Practical Synthetic Biology

Exploring fast and frugal bioengineering
A UK-Africa workshop supported by BBSRC

Practical Synthetic Biology

24 – 27 February 2017
Bakubung Lodge, Pilanesberg National Park, South Africa
Website: http://openplant.org/global-challenges
Hashtag: #practicalsynbio

Aims of the workshop

Synthetic Biology is a new field, defined by the application of engineering principles and approaches to living systems. The field has triggered much excitement over prospects for improved bioproduction, remediation and waste treatment, new medicines and better crops. Internationally, there are large and on-going investments in these areas, which generally require substantial investment in laboratory infrastructure and the deployment of genetically modified organisms. Both of these issues can be highly problematic. BBSRC is funding a series of workshops in order to develop creative priority areas, identify research needs, strengthen established relationships, and develop new linkages relevant to synthetic biology that will impact International Development and meet Overseas Development Aid criteria. The information arising will be used to inform future Global Challenges Research Fund calls.

The 'Practical Synthetic Biology' workshop addresses recent technical advances in biology that have given rise to a different class of cell-free and transient expression systems that are both cheap to deploy and have huge potential benefit for the provision of a wide variety of diagnostics, sensors, vaccines and research materials. We are bringing together key UK and African scientists and application specialists to explore the development and deployment of these new systems, which (i) avoid the complications, delays and regulatory uncertainty associated with uncontained of GMOs, while (ii) providing high level, low cost training opportunities and capacity building.

We will examine the prospects for application of GM-free synthetic biology techniques in Africa for (i) low cost diagnostics and environmental sensors, (ii) programmable cell-free expression systems, (iii) HyperTrans and rapid response vaccines, (iv) biomining and bioproduction, (v) programmed plant breeding (vi) open technologies for biology and (vii) training and education. This study will include identification of potential partners, biological targets, estimation of technical feasibility, feasibility for local use or manufacture, implications for human interaction and social impact, in order to build a priority list for implementation.

Objectives

1. To share knowledge of new technologies: i) Cell-free synthetic biology ii) Transient expression in plants iii) Genome editing in orphan crops.
2. To identify key problems that might be addressed by application of these technologies, to include field applications, research capacity building and education.
3. To generate priority lists for research and investment.
4. To identify a potential framework and pathways for implementation.
5. To identify synergies between UK and African groups and the potential for technical connections between southern and east Africa hubs.
6. To estimate technical and resource deficits, and scale of investments required.

Funded under the Global Challenges Research Fund

The Global Challenges Research Fund (GCRF) is a £1.5 billion fund announced by the UK Government to support cutting-edge research that addresses the challenges faced by developing countries through:

- challenge-led disciplinary and interdisciplinary research
- strengthening capacity for research and innovation within both the UK and developing countries
- providing an agile response to emergencies where there is an urgent research need

This workshop has been convened with support from the Biotechnology and Biological Sciences Research Council (BBSRC) as part of on-going efforts to interact and inform upcoming calls and we foresee substantial opportunities for collaboration with African partners.

GCRF Focus Areas

1. Secure and resilient food systems supported by sustainable agriculture
2. Sustainable health and well being
3. Inclusive and equitable quality education
4. Clean air, water and sanitation
5. Renewable energy and materials
6. Sustainable livelihoods supported by strong foundations for inclusive economic growth and innovation
7. Resilience and action on short-term environmental shocks and long-term environmental change
8. Sustainable cities and communities
9. Understand and effectively respond to forced displacement and multiple refugee crises
10. Reduce conflict and promote peace, justice and humanitarian action
11. Reduce poverty and inequality, including gender inequalities

Organised by

Workshop Participants

The workshop participants represent a cross-section of academics, educators and innovators from the UK, South Africa and elsewhere in Africa. They have been selected due to their interest in synthetic biology and the growth of research and innovation networks to support the application of synthetic biology in the UK and Africa.

Full biographies will be made available on the website: http://openplant.org/global-challenges

Alistair McCormick	University of Edinburgh, UK
Anne Osbourn	John Innes Centre, UK
Bernard Slippers	University of Pretoria/FABI/Future Africa, South Africa
Bruce Sithole	CSIR/UKZN, South Africa
Carol Ibe	University of Cambridge, UK
Eshchar Mizrachi	University of Pretoria/FABI, South Africa
Fernan Federici	Pontificia Universidad Católica de Chile, Chile
Francesca Stoma	BecA-ILRI, Kenya
Geoff Baldwin	Imperial College, UK
Hadrien Peyret	John Innes Centre, UK
Jenny Molloy	University of Cambridge, UK
Jim Ajioka	University of Cambridge, UK
Jim Haseloff	University of Cambridge, UK
John Becker	ACGT: UP/UJ/WITS/ARC/CSIR, South Africa
Karl Rumbold	Wits University, South Africa
Kevin Land	CSIR, South Africa
Lara Allen	Centre for Global Equality, UK
Lucy Ogbadu	National Biotechnology Development Agency, Nigeria
Marian Muthui	Foondi Workshops, Kenya
Mauritz Venter	AzarGen Biotechnologies - Stellenbosch, South Africa
Natalya Nikitina	Wits University, South Africa
Nicola Patron	Earlham Institute, UK
Nox Makunga	University of Stellenbosch, South Africa
Paul Chego	Wits University, South Africa
Steven Hussey	University of Pretoria/FABI, South Africa
Tsepo Tsekoa	CSIR, South Africa
Zander Myburg	University of Pretoria/FABI, South Africa

Timetable

Friday 24 February

17:00	Introductions and mixer
20:00	Dinner

Saturday 25 February

07:00 onward	Breakfast
09:00	Discussions on practical synthetic biology I
10:15	Coffee Break
10:30	Discussions on practical synthetic biology II
13:00	Lunch
15:20	Coffee Break
15:40	Pathways to advanced, sustainable biotechnologies II
17:00	Game Drive (optional)
19:00	Bush braai at boma

Sunday 26 February

05:30	Game Drive (optional)
07:00 onward	Breakfast
09:00	Partnerships for implementation
10:40	Coffee Break
11:00	Reporting Back & Wrap-up
13:00	Lunch
14:00	Breakaway sessions (some delegates leave for airport)
15:30	Coffee Break then more breakaway sessions
17:00	Leisure Time
19:00	Dinner

Monday 27 February (report drafting subgroup only)

05:30	Game Drive (optional)
07:00 onward	Breakfast
09:00	Report Drafting
11:00	Coffee break then more report drafting
13:00	Lunch
14:00	Transfer to Pretoria and OR Tambo

Workshop Themes

The six themes of the workshop are (i) low cost diagnostics and environmental sensors, (ii) programmable cell-free expression systems, (iii) HyperTrans and rapid response vaccines, (iv) biomining and bioproduction, (v) programmed plant breeding (vi) open technologies for biology and (vii) training and education.

Open technologies and training and education cross-cut the technology-driven areas and should be considered throughout the workshop.

Novel technologies for synthetic biology

Cell-free diagnostics and environmental sensors

I*n vitro* synthetic biology, and the use of cell-free extracts offer new ways to develop, prototype and test genetic circuits for diagnostics and environmental sensing. Existing prototype applications include rapid paper-based diagnostic testing for Ebola and Zika Virus and small molecule sensors such as glucose assays. This emerging technology enables engineering of biosensors without the need for genetic modification and in a low-cost manner that makes it accessible for researchers in low-resource settings. Moreover, the ability to study such systems without a fully equipped lab and the reduction of biological complexity makes the system much more amenable to engineering approaches and input from the physical sciences. This meeting will seed interactions between biologists, engineers and physical scientists to explore the potential of *in vitro* synthetic biology and address technical challenges to use in low resource settings.

Transient expression and rapid-response production of human therapies

Enhanced agrobacterium-mediated transient gene expression (agroinfiltration) in plants using the Cowpea Mosaic Virus Hyper-Trans (CPMV-HT) system is a UK-based technology that has been adapted for rapid response production of vaccines. In a DARPA manufacturing challenge, Medicago Inc. produced 10 million doses of an influenza vaccine, 30 days after receiving an emailed sequence file and, similarly, Kentucky BioProcessing produced the ZMAPP monoclonal antibody therapy against Ebola. This technology has huge potential for production of protein and small molecule therapeutics for human and animal health. Given the dangerous fluidity of viral threats in Africa, it could be considered irresponsible not to develop local capacity and expertise. Further, rapid expression platforms such as agroinfiltration are valuable for wider synthetic biology activities and biotechnology applications including metabolic pathway engineering, production of high value small molecules as well as basic applications such as part testing and construct validation.

Transgene-free precision breeding

Programmable nucleases including RNA-guided Cas9 from the CRISPR system have been used to make targeted changes in eukaryotic nuclear genomes. These molecular tools allow the induction of mutations at pre-selected loci, knocking out genes or increasing genetic diversity, resulting in, for example, transgene-free crops with desirable characteristics. Recent examples include low phytate maize, rice resistant to blight, and wheat resistant to powdery mildew. Agencies of several countries, including the USDA and their counterparts in Australia and Brazil, have ruled that such crops fall outside of their regulatory authority.

Innovation systems for fast and frugal biotechnology

New forms of innovation systems including open source models, distributed manufacturing, high-tech hubs, maker spaces and DIY approaches are filtering into biotechnology and potentially democratising its development and application as well as lowering barrier to entry and providing freedom to operate for a more diverse set of actors – from for-profit startups to social enterprises and non-profits. This meeting will examine the contexts in which such changes to innovation systems could be implemented and be impactful.

Training and education

Team-based, project-driven training experiences such as iGEM are already established in synthetic biology but are expensive and not scalable to the benefit of large numbers of students in any one location. Incorporating synthetic biology into undergraduate practical curricular has historically been challenging due to the time and expense involved but faster and frugal technology combined with novel approaches to teaching and learning opportunities. At a graduate and postdoctoral level, there is much scope for improving training opportunities in synthetic biology and developing resources that would be useful in both a UK and African context.

Workshop Sessions

Introductions and Mixer

This is a chance to get to know each other and discover mutual connections and interests. The aims of the workshop will be outlined and there will be an opportunity to ask any questions about the programme and outcomes.

Discussions on practical synthetic biology

Aim
This session aims to stimulate discussion on the technologies presented in Friday's open symposium and generate prioritised ideas about the key areas where synthetic biology might practically be applied to African challenges. The results will frame discussions during the later sessions.

Objectives
1. To share knowledge of new technologies: i) Cell-free synthetic biology ii) Transient expression in plants iii) Genome editing in orphan crops.
2. To identify key problems that might be addressed by application of these technologies, to include field applications, research capacity building and education.
3. To generate priority lists for research and investment.

Pathways to advanced, sustainable biotechnologies

Aim
This session takes the ideas generated in the morning session and identifies pathways to implementation, including relevant context, barriers, bottlenecks and ideas of how to overcome them. Common threads from the focused discussions will be drawn together to describe more general pathways to using synthetic biology and other biotechnologies that could contribute to a sustainable bioeconomy.

Objectives
4. To identify a potential framework and pathways for implementation.
6. To estimate technical and resource deficits, and scale of investments required.

Partnerships for implementation & wrap-up

Aim
This session builds on pathways developed during Saturday afternoon to identify who might be involved in implementing them, including participants and their extended networks but also other partners who might need to be identified and engaged. Synergies between the represented UK and African groups will be a particular focus.

The formal part of the meeting will be wrapped up with a summary of outcomes, re-prioritisation of applications to reflect discussion and refinement since Saturday morning and a discussion of next steps.

Objectives
5. To identify synergies between UK and African groups and the potential for technical connections between southern and east Africa hubs.
6. To estimate technical and resource deficits, and scale of investments required.

Breakaway sessions (subgroup)

Aim
This is unstructured time to allow those who are staying through to Monday to refine ideas from the earlier sessions and think through them in greater detail. There will be an opportunity to feedback progress to the remaining group before dinner.

Report drafting (subgroup)

Aim
The intention of the meeting is to generate a report for BBSRC to inform upcoming GCRF calls and also a whitepaper to share the knowledge and ideas that have arisen from the meeting. This session is dedicated to documenting outcomes and planning any writing tasks to take place after the workshop.

Follow-up and Contact

Outcomes will be shared via the OpenPlant website at http://openplant.org/global-challenges

Questions about the workshop can be addressed to:

- Dr Steven Hussey, University of Pretoria, South Africa (Steven.Hussey@up.ac.za)
- Professor Jim Haseloff, University of Cambridge, UK (jh285@cam.ac.uk)
- Dr Jenny Molloy, University of Cambridge, UK (jcm80@cam.ac.uk)

Participant Biographies

Dr Alistair McCormick

Institute of Molecular Plant Sciences and SynthSys, University of Edinburgh

Email: alistair.mccormick@ed.ac.uk

Web | LinkedIn

Dr Alistair McCormick is a Group Leader in the Institute of Molecular Plant Sciences and SynthSys at the University of Edinburgh. He holds an MSc from the University of Stellenbosch and a PhD from the University of KwaZulu-Natal, which he gained while at the South African Sugarcane Research Institute. He worked as a postdoctoral fellow at the University of Oxford, University of Cambridge and John Innes Centre before joining Edinburgh in October 2013 as a Chancellor's Fellow in plant molecular physiology and synthetic biology.

Alistair's lab works on fundamental and applied aspects of photosynthesis and growth in higher plants and micro-algae. His research focuses on i) finding novel ways to improve the efficiency of photosynthetic carbon capture in plants using synthetic biology approaches, ii) exploiting photosynthesis in micro-algae to generate secondary products and iii) developing tools for dynamic phenotyping of plant growth architecture and performance. Current work includes engineering an algal carbon concentrating mechanism into higher plants, building gene control circuits in cyanobacteria to regulate production of high value pigments, and developing low-cost 3D plant imaging systems (within the Edinburgh Predictive Plant consortium; http://predictiveplant.uk/).

What will make your time feel well spent?

My goal is to identify key strategic research areas where my lab, labs in Edinburgh and the UK could actively collaborate with groups in southern Africa, and ideally specific research groups.

What would you like to share during the meeting?

I would like to share my research interests and those of the Edinburgh Predictive Plant consortium (http://predictiveplant.uk).

Professor Anne Osbourn

John Innes Centre

Email: anne.osbourn@jic.ac.uk

Web | LinkedIn | Twitter

Prof. Anne Osbourn is Director of the Norwich Research Park Industrial Biotechnology Alliance and a Director of OpenPlant. Her lab investigates plant natural products - function, synthesis and mechanisms underpinning metabolic diversification. An important advance from the Osbourn laboratory has been the discovery of gene clusters for specialized metabolic pathways in plants, a finding that has opened up new opportunities for elucidation of new pathways and chemistries through genome mining and for the development of synthetic/refactored clusters for improved/high-value plant traits.

Anne has also developed and co-ordinates the Science, Art and Writing (SAW) initiative, a cross-curricular science education programme for enabling engagement of scientists with society.

What will make your time feel well spent?
Meeting scientists, social scientists, policy makers, educators, and other stakeholders to learn about and discuss the needs and priorities of African science and explore how we might be able to synergise. NB Africa is a huge continent. We are going to need to build on/establish foci.

What would you like to share during the meeting?
I would like to share my work on plant natural products and discuss the potential for synergy with respect to traditional medicines and local knowledge.

Professor Bernard Slippers

Forestry and Agricultural Biotechnology Institute and Future Africa, University of Pretoria

Email: bernard.slippers@up.ac.za

Web | LinkedIn | Twitter

Bernard Slippers is a Professor in Genetics at the University of Pretoria (UP). He is a core team member of the Tree Protection Co-operative Programme and Centre of Excellence in Tree Health Biotechnology in the Forestry and Agricultural Biotechnology Institute (FABI). Bernard's research focuses on the ecology and evolution of insects and micro-organisms that affect tree health, and the development of tools to mitigate their impact. He has received wide recognition for his research nationally and internationally. He has published more than 180 papers, an edited book and a number of book chapters. He is a founding member of the Global Young Academy (GYA) and the South African Young Academy of Science (SAYAS). He has served in the leadership of both these

organizations, including as co-chair of the GYA. Bernard is also a Young Affiliate of The World Academy of Sciences (TWAS). He currently leads the Future Africa project at UP, aimed at developing excellence in transdisciplinary science leadership for innovation in Africa.

Professor Bruce Sithole

Forestry & Forest Products Research Centre, University of KwaZulu-Natal

Email: sitholeb1@ukzn.ac.za

Web | LinkedIn

Bruce Sithole is a Principal Researcher and Director, Forestry & Forest Products Research Centre, University of KwaZulu-Natal/Council for Scientific and Industrial Research, Durban. He is an honorary professor in Chemical Engineering at UKZN where he supervises MSc and PhD students working on biorefinery topics, cellulose chemistry, and pulp and papermaking technologies. His main research focus is on development and implementation of biorefinery technologies, specifically those aimed at beneficiation of forestry, pulp and paper mill wastes. The purpose of the research is to contribute to the revitalization and resilience of the pulp and paper industry by diversifying into biorefinery activities that will add more value to the bottom lines of the mills. He was previously with the Pulp and Paper Research Institute of Canada where he worked on R&DI on pulp and papermaking technologies.

Qualifications:

BSc (hons), chemistry, University of Sierra Leone
MSc, chemistry, University of Aberdeen
PhD, Chemistry, Dalhousie University, Halifax, Nova Scotia, Canada
NRF rated scientist
Publications: Over 90 publications in peer-reviewed journals.

What will make your time feel well spent?

Getting a full picture of the whole value chain, e..g, how synthetic biology can be used to engineer trees with specific properties, e.g., easy to bleach wood fibres; or trees rich with certain phytochemicals.

What would you like to share during the meeting?

Discussions on: currently the forest products industry is extracting only 47% value from trees. What can be done to allow extraction of higher vale form trees?

Ms Carol Ibe

Department of Plant Sciences, University of Cambridge and JR Biotek Foundation

Email: cni21@cam.ac.uk

Web | LinkedIn

Carol N. Ibe is the Founding President of JR Biotek Foundation, a United States charitable organisation established to advance knowledge and technical skills in applied biosciences and STEM in Africa. Carol graduated with a bachelor's degree in microbiology from Nigeria (2003) and a master's degree in molecular biology and biochemistry from Georgetown University, Washington, DC (2006). Carol holds a second master's degree in clinical embryology from the University of Oxford (2009) and she is currently doing a PhD in Plant Sciences at Cambridge University under the prestigious Gates Cambridge Scholarship.

Carol's PhD research aims to investigate accommodation mechanisms for both beneficial and detrimental fungi in rice roots and how these interactions may be enhanced for practical agricultural applications, particularly in Africa. Carol currently combines her research with efforts created by her non-profit to educate, train and empower a new generation of scientists who are capable of improving agricultural productivity, human health, industrial development, sustained economic growth and environmental sustainability in Africa. She is determined to make a difference in Africa's development through her present commitment to strengthen national, regional and international collaborations aimed at improving lives and systems in Africa.

Dr Christian Stutzer

Ticks and Tick-Borne Diseases Group, Department of Genetics, University of Pretoria

Email: christian.stutzer@gmail.com

Web

Dr Christian Stutzer is a postdoctoral fellow in the Tick and Tick-borne Disease research group (Department of Genetics, University of Pretoria), functioning mainly as a senior investigator in the Tick Vaccine Development Program. He has been trained in the discipline of biochemistry, with a background in chemistry and genetics, specializing in the field of molecular parasitology. His technical experience is in molecular biology techniques, proteomics, high-throughput transcriptomics (DNA microarrays), recombinant protein production, cell culture, as well as reverse vaccinology tools (including immuno-informatics) and large-scale sequencing technologies (RNA sequencing). The overall focus of his research interests included understanding the biology of the parasite vector to enable rational selection of targets that can be exploited to control ticks and by extension the devastating diseases that they transmit more effectively. Therefore, the main

research goal is to produce tools (e.g. vaccines) that can improve the health of livestock, as well as food security, for both commercial and resource-poor producers in Southern Africa. Current research includes the identification of novel candidates for rational vaccine design, combining novel immuno-informatics (in silico), proteomic (in situ) and molecular biology tools, as well as in vivo evaluation of candidates in cattle hosts. Additionally, he is part of a greater research project focusing on elucidating the immunological components that are involved in conferring protection in cattle hosts against tick infestation, as well as developing tools for surveillance and elucidation of the mechanism of resistance in South African tick populations to chemical control. A long term goal is the establishment of a platform for the discovery and development of novel vaccines against parasites of agricultural importance in Southern Africa.

Dr Eshchar Mizrachi

Forestry and Agricultural Biotechnology Institute, University of Pretoria

Email: eshchar.mizrachi@up.ac.za

Web | LinkedIn | Twitter

Eshchar Mizrachi is a Senior Lecturer in Genetics and a group leader for systems biology modelling of wood formation in the FMG Programme. His research focus deals with understanding the molecular biology of polysaccharide metabolism, especially cellulose and xylan, during wood formation in Eucalyptus trees. Cellulose is an important raw material for many current commercial high-end value derivatives, and tree species such as Eucalyptus are an important source of cellulose worldwide. The forestry industry is also becoming an important potential resource for renewable bioenergy. A greater understanding of carbon metabolic flux and utilization in secondary cell wall biosynthesis in plants is key to developing successful biotechnology solutions in the future to trees and other biomass-related crops.

He is also very interested in the evolution of land plants, pertaining especially to vasculature and secondary cell wall deposition, as well as synthetic biology and its potential for novel applications in crop biotechnology.

Dr Fernan Federici

Pontificia Universidad Católica de Chile (PUC)

Email: ffederici@bio.puc.cl

Web | LinkedIn

Fernan Federici is a group leader at the Pontificia Universidad Católica de Chile (PUC) in the area of Synthetic Biology. He started his career studying two years of Agricultural Engineering (Universidad

Nacional de Cuyo, Argentina), three years of Molecular Biology (PUC, Chile) and working at Alvarez-Buylla´s lab (UNAM, Mexico) for one year. Fernánobtained his PhD in Biological Sciences from the University of Cambridge and did a postdoctoral research fellowship in Jim Haseloff ´s lab (University of Cambridge, UK). All his education has been kindly supported by the free educational system of Argentina and international scholarships from JP II Foundation; Bill and Melinda Gates Foundation, and Becas LIDER. Fernán´s group promotes open source approaches for bioengineering, science and education in Latin America. He is one of the organizers of TECNOx, a Latin American community that seeks to develop technological solutions to local challenges by applying open source technologies.

What will make your time feel well spent?

Meeting people with similar aims and learning from local participants. More ambitiously, it would be great to create a Latin American-African-UK collaborative team working together to bring biological technologies closer to social development. We could also create a roadmap and concrete plans to start this.

What would you like to share during the meeting?

I would like to share an exploratory project we are initiating in Latin America that seeks to establish a distributed platform of open resources and knowledge in software, hardware and biological technologies for social development. This platform will rely on a growing Latin American network of developers called TECNOx and start with a pilot project on open source fabrication of sensors. It would be great to engage with African and UK partners pursuing similar goals and establish a decentralised network of common resources and distributed developers.

Dr Francesca Stomeo

Biosciences eastern and central Africa – International Livestock Research Institute (BecA-ILRI) Hub, Nairobi, Kenya

Email: f.stomeo@cgiar.org

Web | LinkedIn

Francesca Stomeo was appointed as a Scientist – Capacity Building at BecA-ILRI Hub, in January 2015 after the completion of a three-year post-doctoral fellowship in genomics. She is interested in microbial ecology, genomics, crop improvement and viral diversity. She has worked extensively on microbial diversity studies in different environments, crop diagnostics and improvement, including the understanding of emerging diseases using genomics tool. At the BecA-ILRI Hub she established the genomics platform, currently used routinely for metagenomics, transcriptomics and gene expression analysis in crops and livestock systems and in environmental research projects. As a capacity building scientist, she mentors and supervises visiting scientists and research staff providing them the right environment for their research. She has expertise in microbiology, molecular biology, bio-technology and genomics.

Originally from the South of Italy, Francesca obtained a BSc in Biology from the University of Pavia in the North of Italy, an Advanced Studies Diploma (DEA) in Genetics and Microbial Technologies from the University of Seville (Spain) and a European Marie Curie Ph.D. in Microbiology and Molecular Biology at the Institute of Natural Resources and Agrobiology of Seville (IRNASE), part of the Superior Council of Scientific Investigations (CSIC), in Spain. Before joining the BecA-ILRI Hub in

2012 she was a post doc at the Institute for Microbial Biotechnology and Metagenomics (IMBM) at the University of the Western Cape, (UWC), Cape Town, South Africa.

What will make your time at the workshop feel well spent?

Interacting with the scientific community at the Symposium, understanding research objectives and paving the way for the establishment of new collaborations and partnerships with the BecA-ILRI Hub.

What would you like to share during the meeting?

As a capacity building scientist at the BecA-ILRI Hub, I interact with African scientists from National Agriculture Research Institutes (NARs) in the region and I am conversant with their research priorities and challenges. I think this shared understanding is important for exploring possible collaborations and practical synthetic biology applications in Africa.

Dr Geoff Baldwin

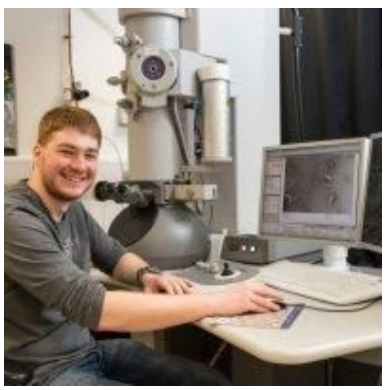
Department of Life Sciences, Imperial College

Email: g.baldwin@imperial.ac.uk

Web | LinkedIn | Twitter

Dr. Baldwin is a Reader in Biochemistry in the Department of Life Sciences and Centre for Synthetic Biology and Innovation (CSynBI) at Imperial College London. He has spent his career at the interface of the physical and life sciences. Having done an undergraduate degree in Chemistry, he moved into biochemistry for his PhD working on DNA-protein interactions and subsequently DNA repair. More recent interests have seen him cross the boundary to engineering in the field of synthetic biology, where his quantitative approach to studying biological systems at the molecular level has found a new application space.

He has been one of the advisors of the very successful Imperial College iGEM teams over the last few years. He has also been responsible for developing the training pipeline of synthetic biologists at Imperial College, having established the final year undergraduate module that is taught across the Life Science and Bioengineering Departments, and being Director of the MRes in Systems and Synthetic biology. He has been involved with setting up the Centre for Synthetic Biology and Innovation where he has an active programme of research in DNA assembly, part characterisation, circuit design and implementation. These are being applied to in vivo approaches to directed evolution for the creation of new specificity and functionality for biosynthetic pathway optimisation. He also has an active programme of research and commercialisation around the use of protein nanocages as drug delivery vectors.



Dr Hadrien Peyret

John Innes Centre

Email: hadrien.peyret@jic.ac.uk

Web | LinkedIn

Dr Hadrien Peyret is a Postdoctoral Scientist in the Lomonosoff Lab at the John Innes Centre.
His research is focused on the production of Virus-Like Particles in plants. Specifically, his project aims to develop a new way of producing vaccines. This new technique uses plants as the expression system, and the core capsid of the Hepatitis B Virus as an antigen carrier. This technique combines genetic elements from numerous viruses, bacteria, and even mammals to create an ideal scaffold onto which proteins of interest, such as antigens, can be attached.

A huge advantage of this technique is that it does not require the target pathogen to be produced in an infectious form, meaning the production process is very safe, and the final product would have no risk of causing an infection. The project brings together numerous techniques from molecular biology, microbiology, plant biotechnology, and biochemistry.

What will make your time feel well spent?

The outcomes that will be beneficial to me (as George Lomonossoff's representative) is to spread the word about our contribution to plant-based synthetic biology (namely, plant-based expression systems). Moreover, I would find it very useful to hear the contributions of others so that I can report back to the Lomonossoff group about recent innovations in the field. In particular I would like to hear about ways to easily share material and knowledge without getting caught up in regulatory red tape.

What would you like to share?

I would like to share the work that our group has done on plant expression systems for overexpression of heterologous proteins in plants. I would also like to share the news about Leaf Systems, the new independent production facility that has just opened on the Norwich Research Park for overproduction of compounds and proteins in plants. This is a success story for plant-based synthetic biology.

Dr Jenny Molloy

Department of Plant Sciences, University of Cambridge

Email: jcm80@cam.ac.uk

Web | LinkedIn | Twitter

Jenny Molloy is the Coordinator for both OpenPlant and the Synthetic Biology Strategic Research Initiative at the University of Cambridge. In this capacity, she assists in building the synthetic biology community in Cambridge and accessing grant funding opportunities. Jenny helps coordinate the OpenPlant seed funding scheme, which has interdisciplinarity and open access to outputs as conditions of the awards. She is deeply interested in the role and impact of open science and open IP in research and innovation and frequently speaks on these topics at local and international meetings.

Jenny holds a DPhil in Zoology from the University of Oxford, where her thesis focused on genetic control of mosquito populations. In addition to her role in the University, she is a founding Director of the Cambridge-based non-profit organisations ContentMine (producing open source software for

text mining scientific papers) and Biomakespace (a community laboratory for engineering with biology) and she co-organises the international Gathering for Open Science Hardware.

What will make your time feel well spent?

I would like to come away with concrete ideas for potential collaborations that could be facilitated through OpenPlant and the Cambridge Synthetic Biology SRI. I'd also like to get a better understanding of the practical barriers to undertaking biological research in contexts where resources and supply chains are limited and contexts in which open source approaches might help or where IP and knowledge sharing are not primary barriers.

What would you like to share during the meeting?

Some of the models for openness in science and innovation have the potential to be transformative, but only in the right contexts. I have been part of projects which aim to explore open and collaborative science for development and would like to share some of their outcomes.

Dr Jim Ajioka

Department of Pathology, University of Cambridge
Email: ja131@hermes.cam.ac.uk
Web | LinkedIn

Jim Ajioka is a Senior Lecturer in the Department of Pathology and Fellow of Jesus College, Cambridge. He received his PhD in Drosophila population genetics from SUNY Stony Brook's Department of Ecology and Evolution and helped establish the Drosophila Genome Project as an NIH postdoctoral fellow in Prof. Dan Hartl's lab at Washington University. Jim's current research combines science and engineering, employing population genetic tools and large-scale molecular biology to i) investigate host-intracellular pathogen interactions using Toxoplasma gondii as a model and ii) implement Synthetic Biology methods for construction of genetic systems in microbes. Both areas of research are underpinned by genomic, transcriptomic, metabolomic, proteomic techniques with associated computational analyses.

Currently, Dr. Ajioka's lab works on large scale DNA assembly of synthetic circuits in Gram positive bacteria and protozoan biology. He is Co-Chair of the University's Synthetic Biology Strategic Research Initiaitive and leads a Wellcome Trust programme to build and employ novel biosensors, using Synthetic Biology techniques. Jim's lab is also funded by the EPSRC for foundational work such as generalised codon optimisation, robust switches and counters and big DNA manipulation.

What will make your time feel well spent?

If we are able to take this meeting forward to further collaborations/capacity building. The best outcome would be to understand how we can contribute to the first question via our expertise in biosensor technology, e.g. teaching, student or postdoc exchange to work on specific projects

What would you like to share during the meeting?

Our experience in the arsenic biosensor project both in vivo and in vitro systems. Along with technical issues, our Responsible Research Innovation experience is probably useful.

Professor Jim Haseloff

Department of Plant Sciedge

Email: jh295@cam.ac.uk

Web | LinkedIn | Twitter

Jim Haseloff is Professor of Synthetic Biology in the Department of Plant Sciences, University of Cambridge, Director of OpenPlant and Co-Chair of the University's Synthetic Biology Strategic Reseach Initiaitve. His lab engineered the first synthetic RNA enzymes with targeted substrate specificity, developed fluorescent proteins for plants, new misexpression systems in plants, new 3D microscopy and visualisation methods and computer models for plant morphogenesis. He has pioneered the application of Synthetic Biology approaches in plants, including new quantitative imaging techniques, genetic circuits for cell-cell communication, and adoption of lower plant systems for bioengineering.

Dr John Becker

African Centre for Gene Technologies (ACGT)

Email: john.becker@up.ac.za

Web | LinkedIn

John Becker completed his postgraduate studies at Stellenbosch University's Institute for Wine Biotechnology. He subsequently joined the CSIR's Systems Biology platform; initially as post-doctoral research fellow and then as senior researcher.

He was appointed as Centre Manager of the African Centre for Gene Technologies (ACGT) in 2011. The ACGT is a collaborative initiative of science councils and universities in the Gauteng region. He has published genomics-related papers in the fields of plant-pathogen interactions and antimalarial drug discovery.

Professor Karl Rumbold

Wits University

Email: Karl.Rumbold@wits.ac.za

Web

A microbiologist by training, Professor Rumbold graduated from the University of Graz, Austria, and started an international academic career at the University of Stellenbosch, South Africa, where he received my PhD. He then held research positions at the University College London and Ghent University, Belgium. Since 2005, he has been Project Manager in charge of interdisciplinary research projects commissioned by leading biotech and chemical companies while working at Ghent University and the Dutch research organization TNO. He accepted a faculty position at the University of the Witwatersrand, Johannesburg (Wits) in 2009 and was appointed Associate Professor in 2015.

At Wits, he founded the Industrial Microbiology and Biotechnology Laboratory. His laboratory has received funding from the DST Biocatalysis Initiative for three ongoing projects, namely "Molecular cloning and characterization of plant fluorinases", "Identification and application of new oxynitrilases from the SA flora for biocatalysis" and "Metabolic pathway engineering of Streptomyces albulus". Two additional projects currently funded by the NRF are titled "Metabolomic interaction between drought-stressed Helianthus annus and Pseudomonas fluorescence" and "Genetic Diversity and Evolution of Saccharomyces cerevisiae in China and Africa".

His future endeavours for growing industrial biotechnology in Africa are:

- to positively influence and stimulate national policy making
- to actively contribute to the growth of the Bio-based Economy
- to better understand Sub-Saharan biosphere diversity
- to functionalize this biodiversity sequence space for industrial applications

Dr Kevin Land

Microsystems Technology Platform Leader

Council for Scientific and Industrial Research (CSIR), Pretoria, South Africa

Email: kland@csir.co.za

Web | LinkedIn | Twitter

Dr Kevin Land is the Platform Leader: Microsystems Technology at the CSIR. Kevin established the BioMEMS and microfluidics technology capabilities at CSIR and has worked extensively on micromanufacturing applications with laser technology at the National Laser Centre. He completed an MSc Physics degree at the University of Pretoria, focussing on the development of nonlinear eye-safe laser systems for range finding. He obtained a PhD in Microsystems Engineering through the Institute for Microsystems Technology (Imtek), University of Freiburg, Germany. Capabilities and

projects in the platform include centrifugal microfluidics, cartridge based microfluidic systems, rapid bacterial detection utilising paper based microfluidics, mobile diagnostic point of care (POC) applications, and printed electronics and biosensors.

Kevin has a passion to develop equipment free or minimally instrumented low cost diagnostics solutions utilising printed functionality and paper substrates - particularly for developing countries where such solutions would have massively transformative impact and have the opportunity to reach billions of people.

What will make your time feel well spent?

- New collaborations/collaboration opportunities - both local and international
- More concrete ways to fund activities, as this is a particular issue at present
- Understanding of new technologies which have the chance to transform diagnostics (health/environment/agriculture/veterinary etc etc)
- Formation of multi disciplinary teams to tackle problem

What would you like to share during the meeting?

- Main thing from my side is to create awareness for engineering platforms available on which to implement biological/chemical etc solutions. Critical for long term success, but often overlooked.
- In this regard, be in a position in forums to share the benefits of developing paper based platforms for limited resource settings
- Discussion of WHO ASSURED criteria, and how the new technologies have the opportunity to address these and other important criteria for developing products for developing world.

Dr Lara Allen

Centre for Global Equality

Email: lara.allen@centreforglobalequality.org

Web | LinkedIn | Twitter

Lara is Director of the Centre for Global Equality (formerly The Humanitarian Centre), a position she has held since October 2014. The Centre contributes to greater global equality by enhancing access for people in the developing world to resources that would not normally be available to them. The Centre works with communities to identify and resolve problems in collaboration with a broad network of civil society organisations, businesses and academics. Innovative solutions to global challenges are evolved through the Centre's Global Goals Innovation Cultivator (GGIC), which takes innovations through a five stage process from problem identification to impact.

Lara has extensive experience working in academia and in international development. Previously, she was Head of Research, Monitoring and Evaluation at the Irish NGO Misean Cara, and Executive Director of Tshulu Trust, a non-profit organisation that promotes sustainable development in an underdeveloped rural part of South Africa's Limpopo Province. She has a particular interest in evolving effective models of interaction between universities and poor communities that make university capacities and resources available to poor communities in a mutually beneficial manner.

Lara holds a PhD in Ethnomusicology from the University of Cambridge. She spent several years in South Africa, where she was a Senior Lecturer and Associate Professor at the University of the Witwatersrand in the Wits School of Arts and the Wits Institute for Social and Economic Research (WISER).

Professor Lucy Ogbadu

National Biotechnology Development Agency (NABDA), Ministry of Science and Technology, Abuja, Nigeria

Email:

Web |LinkedIn |Twitter

Lucy Ogbadu is a Professor of Microbiology and Director-General of the National Biotechnology Development Agency (NABDA), Ministry of Science and Technology, Abuja, Nigeria. She lectured at her alma mater Ahmadu Bello University, Zaria, Nigeria after her Master's degree in 1980 and later at the Benue State University, Makurdi, Nigeria. She obtained her Doctorate degree in Industrial Fermentation in 1988 and had a productive stint in academia having researched and supervised many Ph.D., M.Sc. and Undergraduate Students in Food/Industrial Quality Assurance. She has also published extensively in high impact International journals, Encyclopaedia, Proceedings and Reports.

Professor Lucy Ogbadu has held executive positions in several professional associations. She was appointed as one of the pioneer staff at the National Biotechnology Development Agency, NABDA, Nigerian 2002, where over the years as a Director, she actively coordinated activities of various departments, namely Research and Development, Bioentrepreneurship, Food and Industrial Biotechnology. She also served as Research Director before being appointed Director General/CEO of NABDA in November, 2013. As Director-General of NABDA, Professor Lucy Ogbadu has led the establishment of many initiatives and collaborations both nationally and internationally. Her absolute dedication and efforts to advance biotechnology in Nigeria contributed to the successful passing and signing of the Biosafety Bill into law in Nigeria in 2015.

What will make your time at the workshop feel well spent?

My time would be well spent if I return to Nigeria with the requisite information for setting up an efficient programme/project in the field of Synthetic Biology within the elaborate structure of the National Biotechnology Development Agency (NABDA).

What would you like to share during the meeting?

On-going activities

i. We are currently building NABDA's R&D capacity using the limited resources available;
ii. We have excellent elaborate organizational structure that provides wide platforms evenly spread across the country in the six geo-political zones of Nigeria (Zonal Centers of Excellence) for coordination of biotechnology research and development.
iii. We have twenty-six Bioresources Development Centres established for exploration of Nigeria's biodiversity (Flora and Fauna) for maximum benefits towards achieving food security, improved health of the nation and environmental sustainability.

iv. This elaborate structure is a framework for efficient coordination of biotechnology and biosafety research work in Nigeria.

v. Given the vast scope of work that needs to be done in these areas, we will require collaborations with the research institutions in the UK and other countries to strengthen this work to meet up with global trends of human capacities and modern facilities development.

EXPECTED OUTCOMES

i. Programme Plan of Work that fits into NABDA's elaborate structure for research in synthetic biology;

ii. Specific commitments for joint research infrastructure support on the proposed collaboration; and

iii. Specific commitment on human capacity development support.

Ms Marian Muthui

Mechanical Engineer

Founder, The Mekatilili Program

Email: marianmuthui@gmail.com

Web | LinkedIn

Marian Muthui is an engineer, innovator and educator from Nairobi, Kenya. She holds a Bachelor of Science in Mechanical and Manufacturing Engineering from the University of Nairobi and is a Young and Emerging Leaders Project (YELP) Fellow.

Professionally, she has worked for General Electric (GE) Healthcare as a Field Engineer, where she was involved in providing technical healthcare services and solutions to clients specializing in MR, CT, Ultrasound, Maternal Infant Care and Monitoring Solutions equipment. In this role, she was the recipient of the GE Special Recognition Award for Creating Sustainable Healthcare Transformation in Kenya.

With support from International Development Innovation Network (IDIN) and the D-Lab at the Massachusetts Institute of Technology (MIT), she founded The Mekatilili Program that holds design, engineering and mentorship workshops in girls' high schools in Kenya. For this initiative, she was awarded the 2016 Community Leadership Award by Women in Energy (WIE). She is also the co-editor of Queengineers that is a free, digital magazine that seeks to increase representation of African women in engineering.

Passionate about design thinking, bioenergy, design research, engineering, renewable energy and sustainable energy technologies, Marian has been involved in several community development projects and co-authored the publication: Democratizing Technology: The Confluence of Makers and Grassroot Innovators.

Dr Mauritz Venter

AzarGen Biotechnologies

Email: mauritz@azargen.com

Web | LinkedIn

Mauritz is co-founder and CEO of AzarGen, a biotechnology company focused on developing high-value compounds using advanced genetic engineering and synthetic biology techniques in plants. Mauritz conducted genetic research at Stellenbosch University, completing two postdoctoral fellowships (in plant biotechnology and human genetics respectively) and worked as a contract researcher and lecturer. He was part of the first group of postdoctoral fellows in South Africa to receive the National Research Foundation Innovation-Fund postdoctoral bursary in 2005-2006. During his postdoc fellowship in human genetics, he attracted funding and served as project leader of a Self-Initiated MRC (Medical Research Council-SA)-project. He has presented papers at several national and international conferences and authored or co-authored 15 research, book chapter and review articles in biotechnology and medical genetics. After completing a productive internship at a business management consultancy, he decided to combine his passion for science with business to become a bioentrepreneur.

What will make your time feel well spent?
A clear 'road-map' of what needs to be achieved with this workshop and how AzarGen can play a role as potential commercial partner for R&D projects. Our role would also include fundraising.

What would you like to share during the meeting?

Although we currently focus on biopharmaceuticals and we have developed molecular tools (synthetic promoters) for applications in plants, we would want to explore potential collaboration opportunities with special emphasis on: GENETIC ENHANCEMENT OF TOBACCO FOR HIGH-VALUE COMPOUNDS.

Dr Natalya Nikitina

Wits University

Email: natalya.nikitina@wits.ac.za

Web | LinkedIn

Natalya Nikitina did her postdoc in Prof Bronner lab at the California Institute of Technology. She is a Senior Lecture at the University of the Witwatersrand, Johannesburg. Her research interests include avian sex determination and engineering transgenic avians for agricultural and biomedical applications.

Dr Nicola Patron

The Earlham Institute

Email: Nicola.Patron@earlham.ac.uk

Web (Lab) | Web (Earlham)| LinkedIn | Twitter

Dr. Nicola Patron is a Group Leader in Synthetic Biology at the Earlham Institute. Her work aims to develop technologies to engineer photosynthetic organisms for the biosynthesis of high-value products and therapeutics, and to improve the yield potential and nutritive value of crop plants. Her broader scientific interests are in understanding the regulation of gene expression and the mechanisms and consequences of gene transfer events. As a SynBio LEAP fellow Nicola was recognized as an emerging leader in synthetic biology with a desire to ensure that synthetic biology has positive social impact; she is interested in the complex questions of ownership and intellectual property that surround genetic sequences and biomolecules and how these influence attitudes towards biotechnology.

What will make your time feel well spent?

- Understanding the research priorities and aims of the host and visiting nations.
- Identifying research themes/areas that the UK has in common with other nations.
- Identifying areas, particularly in host and visiting countries, where biotechnology/synthetic biology is likely to able to provide a good and widely-acceptable solution to real-world problems.
- Understanding any non-technology (e.g. political, social, regulatory) obstacles to implementing a biotechnology-based approach or solution.
- Identifying projects and partners with which we can build scientific collaborations.
- Gaining knowledge of existing research programs that fall within the scope of the Global Challenges Research Funding, to which we could potentially contribute.

What would you like to share during the meeting?

- Scientific capabilities and research interests - personal and of my Research Institute.
- Experiences in building community through the application and adoption of standards.

Professor Nox Makunga

Department of Botany & Zoology, University of Stellenbosch

Email: makunga@sun.ac.za

Web | LinkedIn | Twitter

Professor Nox Makunga is a Medicinal Plant Biotechnology expert. After obtaining a PhD in plant molecular biology from the University of KwaZulu-Natal in 2004, she joined Stellenbosch University in 2005.

Makunga's research focuses on the application of biotechnology to Cape medicinal flora. Both transgenic and non-transgenic alterations to specialised metabolism are examined using

metabolomic approaches. She is also interested in people-plant interactions, including the cultural significance of plants and the associated opportunities for socio-economic development.

What will make your time feel well spent?

Looking forward to interacting with other researchers and being able to set up collaborations for future research activities. I see direct applications to my specific area of medicinal plants. I work on plants that are mostly poorly known in terms of their chemistry and general molecular biology. Being able to fast-track our knowledge in these species would be most useful as this will add value to our research activities. Accessing 'new' and/or better technologies is also important to be able to study the local medicinal flora of SA.

What would you like to share during the meeting?

The potential there is in terms of SA biodiversity and this may not be directly obvious to some as we do not work on model species but there are possibilities for the discovery of novel genes and chemical entities that may be useful.

Mr Paul Chego

School of Chemical and Metallurgical Engineering, Wits University
Web | LinkedIn | Twitter

Mr. Mogopoleng Paul Chego, an nGAP (new generation of academic professional) appointment as lecturer. Mr. Chego is a Wits graduate and currently working towards a Ph.D degree in Chemical Engineering under the supervision of Ass. Prof. Craig Sheridan and Dr. Kevin Harding in the Industrial and Mining Water Research Unit (ImWaRu) in the School of Chemical and Metallurgical Engineering. His research interests revolve around renewable energy obtained from wastewater and water remediation, and sustainable technologies thereof. He possesses knowledge and experience (through training and/or workshops) as a Technology Market Analyst, Technology Entrepreneur and Postgraduate Scout (formerly known as Intellectual Property ambassadors).

His PhD work aim to implement a Wits patented anaerobic fluidized granular bed (AFGB) bioreactor. This work was entered in the Jozi My Beginning competition 2016 (launched to find Johannesburg's most innovative township social entrepreneurs) and advanced to the semi-finals. In addition, the reactor characterisation work that Mr. Chego has done was accepted for presentation at the Water Institute of Southern Africa (WISA) 2016 conference. The paper he wrote for the conference won 3rd place Best Technical Paper.

Dr Steven Hussey

Department of Genetics, Forestry and Agricultural Biotechnology Institute, University of Pretoria

Email: steven.hussey@up.ac.za

Web | Twitter

Dr Steven Hussey is a Lecturer in Genetics and group leader for research in the transcriptional and epigenetic regulation of wood development in the Forest Molecular Genetics Programme at FABI. His group uses transcriptomics, DAP-seq, transgenesis, transient protoplast transfection and bioinformatics to functionally characterize key Eucalyptus transcription factors. Currently, they are exploring cutting-edge high-throughput techniques for rapid reconstruction of secondary cell wall transcriptional networks in Eucalyptus using cell-free expression systems and in vitro binding assays (DAP-seq). They are also interested in understanding the role of chromatin architecture in shaping transcriptional responses and their differences between tissues. In addition to understanding the fundamental biology of wood formation, they hope to enhance economically important woody traits through manipulation of transcription factors regulating particular aspects of wood formation.

A Mandela Rhodes Scholar, Steven has served as the instructor of the 2015 and 2016 Pretoria_UP iGEM teams and is helping to develop synthetic biology education and research at UP. He is the recent recipient of a US Department of Energy Joint Genome Institute DNA synthesis community grant to synthesize several hundred secondary cell wall-related Eucalyptus transcription factors and promoters as standardized DNA parts.

What will make your time feel well spent?

I'd like to build new networks that would complement the work we're doing in woody biomass improvement through downstream applications of biomass in biorefineries and chemical products. Since we operate on the scale of long-term GM product development, finding ways of using short-term synthetic biology techniques for our research would be beneficial for us.

What would you like to share during the meeting?

The main contributions from me would be my experience with iGEM as 2015/2016 Pretoria_UP instructor, as well as my recent work in developing a panel of synthetic transcription factors and promoters in *Eucalyptus* that was funded by the DOE JGI.

Dr Tsepo Tsekoa

CSIR

Email: ttsekoa@csir.co.za

Web | LinkedIn | Twitter

Tsepo Tsekoa is a protein biochemist qualified at doctoral level (PhD). His main expertise are in the combined fields of applied biochemistry, structural biology and recombinant production of biologics, including reagent proteins, vaccines and antibodies. In recent years Tsepo's R&D focus has been on developing plant-based (N. benthamiana) and microbial fermentation production processes for biologics manufacture at bench (and for some markets at pilot scale), with an emphasis on downstream processing aspects.

He has expert knowledge of filtration and chromatography as applied to biomanufacturing process development at these scales. In his current environment as Research Group Leader at CSIR's Biosciences unit, Tsepo's main expected tangible output is in the form of technology demonstrators at a maturity of technology readiness level of 5-6. At the same time he continues to pursue an applied research program towards the production of biologics, enzymes and reagent proteins (antibodies and metagenome-derived DNA manipulating enzymes).

Professor Zander Myburg

Forestry and Agricultural Biotechnology Institute, University of Pretoria

Email: zander.myburg@up.ac.za

Web | Twitter

Zander Myburg is Professor of Forest Genomics and Biotechnology at the University of Pretoria. His research focuses on the molecular genetics and genomics of wood formation in fast-growing trees such as Eucalyptus species and their hybrids. He is particularly interested in the molecular basis of quantitative variation in growth and wood properties and the development of biotechnology solutions to improve these properties in trees. Zander's research programme has pioneered the application of genomics technologies, in particular transcriptome profiling by RNA sequencing, for population based analysis of xylem development. Integration of such data with other sources of biological data such as wood chemistry traits and metabolite profiles allows a systems genetics approach towards understanding of the complex biology of wood development.

Feedback form

Please use this section to note thoughts and ideas. This part of the booklet will be collected at the end of the meeting and used to capture individual quotes and divergence from the consensus.

General notes:

Practical synthetic biology

1. What is the perceived importance of sustainable technologies and the bioeconomy in Africa?

2. Is there potential for Africa-UK collaboration in developing better access to i) Cell-free gene expression for production of biomolecules and diagnostics, ii) Transient expression in plants, and iii) Genome editing in orphan crops.

3. Are these new biological technologies useful in the short term (5y) in an African context? What are the specific applications that might be addressed by these technologies.

4. What are the highest priority areas for collaboration and investment in technology transfer?

Training and education

5. Is education and training a high priority? How would you rank this, compared to basic research and applications?

6. What are the main constraints for teaching (at secondary and tertiary levels) in Africa?

Pathways to application

7. Can you identify potential pathways for implementation that would be attractive to you? Estimate technical and resource deficits, and the scale of investments required.

Partnerships for implementation

8. What are the kind of synergies can you see emerging between UK and African groups? What should the GCRF programme promote? Can this initiative help to improve connections between southern, west and east Africa hubs?