OpenPlant Fund Application Form

Title of Project

Plug and play synthetic biology education resource

Primary contact for the team

Dr Payam Mehrshahi
Plant Metabolism Group
Department of Plant Sciences
University of Cambridge
Email: pm579@cam.ac.uk

Team

Team member	Background	Contribution to project
Dr Katia Smith-Litière Biomakespace (fundraising and Partnerships) katia.smithlitiere@biomake.space	Background in plant biotechnology, Innovation and Technology Consulting, Co-founder of Cambridge Science Centre, expertise in informal, hands–on learning and public engagement with cutting edge research.	Katia is the originator of the project concept and will help form and build the interdisciplinary team to deliver the project. Katia will also engage researchers from Norwich and the London Biohackspace community to provide input into the project and help test the prototype resources
Dr Payam Mehrshahi	Payam's research interests concern engineering of photosynthetic organisms to produce high value compounds. To achieve this, Payam is applying synthetic biology principles in microalgae, developing and testing genetic circuits that allow fine-tuning of target metabolic pathways.	The molecular and cell biology techniques that Payam has helped to develop, along with his experience in engineering of gene circuits will directly contribute to the success of this proposal.
Patrick Hickland Plant Metabolism Group Department of Plant Sciences University of Cambridge prh42@cam.ac.uk	Patrick is a PhD student in the plant metabolism group where his research focuses on expanding the molecular toolbox of industrially important marine microalgae through the characterization of inducible expression systems.	Patrick's understanding of molecular microbiology and experience characterizing inducible promoters will contribute to the identification of target circuits and the experimental validation of their suitability.
Tony Naggs Biomakespace tony@biomake.space	Software and electronics engineer, public engagement expertise: organiser of DefCon London and British Science Association volunteer	Tony's experience in electronics is key to developing the hardware for the project
Marek Balint	C/C++ Linux/UNIX professional	Marek is an experienced software engineer with

Biomakespace mareq@balint.eu		interest in molecular biology and will be developing software required for the project
Roger Mason Biomakespace rogermason@ndimension.myzen.co.uk	Electrophysiologist, Director of NDimensions Ltd.	Roger has expertise in neuroscience, electronics and 3-D printing, design and manufacturing small devices and will contribute to the development of the hardware
Norwich synthetic biology researcher (TBC)	Synthetic biologists	Input in selecting example circuits and testing of prototype
London Biohackspace (team member TBC)		Input in selecting example circuits, design electronics circuits, 3-D-printing, testing

Summary

We want to develop a prototype teaching resource that allows audiences to learn about synthetic biology in a hands on way. We aim to bring together an interdisciplinary team of biologists and engineers to develop a plug and play system of physical blocks representing the building components of a genetic circuit which will encourage audiences to learn about physical genetic circuits. The idea is that these example circuits would then be built in the labs at Biomakespace, using pre-existing plasmids where possible. The prototype resources will be tested by the Biomakespace, London Hackspace members and will be used as teaching aids in workshops in and beyond Biomakespace. This project will allow Biomakespace to realise one of its objectives - to teach synthetic Biology to Biomakespace members. Biomakespace will approach organisations that may be interested in using the resources for their key audiences. In the future, Biomakespace may explore running a competition, inviting people to design new genetic circuits and the winning circuit could get synthesized and built in the lab.

Proposal

Aims

Developing an understanding of the modular approach to synthetic biology is necessary in the design and implementation of biological circuits that possess logic gate functionality.. With this project, we aim to teach the concepts of synthetic biology and to develop genetic circuitry skills in key Biomakespace audiences. We will bring together an interdisciplinary team of biologists and electronics/software engineers to create a fun hands on workshop, using plug and play physical blocks to teach the concepts. These circuits would then be built in the labs at Biomakespace, using pre-existing plasmids where possible. The project allows Biomakespace to create a prototype of its first teaching resource to engage participants with synthetic biology and to initiate collaborations with different stakeholders to reach audiences beyond Biomakespace labs. Participants in the workshop will gain knowledge, skills and confidence to participate in multidisciplinary research projects at Biomakespace.

Methods

We want to develop a hands-on way of teaching synthetic biology by allowing people to build logic circuits with physical blocks representing the building components of a genetic circuit. The aim is to build a prototype plug and play teaching tool without the participants needing to solder or code. We will create these resources by bringing together a multidisciplinary team of biologists with molecular biology and synthetic biology expertise and electronic/ software engineers. Blocks will represent inducible promoters, enhancers, inverters, repressors and

reporter genes. We will use an example of a(n) already existing genetic circuit (s). In parallel, we will start developing the plasmids and teaching resources to create the circuits in the labs at Biomakespace.

Biomakespace community meets every Tuesday and Thursday and we envisage that the team will collaborate during a weekly session either the Tuesday or Thursday.

Form team, brainstorm ideas, select suitable circuit examples Milestone: two examples selected, initial approach(es) defined, sensors and outputs selected	1 month
Requirements for system developed, start building of subsystems, Biological plasmids sourced, cloning of gene parts Subsystem prototypes available for testing Design systems	2 months
Develop system with all components, print blocks	1.5 months
Testing of system	1.5 months

Outputs

- A prototype set of physical blocks and sensors that can be connected to create "AND" and "NOR " circuits with a sensor readout that indicates that the blocks have been correctly assembled in the circuit
- A minimum of 2 building logic circuits test workshops with Biomakespace/London Hackspace members and Norwich science outreach community. This will provide us with feedback that will guide our plans for how to improve/make more of the resources
- We will use the prototype to attract additional funding to further develop the resources and to develop an educational workshop that starts with building the physical logic circuit, followed by testing the actual biological circuit in the lab.

Who will be involved?

The core team members have been listed above.

The synthetic biologists will contribute by identifying and selecting and sourcing appropriate biological circuits as examples and start creating the plasmids with the component of the circuits if they don't already exist. We aim to reach out to researchers from Norwich to join the team and provide input ad hoc.

The Electronics/software engineers will create, 3D-print/adapt the blocks with sensors/electronics and create the physical resources

Biomakespace and London BioHackspace members/volunteers and interested 3rd parties will test the prototype resources

Benefits and outcomes

The project requires a truly interdisciplinary team to create the educational resources. The team requires collaboration between molecular biologists/synthetic biologists and electronic engineers/software engineers. Each discipline will contribute their own expertise while learning principles and skills from the other disciplines. We aim to engage Norwich research community and London biohackspace through the project, which will encourage future collaborations and resource sharing. These educational resources will be used to introduce synthetic biology to key audiences through Biomakespace and partner organisations.

Outcomes of the project

- For Biomakespace – a prototype of its first teaching resource to engage participants with synthetic biology and initiating collaborations with different stakeholders to reach audiences beyond Biomakespace labs. Biomakespace will also build a track record in working with local researchers to develop high quality adult hands on teaching resources

- For the Synthetic Biology researchers – developing new skills in electronics and coding through interacting with electronics, software engineers to develop the prototype teaching resource. Exposure to the Biomakespace wider community, meeting people from different science/engineering/art backgrounds but with common interests in learning/sharing new skills
- Electronics and software engineers – develop an understanding of biological/genetic circuits and will gain knowledge, skills and confidence to participate in multidisciplinary research projects at Biomakespace .

The impact of the project will continue beyond the duration of this project as the resources will be further developed and teaching workshops will be created and delivered as part of Biomakespace regular member/outreach activities.

The following audiences will be reached through partnerships with local organisations that already have established links and access to these audiences and the outcomes for 3 key audiences

- Lay audience feel that they are informed and can make decisions based on knowledge and understanding of the topics. We hope to spark interest in bioengineering and inspire curiousity - driven citizen research by providing our audience with an understanding of the practical realities of synthetic biology and promoting longer-term engagement with informal learning and collaborative research in biology. They may become involved in the Biomakespace community, which we will assess via Biomakespace annual membership.
- 16+ year olds will feel inspired and excited by the potential of bioengineering/synthetic biology to address global issues, and encouraging them to continue studying Biology/engineering
- Teachers will gain professional development in synthetic biology, an exciting field of research, and increase their confidence and excitement to bring current research and innovation back into the classroom.

Benefits

The major benefits of the project are that:

- Biomakespace is on its way to develop its first teaching resource to raise awareness, understanding and participation in biology and engineering of biology in the Cambridge area
- A team of biologists, engineers, technologists and others in the Cambridge/London/Norwich will have access to Biomakespace, a space for meeting, co-working and socialising in a creative, cross-disciplinary, community-driven and safe environment,
- The individuals involved in creating the prototype will have developed new skills outside their core are of expertise
- The organisations/groups involved will have a prototype synthetic biology educational resource
- The prototype will be used to attract further funding to continue the development of the resource and the delivery of the workshops in Biomakespace

Sponsor for the research and cost centre

Professor Alison Smith
Department of Plant Sciences
University of Cambridge
Email: as25@cam.ac.uk

Budget

Events at Biomakespace and travel Bringing together the team that will create the resources, travel between Cambridge, Norwich, London Prototype testing sessions with Biomakespace & London Hackspace members, Norwich outreach network and other interested 3rd parties	£700
Hardware and Materials	£2300
2 Elego sensors kits 2 Little bits kits 10 USB bit-wackers 10 Arduinos 3D printer materials - 7 colours Soldering workstation 1x Bentolab (portable PCR/gelelectrophoresis kit for educational settings)	
Reagents	
~10 plasmids from Addgene (a combination of regulatory elements, pre-assembled genetic circuits) Examples Include promoters and terminators, repressors and activators, logic gates (incl shipping costs) Sequencing, enzymes, plasmid isolation kits	£1000
Total	£4000

We currently do not have access to additional funding to develop training and educational resources to teach synthetic biology to members and wider audiences.

The prototype of the plug and play synthetic biology educational tool will be used to attract funding for further developing the resource into robust resources as well as the lab based creation of the circuits as part of a synthetic biology workshop to be delivered in and beyond Biomakespace