



# SynBio SRI

## December 2016 Report

**The Synthetic Biology Strategic Research Initiative provides a hub for anyone interested in Synthetic Biology at the University of Cambridge, including researchers, commercial partners and external collaborators.**

Synthetic Biology is an emerging field which applies engineering principles to the design and modification of living systems. The University of Cambridge has been an important and early contributor in this area. The Synthetic Biology Strategic Research Initiative was established in 2013 with the support of the Schools of Biological Sciences, Physical Sciences and Technology to bring together related activities by researchers across the University.

Academic leadership of the SRI is provided by the Steering Committee, supported by the SRI Coordinator who works with researchers and external partners to implement SRI activities. The major aims of the SRI are to:

1. Provide a hub of interdisciplinary exchange for all those interested in Synthetic Biology at the University of Cambridge, from researchers and students to industrial partners and policy makers.
2. Promote interdisciplinary collaborations across the University through regular events and twice-yearly seed funding competitions.
3. Facilitate funding applications in the field of Synthetic Biology
4. Initiate academic-industrial partnerships across the SRI Research Themes.
5. Explore open technologies for innovation, widening participation in novel IP practices and business models for tools related to Synthetic Biology.
6. Explore the wider social context of GM technologies at the local and global level, particularly responsible innovation for sustainability and conservation.

## 1. Our Achievements 2015-16

The SRI has the objective of building a vibrant, self-sustaining and interdisciplinary community around the new discipline of Synthetic Biology in Cambridge. We see three main areas for development: (i) interdisciplinary exchange, including fostering scientific collaboration, shared curriculum development and participation in large scale funding initiatives, and international leadership in the development of new approaches to (ii) open technologies and (iii) responsible innovation.

**Interdisciplinary exchange:** The SRI provides a hub for exchange and collaboration between the physical sciences, life sciences and engineering to underpin advances in Synthetic Biology. Significant achievements since December 2015 include:

(i) A Readership in Synthetic Biology has been advertised in the Department of Engineering, with the support of the School of Biological Sciences. This is the first new senior synthetic biology position in Cambridge to be created and represents an excellent opportunity to develop interdisciplinary links and synthetic biology research and teaching at the University.

(ii) The Cambridge Synthetic Biology Meetup site<sup>1</sup> provides a hub for engagement and has grown by over 150 members in the last 12 months to a total of 475 with 80-100 active members and 50-100 attending events each month. This includes Cafe Synthetique at the Panton Arms and Science Makers at Cambridge Makespace, which regularly attract varied audiences from both the University and the Cambridge Cluster.

(iii) The Synthetic Biology Forum series provides more formal networking opportunities. Three events have been held since Dec 2015:

a) **Sculpting evolution: engineering biology to address global disease challenges** with Dr Kevin Esvelt (MIT Media Lab) and Professor Luke Alphey (Pirbright Institute, founder of Oxitec Ltd). This was a sold-out event with 100 attendees.

b) **Programmable biology in the test tube** with Dr Vincent Noireaux (University of Minnesota), Dr Nick Rollins (Cambridge Consultants) and Dr Fernan Federici (Pontificia Universidad Católica de Chile and University of Cambridge). 20 attendees drawn from all six schools joined the full-day practical and an additional 30 attendees watched the lunchtime seminars. This workshop was supported by a £500 grant from the EPSRC GCRF IAA.

c) **Synthetic biology for regenerative medicine** with Professor Ron Weiss (MIT) attracted over 80 attendees including a sizeable group from industry e.g. Microsoft Research and Illumina. Prof Weiss' visit was part of an effort to engage with the biomedical community and included a visit to Dr Bon-Kyoung Koo at the Stem Cell Institute.

(iv) The SRI has successfully fostered interdisciplinary exchange at the student level through support of the Cambridge University Synthetic Biology Society, which has grown from 25 members to 200+ over the last year and now has 30-40 students actively engaged in student-led projects. The society are now expanding into biological projects with support from the SRI through an SRI/SRN small grant and an OpenPlant Fund grant.

v) The 2016 Cambridge-JIC iGEM team featured students from across natural sciences and engineering. The team were supported by Cambridge Consultants and won both a Gold Medal and the Best Plant Synthetic Biology Prize (overgrad category) at the iGEM Jamboree, gaining local press coverage<sup>2</sup>.

(vi) Nine SynBio Fund projects were supported during 2016, with 45 team members representing five Schools. Two of the nine awards went to teams whose formation can be traced back directly to SRI activities and five involved industrial collaborators. Notable achievements include:

a) Bernado Pollak and Anton Kan's project 'Synthesis of novel optimised lux reporters for eukaryotic systems' has not only delivered promising genetic markers but after meeting conceptual fashion designer Victoria Geaney in 2015 at an SRI-organised seminar, they launched a fruitful collaboration leading to a bioluminescent garment installation. This featured in the December 2016 edition of WIRED magazine, which has a readership of 270,000.

b) CUTEK organised the UK's first Biohackathon which attracted several hundred applications from around the world. Fifty attendees prototyped hardware and software for biology over four days with industry support from organisations such as Microsoft Research, Cambridge Consultants, SynBioBeta, the London Biohackspace, Bento Bioworks, Synthace and SynBioBeta. The initiative featured on Cambridge TV and Labiotech.eu.

c) A novel collaboration between the Department of Plant Sciences and the Department of Chemistry led to the successful development of a microfluidic device for high-throughput analysis of genetic circuits in plant protoplasts, allowing rapid characterisation and thus quicker identification of DNA promoters for synthetic biology. The device was tested with several plant species and the team have

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<sup>1</sup> <http://www.meetup.com/Cambridge-Synthetic-Biology-Meetup/>

<sup>2</sup> <http://www.cambridge-news.co.uk/business/technology/cambridge-could-lead-way-synthetic-12212106>

been successful in obtaining a follow-on OpenPlant Fund grant to redesign the device for on-chip sorting by fluorescence.

(vii) The SynBio SRI Researcher Directory has been populated with all known students and academics who have interacted with the SRI. Work continues on the website to ensure that our interdisciplinary activities are highlighted and members of the University are able to find relevant collaborators in the field.

**Open technologies for innovation:** We aim to promote the adoption of more open practices for sharing of the new tools required for Synthetic Biology to promote translational research and facilitate international exchange.

(viii) The OpenPlant and SynBio SRI-sponsored common syntax for construction and distribution of eukaryotic DNA parts was accepted for use in iGEM and formed the foundation of the new iGEM Plant Prize. A workshop on the syntax and DNA assembly was held at the iGEM Giant Jamboree, led by Prof Jim Haseloff.

(ix) Open Technology Week in June 2016 featured a total of ten events, from a sold out “Arduino and Sensors Workshop” with the Sensors CDT to a "Technology for Development Workshop" with the Centre for Global Equality and “Improving the research process - discussing an 'open research' position” with the Office for Scholarly Communication, both of which attracted around 50 researchers and students. We piloted an Open Technology for Development Make-a-thon with undergraduate students in the Department of Engineering in collaboration with Centre for Global Equality and this interaction resulted in an extremely popular themed set of Engineering Third Year Projects to which 120 students applied and 12 were accepted.

(x) To facilitate exchange and technology transfer, the SynBio SRI along with OpenPlant has been working with Dr. Linda Kahl of the Biobricks Foundation to draft an OpenMTA: a permissive materials transfer agreement enabling redistribution and commercial use of biological materials as an alternative to the standard UBMTA. Since 2015 substantial progress has been made. The legal wording is now approved by University of Cambridge, Norwich Bioscience Institutes and Stanford University. A video<sup>3</sup> has been produced featuring the SRI Coordinator, Dr John Liddicoat of the Faculty of Law and Daphne Ioannidis from the Research Operations Office. The OpenMTA website is now live<sup>4</sup> and a journal publication is being prepared in addition to efforts to publish the text on the US Federal Register for public comment. The OpenMTA has been discussed at a national level at the Synthetic Biology Leadership Council and at the NIAB Monogram 2016 IPR conference.

(xi) The SRI proposed a Development i-Team project with IfM and Centre for Global Equality on cell-free synthetic biology. A team of eight early career researchers from across all six schools investigated diagnostic and environmental applications in developing countries, mentored by Dr Fernan Fedirici and Richard Hammond of Cambridge Consultants. The SRI successfully bid for a BBSRC GCRF IAA grant to support the continuation of this work and for the i-Team to join forces with CUSBS to deliver early-career researcher led workshops and prototyping projects with a focus on international development. Members of the i-Team will visit partners in South Africa and Kenya to explore local needs and context and seed potential future collaborations.

(xii) The open technology programmes driven through SRI and OpenPlant were presented by invitation at Science Hackday PDX in Oct 2016, where a local group in Portland (OR) led by Oregon Health & Science University are launching a series of events inspired by the SRI's Science Makers programme. SRI activities were also presented by invitation to the Open Biology Forum in London, Nov 2016.

**Responsible innovation for sustainability and conservation:** Social acceptance remains a major potential limitation for the adoption of GM technologies, and the SRI therefore funds work on the wider implications of the technology at local and global scales.

(xiii) The SRI Coordinator has been appointed as an Associate Fellow of the Centre for Science and Policy and co-organises termly lunch meetings with CSaP, Cambridge Centre for the Study of Existential Risk (CSER) and the Office of External Affairs as a node of the Virtual Institute for Responsible Research (VIRI) based at Arizona

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<sup>3</sup> [https://www.youtube.com/watch?v=zt6b8\\_mY-i4](https://www.youtube.com/watch?v=zt6b8_mY-i4)

<sup>4</sup> <http://openmta.org/>

State University (ASU). We now host the web page<sup>5</sup> for this University-wide RRI group and our SRI activities were presented by Lalitha Sundaram at the Annual VIRI Meeting in Spain.

(xiv) The SynBio Forum partnered with CSER, CSaP and the Faculty of Law to explore legal, ethical and regulatory aspects of gene drive technologies for non-human population control. The SRI supported a summer student in Law to investigate comparative regulation of synthetic gene drives and co-authored a briefing paper for a workshop examining this emerging technology in the UK context. The workshop was attended by representatives from government departments, learned societies, research and policy across multiple fields. A whitepaper is under preparation and opportunities to attract an interdisciplinary postdoc to continue work on this issue are being explored.

(xv) In collaboration with CSER, the SRI helped organise an international Bioengineering Horizon Scanning Exercise, which brought together around 20 individuals to select the 15 highest priority but least recognised issues in biological engineering that will impact the world in the next 15-20 years. These included technical advances but also societal considerations and a collaboratively drafted manuscript is under development for publication, which we expect to be picked up by the media.

#### **Other achievements:**

xvii) The SRI has undergone a rebranding exercise to deliver a new logo and visual identity in collaboration with a graphic designer. This complements a corresponding exercise for the OpenPlant Centre. Due to the many activities ongoing underneath or affiliated to the SRI, this has been a major step forward in presenting a coherent and recognisable brand for synthetic biology in Cambridge.

xvi) The Synthetic Biology SRI and OpenPlant stand at the Cambridge Science Festival got a special mention in the report that led to the Plant and Life Sciences Marquee being awarded a prize in the 2016 Cambridge BID (Business Improvement District) Awards through the Science Festival 'mystery shoppers' programme. Our stand received a score of over 94% in the evaluation.

## **2. Context**

Cambridge continues to develop an internationally recognised lead in the area of plant synthetic biology and the adoption of open practices. This puts it in a unique position among other UK universities and centres.

In 2015 we anticipated that there were likely to be substantial funding opportunities through implementation of the draft "Biodesign for the Bioeconomy" report. With the disruption seen through 2016, these opportunities have yet to materialise, but the 2016 Autumn Statement saw the announcement of a £2.0 Bn pa initiative to support UK R&D, including biotechnology. We expect that synthetic biology funding initiatives at a national level will aim to enhance translational research and applications to drive economic growth, building on the earlier funding of the UK Synthetic Biology Research Centres. A major priority of the Synthetic Biology SRI is to better position the University to take advantage of potential new funding opportunities in this area.

The £1.5 Bn Global Challenges Research Fund is another major new opportunity for the the SRI, particularly given our focus on open technologies for international exchange and existing efforts within the University, such as the Arsenic Biosensor project. We will be directing substantial efforts to seeding collaborations in this area, both within Cambridge and with external collaborators, with a focus on Africa and Latin America.

## **3. Plans for 2017**

During the fourth year of SRI activity we plan to converge efforts around key themes while expanding the community further out into the School of Physical Sciences and School of Technology. We will also build on the strong relationships we have developed with the Faculty of Law and CSER in the School of Humanities and Social Sciences to develop interdisciplinary research ideas around open technologies and responsible innovation. These decisions have been taken with a view to better defining our position to become an Interdisciplinary Research Centre, for which we plan to explore external funding opportunities via CUDAR

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<sup>5</sup> <http://www.synbio.cam.ac.uk/initiatives/viri-cambridge-node>

and other mechanisms over the next year. These plans will be aided by new hire Andrew Balmer, who is working 0.5 FTE as the SRI Assistant Coordinator. His contribution to event management and communications activities will greatly assist in furthering our interdisciplinary community building activities.

**Programme on cell-free synthetic biology:** *In vitro* or cell-free synthetic biology is an emerging area of interest using cell-free extracts from bacteria, plants, yeast or other organisms to transcribe and translate engineered DNA (i) over a short time course, (ii) without GMOs and associated containment and (iii) with desiccated extracts that allow room-temperature shipping and use in resource-poor environments. Recent technical advances now allow rapid prototyping of genetic circuits and metabolic pathways with high levels of protein production and this has many applications from production of biologics to paper-based diagnostic tests and biosensors. We see clear potential for interactions between different departments, including CEB, Engineering, Physics and the Institute for Manufacturing. This theme ties together some major strands of activity:

**i) Early-career community building:** Following on from the success of the ‘Programmable biology in the test tube’ workshop in Oct 2016, at least two more early career researcher-led workshops are to be co-developed by the Cambridge University Synthetic Biology Society and Development i-Team along with other interested parties. The two groups collectively have access to £15k in grants to explore variations on collaborative prototyping projects, student-led learning activities and explorations of applications in a development context.

**ii) Curriculum development:** We plan to develop teaching materials and resources for cell-free synthetic biology, using a practical design-build-test model complemented with numerical and computational tools. OpenPlant Funds have been distributed to encourage technical development for ambient temperature shipping and storage and resource development in collaboration with the National Centre for Biotechnology Education. The SRI Steering Committee discussed the possibility of seeking further resources from the Teaching and Learning Innovation Fund to examine how cell-free practicals could be incorporated into undergraduate curricula across three schools and planning is ongoing. Broader discussions are also continuing with CEB, Genetics and SBS exploring the prospect of an MPhil/Part III course that would dovetail with the Part III Systems Biology and MPhil Biological Computing courses and contain a substantial synthetic biology component.

**iii) Fostering open innovation:** Biomakespace has been established as a non-profit organisation and is soon to sign a lease with the University for premises in the Old MRC-LMB, building on initial support from the SynBio Fund which brought together the founding members. The space offers a venue for collaborative work between University researchers and students with scientists, engineers and technologists drawn from the Cambridge Cluster and is already the planned site of the CUSBS student projects.

**iv) GCRF Activities:** We see great potential for upcoming GCRF calls to fund activities in synthetic biology. OpenPlant and the Earlham Institute Foundry successfully bid for BBSRC funding to run a synthetic biology workshop at the University of Pretoria in Feb 2017 which will feature *in vitro* diagnostics and biosensors, transient expression in plants and genome editing for orphan crop species as core themes. This will bring together researchers from the UK and across Africa to discuss at a high level the types of activities and collaborations which might be most beneficial and report back to BBSRC.

The SRI Coordinator and Steering Committee Members have been involved in establishing the Global Challenges Forum, a collection of academics and students in Cambridge chaired by Professor Alan Blackwell (Computer Lab), Dr Alexandra Winkels (Centre for Development Studies) and facilitated by Dr Lara Allen (Centre for Global Equality). The group are meeting to address ways in which responses to GCRF funding could best meet needs presented by civil society and global South NGOs. This will initially be undertaken through civil society workshops and other activities aimed at early career researchers.

**SynBio Forum and other events:** We will continue to run our regular community events and from 2017 arrange a termly high-profile SynBio Forum in conjunction with a partner, enabling us to reach new audiences and bring prominent international speakers to Cambridge. The current plan is to focus on ‘De-extinction and synthetic genomes’ in Lent 2017 for which we plan to approach the Conservation Initiative and ‘Synthetic Biology, AI and Emergence’ in Easter Term with the Leverhulme Centre for the Future of Intelligence, who have already expressed interest. In line with our goals to reach out to the Schools of

Physical Science and Technology we have offered support to the organisers of the Physics of Living Matter conference and plan to arrange Open Technology Week next Michaelmas Term with an expanded maker faire style event.

**Interdisciplinary work on open technologies:** We will pursue further engagement with CSER as they expand their biologically themed research programme and the Faculty of Law in terms of opportunities for interdisciplinary postdocs or Fellows to explore open technologies and responsible innovation. The IfM have recently advertised for a PhD student on OpenIP strategies for emerging technologies and we believe there are further opportunities in this area to complement the pragmatic application of open technologies in the SRI's technical and scientific research-led themes. We plan to produce a whitepaper to follow the Gene Drive SynBio Forum and a second meeting will be held in Hong Kong in Mar/Apr 2017 drawing directly on our discussions.

**Expansion of the Steering Committee:** Several new members have been invited to the 2017 Steering Committee to represent important strategic relationships that we would like to foster and also to give a voice to students and postdocs, particularly given that many of our activities are centred around early career researchers. The newly invited members are:

- Cambridge University Synthetic Biology Society (CUSBS) Representative
- Steven Burgess (Plant Sciences) as postdoc representative
- Florian Hollfelder (Department of Biochemistry)
- Oliver Hader (Sensor CDT and CamBridgeSens)
- Helene Steiner (Designer and Independent Researcher at Microsoft Research)
- Lara Allen (Centre for Global Equality)