



Australian Government
Department of Industry,
Innovation and Science



Australian Academy of Science



AUSTRALIA-CHINA SYMPOSIUM *on* *synthetic biology*

PROGRAM
17-19 OCTOBER
BRISBANE, AUSTRALIA



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Welcome

The Australian Academy of Science, the Australian Academy of Technology and Engineering (ATSE), and the Chinese Academy of Sciences (CAS) have held annual symposia since 2004, alternating between sites in China and Australia. Each symposium has focused on a topic of great importance to both countries, such as energy, food security, astronomy and biotechnology. These meetings have provided opportunities to build strong bilateral networks and increase international research collaborations between China and Australia.

The Australian Academies are delighted to be hosting this year's symposium on the topic of synthetic biology, one of the fastest growing areas of modern science. It is a pleasure to welcome the Australian and Chinese researchers, including a cohort of early- and mid-career researchers from both countries.

This event has been made possible due to the funding and support of the Australian Government Department of Industry, Innovation and Science, through the Australia–China Science and Research Fund (ACSRF) and the Chinese Academy of Sciences.

Program

MONDAY, 16 OCTOBER 2017

17.00 – **Registration at Mantra Midtown Hotel**
18.00 127 Charlotte Street, Brisbane
No formal events
Accommodation at Mantra Midtown Hotel

TUESDAY, 17 OCTOBER 2017

6.30 – **Breakfast available at**
9.00 **Mantra Midtown Hotel**

9.30 **Delegates check out of hotel**
(luggage to be left at reception)
Bus departs Mantra Midtown Hotel for site visits

10.00 **Site visits to the Australian Institute for
Bioengineering and Nanotechnology and CSIRO**

15.00 **Return to Mantra Midtown Hotel to collect luggage**

16.00 **Bus departs Mantra Midtown Hotel for Mercure
Clear Mountain Lodge**

17.00 **Arrive at Mercure Clear Mountain Lodge
and check in**

19.00 – **Official symposium dinner**
22.00 Accommodation at Mercure Clear Mountain Lodge,
564 Clear Mountain Road, Clear Mountain

WEDNESDAY, 18 OCTOBER 2017

6.30 – **Breakfast available at**
8.00 **Mercure Clear Mountain Lodge**

8.15 **TEA AND COFFEE AVAILABLE IN SEMINAR ROOM**

Keynote presentations

8.25 **Introduction of keynote speakers**

8.30 *Synthetic biology—nirvana of a bacteriology lab;
rebirth in the fire of convergence innovation*
Professor Guo-ping Zhao
Chinese Academy of Sciences

9.00 *Synthetic biology in Australia*
Associate Professor Claudia Vickers
University of Queensland and CSIRO

9.30 *Synthetic biology: China's perspectives*
Professor Xian-en Zhang
Chinese Academy of Sciences

10.00 **Questions and answers**

10.15 **MORNING TEA**

Session 1: Macromolecular design

Chairs: Professor Ian Small and Professor Duanqing Pei

10.45 **Welcome from chairs and overview of session**

10.50 *A synthetic biology pipeline for understanding
antibiotic resistance and producing new antibiotics*
Associate Professor Oliver Rackham
University of Western Australia

11.15 *Single-cell characterisation and rational
design of regulatory parts for Streptomyces*
Professor Chunbo Lou
Chinese Academy of Sciences

11.40 *The CYBERNOSE®/ CYBERTONGUE®
Biosensing Platform*
Dr Alisha Anderson
CSIRO

12.05 *Synthetic gene circuits interrogate
Escherichia coli cell cycle*
Professor Chenli Liu
Chinese Academy of Sciences

12.30 **LUNCH**

13.30 *Artificial synthesis of multi-subunit protein
machines using synthetic DNA templates*
Dr Lawrence Lee
UNSW Sydney

13.55 *Data-driven models for design protein
sequences and structures*
Professor Haiyan Liu
University of Science and Technology of China

14.20 **Session wrap up**

Session 2: Pathways

Chairs: Professor Peter Gray and Professor Chenli Liu

14.45 **Welcome from chairs and overview of session**

14.50 *Programmable DNA looping using
engineered bivalent dCas9 complexes*
Associate Professor Keith Shearwin
University of Adelaide

15.15 **AFTERNOON TEA**

15.45 *Engineering physiological functionalities
of industrial microbes*
Professor Yin Li
Chinese Academy of Sciences

16.10 *Editing the epigenome*
Professor Ryan Lister
University of Western Australia

16.35 *Tracking and engineering dynamic
photosynthetic metabolism*
Professor Chen Yang
Chinese Academy of Sciences

17.00 – **Video presentation**
17.15 *The Gold Coast Health and Knowledge Precinct*
Ms Kimberly Percival
Office of the Commonwealth Games,
Queensland Government

18.00 **Early- and mid-career researcher poster session**

19.00 – **Networking barbeque**
21.00 Accommodation at Mercure Clear Mountain Lodge

THURSDAY, 19 OCTOBER 2017

6.30 – 8.00	Breakfast available at Mercure Clear Mountain Lodge
8.00	Delegates check out of hotel (luggage to be left at reception)
8.25	Recap of Pathways session
8.30	<i>Complex pathway engineering: long-chain omega-3 fatty acids in canola seed</i> Dr James Petrie CSIRO
8.55	<i>Natural product synthetic biology: from bacteria to plant</i> Professor Yong Wang Chinese Academy of Sciences
9.20	Session wrap up session
Session 3: Genome scale	
Chairs: Associate Professor Claudia Vickers and Professor Yin Li	
9.45	Welcome from chairs and overview of session
9.50	<i>The International Synthetic Yeast Genome Project (Yeast 2.0) stretching the realms of possibility in precision genome engineering</i> Professor Sakkie Pretorius Macquarie University
10.15	<i>Decode and reprogram the yeast genome</i> Professor Junbiao Dai Chinese Academy of Sciences
10.40	MORNING TEA
11.10	<i>Genomic and functional regulation of gene expression in health and disease</i> Professor Aleksandra Filipovska University of Western Australia
11.35	<i>A created single chromosome yeast</i> Professor Zhongjun Qin Chinese Academy of Sciences
12.00	<i>Engineering biosensors, metabolic pathways, and whole genomes</i> Professor Ian Paulsen Macquarie University
12.25	Session wrap up

12.50	LUNCH
Session 4: Ethics	
Chairs: Professor Sakkie Pretorius and Professor Zhongjun Qin	
13.50	Welcome from chairs and overview of session
13.55	<i>Bioethical considerations in synthetic biology</i> Associate Professor Ainsley Newson University of Sydney
14.10	<i>Cell fate decisions during somatic cell reprogramming</i> Professor Duanqing Pei Chinese Academy of Sciences
14.25	<i>Regulatory considerations in synthetic biology</i> Dr Alison McLennan University of Canberra
14.40	<i>Equity issues in enjoying scientific results in emerging biotechnologies: the case of SynBio</i> Professor Ruipeng Lei Huazhong University of Science and Technology
14.55	Panel discussion and questions and answers
15.15	STRETCH BREAK
15.25	Group discussion on next steps
15.50 – 16.00	Closing remarks
16.15	Bus departs Mercure Clear Mountain Lodge for Brisbane airport
17.00	Arrival at Brisbane airport Australian delegates depart
17.15	Bus arrives at Pullman Brisbane Airport Hotel 2 Dryandra Road, Brisbane Accommodation for Chinese delegates at Pullman Brisbane Airport Hotel

FRIDAY, 20 OCTOBER 2017

5.30 – 9.00	Breakfast available at the Pullman Brisbane Airport Hotel Chinese delegates depart
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Delegation leaders

PROFESSOR KAYE BASFORD

Vice President

Australian Academy of Technology and Engineering



Professor Kaye Basford is Professor of Biometry at the University of Queensland (UQ) and her research leadership and impact is at the interface between statistics, quantitative genetics and plant breeding, with a focus on building strong and influential partnerships.

She is currently Head of the School of Biomedical Science and was previously President of UQ's Academic Board and Head of the School of Land, Crop and Food Sciences. Professor Basford is Deputy Chair of the Board of Trustees of the International Rice Research Institute, Vice President of the Australian Academy of Technological Sciences and Engineering (chairing both the Audit and Risk Committee and the International Strategy Group), and a member of the Boards of the Crawford Fund Ltd and Union College. She is a Past President of the International Biometric Society and the Statistical Society of Australia Incorporated.

PROFESSOR JINGHUA CAO

Director General

Bureau of International Cooperation

Chinese Academy of Sciences



Professor Jinghua Cao is Director General, Bureau of International Cooperation, Chinese Academy of Sciences (CAS). He is an English major and graduate from Beijing Foreign languages Institute and masters in business management and international relations from CCNY,

US. As a specialist in international cooperation and policy, he has worked in different posts in international relations and scientific administration at CAS such as Deputy Director

of the Office of External Financing, and Division Directors and Deputy Director General of the Bureau of Cooperation, and has helped promote and initiate a large number of international partnerships and programs. He also worked as a First Secretary in the Science and Technology Section of the Chinese Embassy in the US. His research interests are science policy and international science and engineering. His publications include a few articles in international SCI journals.

PROFESSOR ANDREW HOLMES

President

Australian Academy of Science



Professor Andrew Holmes held an ARC Federation Fellowship and Inaugural veski Innovation Fellowship at the Bio21 Institute in the University of Melbourne. He was a CSIRO Fellow, a University of Melbourne Laureate Professor, Distinguished Research Fellow at Imperial College and was

the Newton Abraham Visiting Professor, University of Oxford. He was Chairman of the Editorial Board of Chemical Communications and is an Associate Editor of Organic Letters. He is President of the Australian Academy of Science. Professor Holmes' research interests involve applications of synthesis to materials science and biology. He has made extensive contributions in the area of light emitting and photovoltaic devices, and co-founded Cambridge Display Technology to exploit the technology.

Steering committee

PROFESSOR SIMON FOOTE

Australian National University

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Professor Simon Foote is a molecular geneticist. He is the Director of the John Curtin School of Medical Research at the Australian National University. He has been Dean of the School of Medicine at Macquarie University, Director of the Menzies

Research Institute at the University of

Tasmania and Divisional Head at the Walter and Eliza Hall Institute, Melbourne. He was a postdoctoral fellow at the Whitehead Institute at the Massachusetts Institute of Technology. Professor Foote has a medical degree and PhD from Melbourne University and a Doctorate in Science from the University of Tasmania. He is a Fellow of the Australian Academy of Science, the Australian Academy of Technology and Engineering and the Australian Academy of Health and Medical Sciences. His research interests involve looking at the response of the host to infection by the malarial parasite and in studying renal disease in Australian Indigenous populations.

PROFESSOR PETER GRAY

University of Queensland

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Professor Peter Gray was the inaugural director of the Australian Institute of Bioengineering and Nanotechnology (AIBN) at the University of Queensland. Before joining AIBN, he was Professor and Head of Biotechnology at the University of New South Wales, and was Senior Principal Research Fellow

at the Garvan Institute of Medical Research. He previously held academic positions at University College London and at the University of California, Berkeley. Professor Gray has had

commercial experience in the USA working for Eli Lilly and Co and the Cetus Corporation. He was one of the founders and is a past President of the Australian Biotechnology Association (Ausbiotech) and was the President of ATSE (the Australian Academy of Technology and Engineering). Professor Gray is an Honorary Professor at Fudan University, Shanghai, China and Emeritus Professor at the University of New South Wales. His research interests are in the fields of stem cell bioprocessing and biologics production.

PROFESSOR IAN SMALL

University of Western Australia

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Professor Ian Small's PhD at Edinburgh University was followed by a career with France's National Agronomy Research Institute (INRA). He held the Vice-Director position at the Plant Genetics and Breeding Station in Versailles and the Plant Genomics Unit in Evry. He was awarded a WA State

Premier's Research Fellowship and moved to Perth to become the Director of the ARC Centre of Excellence in Plant Energy Biology. He now works as an ARC Laureate Fellow at the Centre. Professor Small's work contributed to the development of INRA's technology for male-sterile brassicas used in the breeding of elite hybrid lines. Much of the canola grown globally is now produced using this technology. His research interests cover molecular biology and bioinformatics applied to the study of energy organelles (mitochondria and chloroplasts), with potential applications in agricultural, environmental and health biotechnology. He was awarded Scientist of the Year in the WA Premier's Science Awards and is a Fellow of the Australian Academy of Science. He has represented the Academy in recent panels discussing synthetic biology, new gene drive technologies and new plant breeding technologies.

Speakers

Keynote presenters

PROFESSOR GUO-PING ZHAO

Chinese Academy of Sciences

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Professor Guo-Ping Zhao is a molecular microbiologist. He obtained his PhD in biochemistry from Purdue University. He is the Chief Scientist of the Big Data Center for BioMedicine at the CAS-MPG PICB, the Chairman of the Advisory Committee of CAS-Key Laboratory of Synthetic Biology and

the Director of the Department of Microbiology and Microbial Engineering at the School of Life Sciences, Fudan University. He is a Fellow of CAS and the Honored President of the Chinese Society for Microbiology after serving as the president. Along with his scientific organisational and institutional duties, Professor Zhao focused his research activities on genomics and systems biology of microorganisms. He significantly contributed to important projects including the molecular evolution study of SARS-CoV conducted during the SARS epidemic of 2003 to 2005.

Synthetic biology—nirvana of a bacteriology lab; rebirth in the fire of convergence innovation

Initiated by Professor JS Chiao in the 1950s, our laboratory focused on the development of bacterial fermentation technology relying on both forward genetics and biochemical characterisation of fermentation-related enzymes. With the introduction of molecular biology and genomics since the 1990s, bacterial physiology has been studied based on a broader spectrum of complete nature blueprints employing recombinant technology in industrial strains for better and broader applications. Meanwhile, the mainstream research of microbiology was promptly transformed to omics-based systems biology analyses, facilitating the quantitative understanding of the nature of biological processes and the improvement of production of biological molecules. At the dawn of this century, bottom-up forward engineering strategy as well as robust technology toolkits and 'standardised' bioparts were shown to enable both the design and construction of novel artificial biological pathways, organisms or devices, or the redesign of existing natural biological systems. Our efforts since have proved that synthetic biology is rejuvenating life science and biotechnology via convergence research and disruptive innovation. Three generations' endeavor indicated that via efficiently integrating dedicated research teams, it is possible

to revolutionise the capability of traditional laboratories with concurrent biology concepts, serving the wealth and health of human beings.

ASSOCIATE PROFESSOR CLAUDIA VICKERS

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Associate Professor Claudia Vickers obtained a PhD in cereal crop biotechnology at CSIRO Plant Industry/the University of Queensland (UQ) in 2004. Following her PhD, she held a post-doctoral position at Essex University in the UK, where she worked on abiotic stress and

the metabolic regulation/physiological function of volatile isoprenoids in plants. On returning to UQ, she joined the Australian Institute for Bioengineering and Nanotechnology (AIBN) to expand her research into microbial metabolic engineering. She is currently a Group Leader in Synthetic Biology at AIBN; her research focuses on engineering microbes (*E. coli*, yeast, cyanobacteria) to produce industrially-useful biochemicals using advanced systems and synthetic biology approaches. Target compounds sit in the isoprenoid group of natural products, and include jet fuel, plant hormones for agricultural applications and flavours and fragrances. Associate Professor Vickers now holds a joint appointment with CSIRO as Director of the CSIRO Synthetic Biology Future Science Platform (SynBioFSP), a \$30 million R&D portfolio aimed at expanding synthetic biology research in Australia.

Synthetic biology in Australia

This presentation will provide an overview of synthetic biology initiatives and research programs in Australia.

PROFESSOR XIAN-EN ZHANG

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Professor Xian-En Zhang graduated from Hubei University, then received his MPhil and PhD from the Chinese Academy of Sciences (CAS). He became a professor in Wuhan Institute of Virology, CAS, and has published over 230 papers and three books on biosensors, nanobiology and analytical

microbiology. He has roles in several international and national academic organisations, and serves as a member

of the editorial or advisory boards of six scientific journals. Professor Zhang was Director-General for Basic Research in China's Ministry of Science and Technology, responsible for the national strategic planning for science. He then joined the Institute of Biophysics as a distinguished professor, and is the Chinese executive representative in the APEC Chief Science Advisors or Equivalents Meeting and an advisor to the National Key Basic Research Program. He was awarded an Honorary Doctor of Science degree by the University of Alberta, Canada.

Synthetic biology: China's perspectives

The discovery of DNA double helix and completion of the Human Genome Project have revolutionised the life sciences. Synthetic biology now is known as an emerging and disruptive technology. It aims to creating new life system based on deep understanding of biological mechanisms, and to greatly upgrade capability of biotechnology through genome-wide redesign and editing, leading life sciences and biotechnology into a new era. In China, government agencies have offered generous supports to synthetic biology. In particular, 10 key projects have grants from the National 973 Program. They cover a wide range of topics including cell factory, artificial leaf, synthetic systems for microbial drugs, biomaterials, nitrogen fixation, crop stress-tolerance and medical application. Progress is substantial, including the number and quality of peer-reviewed papers, and international collaborations. The scientific, technical, and policy issues associated with synthetic biology were fully discussed at the China-USA-UK Six-Party Symposia on Synthetic Biology. About 20% of papers were coauthored with international partners. China is now formulating its National Key R&D Program for synthetic biology. Implementation of this mega research program will undoubtedly give a strong push to the development of the field.

Session 1: Macromolecular design

ASSOCIATE PROFESSOR OLIVER RACKHAM

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Associate Professor Oliver Rackham gained his BSc (Hons) and PhD in biochemistry from the University of Otago, New Zealand. He joined the MRC Laboratory of Molecular Biology, UK, as an MRC Career Development Fellow, working with Professor Jason Chin on re-engineering the genetic

code. Oliver then established his own group at the University of Western Australia as an NHMRC Peter Doherty Fellow.

He has been awarded a Wenner-Gren Foundation Fellowship, an ARC Future Fellowship, the Marshall Medal, and a Humboldt Research Fellowship for Experienced Researchers. Associate Professor Rackham's research has been influential in shaping the field of synthetic biology. He pioneered an 'orthogonal' approach to create synthetic cellular networks and created synthetic ribosomes and artificial RNA-binding proteins. His work was described as one of the seminal achievements for synthetic biology (Faculty of 1000) and resulted in his admission to the European Inventor Hall of Fame in 2013.

A synthetic biology pipeline for understanding antibiotic resistance and producing new antibiotics

The emergence of 'superbugs', bacteria that resist all current antibiotics, poses a significant risk to public health. The development of new antibiotics has dwindled since most of the pharmaceutical giants have abandoned or severely curtailed their antibiotic discovery programs, but the need for new approaches to address this problem is immediate. Reassembling the genes for antibiotic production in well-characterised microbes that can be readily grown at industrial scales provides a promising avenue to address these issues. Our vision is to harness the tremendous potential of synthetic biology to build yeast that can make valuable new antibiotics. We have developed a variety of genetic selection systems that allow the re-engineering of macromolecules via life/death selections in yeast and we have applied these systems to enable the determinants of antibiotic resistance to be systematically mapped. We are now adapting these approaches to link the survival of yeast engineered to contain genetic pathways for antibiotic biosynthesis to the production of new antibiotic derivatives.

PROFESSOR CHUNBO LOU

Chinese Academy of Sciences

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Professor Chunbo Lou is an Investigator at the Institute of Microbiology, Chinese Academy of Sciences (CAS). He obtained his PhD in biophysics from Peking University, and started his postdoctoral research with Professor Chris Voigt at the University of California, San Francisco

and Massachusetts Institute of Technology. He has designed and constructed several complex genetic circuits, such as a push-on push-off switch. He also developed design principles for synthetic biology, such as an insulator for genetic circuits. His lab is currently developing high-quality genetic parts and applying them to control the metabolic process.

Single-cell characterisation and rational design of regulatory parts for *Streptomyces*

There is a great demand to precisely quantitate and dynamically control the expression of genes of interest in streptomycetes. In the first section, we developed a quantitative method based on flow cytometry and a fluorescent reporter gene (sfGFP) at single-cell resolution in *Streptomyces*. Single cells of filamentous bacteria were obtained by releasing the protoplasts from the mycelium, and the dead cells could be distinguished from the viable ones by propidium iodide (PI) staining. With this sophisticated quantitative method, some 200 native or synthetic promoters and 200 ribosomal binding sites (RBSs) were characterised in a high-throughput format. In the second part, we presented several high-quality regulatory parts and devices for streptomycetes, in order to dynamically activate the silent gene clusters to produce diverse active natural product. These rationally designed parts and devices include quorum sensing systems, tightly inducible promoter, modular promoters and RBSs. We believed that the work presented here substantially enriched the regulatory toolbox which will facilitate the functional optimisation of gene clusters and the drug discovery process in *Streptomyces*.

DR ALISHA ANDERSON

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Dr Alisha Anderson is the Group Leader of the Innovative Bioproducts group in CSIRO Health and Biosecurity. Dr Anderson received her PhD from Monash University. She has a broad background in genetics and molecular biology. Her current research is focused on understanding the

molecular basis of biological chemosensory systems and drawing on this understanding for new sensing technologies. Dr Anderson leads the Innovative Bioproducts group which has developed the CYBERNOSE®/CYBERTONGUE® technology for rapid and sensitive chemical sensing across multiple industries including defence, water utilities, food and beverage, and health.

The CYBERNOSE®/ CYBERTONGUE® Biosensing Platform

Evolution has developed multiple sophisticated chemical sensing systems including the olfactory and gustatory systems of animals, and nutrient and quorum sensing in bacteria. These systems measure chemicals in real time, can be extraordinarily sensitive, and have the ability to distinguish chemicals in complex backgrounds. In order to harness the sophistication of biological systems for chemical sensing in multiple industries, we have developed a protein-based sensing platform. We have coupled bioluminescent resonance energy transfer (BRET) to a range of proteins

including G-protein-coupled receptors (GPCRs), bacterial periplasmic binding proteins (PBPs) and engineered enzyme sensing proteins. We show, using this BRET transduction system, we can measure ligand-induced conformational changes at femtomolar concentrations for GPCRs, nanomolar concentrations for PBPs and picomolar concentrations for enzyme detection. Finally, we have developed a microfluidic-based system to enable rapid chemical analysis, using these protein-based sensors, at the point-of-use. These studies pave the way for the development of engineered chemical sensing arrays that have the speed, sensitivity and selectivity of evolved biological chemical sensing systems.

PROFESSOR CHENLI LIU

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Professor Chenli Liu is a Professor in Shenzhen Institute of Advanced Technology (SIAT), Chinese Academy of Sciences, and the Director of the Center for Synthetic Biology Engineering Research of SIAT. He received his BSc and MSc degrees in biochemistry and molecular biology

from Xiamen University, where he isolated, identified, and characterised several novel marine oil-degraders and their key degrading enzyme genes. He obtained his PhD in biochemistry from the University of Hong Kong, where he described a synthetic genetic circuit that couples cell density and motility to form periodic stripe patterns; he also studied the mechanisms responsible for beneficial cerebrovascular effects of *Salvia miltiorrhiza*, and for the cell death caused by the single-stranded oligodeoxynucleotides mediated gene therapy. Professor Liu obtained his postdoctoral training in Nancy Kleckner's lab in MCB, Harvard University, where he worked on RNA's roles in chromosome organisation. His current research interest focuses on bacterial cell cycle, therapeutic synthetic biology, and continuous directed evolution. He also is the recipient of several prestigious awards, including 1000 Young Scholar Plan, Guangdong Natural Science Foundation for Distinguished Young Scholars, and Hong Kong Young Scientist Award.

Synthetic gene circuits interrogate *Escherichia coli* cell cycle

Bacteria tightly regulate and coordinate the various events in their cell cycles to duplicate themselves accurately and control their cell sizes. Currently, there exists several models attempting to describe cell cycle regulation in *E. coli*, but none can elucidate all empirical findings. Important among these findings is the Schaechter-Maaløe-Kjeldgaard growth law (S-M-K law), which says that the average cell size scales exponentially with the growth rate, with a scaling constant equal to the duration from initiation of chromosome

replication to cell division. The S-M-K law is believed to be a consequence of the tight coupling between replication initiation and division. Here, we sought to constrain the models by testing the robustness of the law to systematic perturbations in cell dimensions via synthetic genetic circuits. We found that decreasing the mreB level resulted in increased cell width, with little change in cell length, whereas decreasing the ftsZ level resulted in increased cell length. Furthermore, the time from replication termination to cell division increased with the perturbed dimension in both cases. The S-M-K law still remains valid across growth rates and across cell dimensions. The robustness of the growth law further support models that regulate the cell cycle not at divisions, but at initiations.

DR LAWRENCE LEE

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Dr Lawrence Lee is a Senior Lecturer and Group Leader at the EMBL Node for Single Molecule Science in the School of Medical Sciences at the University of New South Wales, Sydney. He received his PhD from the Faculty of Pharmacy at the University of Sydney before undertaking a

postdoctoral position in the Structural and Computational Biology Division at the Victor Chang Cardiac Research Institute, where he is still an Honorary Faculty Member. Following this, Dr Lee established his own research group that uses molecular design and self-assembly to artificially construct complex protein assemblies. Dr Lee has received multiple awards and prizes including the NARF Early Career Researcher of the Year, a New and Notable Speaker at the US Biophysical Society, an ARC Discovery Early Career Award and a NSW Young Tall Poppy award.

Artificial synthesis of multi-subunit protein machines using synthetic DNA templates

Large multi-subunit protein complexes self-assemble spontaneously yet do not prematurely form unwanted aggregates. Static snapshots of intact complexes or component parts provide little insight into how this occurs. We combine high-resolution crystal structures combined with small-angle X-ray scattering and in vivo biochemical crosslinking, to elucidate a structural and thermodynamic mechanism for the controlled synthesis of the bacterial flagellar motor, a biological motor consisting of hundreds of subunits that can rotate at over 1300 Hz. The mechanism describes how a structural template can trigger and guide the polymerisation of subunits via a domain-swap mechanism during assembly. We also describe our efforts to replicate this process in vitro by replacing the natural scaffold with synthetic scaffolds constructed from DNA origami. By observing the kinetics of artificial synthesis, we

can probe fundamental questions about supramolecular protein complex assembly and their dynamics.

PROFESSOR HAIYAN LIU

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Professor Haiyan Liu received his BS and PhD from the University of Science and Technology of China (USTC), and was a visiting PhD student in Laboratory of Physical Chemistry, ETH-Zurich. He took up roles as a postdoctoral associate, first in the Department of Chemistry, Duke

University, and then jointly in Department of Biophysics and Biochemistry, UNC-Chapel-Hill. He then became a Professor of Computational Biology at USTC.

Data-driven models for design protein sequences and structures

Professor Liu will present two statistical methods for protein design. The first method, which is named ABACUS, is for designing amino acid sequences with given backbone structures. De novo sequences designed with ABACUS have been experimentally verified to fold into desired target structures which are of different structural classes. The second method is for designing new backbone structures. It uses local conformational terms and local-conformation-dependent packing terms to evaluate backbone structures without sidechains. The model leads to the computational generation of realistic backbone structures.

Session 2: Pathways

ASSOCIATE PROFESSOR KEITH SHEARWIN

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Associate Professor Keith Shearwin completed a BSc (Hons) at Griffith University and a PhD in physical biochemistry at the University of Queensland. This was followed by a three-year stint at Brandeis University in Boston studying the effect of various small molecules on the self-assembly

of the tubulin protein into microtubules. He joined the University of Adelaide as a postdoctoral fellow and is now an Associate Professor in the Department of Molecular and Cellular Biology. Associate Professor Shearwin's research integrates biochemistry, genetics and mathematical modelling to characterise fundamental mechanisms of gene control and how these elements can be combined to create gene regulatory circuits with complex functions.

Programmable DNA looping using engineered bivalent dCas9 complexes

DNA looping is a ubiquitous and critical feature of gene regulation. Although DNA looping can now be efficiently detected, tools to readily manipulate DNA looping are rare. In order to develop a simplified system for studying looping, we have recapitulated in *E. coli* the long range DNA looping typical of multicellular organisms, using a set of well-defined DNA looping proteins. In addition, we have developed a set of CRISPR-Cas based DNA looping reagents for the creation of programmable DNA loops. Cleavage-defective Cas9 (dCas9) proteins of different specificity were linked by heterodimerisation or by translational fusion to create bivalent complexes able to link two separated DNA regions. After model-directed optimisation, the reagents were validated using a quantitative gene regulation-based DNA looping assay in *E. coli* cells. Consistent with the modelling, overall looping efficiency could be significantly improved by expressing additional guide RNAs to create multiple DNA loops. Such reagents should allow manipulation of DNA looping in a variety of cell types, aiding understanding of endogenous loops and enabling creation of new regulatory connections.

PROFESSOR YIN LI

Chinese Academy of Sciences

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Professor Yin Li received his PhD in Fermentation Engineering at Jiangnan University in China. He then worked in the Netherlands and Ireland as a postdoctoral researcher. He was appointed as Professor by the Institute of Microbiology, Chinese Academy of Sciences and a visiting professor by

Cornell University. He is the Deputy Director-General of Tianjin Institute of Industrial Biotechnology, Chinese Academy of Sciences. He is interested in molecular physiology and metabolic engineering that enable the sustainable and efficient production of bio-based chemicals. He and his colleagues have published more than 120 papers, with an H index of 32. He is the chair of the TWAS Young Affiliate Network (TYAN), and serving as editor, research editor, or member of the editorial board of Microbiology, Microbial Cell Factories, Biotechnology Journal, Industrial Biotechnology, and Food Bioscience.

Engineering physiological functionalities of industrial microbes

Microbial fermentations and bioconversions play a central role in the production of pharmaceuticals, enzymes and chemicals. To meet the demands of industrial production, it is desirable that microbes maintain a maximised carbon flux towards target metabolites regardless of fluctuations

in intracellular or extracellular environments. This requires cellular systems to maintain functional stability and dynamic homeostasis in a given physiological state, or manipulate transitions between different physiological states. Stable maintenance or smooth transition can be achieved through engineering dynamic controllability, modular and hierarchical organisation, or functional redundancy, three key features of biological robustness in a cellular system. This presentation will summarise how metabolic engineering can be used to improve the physiological functionalities of industrial microbes

PROFESSOR RYAN LISTER

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Professor Ryan Lister leads a research group investigating the epigenome at the University of Western Australia (UWA) and the Harry Perkins Institute of Medical Research. After receiving his PhD from UWA, he undertook postdoctoral studies at The Salk Institute for Biological Studies in

California, where he developed new techniques to map the epigenome. His discoveries include generating the first accurate maps of the human epigenome, and characterising the complexity of the human brain epigenome. His research has yielded new insights into the composition and function of the epigenome in a variety of systems, including plants, the brain, stem cells, and developing vertebrate embryos. Having returned to UWA, Professor Lister's laboratory is focused on understanding how the epigenome patterns are established and changed, how they affect the readout of underlying genetic information, their involvement in development and disease, and developing molecular tools to precisely edit the epigenome.

Editing the epigenome

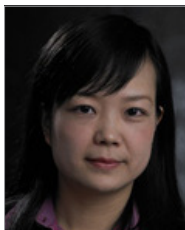
Covalent modifications of DNA and histones play critical roles in the regulation of gene expression, cell activity, development and disease. DNA methylation is a critical layer of the vertebrate epigenome, however despite several decades of investigation, the precise roles of DNA methylation in the control of genome and cell activity are still not clearly understood. A major obstacle in deciphering the mechanistic roles of epigenomic modifications has been the inability to precisely control and change the modification states in the genome. However, genome editing technologies are now rapidly being repurposed to achieve editing of epigenomic modifications where desired in the genome, in order to elucidate the causal relationships between these modifications and genome regulation, and as artificial regulatory tools to control cell activity and identity. We employed a broadly active artificial epigenome modifying protein to achieve genome-wide manipulation of promoter

DNA methylation, enabling comprehensive assessment of its effects upon transcription and histone modifications, and the stability of artificially induced methylation. We have developed new CRISPR-Cas9 based tools that enable highly specific addition or removal of DNA methylation at desired locations in the genome in a controlled fashion. In addition to optimising the efficacy and specificity of these functional epigenomics tools, we have utilised them to explore the sensitivity of DNA binding proteins to DNA methylation state. Overall, recent developments in epigenome editing tools are providing new insights into the role of covalent genome modifications in regulating gene expression, and new platforms for the manipulation of cell activity and identity.

PROFESSOR CHEN YANG

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Professor Chen Yang received her BS in biochemical engineering from Zhejiang University of China and her PhD in bioengineering from Kyushu Institute of Technology of Japan. She was a postdoctoral fellow in Keio University of Japan and then in Burnham Institute for Medical

Research, USA. She was selected into the 100 Talented People program of CAS. Her research interests include technological development for fluxomics and metabolomics analyses, regulation and control of metabolic fluxes, and metabolic engineering of microbes for production of biochemicals. She is the author of over 60 scientific articles published in prestigious journals including *Science*, and *Energy and Environmental Science*. Her publications have been cited over 2000 times by experts in the field.

Tracking and engineering dynamic photosynthetic metabolism

This presentation is about tracking dynamic metabolic responses in cyanobacteria to changing environments or perturbations to understand the flexibility and robustness of natural metabolic systems. It will also cover engineering cyanobacteria with guidance provided by dynamic flux analysis and metabolite profiling. We optimised the methylerythritol phosphate pathway flux in cyanobacteria, resulting in significant increase for terpenoid production by photoautotrophic microorganisms.

DR JAMES PETRIE

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James Petrie is a Senior Research Scientist at Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Canberra. He is a member of the Plant Oil Engineering group and leads a cluster of 'leaf oil' projects which aim to greatly increase the yield of plant-

derived oil by producing triacylglycerol in plant biomass rather than seed alone. Dr Petrie has also been instrumental in producing transgenic oilseeds which contain fish oil-like quantities of long-chain omega-3 fatty acids.

Complex pathway engineering: long-chain omega-3 fatty acids in canola seed

Complex pathway engineering is an important way in which synthetic biology can contribute new traits to modern agriculture. An example of this is the introduction of long-chain omega-3 fatty acids such as EPA and DHA to plant seeds. These fatty acids are critical for human health and development and numerous studies have indicated that deficiencies in these fatty acids can increase the risk or severity of cardiovascular, inflammatory and other diseases or disorders. EPA and DHA are predominantly sourced from marine fish although the primary producers are microalgae. This talk will describe the challenges associated with engineering an entire biosynthetic pathway in plants, beginning with the exploration of synthetic design principles in *Arabidopsis* and culminating in the successful development of a new canola variety with DHA levels that exceed the amount typically found in bulk fish oil and with high omega-3/omega-6 ratios. This engineering involved the transfer of a seven-gene algal pathway and was achieved using a single multi-gene construct that allowed for simpler deregulation and breeding.

PROFESSOR YONG WANG

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Professor Yong Wang is Professor/ Principal Investigator of key laboratory of synthetic biology, Center for Excellence in Molecular Plant Sciences, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences. Professor Wang received his PhD degree from East China

University of Science and Technology. His research is centred on the design and assembly of recombinant microorganisms or other chassis for the production of complex natural products. A particular focus is the

elucidation of design principles for the production of natural compounds within the framework of the nascent field of synthetic biology. He has published more than 60 papers.

Natural product synthetic biology: from bacteria to plant

Natural products (NPs) are important drug pools for human disease prevention and treatment. The great advances in synthetic biology have greatly revolutionised the strategies of NPs development and production. However, attempts to produce complex natural products with synthetic biotechnology have been hampered by the limited characterised parts, incompatible parts and products tolerance. To address these problems in the past we made specific efforts to identify and characterise more parts from various resources, develop tools and methodologies for parts assembly and modulation, and engineer transporters to improve the compounds production. Lots of parts related to the natural products biosynthesis were collected and characterised for further design. In silico tools and system biology based methodology were developed for parts design and optimisation. We got different representative natural products, such as terpenoids, polyketides and phenylpropanoids, produced successfully in the engineered *E. coli* or *Nicotiana benthamiana* systems. Some of the products and technologies have been initiated through industrial research collaboration with enterprises.

Session 3: Genome-scale

PROFESSOR SAKKIE PRETORIUS

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Professor Sakkie Pretorius is Deputy Vice Chancellor: Research at Macquarie University, Sydney. He has a background in molecular yeast genetics and wine biotechnology. Sakkie began his career in South Africa. At Stellenbosch University he became the founding Director of

South Africa's Institute for Wine Biotechnology. In the US and Europe, he conducted research at the Albert Einstein College of Medicine in New York, the Max Planck Institute for Biophysical Chemistry in Göttingen, Germany, and the Katholieke Universiteit Leuven in Belgium. Professor Pretorius relocated to Adelaide to take up the role of Managing Director of the Australian Wine Research Institute. He was then appointed Deputy Vic-Chancellor and Vice-President: Research and Innovation at the University of South Australia, followed by his current role as Deputy Vice Chancellor: Research at Macquarie University. Professor Pretorius has published over 200 research papers, won many research grants and awards, and filed six patents.

Over the past three decades, he has supervised or co-supervised 33 PhD students and 56 MSc students.

The International Synthetic Yeast Genome Project (Yeast 2.0) stretching the realms of possibility in precision genome engineering

The International Synthetic Yeast Genome Project (Yeast 2.0 or Sc2.0) tossed a challenging 6000-piece jigsaw puzzle of the budding yeast's genetic make-up onto the lab benches of a dozen or so synthetic biology research groups in the USA, UK, China, Singapore and Australia. The design of the Sc2.0 genome draws on the data from the *Saccharomyces cerevisiae* genome sequence first announced in 1996. The ~12 Mb (non-redundant) to ~14 Mb (total) genome sequence carries approximately 6000 genes of which about 5000 are individually non-essential. The 6000 genes are distributed along 16 linear chromosomes of varying length (200 to 2000 kb). To date, six of the 16 chromosomes have been synthesised and built into discrete strains by the various Sc2.0 teams. Macquarie's Sc2.0 team has completed the synthesis of two chromosomes (14 and 16). It is expected that all 16 chromosomes will be synthesised by the end of this year. The Sc2.0 project is on track to consolidate the 16 chemically-synthesised chromosomes into a single cell, delivering the world's first synthetic eukaryotic genome by 2018. As the Sc2.0 project is progressing, genome engineering technologies are being advanced at a rapid pace while important fundamental biological intricacies of yeast cells are being figured out. By the end of this project, it would be known, for example, if the removal of all introns and transposable elements will affect cell fitness, and whether the relocation of all tRNA genes to a 17th mini-neochromosome will disadvantage the genetic processes and protein synthesis machinery of the redesigned haploid laboratory strain of *S. cerevisiae*.

PROFESSOR JUNBIAO DAI

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Dr Junbiao Dai is a Professor in the Center for Synthetic Biology Engineering Research (CSynBER) at Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences. He received his BS degree from Nanjing University, MS degree from Tsinghua University, and PhD

degree from Iowa State University. He was a post-doctoral fellow at the Johns Hopkins University School of Medicine before joining the faculty at Tsinghua University in 2011. His research interests lie in synthetic biology using budding yeast, microalgae and fly as model systems, focusing on the development of new technologies for genes synthesis and genome design and construction to deepen our understanding and application of biology. Recently, his

team has finished the synthesis of yeast chromosome XII, the largest eukaryotic synthetic chromosome.

Decode and reprogram the yeast genome

New technologies to synthesise DNA provides a great opportunity to completely redesign the entire genome of an organism. Together with several other groups worldwide, we teamed up to re-synthesise a designer eukaryotic genome, Sc2.0. In my lab, a 976,067-base pair linear chromosome, synXII, was designed and assembled using a two-step method, producing a functional chromosome. The ribosomal gene cluster (rDNA) on synXII was retained during the assembly process and subsequently replaced by a modified rDNA unit used to regenerate rDNA at three distinct chromosomal locations. The signature sequences within rDNA, commonly used as the molecule barcode of a species, were swapped to generate a *Saccharomyces* strain that would be identified as *Saccharomyces bayanus*. Furthermore, we designed a reporter of SCRaMbLEd cells using efficient selection (ReSCuES) to isolate SCRaMbLEd strains based on the loxP-mediated switch of two auxotrophic markers, which not only allow us to rapidly identify strains of interest from a SCRaMbLEd synthetic yeast population, but also provides methods to dissect the underlying mechanisms of resistance.

PROFESSOR ALEKSANDRA FILIPOVSKA

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Professor Aleksandra Filipovska received her PhD from the University of Otago, New Zealand. She was a NZ Foundation for Research, Science and Technology Fellow at the MRC Mitochondrial Biology Unit in Cambridge, UK. In 2006 she relocated to Australia as an NHMRC Howard

Florey Fellow and established her research group at the Perkins Institute of Medical Research at the University of Western Australia. She was an Australian Research Council Future Fellow and is currently an NHMRC Senior Research Fellow and a Professor at UWA and the Perkins Institute of Medical Research. Professor Filipovska's research interests are in the regulation of gene expression by RNA-binding proteins and the use of transcriptomic technologies to elucidate their molecular functions in health and disease. Her research group uses genomic technologies and synthetic biology to design new mouse models of cancer, neurodegenerative, metabolic and cardiovascular diseases.

Genomic and functional regulation of gene expression in health and disease

There are two families of modular RNA-binding proteins that control RNA metabolism in eukaryotic cells, the

pentatricopeptide repeat (PPR) proteins and Pumilio and FBF homology protein (PUF). We have investigated both families of RNA-binding proteins in the regulation of cytoplasmic and mitochondrial gene expression at the level of RNA and developed them as tools for modulating gene expression. Although recent computational and structural studies have provided insights into RNA recognition by PPR proteins, their highly insoluble nature and inconsistencies between predicted and observed modes of RNA binding have restricted our understanding of their biological functions and their use as tools. We have used a consensus design strategy to create artificial PPR domains that are structurally robust and can be programmed for sequence-specific RNA binding. The atomic structures of these proteins provide structural basis for their stability and modelling of RNA-protein interactions provides mechanistic insights into the importance of RNA recognition and binding. We use genomic technologies to understand their binding and editing targets. The modular mode of RNA-binding holds great promise for the engineering of new tools to target RNA and to understand the mechanisms of gene regulation by natural PUF or PPR proteins.

PROFESSOR ZHONGJUN QIN

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Professor Zhongjun Qin is Director of the Laboratory of Synthetic Biology, Shanghai Institute of Plant Physiology and Ecology, Chinese Academy of Sciences (CAS). He obtained his PhD in microbiology from Huazhong Agricultural University, China and was a post-doctoral fellow at the

Department of Genetics at Stanford University. Professor Qin has been working on microbial molecular genetics since 1995. His laboratory is interested in synthetic biology of *Escherichia coli* and *Saccharomyces cerevisiae*.

A created single chromosome yeast

In nature, most prokaryotic cells contain a single circular chromosome, while all known eukaryotic cells contain multiple linear chromosomes. It is unknown whether a single linear or circular chromosome is sufficient to hold the life of a eukaryote. In this study, we created a biologically functional single linear chromosome yeast (SY14) from a haploid cell of budding yeast *Saccharomyces cerevisiae* containing native 16 linear chromosome. The fusions of 16 linear chromosomes into one resulted in dramatic changes in chromosomal three-dimensional structures, represented by losing most of the centromere and telomere mediated inter-chromosomal interactions, and retaining 25% of intra-chromosomal interactions and 45% of the chromosomal topologically associated domains. Surprisingly, the transcriptome profiles of the SY14 cells

are nearly the same as those of wild-type cells. Additionally, the SY14 cells behave much like the wild-type cells (e.g. morphology, growth rate), and are able to produce progenies sexually through forming diploids and undergoing meiosis. The SY14 cells are robust under environmental and genotoxin stresses. The end-to-end fusion of the linear chromosome of the SY14 strain generates a single circular chromosome yeast (namely SY15), which displays less fitness to various treatments than the SY14 strain.

PROFESSOR IAN PAULSEN

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Professor Ian Paulsen is a Distinguished Professor at Macquarie University and Deputy Director of the Macquarie Biomolecular Discovery and Design Centre. He is an ARC Laureate Fellow and an ISI Highly Cited Researcher with more than 250 publications. He received a PhD from

Monash University and was an NHMRC C.J. Martin Fellow at the University of California at San Diego. He then took a faculty position at the Institute for Genomic Research (TIGR), where he led many microbial genome sequencing projects. He returned to Australia in 2007 as a Professor at Macquarie University and received a Life Science Research Award from the NSW Office of Science and Medical Research. He is the founder and Director of the new Synthetic Biology Laboratory at Macquarie University.

Engineering biosensors, metabolic pathways, and whole genomes

Advances in synthetic biology and metabolic engineering are beginning to enable alternative routes for chemical, fuel, and pharmaceutical manufacturing. However, there are significant challenges involved in engineering microbial cells to produce desired products at commercially viable titers, rates, and yields. These challenges arise because multiple biological components often interact synergistically to control complex metabolic regulation, and their optimisation therefore entails a combinatorial explosion of traits that require building and testing for performance. An elegant way to overcome these challenges is to harness the power of natural selection. Using adaptive laboratory evolution (ALE) involves growing a microbial population under industrially relevant stress conditions such that only cells with advantageous mutations can proliferate. Unfortunately, ALE cannot be readily applied to the evolution of high metabolite production because phenotypes such as metabolic productivity are not naturally coupled to cell survival. One of the most promising ways to make this connection and enable ALE of metabolic productivity is to use a biosensor that detects the intracellular concentration of a metabolite of interest and outputs a survival function in response. We

have developed a novel biosensor that can be used to detect the intracellular concentration of valuable organic acid products such as para-hydroxybenzoic acid (PHBA), and activate GFP expression in response. This system enables the use of fluorescence activated cell sorting to identify high-producers from a genetically diverse yeast population containing billions of variants. Using principles of synthetic-biology circuit design, the dynamic range and noise levels of the biosensor were dramatically improved such that the high-throughput screening efficiency increased 5000-fold. These design principles are applicable to most other biosensors, and will enable the laboratory evolution of high metabolite-production phenotypes in yeast.

Session 4: Ethics

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Associate Professor Ainsley Newson is Associate Professor of Bioethics at the University of Sydney. Ainsley's research focuses on ethical aspects of emerging biotechnologies and their implementation; with a focus on human health and disease. She has published widely on aspects of

genetics, genomics, reproductive technologies, genome editing and synthetic biology. She obtained a project grant from the European Commission in 2009 for the SYBHEL project: Synthetic Biology and Human Health—Ethical and Legal Issues. This project examined ethical issues in synthetic biology from ethical, legal and regulatory perspectives. She co-edited a special issue of Bioethics arising from this project in 2013. Associate Professor Newson has a PhD in Bioethics, a Bachelor of Laws (Hons) and a Bachelor of Science (Hons) from the University of Melbourne. She sits on a range of committees and groups related to bioethics and is experienced in public and media engagement on ethical issues in genetics and emerging biotechnologies.

Bioethical considerations in synthetic biology

What has bioethics offered to debates on synthetic biology thus far, and how should these debates progress in the future? This presentation will offer some ideas in answer to this question. After explaining bioethics scholarship, some over-arching claims will be offered regarding what bioethics both should and should not do with respect to synthetic biology. Then, the key ethically relevant features of synthetic biology and the issues they give rise to will be teased out, using examples where relevant. Ideas will then be offered as to how future ethical deliberation in synthetic biology might proceed.

PROFESSOR DUANQING PEI

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Professor Duanqing Pei is Professor of stem cell biology and also serves as the Director General (President) at the Guangzhou Institutes of Biomedicine and Health (GIBH), Chinese Academy of Sciences. He obtained his PhD from the University of Pennsylvania and trained as a postdoctoral fellow

at the University of Michigan before becoming a faculty member at the University of Minnesota School of Medicine. He joined the Medical Faculty at Tsinghua University in Beijing China followed by a move to the newly formed GIBH. On returning to China, he once again changed his field of study and started working on pluripotency first and then reprogramming. The Pei lab in Tsinghua began to publish in the stem cell field on the structure and function of Oct4, Sox2, FoxD3, Esrrb, and Nanog, and their interdependent relationship towards pluripotency. Based the understanding of these factors, the Pei lab was the first in China to create mouse iPSCs using a non-selective system, and then improved the iPS process systematically. The Pei lab subsequently disseminated the iPS technology in China by providing resources and training. Recent publications from the Pei lab includes the discovery of vitamin C as a potent booster for iPSC generation and the histone demethylases Jhdm1a/1b are key effectors of somatic cell reprogramming downstream of vitamin C, as well as a mesenchymal to epithelial transition initiates the reprogramming process of mouse fibroblasts. The lab continues to explore new ways to improve iPSC technology, dissect the reprogramming mechanisms driven by Oct4/Sox2/Klf4 or fewer factors, and employ iPSCs to model human diseases in vitro.

Cell fate decisions during somatic cell reprogramming

Somatic cell reprogramming is emerging as an ideal system for the analysis of mechanisms involved in cell fate decisions. With clearly defined starting cells and the final iPSCs, it has becoming possible to define the molecular events associated with the various fate changes. We initially reported that a mesenchymal to epithelial transition or MET initiates somatic cell reprogramming and have also identified factors critical for this starting step. Subsequently, we refined this mechanism by demonstrating a sequential EMT-MET process for optimal reprogramming. Therefore, the switching between mesenchymal and epithelial fates appears to underlie the cell fate decisions during somatic cell reprogramming. We then focused on the molecular mechanisms that specify the mesenchymal and epithelial fates and factors that can facilitate or inhibit the transitions.

We will discuss the newly identified factors for these fate decisions. We believe that a comprehensive analysis for the EMT-MET process may help us better understand not only reprogramming but also other cell fate changes in both normal development and diseases.

DR ALISON MCLENNAN

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Dr Alison McLennan is with the Faculty of Business, Government and Law at the University of Canberra. She completed her PhD on the regulation of synthetic biology, an emerging biotechnology, at the Australian National University.

Dr McLennan has also worked in legal policy in the Commonwealth Attorney-General's Department and as a Judge's Tipstaff in the NSW Land and Environment Court. She researches intellectual property and the regulation of emerging technologies. She is interested in how we can manage the risks and maximise the potential benefits of new technologies.

Regulatory considerations in synthetic biology

Synthetic biology offers to transform how we tackle our most difficult global problems, through applications such as greener energy and synthetic vaccines. However, it also poses risks such as damage to the environment and bioterrorism. The accelerating pace of scientific research in this field and uncertainties about the risks and benefits create complex challenges for regulation. What is the role of regulation when new technologies like synthetic biology emerge? Does this new technology require a new regulatory approach? How can the law possibly keep up with the science? How should scientists be involved in developing regulation and policy? These are questions that are being grappled with not only by scientists and lawyers, but also by governments around the world, the biotechnology industry, environmentalists, bioethicists, philosophers, sociologists, and the public. This presentation will explore some of these questions by focusing on the regulatory issues raised by synthetic biology. The major regulatory challenges lie in diverse fields of law. These include intellectual property, biosafety, biosecurity and management of environmental risk. Important issues arise as to the extent to which the regulatory challenges posed by synthetic biology in these areas are distinctive from the challenges posed by earlier biotechnologies.

PROFESSOR RUIPENG LEI

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Professor Ruipeng Lei is Chair of the Department of Philosophy, and Executive Director of the Center for Bioethics, Huazhong University of Science and Technology. She is a board member of the Chinese Society for Bioethics, Associate President of the Asian Bioethics Association, a

research fellow of the International Biomedical and Health Research Ethics Program at Harvard School of Public Health and a member of the International Network on Feminist Approaches to Bioethics. Her research focuses on ethical and policy issues raised by emerging technologies such as synthetic biology, as well as philosophical reflections and ethical analysis on xenotransplantation and biobanks.

Equity issues in enjoying scientific results in emerging biotechnologies: the case of SynBio

The ethics of synthetic biology is part of an ongoing larger debate on the ethics of emerging technologies and biotechnologies. As for other new technologies, the responsible development of synthetic biology must be based on fundamental ethical principles. A consistent ethical framework is needed to undertake a thorough ethical analysis. What we have seen is that the emergence of new technology did deepen existing health inequality and social inequity. How to avoid technological divide and overcome Gattaca argument (genetic divide) is crucial for implementing SynBio in public health or global health. A comprehensive approach should be taken for regulating emergent technologies including SynBio research, development and application: self-regulation, institutional regulation and governmental regulation.

Early- and mid-career researchers

DR ZHENLING CUI

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Dr Zhenling Cui obtained her masters degree in biochemistry and molecular biology at Qingdao Institute of Bioenergy and Bioprocess Technology (QIBEBT), Chinese Academy of Science, China. She then went to the University of Queensland in Australia where she obtained the International

Scholarship and Centennial Scholarship, and completed her PhD in chemical and biological sciences. Her PhD project was supervised by Professor Kirill Alexandrov and mainly focused on exploiting redundancy of the genetic code for site-selective protein labeling in vitro. She received the Dean's 2016 Award for Outstanding Higher Degree by Research Theses. She continued her postgraduate work at the Institute for Molecular Bioscience working in the area of in vitro protein engineering.

DR NATALIE CURACH

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Dr Natalie Curach works closely with the university executive to manage the Future Shaping Research Priority in Synthetic Biology at Macquarie University, Sydney. She has been responsible for the allocation of several million in funds for the establishment of a specialised research laboratory

targeted towards the development of Australia's first Genome Foundry. Through her relationships and collaborations, she has become entrenched in the global synthetic biology community and an advocate for Australia's involvement in the emerging bioeconomy and the implementation of the underpinning technology that enables it. Dr Curach completed her PhD on optimised expression of industrial enzymes in fungi followed by several research positions in government and private laboratories. In addition to her scientific experience, she has spent several years managing small family-run companies and has a Graduate Diploma in Management, continuing towards completion of a MBA. She is the newly elected vice-president for the Synthetic Biology Australasia Association.

PROFESSOR WENBIN DU

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Professor Wenbin Du received his PhD in chemistry from Zhejiang University, and was a postdoctoral researcher at the University of Chicago. He became a research fellow in the Department of Chemistry at Renmin University of China, before joining the Institute of Microbiology, Chinese Academy of

Sciences. His research lab specialises in microfluidics and microbiology applications. Recent efforts have been focused on using microfluidic droplets for high-throughput culturing and screening of single cells in nanoliter to picoliter volumes, and development of automated workflows and devices for large scale single-cell isolation, cultivation, interaction and sequencing.

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Professor Xiongfei Fu is Professor at the Center for Synthetic Biology Engineering Research (CSynBER), Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences. He received his PhD in physics from the University of Hong Kong. He did postdoctoral training at

the Department of Molecular, Cellular, and Developmental Biology, Yale University. In 2016, he started his lab in CSynBER, focusing on the application of quantitative analytics and advanced instrumentation from physics and engineering to biological study, to facilitate our design ability of living systems.

DR EDWARD HANCOCK

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Dr Edward Hancock received his BE (electrical) and BSc (mathematics) degrees from the University of Sydney, and a DPhil degree from the University of Oxford, UK. He is currently based at the University of Sydney with the School of Mathematics and Statistics

and the Charles Perkins Centre. He was previously a post-doc at the University of Oxford and a visiting researcher at Imperial College London. His research interests include systems and synthetic biology, with a particular interest in modelling, design, and determining underlying design principles of metabolic regulation, signalling networks and gene regulatory networks.

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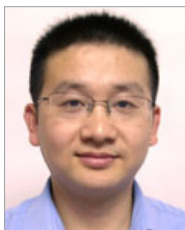
Dr Nan Hao is an ARC DECRA fellow based in the School of Biological Sciences, the University of Adelaide. His research aims to advance fundamental knowledge and addresses widespread but poorly understood processes in gene transcription such as transcriptional

interference, transcriptional roadblocking, feedback control and DNA looping, all of which are likely to be highly significant for regulation of gene expression. In addition, one important aspect of his research is to apply mathematical thinking to understand the 'design' features of the genome. Mathematical modelling has emerged as an increasingly valued tool. Once constructed, the model aids generalisation, allowing information that is derived from one system to be extrapolated to provide predictions for quite different systems.

PROFESSOR HUIFENG JIANG

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Professor Huifeng Jiang received his PhD from the Kunming Institution of Zoology, Chinese Academy of Sciences, and was a postdoctoral fellow at the Division of Nutritional Sciences, Cornell University. He then became a principle investigator in Tianjin Institute of Industrial

Biotechnology, Chinese Academy of Sciences (TIB-CAS). Dr Jiang's research focuses on understanding the origin and evolution of plant specialised metabolism at enzyme, pathway and systems levels. Through synthetic biology and metabolic engineering approaches, he develops new platforms for producing high-value natural products in a sustainable manner. Dr Jiang has won numerous awards in his career, including The Hundred Talents Program of the Chinese Academy of Sciences, Tianjin Thousand Youth Talents Plan and Tianjin Innovative talent promotion program. He has published 27 papers, including in PNAS,

Genome Research, PLoS Genetics, Cell Research, Molecular Biology and Evolution, Biotechnology for Biofuels, and Scientific Reports.

PROFESSOR FENG LI

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Professor Feng Li is a Principal Investigator at Wuhan Institute of Virology (WIV), Chinese Academy of Sciences (CAS) and the Deputy Director of the Center for Analytical Microbiology and Nanobiology. He received his BS from Shandong University and his PhD from WIV, CAS.

After postdoctoral training at Suzhou Institute of Nano-Tech and Nano-Bionics, CAS, he returned to WIV and started independent research. Professor Li has been working in the multidisciplinary field of nanobiotechnology for more than 10 years. He is the first to demonstrate virus tracking by quantum dot encapsulation inside the capsid. His research interests include integration of bio-synthetic protein nanomaterials (especially virus-based nanoparticles) with chemically-synthesised nanomaterials in controllable ways, and cutting-edge applications of these hybrid nanostructures for delivery and sensing. He has published a series of peer-reviewed papers in high-impact journals, including JACS, Angew Chem Int Ed, ACS Nano, and Small.

DR FRANK SAINSBURY

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Dr Frank Sainsbury's research is focused in the areas of biomolecular engineering, protein self-assembly, plant biotechnology and nanotechnology. He is credited with inventing an innovative method for high yielding protein expression in plant leaves which has been applied

to engineer virus-like particles (VLPs) for various bionanotechnological applications including next-generation vaccines. He also leads research into the structure–function relationship of peptide-stabilised nanoscale emulsions that hold considerable promise in drug delivery, molecular imaging and designer vaccines. More recently his research has focused on bioengineering VLPs for guest protein encapsidation. Fundamental understanding of the supramolecular self-assembly mechanisms of different VLPs is leading to applications in therapeutic delivery and biocatalytic nanoreactors.

DR STEFAN SIIRA

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Dr Stefan Siira was awarded his PhD from the University of Western Australia. He received an Australian Postgraduate Award scholarship and has published nine research articles in leading international journals including Nature Communications, Cells Reports and The American Journal of Human

Genetics. He was awarded a grant from the Australian Mitochondrial Disease Foundation and presented at the 2016 AussieMit conference. Dr Siira developed a new bacterial selection system to identify soluble protein fragments in bacteria which enabled him to produce a soluble variant of a difficult-to-study protein, PTCD1, allowing its RNA targets to be studied in vitro. He has made significant contributions to identifying molecular mechanisms and pathogenic mechanisms in disease. He has made seminal developments in the analysis of mitochondrial RNA regulation to study, for the first time, RNA processing and RNA engagement by the protein synthesis machinery in vivo.

DR THOMAS VANHERCKE

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Dr Thomas Vanhercke obtained his MSc and PhD degrees at the Faculty of Bioscience Engineering, Ghent University, Belgium. Following his PhD in collaboration with Bayer BioScience, Zwijnaarde, Belgium, he worked as a postdoctoral fellow in the plant oil

engineering group of Dr Surinder Singh at CSIRO Plant Industry. Dr Vanhercke is engineering vegetative plant parts (leaf, stem, root...) to accumulate high levels of valuable plant oils that are normally stored only in certain seed(-associated) tissues. He has created tobacco model plants that can store more than a third of their leaf dry weight as oil via combinatorial metabolic engineering. These 'fat plants' offer the potential of delivering game-changing oil yields that potentially outperform current oil crops several-fold. CSIRO's 'leaf oil' technology he helped develop is now being successfully deployed in a variety of crops. He is also actively exploring the possibility of extending synthetic biology principles into the plant kingdom to lift metabolic engineering and forward/reverse genetics to a high throughput level.

ASSOCIATE PROFESSOR JIN WANG

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Associate Professor Jin Wang received his PhD in microbiology from the Shanghai Institutes for Biological Sciences (SIBS), Chinese Academy of Sciences. He then worked as a postdoc in the Department of Microbiology in the Chinese University of Hong Kong. He returned to SIBS

and is now an associate professor in the CAS Key Laboratory of Synthetic Biology. His interest has focused on developing the enabling technology in synthetic biology.

