Rothamsted Research – Written evidence (LSI0124)

Rothamsted Research is the world's longest running agricultural research institute, globally recognised for excellent science and lasting benefits to agriculture and farming practices over more than 170 years. Our mission is to work from gene to field to secure food production, protect the environment and benefit farmers and communities worldwide.

Our founders were among the scientific innovators behind modern agriculture. The annual contribution of Rothamsted to the economy is estimated at more than £3000 million[1]. Examples of major impacts arising from our research include synthesis of fertilisers (from organic compounds containing phosphate), pyrethroid insecticides that help protect crops from pests and people from malaria; and the experimental statistics (Fisher's statistical tests) that underpin clinical trials and helped to found modern medicine.

Rothamsted Research receives funding from the Biological and Biotechnological Sciences Research Council (BBSRC) in support of strategic, integrated agricultural science through four challenge-led programmes. A fifth programme, on smart crop protection, is among the first funded by the Industrial Strategy Challenge Fund. Rothamsted Research is a founding member of three of four new Centres for Agricultural Innovation (Agri-Tech Centres): Agrimetrics; Centre for Innovation Excellence in Livestock and the Crop Health and Protection Centre. Industrial funding constitutes 10% of total income, including strategic alliances with Syngenta and Bayer.

1. Industrial Strategy

Rothamsted Research welcomes the Government's Green Paper "Building our Industrial Strategy", published in January 2017, and gives full support to its stated overriding objective: "to improve living standards and economic growth by increasing productivity and driving growth across the whole region".

What should be the priority areas for science, research and innovation investment?

Rothamsted suggests four interdisciplinary research and innovation areas should be the focus of future investment.

1.1 Genome editing; to enable tailored and accelerated improvement to crops, livestock and medicine/health.

1.2 Robotics, sensors, machine to machine communication and data integration and visualisation; to enable real-time monitoring, precision engineering and automation. The Rothamsted Field Scanalyser and North Wyke Farm Platform are two examples of unique UK capabilities that exploit state-of-the-art instrumentation, sensor technologies and data informatics for agriculture.

[1] Séan Rickard. Rothamsted Research and the Value of Excellence: October, 2015.

1.3 Remote imaging, satellites and drones; to enable high throughput data collection on physical and natural resources to increase productivity and performance.

1.4 Big Data, Internet of Things and advances in computing power and modelling; to enable more accurate predictions of risks from climate change, pests and diseases, and collection of robust data on environmental impacts.

2. Life Sciences and the Industrial Strategy

Re: Q6[2]. Does the strategy contain the right recommendations? What should it contain/what is missing?

2.1 Rothamsted Research welcomes Professor John Bell's "Life Sciences - Industrial Strategy" report, and recognition of the potential for biosciences to underpin a highly competitive industrial sector. However, we believe the interpretation of Life Sciences is too narrow. Health in people begins with healthy diets. **Provision of safe, healthy, nutritious food, affordable and accessible to all, is a major route to reducing health issues, yet this is entirely missing from the strategy. In our view, this is a major oversight.**

There is a huge opportunity to improve human health through research on nutrient flows from soil→ crop→ human, and soil→ pasture→ animal→ human. To provide one example, accumulating evidence indicates that whilst food supply has increased through yield enhancement, the nutritional value of our staple cereals (such as wheat and rice) has decreased to sub-optimal levels, resulting in deficiencies in essential micronutrients such as zinc and selenium in human diets. Similar trends have been noted in fruit and vegetables. The causes are not yet fully understood (see Rothamsted study "Empty Calories", Shewry et al. 2016, Nature Plant; www.nature.com/natureplants). **There is a pressing need to shift emphasis to "nutrient yield" rather than yield alone.**

2.2 Another omission is recognition of the importance of our natural capital in underpinning health and welfare. Soil, for example, is one our most important natural assets. In England & Wales, soil degradation costs around £1bn per year[3].

Innovation in analytical tools offers a new perspective on soil characteristics, including micronutrients. Mid-infrared diffuse reflectance spectroscopy allows the simultaneous analysis of many soil characteristics compared to the traditional analysis of measuring each characteristic individually. Handheld X-ray fluorescence and diffraction spectroscopy can tell you which elements and minerals are present in seconds. Laser diffraction particle size analysis measures soil texture and micro-aggregate stability in a fraction of the time of traditional approaches. These technologies will help to link soil characteristics with the uptake of

[2] Call for Evidence, HoL Select Committee on Science and Technology, Life Sciences and the Industrial Strategy.

[3] POST note Number 502 August 2015 Securing UK Soil Health.

nutrients by plants in a step towards precision agriculture and improved nutritional quality of crop and animal products for human consumption. One example is the Africa Soils Information Service funded by the Gates foundation (*africasoils.net)* for which Rothamsted Research is the leading organisation since December 2016.

2.3 The Life Sciences Industrial Strategy could place stronger emphasis on public consultation and engagement. One powerful lesson that science might learn from the Brexit referendum result is the need for science to evolve in conversation with a public that not only supports it financially, but also feels genuinely enfranchised in helping to shape its goals and purpose.

3. Strengthening the regions

Re: Q6[4]. How will the life sciences strategy interact with the wider industrial strategy, including regional and devolved administration strategies? How will the strategies be coordinated so that they don't operate in 'silos'?

3.1 We believe the Life Sciences Industrial Strategy would benefit from more explicit cross links to the agricultural sector where digital, data-driven, real-time and precision technologies are already driving transformations in small-scale farmers and large-scale industries alike. **Agriculture produces value for the UK not only by providing food, but also exports. It is an innovative sector producing intellectual property that is exported globally.**

3.2 The 2013 "Strategy for Agricultural Technologies" published by the Department for Business, Innovation and Skills, identified opportunities for economic growth in the agri-tech sector. Stronger cross-sector linkages would strengthen UK competitiveness across *all* industries, and extend reach into *rural regions;* farming businesses provide excellent examples of "local innovation strengths" (Pillar 9 of the Industrial Strategy Green Paper).

3.3 All 10 pillars outlined in the Industrial Strategy Green Paper are directly relevant to the agricultural sector, facilitating routes to cross-sectoral linkages. The Industrial Strategy should encourage support for cross-cutting opportunities that connect leading organisations and companies within regions to meet regional and community priorities. A speedier more efficient replacement of ERDF funding is required to incentivise this, but will require re-examination of state-aid policies and requirement for match funds.

4. Funding the Life Sciences Strategy

Re: Q8[5]. Where should the funding come from to support the implementation of the strategy?

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[4] Call for Evidence, HoL Select Committee on Science and Technology, Life Sciences and the Industrial Strategy.

[5] Call for Evidence, HoL Select Committee on Science and Technology, Life Sciences and the Industrial Strategy.

4.1 The UK should be **spending on research and innovation** at a level that is relative to our competitors and enables the UK to meet its productivity, efficiency and environmental goals; The stagnation of UK public sector R&D spend at about 1.7%. does not compare well with Germany, for example, where the new coalition government under negotiation has agreed a cross-party target of 3.5%.

4.2 Government should also ensure continued access to EU and international funding streams, through negotiating the optimum status and position of the UK in mechanisms such as Horizon 2020.

5. Science and Innovation

Re: Q1[6]. How can investors be encouraged to invest in turning basic life science research into new innovations in treatment? Why has investment been lacking in this sector? Does the research base have the necessary infrastructure to be world-leading?

5.1 The UK has an excellent science base, but there is real danger that **discovery and innovation are being choked by administration**. The demands made of science have become heavily bureaucratic, such that highly creative and skilled people spend less and less time at the coal face doing science with a purpose.

5.2 **We need to recognise and reward translational and applied research.** The current incentive system for scientists (based on the research excellence framework criteria) does not favour working on applied problems. To advance, scientists need to publish high-impact papers which in turn allow them to win grants and achieve promotion. Under such pressures, **many excellent scientists may never conduct research that addresses a practical problem.** It is very difficult to change this culture under the current funding and assessment schemes. Greater weighting should be given to problem-led translational research, to relevance and realistic adoption by users and to the achievement of impactful outcomes.

5.3 We need *much* faster, simpler, mechanisms for funding. For example, ERDF applications run to 80 pages in length, take on average 2 years from initial submission to award letter and require 4-8 revisions of the initial proposal. There are many other similar examples. Such times scales are not commensurate with innovation, exhaust our scientists and put off industrial partners.

6. Science and Intellectual Property

Re: Q2[7]. Why has the UK underperformed in turning basic research in the life sciences into intellectual property? What needs to be done to address this

[6] Call for Evidence, HoL Select Committee on Science and Technology, Life Sciences and the Industrial Strategy.
[7] Call for Evidence, HoL Select Committee on Science and Technology, Life Sciences and the Industrial Strategy.

historic weakness in the UK and grow new companies to commercialise new research and related technologies in the life sciences?

6.1 There are huge gaps in funding for applied research that focusses on improved practices, and the new science, knowledge and skills that this will require. The UK lacks systematic, large, applied research programmes that really address and solve practical problems. The strategic role of our institutes should be recognised in this context. Yet institutes such as Rothamsted and its peers are scarcely mentioned in the Strategies.

6.2 The gaps are particularly evident in the agricultural sector and may be among the primary reasons why Total Factor Productivity growth in the UK has slowed down compared to other countries. With high capital and other costs in UK agriculture, farmers need to be very skilled and need, for example, the best, forward-looking soil, agronomic and livestock husbandry practices in place to succeed. At present, such practical imperatives are not seriously addressed through the investments in research made by funders.

6.3 To resolve the applied research and skills development gap, **the UK needs a new, independently managed, fund for applied agricultural research, in addition to investments made by UKRI and by the private sector.** This fund would help leverage funding from other relevant bodies, together with industry, to pool resources in key areas to develop a challenge led and practical problem-solving approach, thereby harnessing economies of scale-up and encouraging collaborative engagement to improve farming practice and productivity. Such an approach would ensure a continuum of research and a fully integrated innovation pipeline, thus enabling more value to be captured from investments in upstream science as well as the Agri-Tech Centres, such that innovation reaches more of our farms sooner. This approach is recognised as valuable in medical and health innovation and could apply to other sectors.

6.4 **Government should encourage the use of "lean" approaches, which support dynamic, co-development of ideas by researchers and practitioners** so that partners learn by testing "minimal viable products". Government should provide funding for collaborative activities between academics and companies that adopt lean and agile approaches such as "start fast; fail early" principles. Rothamsted Research is applying for funds to develop a new agricultural research and innovation accelerator (AgRIA) to support "short leap projects" as an example of such a mechanism. In Europe, Wetsus, is worthy of examination as a centre where a similar approach has been highly successful (https://www.wetsus.nl/).

7. Skills and training

Re: Q3[8]. What can be done to ensure the UK has the necessary skills and manpower to build a world class life sciences sector, both within the research base and the NHS?

7.1 **We need to up-skill the next generation of innovative scientists** through training and offering funded opportunities for "learning by doing" in supported environments. BBSRC's and UKRI's Impact Accelerator and Seeding Catalyst Funds, competitively available to Institutes and Universities, are an excellent model for provision of flexible funding support. These should be further supported. Many researchers aspiring to establish start-ups fail due to lack of appropriate mentorship and training in the development of business models and inability to attract even small amounts of funding to test their innovations.

8. Scale-Up approaches in agriculture

Re: Q7[9]: What opportunities for small and medium sized enterprises (SMEs) are there/should there be in the strategy? How can they be involved in its development and implementation?

8.1 Start-ups and micro SMEs are changing farming. Although large corporates are investing in digitalization and big data, the farming industry is also adopting technologies directly from entrepreneurs. There is huge potential for growth of micro SMEs in this sector. To encourage this trend, **Government should create a match funding resource, managed by innovation hubs linked with institutes and universities that operate "start fast; fail early" practices**. Wetsus (see Point 6.4), for example, is funded by a 2:1 public: private funding model.

The aim should be to nurture a supportive environment for open innovation, including farmer-led innovation. We also need to re-think our investment and risk models to accommodate longer time-frames and account for disruptive innovation, so-called patient investment.

9. Lessons from international best practice

Re: Q4[10] How does the UK compare to other countries in this sector, for example Germany and the United States?

9.1 The United States has a more entrepreneurial culture, where lean and agile approaches are commonplace. This environment is less risk-averse and funds long-term systematic, large, applied research programmes that really address and solve practical problems (lacking in the UK). Examples are the Department of Bioenergy Centres.

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[8] Call for Evidence, HoL Select Committee on Science and Technology, Life Sciences and the Industrial Strategy.
[9] Call for Evidence, HoL Select Committee on Science and Technology, Life Sciences and the Industrial Strategy.
[10] Call for Evidence, HoL Select Committee on Science and Technology, Life Sciences and the Industrial Strategy.

9.2 The Netherlands could be viewed as trend-setting in business and enterprise. Wageningen University and Research Centre provides an interesting example of applied and translational research, as well as Wetsus, mentioned previously (see point 6.4).

9.3 In Germany, entrepreneurship is encouraged via the bioeconomy cluster of Central Germany (CBP) based at Halle (Saxony-Anhalt) of which the Fraunhofer Centre for Chemical-Biotechnological processes (CBP) in Leuna forms an innovative core. The BioSc Cluster, part of Industrielle Biotechnologie (CLIB 2021) of North-Rhine Westphalia, won public funds of some €20 million when it was set up in 2009. Germany's manufacturing industry is heavily involved in these clusters and they include foreign members such as the Russian Academy of Sciences, and collaboration with Brazil, Canada, Malaysia and closer to home, the Belgian Biobase pilot plant. German clusters are part of the German Bioeconomy 2030 strategy, coordinated by the Federal Ministry of Research and Innovation. This strategy, and the Federal Bioeconomy Council that it created, has made significant impact on the European debate and the development of further bioeconomy clusters, particularly in France Belgium, Italy and the Netherlands. In these countries, such clusters are built on enterprises of all sizes in the manufacturing and large-scale chemical and materials industries. Equivalent examples in the UK, albeit at a smaller scale, include BioVale (York), the Norwich Science Park, the UK Midlands Energy Research Accelerator and the Cambridge Innovation Cluster.

10. Brexit

Re: Q17[11] How should the regulatory framework be changed or improved after Brexit to support the sector?

10.1 Brexit will result in substantive challenges for the food and farming industry. The main concerns for science and innovation will be access to labour, loss of free movement, difficulties in recruiting and reduced opportunity for collaboration with leading experts in Europe.

10.2 A focused push on research and innovation will be needed to sustain a competitive knowledge base and farming industry. The suggestions in points 6.3 to 7.1 would address key issues facing the agricultural sector in the years ahead, including Brexit. In addition, we need to apply innovation approaches to the development of policy such that this supports better practices, informed by evidence.

10.3 **The UK should quickly become a leader in genome editing and GM technologies, and its actual use in farming, translating research into new commercial solutions, or even new industries.** Recent examples include science at Rothamsted Research in which we enhanced the seed oil profile of the commercial crop Camelina by the transgenic accumulation of omega-3 fish oils. This highly acclaimed development provides a drop-in replacement for the current

[11]Call for Evidence, HoL Select Committee on Science and Technology, Life Sciences and the Industrial Strategy.

unsustainable practice of providing omega-3 for the human diet by feeding fish products to fish[12].

10.4 Rothamsted Research convened a workshop with the NFU in November 2016 to discuss "How to deliver an improved UK agri-science sector outside the EU". Attendees included leading organisations involved in agricultural science, technology and knowledge transfer. For detailed recommendations see https://www.rothamsted.ac.uk/news/how-deliver-improved-uk-agriscience-sector-outside-euHeadline.

11. Sector deals

11.1 The issues raised in points 4.1 to 8.1 hold true for sectors beyond agriculture. Resolving these would best enable the UK to exploit the exciting developments that most often occur at the boundaries. We urge an open, connected, dynamic approach.

11.2 Rothamsted welcomes the Final Report of the independent Industrial Strategy Commission, chaired by Dame Kate Barker.[13]

In particular, we echo the following amongst its recommendations:

- **Diffusion of innovation:** World-class innovation happens in the UK but the effects should diffuse throughout the economy. We need to re-link excellence in basic and applied research.

- **A balanced, long-view approach is required**: Decision-making for large strategic projects needs to be overhauled to better account for the potential impact on everyday behaviour. Cost-benefit analysis should apply to the real world, not just to a spreadsheet.

- **Science changes societies by unforeseen discoveries supported by efficient translational strategies:** The Strategy should recognise the state's essential role in driving technological innovation, and focus on diffusion, as much as disruption.

12. **In Summary**, Rothamsted believes it essential that the new Industrial Strategy succeeds, and that in enhancing the environment, health and well-being of the UK it brings the enhanced economic output this promises.

07 November 2017

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[12] Ruiz-Lopez et al, 2014, Plant J 77: 198-208, Successful high-level accumulation of fish oil omega-3 long-chain polyunsaturated fatty acids in a transgenic oilseed crop; http://onlinelibrary.wiley.com/doi/10.1111/tpj.12378/abstract

[13] The Final Report of the Industrial Strategy Commission, November 2017, www.industrialstrategycommission.org.uk