Dr Jim Ajioka – Supplementary written evidence (ENB0051)

Follow up evidence from Dr Jim Ajioka (Chief Scientific Officer at Colorifix)

1. Could you each briefly set out what your company does and what its business model is?

As had been described in your previous discussions, our business is to replace a chemical process with a biologically based one. We build microbes that will produce, deposit and fix pigments onto surfaces. We focus on textiles, so our business has two components, 1) match colours with fabrics then license microbe and growth SOP for the specific fabric to a dyehouse/mill plus charge a royalty per kg of fabric dyed and 2) sell our bioreactors to the dyehouse/mill and sell the media as described in the growth SOP. This later part standardises our process/product and also works as an inkjet-ink cartridge business model.

2. What are the key areas of science involved and how are you hoping to innovate on existing processes or products using engineering biology?

Key areas of science:

- **Chemical colour identification: literature scanning, databases and with Kew Gardens (collaboration on chemical analysis as well)**
- **Bioinformatics for designing DNA that encode enzymes that make pigments from normal cellular constituents**
- **DNA synthesis and assembly for expression in the microbe of choiceAnalytical tools for colour: spectrophotometry, HPLC, Mass Spec**
- **Textile specific analytics: light, wash, rub fastness testing; fabric spectrophotometry**
- **Cytotoxicity and allergenicity testing (3rd party)**
- **Theoretical toxicity and colour prediction, machine learning/AI (with U. Nottingham, Dimitri Karlov (Colorifix), Drs Jonathan Hirst and Richard Wheatly, Innovate UK KTP grant**
- **Fermentation at all scales, ranging from millilitres to 3000 litres (designed and built our own plug-and-play fermenters and media supply-standardization**

3. What are the major challenges that companies and startups face in scaling up from the initial scientific innovation in engineering biology and in your field to large-scale, industrial processes?

ASK YOURSELF A LOT OF HARD QUESTIONS

- **Understanding your potential: convincing proof of principle, market, market entry, competition. What do you know and more importantly what do you not know?**
- **Can you implement a DBTL cycle that works on a time frame required by your product and market?**
- **Estimate how much money you need at each stage**
- **How fast can you produce a product, enter the market and potential REVENUE**
- **Use a Foundry or similar to get metrics for scaling your process**
- **Is scaling feasible within the time frame required, i.e. your funding runway?**
- **Sustainability impacts all EngBio companies and metrics impact your business, does it REALLY make sense? LCA!?!**

Scale-up:

- **Can you produce your product at industrial scale? BUILDING BIOREACTORS**
- **Is your workflow fast, accurate and safe enough for production? WORKFLOW**
- **At scale how competitively priced is your product? COMPETITION IS CHEMICAL DYEING PROCESS (Green premium is a myth, no one with funding money or the market really cares).**
- **How fast can you make your product compared to demand? ALIGNING ALL PARTS OF THE COMPANY**

4. Are there any policy changes the Government should make, or initiatives it should support that would help engineering biology companies to scale up more easily?

To reiterate previous discussions:

- **Grant funding: Make US DARPA type funding available, i.e. from somewhere with deep pockets analogous to the US Department of Defense.**
- **Facilitate EU Horizon 2020 grants (We used a facilitator company to get £2M but it cost us 10%) Grant funding is great because it doesn't impact equity.**

- **Need to increase work force:**
  - **Post A-level: Increase Btech, BA-apprenticeship scheme**
  - **Increase Engbio PhD funding**
  - **Increase University/Industry Postdoc positions (here maybe classify some Postdocs with "student status" so they have more IP freedom?)**
- **Provide scale-up facilities like product-dedicated Foundries (e.g. mixing tissue culture with microbial growth isn't great) and maybe GMP facilities:**
  - **BIOREACTORS for every scale**
  - **COMMON DSP FACILITIES**
  - **ANALYTICAL TOOLS**
- **Look at regulation for things like cultured meat.**

5. How easy is it for startups in the engineering biology sector in the UK to obtain investment?
   - **For seed money, pretty easy, very difficult past Series A**
   - If you have secured funding from Innovate UK or other UK government funding, how was this process? Does it "crowd-in" private investment?
   - **For Innovate UK, we have been 100% successful and it does help but big grants like EU Horizon2020 are proportionately more impactful.**

6. How easy is it for companies that have started-up to scale up? What are the major barriers here?

   - Do they have access to sufficient funds for scale-up of infrastructure, for example from the British Business Bank? If venture capital won't provide these funds, where can they come from?
   - **No experience here, but sounds like a good opportunity**
   - In which areas of engineering biology does the UK have the right ecosystem to scale up – for example, pull from major chemical, fuel, or pharmaceutical companies, or availability of sufficient feedstocks to make a scaled-up business viable in the UK?
   - **No experience but by observation companies can scale enough to bought out.**
   - **Feedstocks depend on the product, we couldn't source our feedstocks at a viable price in Europe/UK.**

   - How should the Government encourage larger companies to take up engineering biology processes or products, and does this require a broader industrial strategy?

- **Depends on the product, so yes. Ginkgo Bioworks made $450M contract with Merck to "streamline production and boost output through cell engineering and protein characterization". For example, for that kind of money, we could probably put together a consortium with AstraZeneca to build a facility to more easily exploit the AI investment they've made…**

7. Who are the main regulators that you interact with as engineering biology companies? What are the major regulations affecting your operations, and the sector more broadly?

    - Are there specific changes in regulation that would significantly benefit the engineering biology sector? For example, does the sector need more ISO standards to grow and develop?
    - **Yes, especially around key organisms and their growth conditions**
    - Are regulators sufficiently well-resourced, in terms of expertise and capacity, to regulate engineering biology? Are they able to move fast enough to keep up with developments in engineering biology?
    - **They could use more, but the organisation of regulation needs serious help as Paul Freemont discussed.**

    - How does the regulatory landscape in the UK compare to that in other countries?

    - **For the most part, it seems pretty good. HSE for example, is great compared to some other countries in terms of GM regulations. Regulations for newer products probably needs review, e.g. cultured meats.**

    - Are there any cross-disciplinary regulation issues when using engineering biology in a field that would not usually be involved in synthetic biology (e.g., medical laboratory standards being applied to cultivated meat production)? Are regulators consistent amongst themselves?

    - **See above. Each industry will have their own set of regulations and standards so it will probably take some work to harmonise. We work with Oeko tex, an industry recognised standards company for clothing safety/sustainability. This includes helping establish standards for bio-based dyes and dyeing processes.**

8. What facilities do you have available for undertaking industrial research in engineering biology? Has your company made use of any publicly funded facilities, such as the biofoundries or the Centre for Process Innovation? How would you characterise the facilities available, and your interactions with them?

    - **We set up a foundry within the company because they original foundry at SynbiCITE wasn't completely running when we started and more importantly, we need a fast DBTL cycle in house. We do work with the Foundry at the Earlham Institute in Norwich as they have excellent facilities some of the analytical tools we need for R&D but not for routine throughput. Our work with the Earlham Foundry has been great and we will continue to work with them on projects.**

    - Which facilities or research infrastructure is the UK lacking that the Government should invest in? In particular we have heard that there is a lack of pilot-scale facilities, beyond proof of concept, to demonstrate scaling up of processes and cost reduction. Is this a fair characterisation?

    - **To reiterate from earlier sessions, the Foundries need money to support staff. We have also started discussions with SynbiCITE to install one of our latest version 300L bioreactors to characterise the machine in scaling up fermentation of microbes we haven't yet used at Colorifix and as a service for more standard microbes. Some government support here would be welcomed as although the cost of a 300L machine is modest compared to other machines of similar capacity, all scaled fermentation requires some infrastructure changes because they are industrial machines, like dedicated floor space/housing, steam, large water capacity and other things that are normally found in a dye house.**

    - You have academic backgrounds and/or your company has arisen as a spin-out from university research. How easy is collaboration between academia and industry in the UK? Where are the major barriers to this collaboration, and how could these be addressed?

    - **Cambridge has been pretty good for the most part, but getting Cambridge Enterprise to understand how to assess technology applications like ours wasn't**

straightforward, unlike biomedical applications where they have experience. They were relatively unobtrusive with a Board seat at the beginning, but again, lack of understanding Engineering Biology and laboratory work led to some clashes.

9. A skilled workforce is crucial for technology and R&D intensive companies to grow. Are there any major skills shortages or positions that you have difficulty hiring for in your company? If so, why do you think this is and what can the Government do about it?

- **No, but then we are in a very strong Cambridge-Norwich corridor. Also the obvious sustainability aspect of Colorifix, colours as output and fashion help a lot in recruiting.**

10. The Government has announced that engineering biology is one of its five priority technologies and has set out its strategy in the "National Vision for Engineering Biology". How have current policy efforts been received and what would you recommend the Government to focus its policy attention, and the headline announcement of £2bn in spending over the next decade, on?

- **s discussed in other sessions,**
    - **Fund Education at all levels**
    - **Continue grants, UKRI, etc. but look for alternative funding mechanisms like US DARPA. This will be true for all of the 5 identified focus technologies, particularly since there should be significant cross-discipline R&D.**
    - **Facilitate EU Horizon2020 grants**
    - **Provide sustainable funding for Foundries**
    - **More lab space for startups**
    - **Review regulation for new markets like cultivated meat**

11. Are other countries doing better or providing more support, and if so, where and what can the UK learn from this?

Yes. Most of it was outlined very well by Paul Freemont.

One major area that has been missed out in the UK is Engineering Plants. The Cambridge-Norwich alliance is world leading and should be supported more. The John Innes Centre (JIC) Norwich, Plant Sciences at the University and the Sainsbury Lab in Cambridge do cutting edge work in Engineering Plants. Professors Jim Haseloff runs the OpenPlant consortium in Plant Sciences, Anne Osbourn

started HotHouse BioEngineering at JIC and George Lomonossoff, Leaf Expression Systems at the JIC, need to be brought in as witnesses for this enquiry.

Outside the UK, Singapore might be a good model as it is essentially a city-state on a small island with 5 million people. They have been involved with the UK on Engineering Biology for over a decade, but aside from their University-level engagement, they have focused on key areas that are important for them, one being food security. Here they have set up the Singapore Institute for Food and Biotechnology Innovation which houses all aspects of food technology. Notably, if a product made here that passes the Institute's regulation and QC, it can go directly to market.

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