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Application of Synthetic Biology to increased Agricultural Productivity in Australia

SUBMISSION TO THE HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON AGRICULTURE AND INDUSTRY – AGRICULTURAL INNOVATION

Macquarie University welcomes the opportunity to provide this submission to the House of Representatives Standing Committee on Innovation in Agriculture. The submission sets out the role and potential of the field of Synthetic Biology to contribute to agricultural innovation, enhanced productivity and development of agriculture sector skills in the Australian context.

Challenges for Agriculture in Australia

Australian agriculture faces an increasingly challenging future, with slowing productivity growth, the emergence and re-emergence of key biosecurity threats, energy and water security issues, and a fiercely competitive global environment.

Future food security has been identified as a significant economic issue for Australia; in particular, vulnerability to climate change/climate variability, slowing productivity growth, increasing land degradation and soil fertility decline, increasing reliance on imports of food and food production inputs (e.g., fertilisers), and vulnerability to pandemic disease.[1]

It is estimated that the world population will increase to >9 billion by 2050; requiring 60 % more food calories than we produce now [2]. Current food production approaches are not capable of providing these calories without serious adverse environmental impact. Climate change and water stress will both exacerbate these issues and also introduce unfamiliar and unpredictable new challenges (e.g., effects on pest/pathogen behaviour)[3].

Demand for agricultural products, particularly for protein-based foods and value added products, by Australia's local trading partners (especially Asia) will increase in response to growing population and wealth in these countries. Investment in food production (both domestic and internationally) will drive a demand for new knowledge, tools and skills in the agricultural biotechnology space. Given all of these considerations, underinvestment in agricultural biotechnology has been identified as a significant risk for the future capacity of Australian agriculture[1, 4].

Synthetic Biology – The Emergent Biotechnology

Synthetic Biology is the design and construction of new biological parts, devices and systems, and the redesign of natural biological systems for useful purposes [5]. Synthetic Biology has a huge economic potential: in 2013 the global Synthetic Biology market was US$2.1 Bn, and it is expected to expand to US$11.8 Bn by 2018 [6]. Synthetic Biology forms a cornerstone of the growing 'green chemical' industry, which is predicted to comprise at least 22 % of the US$2 trillion global chemical market by 2025 [7].

The relevance of Synthetic Biology across the Australian agriculture sector is far reaching and rapidly advancing. Synthetic Biology surpasses the application of conventional genetic engineering and transcends the breakthroughs of the genomics and proteomics era of the early 2000s. Technologies now enable scientists from across disciplines such as biology, protein chemistry, bioinformatics and engineering to tweak or combine whole biological systems and highly integrated biochemical pathways in ways to reach a positive effect. Earlier this year, engineered tomato plants activated drought protection mechanisms on application of fungicidal spray [8]. In 2009 vanilla was produced in bakers yeast [9] and the commercial release of synthetic saffron is

due in 2016 (Evolva). These examples are just a few of a new generation of engineered foods in development across the world by companies such as Evolva, Monsanto, Bayer Crop Science and Intrexon [11].

However, the breadth of Synthetic Biology extends beyond crop development. Synthetic Biology has potential to benefit farm management through the development of biosensors and integration with agri-intelligence systems to reduce requirements for pesticide and fertilizers, novel microbial recycling technologies and biofuels, as well as with potential in post-harvest applications to reduce risks of product spoilage.

The Australian Academy of Technological Scientists and Engineers report on Food and Fibre [12] states that actions such as reducing methane emissions from livestock, nitrous oxide emission from nitrogenous fertilisers, capturing methane from manure management, and improving soil health and function through carbon sequestration could have beneficial effects on farm performance and profitability, as well as mitigating the contribution of one of Australia's biggest greenhouse gases emitting sectors.

All of these activities are mediated by microbial action and Australian scientists are currently exploring these areas in light of Synthetic Biology technologies without the release of GM organisms into the environment.

Potential, Society, Ethics and Education

The indirect applications of Synthetic Biology can be strongly positioned to enhance Australian agriculture whilst maintaining the "clean, green and safe" perception of Australian produce. Within this context, responsible scientists recognize the need for public education, transparency and open discussion regarding the directions of research, and application in this emerging field.

To this end Macquarie University commenced open discussion on Synthetic Biology at the *Ethics and Regulation of Synthetic Biology Workshop*, conducted on campus in 2014. Macquarie will extend this under a growing leadership, partnered role in Synthetic Biology research and application in Australia and internationally. The University is working with The Ethics Centre to further this discussion and hold the next public event in November. This will bring leading scientists, ethicists and community representatives together to further build discussion on the ethics and applications of Synthetic Biology.

In addition to research, Macquarie is also committed to leading Synthetic Biology education at undergraduate student level. In September 2015 a team of 31 students from the Department of Chemistry and Biomolecular Sciences lead a field of 230 teams from around the world to win a gold medal for their entry "*Solar Synthesisers: a Synthetic Biology Solution to the Global Energy Crisis*" at the International Genetically Engineered Machine (iGEM) Competition, held in Boston. The iGEM Foundation is dedicated to education and advancement of synthetic biology, and the development of open community and collaboration.

National Collaboration focused on Agricultural Productivity through Synthetic Biology

Synthetic Biology research, application, education and governance directed to agricultural productivity within the Australian context are important, as is a national approach in this field.

Macquarie University is leading a pan - Australia collaborative proposal for the creation of a Centre of Excellence in Synthetic Biology. This is the first nationally coordinated initiative with a focus on improving the efficiency, productivity, and sustainability of agriculture through Synthetic Biology.

These elements in combination will contribute to maintain and build Australia's ongoing competitiveness as a high value agricultural producer and exporter and will help address the specific issues of agriculture on our continent. Furthermore the broader potential of this field in other sectors is significant. There is substantial evidence that Synthetic Biology will have major impacts in diverse areas including human health, biofuels and fine chemical production.

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References

1. Anon, *Australia and Food Security in a Changing World*. 2010, Prime Minister's Science, Engineering and Innovation Council: Canberra, Australia.
2. Alexandratos, N. and J. Bruinsma, *World Agriculture Towards 2030/2050: The 2012 revision*. 2012, Food and Agriculture Organisation of the United Nations.
3. WHO, *Climate change and human health - risks and responses*. 2003, World Health Organisation.
4. ACOLA, *Securing Australia's Future program: Australia's Agricultural Future*. 2015, Australian Council of Learned Academies.
5. Nancy J. Kelley, D.J.W., Ellyn Kerr, Aidan Apel, Robyn Beliveau, Rachael Scanlon, *Engineering Bioogy to Address Global Problems: Synthetic Biology Markets, Needs and Applications*. Industrial Biotechnology, 2014. **10**(3): p. 140-149.
6. Bergin, J., *Synthetic Biology: Global Markets*. 2014, BCC Research.
7. USDA, *U.S. Biobased Products: Market Potential and Projections Through 2025*. 2008, United States Department of Agriculture. p. 1-294.
8. Sang-Youl Park, F.C.P., Assaf Mosquna, Jin Yao, Brian F. Volkman, Sean R. Cutler, *Agrochemical control of plant water use using engineered abscisic acid receptors*. Nature, 2015. **520**: p. 545-.
9. Esben H. Hansen, B.L.M., Gertrud R. Kock, Camilla M. Brünner, Charlotte Kristensen, Ole R. Jensen, Finn T. Okkels, Carl E. Olsen, Mohammed S. Motawia and Jørgen Hansen, *De Vovo Biosynthesis of Vanillin in Fission Yeast (Schizosaccharomyces pombe) and Baker's yeast (Saccharomyces cerevisiae)*. Applied and Environmental Microbiology, 2009. **75**(9): p. 2765-2774.
10. Evolva. 2015; Available from: http://www.evolva.com/products/saffron/.
11. Archana Chugh, P.B.a.A.J., *Synthetic Biology for the Development of Biodrugs and Designer Crops and the Emerging Governance Issues*, in *Systems and Synthetic Biology*, P.K.D. V. Singh, Editor. 2015, Springer: Dordrecht. p. 299-325.
12. ATSE, *Food and Fibre: Australia's opportunities*, in *The Australian Academy of Technological Sciences and Engineering*. 2014: Melbourne.