic powerhouses as we all know, but it is speculation rather than factual.

Dr Jim Ajioka: Yes. AstraZeneca is based in Cambridge. It has invested hugely into AI, so it knows where it thinks it is going to go with it. It also collaborates with other companies. Ginkgo Bioworks, which is a giant founder in the states, does lots of work with different companies to try to accelerate their processes. It has made a huge deal, almost half a billion dollars, with Merck to try to accelerate their processing. There are things out there where engineering biology is impacting directly into big companies.

Lord Drayson: Is that investment in the US?

Dr Jim Ajioka: Yes, that is in the US, but the principle is the same.

Q33 **Baroness Neville-Jones:** In the list of things towards the end of our discussion, when asked what the Government could do better, or do that they are not doing at the moment, immigration was mentioned but it was not in your list of things that you would like to see the Government tackle. Is it an issue or is it really not so much an issue? Where do you rate it in the various difficulties you face?

Will Milligan: For us, it is an issue on the horizon. We are aware that, as we want to grow quickly, it will become a bottleneck for us. In the near term, we are focused on where we are going to build our business, the near-term skills that we need to develop in the team and the infrastructure we need to make that happen.

Baroness Neville-Jones: So what is your conclusion?

Will Milligan: Yes, it should be addressed. For us, it is not immediate, but it will be in the future.

Baroness Neville-Jones: Not crucial.

Rosemary Sinclair Dokos: Having better access to missing skills is vital. Like we said, in the initial stages of a biotech company you can get by with a lot of the talent that we have in the UK. To go from 2,000 or 3,000 to 30,000 people in an industry sector in the UK where you do not really have peers, the only talent you are going to find does not reside in the UK. It is not that you have to hire it all from abroad, but it just accelerates it if you bring certain leadership roles in so that you can actually develop the team that you have in the UK. Bringing in someone who has done it before and knows what the hurdles are going to be is a massive accelerator. The local teams learn and then get on with it.

Baroness Neville-Jones: The UK breeds the early talent, or the talent for the early stages, and then there comes a point where we need some entrepreneurial experience.

Rosemary Sinclair Dokos: We just need scale-up experience.

Baroness Neville-Jones: Yes.

Will Milligan: Obviously, start-ups are incredibly resourceful in the UK, and they do a lot with less capital than US counterparts. We have to, because we get five to 10 times less funding than some of our US competitors.

Q34 **Lord Lucas:** Could this committee do our job better if we used AI and, if so, who should we be talking to?

Rosemary Sinclair Dokos: That is an interesting question. Everyone should be looking at how to incorporate AI to improve their output and what they can achieve on a daily basis. Anyone who is not doing that will fall behind. It is a very scary thing to start interacting and asking someone to write notes for you. If you had an AI note taker, you might save an immense amount of hand-ache. There will be a time and a place for it, but of course an enormous amount of due diligence is still required.

Dr Jim Ajioka: People have to start thinking about who is paying for the electricity for large language models.

The Chair: Let me thank our three witnesses in this session. It has been a very interesting session and we have very much appreciated your inputs.