The United Kingdom Science Park Association magazine | Issue 6 | Winter 2018

UKSPA
BUILDING·TECHNOLOGY·BUSINESS

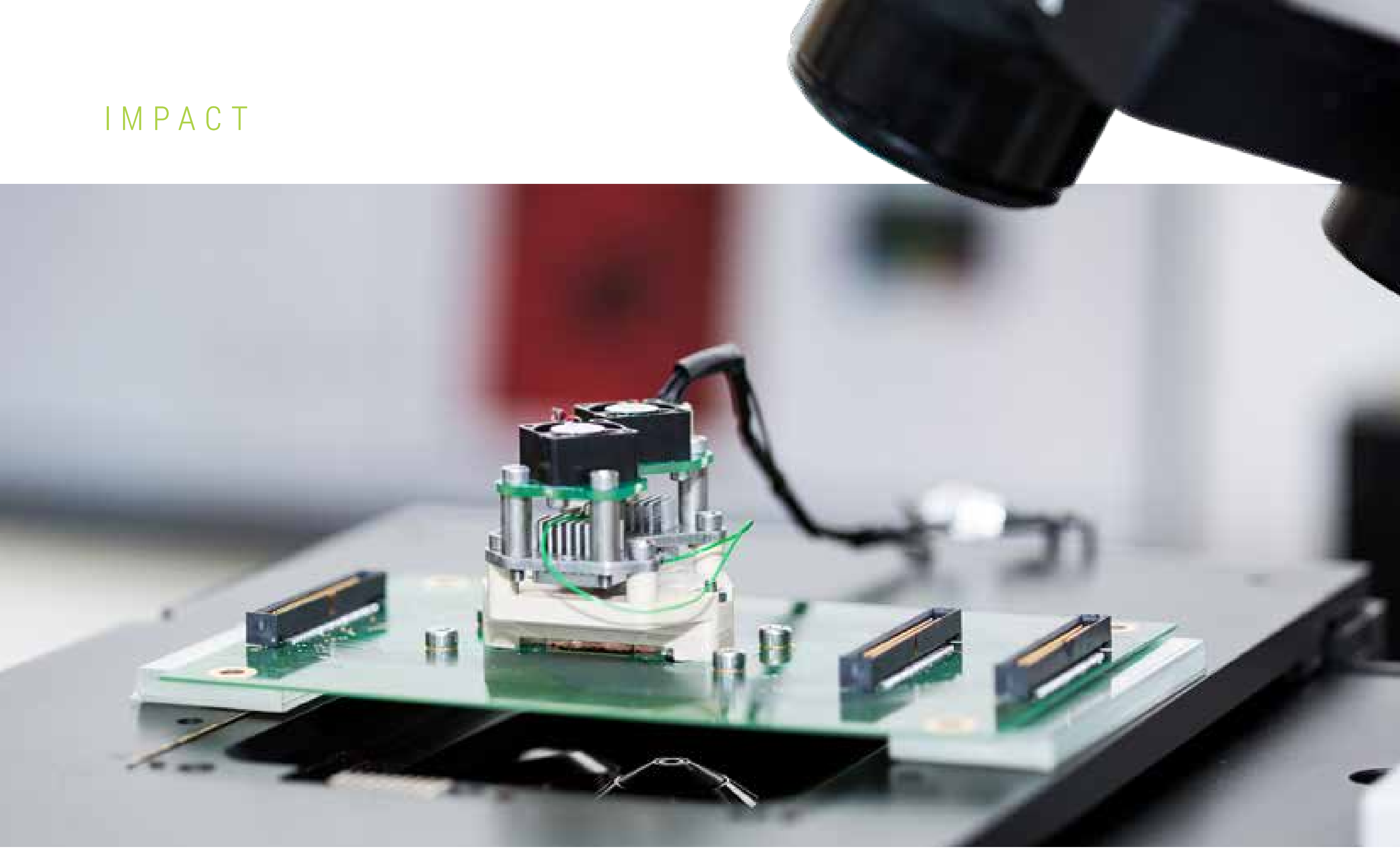
BREAKTHROUGH

Blue Skies Green Fields

The future of farm to fork technology

BREAKTHROUGH | The United Kingdom Science Park Association magazine | Issue 6 | Winter 2018

ukspa.org.uk



Synthetic biology and plant agriculture

An emerging field tackling the need for food supply increases

The world population, currently 7.6 billion, is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100[1]. This growth brings with it unprecedented challenges, not least of which is the need for substantial increases in food supply supported by sustainable and reliable agricultural production. Many technologies will contribute to the required solutions, among them the emerging field of synthetic biology.

Synthetic biology is broadly defined as the design and construction of novel artificial biological pathways, organisms or devices, or the redesign of existing natural biological systems[2]. It is generally accepted that synthetic biology is poised to deliver a wide range of new products and to disrupt industries from agriculture, pharmaceuticals, renewables and industrial biotech. It presents the opportunity to exploit biology as never before and could be fundamental in helping us manage the Earth's resources. In the agricultural field, it not only offers the prospect of improving productivity, but also reducing reliance on petroleum-based products and thus environmental impact.

Dr Tim Brears
CEO, EVONETIX LTD

Tim is CEO of Evonetix, where he leads the company in developing a bench-top DNA writer, to transition DNA synthesis from a service industry to one where scientists can make genes at will. He holds a PhD from Cambridge University and has an MBA from Duke University's Fuqua School of Business

THE HOLY GRAIL

Nitrogen fertiliser[3] is an area of particular interest as this is widely used to support high crop yields. The Haber-Bosch process, the starting point in the synthesis of inorganic nitrogenous fertiliser, produces around 450 million tonnes of fertiliser annually and uses around 3-5% of the world's natural gas[4]. However, there are serious issues associated with the use of nitrogenous fertiliser, as significant quantities of nitrogen are lost to the environment either as greenhouse

SYNTHETIC BIOLOGY IS BROADLY DEFINED AS THE DESIGN AND CONSTRUCTION OF NOVEL ARTIFICIAL BIOLOGICAL PATHWAYS, ORGANISMS OR DEVICES, OR THE REDESIGN OF EXISTING NATURAL BIOLOGICAL SYSTEMS

gasses or as soluble nitrates that find their way into aquatic systems[5,6]. For some time, scientists have considered the possibility of engineering crop plants to fix their own nitrogen in the same way that legumes, through symbiotic Rhizobia, are able to fix many kilograms of atmospheric nitrogen per hectare. This would clearly be a complex and highly challenging process requiring the transfer and optimisation of many genes[7], but significant progress on the underlying biology has been made.

In separate approaches, scientists are looking to engineer microbes as the delivery agent of useful traits. In one example, a company is combining its understanding of the crop microbiome, microbial sequence information and microbial ecology to enable microbes to increase nutrient uptake by crops. In 2018, the company started beta testing its first product, a nitrogen-producing microbe that has had this ability 'reawakened'[8]. Another company, focussed on using synthetic biology to create novel microbial products, believes that its first products are likely to be seed treatments with nitrogen fixation capability[9].

TAPPING INTO THE MICROBIOME

Much like the gut microbiome, which is recognised as a seriously untapped source for use in human health, so the soil microbiome contains a myriad of microbes of potential utility. This rich source can be tapped into by screening millions of microbes, analysing vast quantities of sequence data, recreating and testing new strains and developing these as sources of new biological activities[10].

Using this approach opens new horizons in the development of novel active ingredients (to be developed as traditional agrochemicals), biological products (to be developed as biological pesticides) and transgenic traits (to be engineered into plants). Engineering crop plants with the ability to synthesise a microbe-derived natural fungicide or insecticide would be no trivial matter given the number of genes and optimisation required, but this would be a significant development.

EMERGING FIELD

Synthetic biology is enabled by the vast amounts of DNA sequence information available from a huge array of organisms, and the availability of genomic and metagenomic tools to understand the potential functionality of such information.

Crucial for the achievement of many of the opportunities in synthetic biology is the further development of synthetic DNA synthesis. Whereas DNA sequencing underwent a revolution in the mid-2000s resulting in massive parallelisation and reduction in cost, a comparable breakthrough in DNA synthesis would catalyse many opportunities in this area.

While companies have made great progress in upscaling DNA synthesis, there remain challenges in achieving further scale, greater accuracy and reduced cost. New approaches include the development of ever-smaller sites of synthesis and enzymatic techniques in which base additions are made by template-independent enzymes.

Activated silicon, an approach being pioneered by Evonetix, represents an exciting opportunity to achieve highly parallel, high-fidelity DNA synthesis in an environment without the usual physical separation of reaction sites. Independent thermal conditions at each site are used to localise the reactions and maintain exquisite control of de novo DNA synthesis and assembly.

Overcoming some of the challenges to allow robust, scalable and cost-effective synthesis of high-fidelity DNA will enable DNA synthesis to enjoy a sea change similar to sequencing in the mid-2000s. ■

For further information, please visit: www.evonetix.com

[1] https://esa.un.org/unpd/wpp/
[2] https://royalsociety.org/topics-policy/projects/synthetic-biology/
[3] Journal of Experimental Botany, Volume 65, Issue 8, 1 May 2014, Pages 1939–1946
[4] https://en.wikipedia.org/wiki/Haber_process
[5] Raun WR & Johnson GV (1999); Improving nitrogen use efficiency for cereal production. Agronomy Journal: 91 357–363
[6] Glendining MJ et al. (2009); Is it possible to increase the sustainability of arable and ruminant agriculture by reducing inputs? Agricultural Systems: 99 117–125
[7] Rogers & Oldroyd (2014); Synthetic biology approaches to engineering the nitrogen symbiosis in cereals. J Exp. Bot. 65: 1939-1946
[8] http://pivotbio.com/newsitem/sustainable-nitrogen/
[9] https://joynbio.com/
[10] http://agbiome.com/platform/