Biomolecular Interaction Centre

building connections

2015 – 2016 REPORT

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Our Mission

The Biomolecular Interaction Centre is a multi-disciplinary centre dedicated to the study of molecular interactions critical to biological function.

Understanding biomolecular interactions is central to a range of fundamental sciences, new treatments for disease, and a wide range of functional products. This gives us a variety of pathways through which we can connect to industry.

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Design and photography by Matt Walters,
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THIS REPORT COVERS THE PERIOD 1 NOVEMBER 2014 – 31 OCTOBER 2016

Directors' Report

ANT POOLE (DIRECTOR) AND REBECCA HURRELL (INSTITUTE MANAGER)
Biomolecular Interaction Centre

A DECADE AS A PREMIER RESEARCH CENTRE

The Biomolecular Interaction Centre will, in 2017, mark its tenth anniversary. Over the past two years, the Centre has undergone extensive changes in leadership as it has sought to redefine what makes it one of the University of Canterbury's Premier Research Institutes. I am pleased to say that this exercise, while challenging at times, has resulted in our centre evolving into a stronger unit with focused, team-based leadership.

The Centre has welcomed in new blood, in the form of a superb Institute Manager, Rebecca Hurrell, and has developed and implemented a management team model, which has created much-needed robustness and continuity at the helm.

That said, the Centre is still undergoing change, with former Director, Professor Emily Parker and myself both leaving UC for new challenges in early 2017. At the same time, we have expanded our UC-based PI community, with Associate Professor Paul Gardner and Professor Antony Fairbanks adding to the PI base. We expect several new AIs and PIs to join BIC's ranks in the coming year, and our investigator community is now bigger and more diverse than in the past.

We continue to be successful in winning grants, with more than 40 grants worth $5.8 million having come into BIC over the past two years. A key feature of our success here can be traced to the strong culture of mentoring that BIC has developed, both for emerging scientists to begin applying for their own funding (for example, two BIC postdocs made it through to the second round of the 2016 Marsden Fund) and for established and emerging scientists to get feedback on their draft applications. Through 2015 and 2016, we have seen a marked growth in successful applications for MBIE and other funding.

We finish 2016 the news that BIC PI Professor Antony Fairbanks has secured Marden funding and Dr Duncan McMillan, currently at the University of Tokyo, has gained a Rutherford Discovery Fellowship. Duncan will join BIC in late 2016. Moreover, the successes are forging an exciting path from basic research through to near-to-market breakthroughs. We are very excited by this development, and believe we are likely to see the formation of at least one spin-out company over the next two years.

Ant Poole


BECKMAN COULTER
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60,000 RPM

Income

Biomolecular Interaction Centre income (all sources)

	2012	2013	2014	2015	2016*
University Institute Support	$1,076,575	$384,551	$470,453	$182,648	$265,515
External Revenue	$1,468,658	$2,653,686	$3,036,913	$3,569,339	$2,299,474
Total	$2,545,233	$3,038,237	$3,242,632	3,751,987	$2,564,989

*Forecast as at 31 October 2016

BIC'S EXTERNAL REVENUE HAS REMAINED SIGNIFICANT

EVOLVING AND ENGINEERING BIOMOLECULES

FLAGSHIP LEADER – RENWICK DOBSON

"Nothing in Evolution makes sense except in the light of Biology" (Professor Tony Dean, University of Minnesota). This cheeky rewording of Theodosius Dobzhansky's famous quote makes the point that the molecular consequences of evolution (the molecular phenotype) are often overlooked. BIC researchers involved in the Evolving and Engineering Biomolecules flagship theme are changing this view of molecular evolution. Current research includes enzyme evolution, RNA (co)evolution, and how evolution can be harnessed to engineer enzymes with novel properties.

2015 and 2016 have been productive and exciting, producing a slew of high impact publications.

FLAGSHIP HIGHLIGHTS

AVOIDING UNWANTED RNA INTERACTIONS

Translation is the process by which the genetic information in a molecule of messenger RNA (mRNA) produces a protein, and the translation efficiency is the rate at which protein is produced from a given mRNA molecule. This rate is different for different mRNA molecules, which is why researchers are trying to determine the features of these molecules that affect translation efficiency. In *eLife*, first author and BIC PhD student Sinan Umu along with BIC PIs Paul Gardner, Anthony Poole, and Renwick Dobson report that the translation efficiency in bacteria and archaea is influenced by a phenomenon called "avoidance".[1] Avoidance is the degree to which an mRNA molecule avoids random interactions with noncoding RNA molecules in the cell. Noncoding RNAs, as their name suggests, do not code for proteins, but they make up a majority of the RNA in any given cell. Indeed, the BIC team show that the levels of noncoding RNAs in bacterial cells are two orders of magnitude greater than the levels of mRNAs. This work was supported by a BIC Seed grant in 2014 to PIs Gardner and Dobson ($6,000) and a BIC-BlueFern PhD scholarship for Sinan.

1. S. U. Umu, A. M. Poole, R. C. J. Dobson, and P. P. Gardner, "Avoidance of stochastic RNA interactions can be harnessed to control protein expression levels in bacteria and archaea.," *Elife*, vol. 5, p. e13479, Sep. 2016.

ENGINEERING NEW ENZYMES FOR THE PRODUCTION OF NEW GLYCOPROTEINS

PI Antony Fairbanks and his team have been engineering ENGase (endo-β-N-acetylglucosaminidases) enzymes as biocatalysts for the production of homogenous glycopeptides and glycoproteins. They published two recent standout publications [3,4] in this area. In *Angewandte Chemie*[3] they report the first-ever production of a glycoprotein bearing mannose-6-phosphate residues using ENGases. Mannose-6-phosphate is an important biomarker, the addition of which results in protein transport to the lysosome. This project, which has significant implications for the development of better treatments for lysosomal storage disorders by enzyme replacement therapy, has just been supported by the awarding of $870,000 of Marsden funding. This will see Antony collaborate with Dr Antonia Miller, of Callaghan Innovation's UC-based Protein Science and Engineerging Team; along with Professor Fran Platt, University of Oxford, and Professor Matthieu Sollogoub from the Pierre and Marie Curie University, Paris, France.

The second publication in *Chemical Science*[4] relates to a collaborative project undertaken with the research groups of Margaret Brimble and Rod Dunbar (University of Auckland). In this landmark study ENGase enzymes were used to produce glycopeptide vaccine candidates decorated with homogeneous high-mannose glycans, which they then demonstrated were more effectively taken up by dendritic cells than non-glycosylated versions.

2. P .Priyanka, T.B. Parsons, A. Miller, F.M. Platt, and A.J. Fairbanks, "Chemoenzymatic synthesis of a phosphorylated glycoprotein." *Angewandte Chemie International Edition* vol. 55, no. 16, pp. 5058-5061, March 2016.

3. J.D. McIntosh, M.A. Brimble, A.E.S. Brooks, P.R. Dunbar, R. Kowalczyk, Y. Tomabechi, and A.J. Fairbanks, "Convergent chemo-enzymatic synthesis of mannosylated glycopeptides; targeting of putative vaccine candidates to antigen presenting cells" *Chemical Science*, vol. 6, no. 6, pp. 4636-4642, May 2015.

BIC PI Associate Professor Paul Gardner

UNTANGLING HOW A GOLIATH EPIGENETIC REPRESSOR HAS A TENDER TOUCH ON DNA

Structural **m**aintenance of **c**hromosomes flexible **h**inge **d**omain containing 1 (Smchd1) is an epigenetic repressor. It has been shown to play an essential role in autosomal and X-linked gene repression, with critical consequences for normal biology and disease, particularly facioscapulohumeral muscular dystrophy. BIC researcher Dr Sarah Kessans and PI Ren Dobson, along with collaborators from Australia and the Netherlands, published a featured article in PNAS. The underlying molecular mechanism by which Smchd1 functions is unknown. The work provides the first biochemical and biophysical evidence that Smchd1–chromatin interactions are established through the homodimeric hinge domain of Smchd1 and, intriguingly, that the hinge domain also has the capacity to bind DNA and RNA. The results suggest Smchd1 imparts epigenetic regulation *via* physical association with chromatin, which may antagonize other chromatin interactions, resulting in coordinated transcriptional control.

4. K. Chen, J. Hu, D. L. Moore, R. Liu, S. A. Kessans, K. Breslin, I. S. Lucet, A. Keniry, H. S. Leong, C. L. Parish, D. J. Hilton, R. J. L. F. Lemmers, S. M. van der Maarel, P. E. Czabotar, R. C. J. Dobson, M. E. Ritchie, G. F. Kay, J. M. Murphy, and M. E. Blewitt, Genome-wide binding and mechanistic analyses of Smchd1-mediated epigenetic regulation. *Proceedings of the National Academy of Sciences of the United States of America*, vol. 112, no. 27, pp. E3535–44, Jul. 2015.

CONTROLLING ENZYME ACTIVITY

The work on the understanding of complex allosteric mechanisms for the control of enzyme activity has continued in the lab of BIC PI Emily Parker. A new collaboration with Eileen Jaffe (Fox Chase Cancer Center, Philadelphia) assisted with the understanding of the way in which the human enzyme phenylalanine hydroxylase[5] operates. Mutations to this enzyme are the cause of the phenylketonuria, the most common inborn error of amino acid metabolism.

Research has also continued with understanding the complexity of regulation for the shikimate pathway. Complex domain movements were shown for the *Geobacillus* sp. 3-deoxy-D-arabino-heptulosonate 7-phosphate synthase (DAH7PS), and this work was highlighted as "Paper of the Week" in the *Journal of Biological Chemistry*.[6] PhD students Eric Lang and Logan Heyes study of the dynamic networks involved in the allostery was published in the *Journal of the American Chemical Society*.[7]

5. Arturo, E. C., Gupta, K., Heroux, A., Stith, L., Cross, P. J., Parker, E. J., Loll, P. J., and Jaffe, E. K. (2016) First structure of full-length mammalian phenylalanine hydroxylase reveals the architecture of an autoinhibited tetramer. *Proc. Natl. Acad. Sci .USA* 113, 2394-2399.

6. Nazmi, A. R., Lang, E. J. M., Bai, Y., Allison, T. M., Othman, M. H., Panjikar, S., Arcus, V. L., and Parker, E. J. (2016) Interdomain Conformational Changes Provide Allosteric Regulation En Route To Chorismate. *J. Biol. Chem.* 291, 21836-21847.

7. Lang, E. J., Heyes, L. C., Jameson, G. B., and Parker, E. J. (2016) Calculated pKa variations expose dynamic allosteric communication networks. *J. Am. Chem. Soc.* 138, 2036-2045.

FLAGSHIP FUNDING SUPPORT – 2015-2016

The focus of funding support is on projects to obtain preliminary data for future grant applications by BIC PIs and AIs, particularly those that involve collaboration between AIs and PIs together. $40,000 has been dispersed across 2015 and 2016.

PIs Ant Poole and Paul Gardner were granted $5,000 to support an experimental evolution experiment that provided preliminary data for a Marsden application in 2016.

PIs Volker Nock, Ren Dobson and Grant Pearce gained $10,000 to support a shared studentship on membrane studies. This was funding that crossed flagships one and two to encourage interactions across engineering and science. This work led to new PhD scholarship funding from Callaghan Innovation to support Serena Watkin to develop "labs-on-a-chip" for protein interaction characterisation and cell studies.

New academic in September 2016 in the School of Biological Sciences, Dr Mitja Remus-Emsermann was granted $5,000 to support him in establishing his research at UC. Dr Remus-Emsermann, a microbiologist, has been active in establishing new connections within the BIC community.

PIs Grant Pearce and Paul Gardner recieved funding of $5,000 to study evolutionary relationships between DHDPS like enzymes.

PI Antony Fairbanks was funded to obtain preliminary data for an MBIE application (to be submitted in 2016), which revolves around untangling how endo-N-acetylglucosaminidases function and how they may be repurposed for bespoke synthetic chemistry.

$3,000 was provided to establish a collaboration between BIC PI Ren Dobson and ESR's Dr Craig Billington. The project will investigate the biological function of novel bacteriophage endolysins—enzymes that punch holes in bacterial cell walls. ESR have committed $46,500 in new funding for the project.

AI Deb Crittenden and PI Emily Parker requested funding ($5,000) for "Enhanced conformational sampling along torsional coordinates". The aim is to develop a computational method to enable modelling of biomolecules on experimentally realistic time and length scales.

Funding of $2,000 was provided to Grant Pearce for travel to the University of Otago to use the CryoEM instrument for the purpose of determining protein structures. CryoEM is fast becoming a central experimental technique in the field of structural biology.

FLAGSHIP FUNDING SUCCESSES

PI Paul Gardner has received funding from the BioProtection CoRE for two projects: "To identify determinants of virulence and adaptation in the kiwifruit pathogen *Pseudomonas syringae* pv. *actinidiae*", and "Provide bioinformatics expertise to allow genomic comparisons" ($91,000; 2016-2019).

PI Antony Fairbanks secured Marsden Funding from the Royal Society of New Zealand (2017-2020) to study "A new paradigm for organelle targeting" ($870,000).

PI Ren Dobson was successful in securing Marsden Funding from the Royal Society of New Zealand (2016-2019) to study bacterial sialic acid metabolism ($770,000). This work was initiated by a 2014 BIC seed grant $5,000.

International collaborator A/Prof Andre Hudson (Rochester Institute) and PI Ren Dobson secured NIH funding (US$413,000) to explore inhibitors of enzymes in the lysine biosynthetic pathway. The grant is entitled "Genetic and structural analysis of L,L-diaminopimelate aminotransferase (DapL): An attractive target for the development of narrow-spectrum antibiotics" (2016-2019).

PIs Ren Dobson and Conan Fee secured funding from the Riddet CoRE at Massey University. Funding of $123,000 over two years will support projects of mutual interest to BIC and the Riddet Institute (2016-2018).

PI Ren Dobson obtained $49,000 from the Lotteries Health Research fund to upgrade facilities of the New Zealand Centre for Analytical Ultracentrifugation (NZAUC) . This provided for the purchase of a 4-hole rotor, which allows samples to be centrifuged at greater speeds (2015).

Flagship Two

ENGINEERING BIOTECHNOLOGY

FLAGSHIP LEADER - DR VOLKER NOCK

We bring together rapid prototyping and advanced manufacturing technologies from the engineering disciplines to help inform molecular and cellular life sciences. To achieve this, the Flagship incorporates a diversity of input from the physical sciences and engineering with the aim to develop new platforms that help unravel the complexity of biology. We work with cells, animals and plants and our research spans the biological hierarchy from molecules to whole organisms.

We are focusing on the following broad areas of activity: 3D printed devices for bioseparations, biomolecular interactions on surfaces, biomolecular interactions related to disease, biochemistry on chips and sourcing of advanced materials from nature's pantry. In a drive to increase cross-disciplinary research, several major projects are currently being funded under this Flagship.

FLAGSHIP HIGHLIGHTS

3D PRINTING OF MICROSTRUCTURED MATERIALS

The Biomolecular Engineering Research Group in the Department of Chemical & Process Engineering (CAPE), led by PI Professor Conan Fee and Associate Professor Matt Watson of CAPE, have continued BIC's world-first work on creating porous materials using 3D printing. This idea, funded through an MBIE Phase 2 'Smart Ideas' grant, has wide applications, including for chromatographic purification of proteins, enzyme catalysis, chemical catalysis, filtration, reactors and even heat exchangers and batteries. In the context of BIC, the major focus has been on protein chromatography and the group has been successful in creating printed agarose monoliths that can separate proteins in the presence of yeast cells. This new approach will eliminate at least two process steps from recombinant and therapeutic protein production processes, reducing cost while increasing yield and bioactivity. The 3D printing work has so far involved around nine doctoral students, 19 other research students, as well as 14 staff across five departments.

Dr Simone Dimartino (former BIC PI now at the University of Edinburgh) recently received the Csaba Horváth Young Scientist award for his presentation on aspects of this work at the 44th International Symposium on High Performance Liquid Phase Separations and Related Techniques, HPLC 2016, San Francisco. The project covers experimental and computational fluid dynamics, materials science, surface chemistry, laser physics, separations and reaction engineering and it has now attracted collaboration from several high-profile international companies, universities and research institutions.

MEASURING THE DIFFUSION OF MACROMOLECULES AND THEIR INTERACTIONS ON CHIP

Biomolecular interactions of macromolecules are inherently difficult to characterise and measure, particularly in complex solutions. Emerging devices harnessing the unique physics of multi-stream microfluidic flow provide a promising platform technology for new analytical tools to study these interactions. BIC PIs Grant Pearce, Volker Nock and Ren Dobson, are setting out to design devices that characterise interactions in real time and in complex solutions. The team has recently been joined by PhD student Serena Watkin, who is co-funded by a BIC-Callaghan Innovation scholarship. Serena is using ultracentrifugation, SAXS and microfluidic flow devices to characterise biomolecule interactions.

FLEXIBLE MICROPILLAR ARRAYS FOR THE STUDY OF PROTRUSIVE FORCES IN HYPHAL INVASION

The role of the cytoskeleton in invasive hyphal growth of fungi and oomycetes is the focus of a successful collaboration between BIC PI Volker Nock and Associate Professor Ashley Garrill. Their aim is to develop a microfluidic platform for the study of protrusive forces in hyphal invasion based on flexible micropillars. Fungi and oomycetes grow as pathogenic species on both plants and animals. They can have significant effects on humans, either directly through infections or indirectly through loss of crops and other species. Using newly developed microfluidic devices the team was recently able to show the first on-chip measurement of protrusive force exerted by single hyphal tips of pathogenic microorganisms. The team hopes that better understanding of the molecular generation of protrusive force may impact on ways to address the many diseases and infections that occur due to invasive fungal and oomycete growth.

FLAGSHIP FUNDING SUCCESSES

PI Volker Nock was successful in securing funding from the Brian Mason Trust and Marsden Fast-Start Funding from the Royal Society of New Zealand to study protrusive forces in hyphal invasion. His Marsden grant is entitled: ***Hyphae-on-a-chip: a microfluidic platform for the study of protrusive forces in hyphal invasion.*** Volker has also been successful in securing National Science Challenge funding to develop insulin sensors and MBIE-project funding to develop sensors related to invasive species.

FLAGSHIP PROJECT SUPPORT

BIC AI Gabriel Visnovsky has been awarded funding to strengthen collaboration between the College of Engineering and the School of Biological Sciences.

BIC PI Volker Nock and University of Otago-based AI Dr Monica Gerth have funding to jump-start a joint project on chemotaxis in microfluidic devices.

PIs Grant Pearce, Renwick Dobson and Volker Nock have funding for fluidic consumables for two doctoral projects to develop Labs-on-a-chip for protein interaction characterisation and cell studies.

PI Volker Nock will purchase consumables for joint projects with Ashley Garrill, Maan Alkaisi, Kenny Chitcholtan and Azam Ali.

There has also been general support given ***via*** the Flagship to purchase commercial microfluidic chips, O_2 sensors and to establish a chip alignment setup.

Flagship Three

FROM INTERACTION TO APPLICATION

FLAGSHIP LEADER - DR ANTONIA MILLER

An established strength of BIC is our capacity to take ideas from the research laboratory into the real world. Our relationship with the Callaghan Innovation Protein Science and Engineering Team continues to be productive, and we have worked to widen the interactions between our researchers and industry. In addition, Dr Neil Pattinson (Board Chair of AuramerBio) has consulted with BIC PIs on commercialisation opportunities. We continue to progress initiatives to support the evaluation of current and future research in the context of application to industry.

FLAGSHIP HIGHLIGHTS

NZBIO

BIC Director Anthony Poole and Institute Manager Rebecca Hurrell attended the Annual NZBIO conference in Auckland in September. NZBIO is New Zealand's industrial biotechnology conference and a key opportunity for BIC to engage with researchers, industry and research commercialisation professionals. Anthony and Rebecca gained insights into industry trends and formed new contacts. They also gained important knowledge around approaching commercialisation of BIC projects.

MBIE AND COMMERCIALISATION WORKSHOP

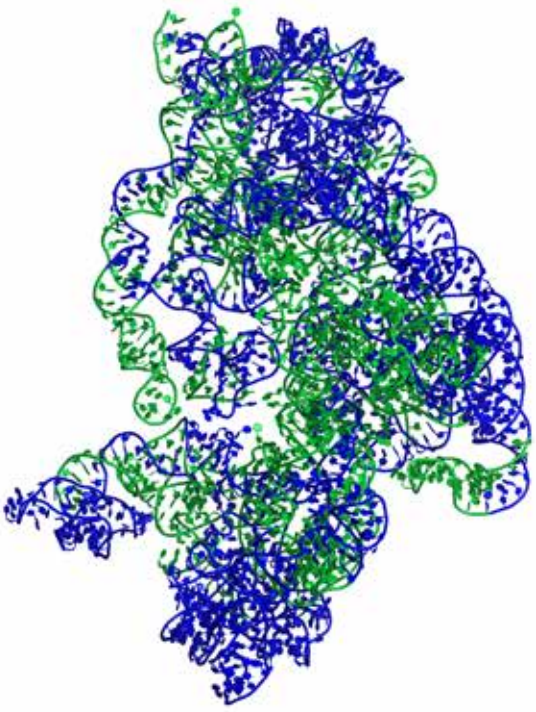
Organised by Institute Manager Rebecca Hurrell and Ren Dobson, BIC PIs, AIs and commercialisation experts got together for an afternoon to brainstorm potential commercialisation and MBIE opportunities. The workshop included former MBIE panel members, Heather Thomas (UC Research and Innovation), Neil Pattinson (CEO of AuramerBio), Nigel Harris (Māori Research Kaiārahi, UC), and George Slim (Rhadegund Life Sciences Ltd).

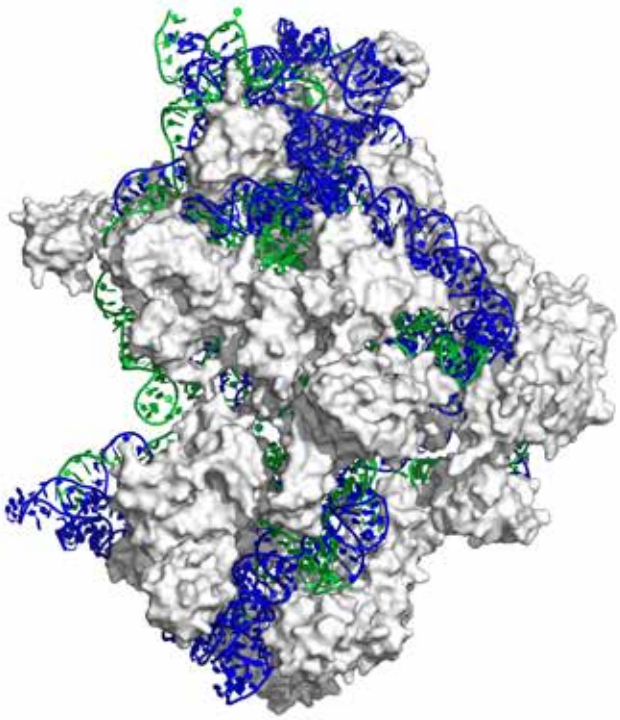
TECH JUMPSTART AWARD

BIC PIs Ren Dobson and Volker Nock, have been awarded a UC Tech Jumpstart prizes of $20,000 for their project "A point-of-care microfluidic device that tests for blood incompatibility". A serious and sometimes lethal complication that can occur during blood transfusions is the infusion of an incorrect, incompatible blood type. Ren and Volker are aiming to develop a device to monitor blood at a patient's bedside, to ensure the infusion of the correct blood type. This is an excellent example of BIC success in combining engineering and biochemistry to deliver applicable solutions to industry.

COMMERCIALISATION OF BIC RESEARCH

PI Paul Gardner, in collaboration with Ren Dobson and Ant Poole, recently published breakthrough research in the prestigious open-access ***eLife*** journal. Their work demonstrated that a previously overlooked mechanism controls additional variation in gene expression. They are exploring a number of potential biotech applications as a result of these research findings, particularly in the area of designing mRNAs for genes to improve protein production. Paul is working with colleagues at Callaghan Innovation and Powerhouse to realise the opportunities.





Equipment

CAPITAL EXPENDITURE AND EQUIPMENT MAINTENANCE

Outstanding facilities and equipment are critical to BIC's mission of delivering world-class research in biomolecular interactions at the interface of engineering and science. As such, BIC continues to invest strategically in capital equipment and in its ongoing maintenance.

In 2015, BIC supported the purchase of a ForteBio BlitZ instrument based in the School of Biological Sciences. The capabilities of this will complement those of the existing surface plasmon resonance (SPR) instrument (Fee) and the analytical ultracentrifuge (AUC) (Dobson). To support structural biology initiatives, we purchased two MacBookPro computers for running protein dynamics simulations and crystallography projects which are also supported through Flagship one (Parker and Dobson). To support the New Zealand Centre for Analytical Ultracentrifugation, BIC secured external funding from the Lotteries Health Research Fund ($48,000) to upgrade the AUC's capabilities. In total in 2015, BIC funded $98,000 of research equipment through its CAPEX allocation and secured $49,000 in external funding.

In 2016, BIC purchased a replacement real-time PCR (polymerase chain reaction) instrument (Pearce), upgraded the Fluorescence Microscope (Nock), purchased a computer node to increase capacity on the biology cluster, and purchased a vibration free incubator to support the growing number of structural biology projects within BIC (Dobson). In total, we funded $80,000 for new capabilities, upgrades and replacements from the BIC CAPEX allocation.

In order to maintain BIC equipment and other equipment used heavily by BIC researchers we allocated over $45,000 in 2015-2016 to servicing and repairs.

BIC Bites

RIDDET FUNDING SUCCESS

BIC PIs Conan Fee and Ren Dobson have secured funding from the Riddet Centre of Research Excellence at Massey University. The funding ($123,000 over two years) will support projects of mutual interest to BIC and the Riddet Centre. Both Ren and Conan are Riddet Associate Investigators. Their initial work centres on the development of an affinity ligand for removing beta-lactoglobulin from bovine milk to reduce infant allergies. Previous work in Fee's group discovered a promising ligand that appears to have biospecific affinity for beta-lactoglobulin, and on-going work is now associated with optimising the ligand conjugation technique through peptide engineering. If successful, this work will not only form a possible industrial processing method, but will enable collaborative work with PI Renwick Dobson to explore the role of beta-lactoglobulin in a range of biomolecular interactions through surface plasmon resonance (Fee) and analytical ultracentrifuge techniques (Dobson).

DR SARAH KESSANS, NASA ASTRONAUT CANDIDATE

In February 2016, BIC researcher Dr Sarah Kessans applied to become an Astronaut Candidate in NASA's 22nd Astronaut Class. There were a record number of applicants in the selection cycle (18,300), but her application stood out enough to make it through to the highly qualified pool in July (the top 450 applicants). In August, she was notified she had been selected as an initial interviewee (the top 120 applicants). As part of this, Sarah was invited to the Johnson Space Centre (JSC) in Houston in late August for initial interviews. That week in Houston was hands down the best week of her life. Getting to interact with the current Astronaut Corps and tour the facilities at JSC solidified her desire to become an astronaut and contribute her skills to the inspiring missions of exploring our universe, pushing science forward, and connecting humanity on a global scale.

Sarah should find out in December 2016 if she has made it to the next selection round (the top 60). If she makes this cut, she will be invited back to Houston between January and April for another week of tests. In June 2017, NASA will choose 8-14 finalists to become the Astronaut Candidate Class of 2017, reporting for duty in August 2017 (conveniently when her current BIC contract concludes). The journey thus far has been an incredible one, and the support that Sarah received from the BIC community has been phenomenal. Regardless of the outcome of selection, she is thankful for the encouragement and inspiration every step of the way!

SERENA WATKIN, CHAPTER AUTHOR

Callaghan Innovation and BIC co-funded doctoral student Serena Watkin has written a book chapter titled "Microfluidics for Small-angle X-ray Scattering". This will be published by InTech in "X-ray Scattering" in the near future. Serena's research looks at ways protein biochemists can take advantage of microfluidic technology for studying protein function, interactions and dynamics, and she is working on developing new microfluidic tools for such purposes. The chapter is based on a literature review Serena carried while she was investigating the use of microfluidics for time-resolved measurements of protein size and shape changes, which can be readily monitored using small-angle X-ray scattering (SAXS). The team, which includes BIC PIs Volker Nock, Ren Dobson and Grant Pearce, along with beamline scientist Tim Ryan, is hoping to establish a microfluidic setup at the Australian Synchrotron SAXS beamline to enable rapid-mixing and time-resolved data to be acquired with ease.

CUSTOM SCIENCE NZSBMB AWARD

The Custom Science NZSBMB Award is the New Zealand Society of Biochemistry and Molecular Biology's premier prize for research excellence. The award is based upon nominated papers published in the previous three years, contribution statements for these and the applicant's CV. Paul Gardner (BIC PI) has been awarded the 2016 Custom Science NZSBMB Award. And is really happy about it!

STRENGTHENING COLLABORATION

BIC PI Grant Pearce has secured co-funding from AgResearch and BIC to fund a doctoral student for three years. The project will focus on linking the consumer-relevant properties of foods to the modification profile of their constituent proteins and the oxidative influence of lipids. Ziqi Yu has previously carried out an MSc at Wageningen University studying ingredient functionality. She is expected to start the project before the end of 2016.

SUMMER SCHOLARS

At the end of 2016 BIC will co-fund up to twelve UC Summer Research Scholarships. These scholarships are worth up to $5000 to students to undertake ten weeks of research on a project over the summer period. The key purpose of the programme is to give senior students experience in research and to encourage them to pursue postgraduate study. The scholarships are co-funded by the UC Foundation. The BIC-supported projects are on a broad range of topics including: sweaty robots, developing protein cross-linking technologies, isolating and testing new bioactives, groundwater index of health and nanomaterials from waste. Students will have the opportunity to work with BIC AIs and PIs, both UC and non UC-based, including projects in collaboration with Callaghan Innovation and ESR.

UC DOCTORAL SCHOLARSHIP SUCCESS

Mohammad Firoozinia has been awarded a UC doctoral scholarship for his studies. This scholarship is awarded annually to the top BIC doctoral student.

SUPPORTING POSTGRADUATE STUDY

BIC acknowledges that there are a number of postgraduate students at masters and doctoral level who are self-funded and, in order to support them, we have set aside a small pool of funding. The funding is directed towards students who are carrying out research in areas BIC sees as fitting the scope of BIC reserach and is strategically important.

In 2015, $38,000 was distributed to seven UC students of BIC AIs and PIs, and in 2016 $27,000 was distributed to eight students.

Serena Watkin

BEST POSTER PRIZE

Congratulations to PhD student Azadeh Hashemi (co-supervised by Volker Nock and Professor Maan Alkaisi) for taking out best poster prize at the 42nd International Conference on Micro and Nano Engineering in Vienna with her work on "Enhancing the resolution and stability of bioimprinted casein microdevices". This is a major European conference and Azadeh's poster was chosen from ~300. Well done! The work was supported in part by BIC.

BIC DOCTORAL SCHOLARSHIP SUCCESS

Alannah Rickerby has commenced a BIC-funded PhD with BIC PI Ant Poole on the topic of *Using synthetic evolution to streamline translation*. Funding of $21,000 per annum, plus tuition fees for three years has been awarded.

BIC POSTDOCTORAL FELLOWS

Over 2015 and 2016, BIC has funded nine postdoctoral fellows to undertake research with BIC PIs. Each recieved between six and 13 weeks of funding to carry out specific targeted research. Projects included investigating the synthesis of phosphorylated glycoproteins; RNA *vs* protein - investigating evolutionary robustness; and studying gelation properties of self-assembling peptides. BIC funds the equivalent of one full-time postdoctoral fellow each year.

SPONSORSHIP

The Canterbury Omics Symposium is a regular fixture in the Canterbury science calendar. It evolved out of a BIC research symposium that BIC PI Paul Gardner organised in November 2014. BIC has sponsored and had strong representation at every subsequent meeting:

- Canterbury 'Omics Symposium II, Lincoln University, Friday 1 May 2015
- Canterbury 'Omics Symposium III,University of Otago, Christchurch, Wednesday 4 November 2015
- Canterbury 'Omics Symposium IV, Plant & Food Research, Lincoln, Wednesday 30 March 2016
- Canterbury 'Omics Symposium V, University of Canterbury, Thursday 27 October 2016

BIC also sponsored the following conferences:

- Queenstown Molecular Biology Main Meeting 2016, Rutherford Hotel, Nelson, 29 - 31 August 2016
- Big Data, Little Organisms, Joint Conference of the New Zealand Microbiological Society and NZ Society for Biochemistry and Molecular Biology, University of Canterbury, 14 - 17 November 2016

NZSBMB SUCCESS

New Zealand Society for Biochemistry and Molecular Biology (NZSBMB) awarded prizes to three BIC-associated doctoral students at the Big Data, Little Organisms conference in Christchurch, 2016. Alicia Lai (Anthony Poole) was awarded first place in the oral competition and Nicole Wheeler (Paul Gardner) was awarded second place. Fatemeh Ghomi (Paul Gardner) was awarded third prize in the poster competition.

Left to right: Volker Nock, Azadeh Hashemi and Maan Alkaisi

Our Growing Capability

BETHANY JOSE

TACKLING PATHOGENS WITH COMPUTERS

Pathogenic bacteria impact human health, livestock, horticulture, and our native species. While DNA sequencing is now routine, we may be missing large swathes of important genetic information hidden in the genomes of pathogens. This so-called genomic 'dark matter' includes genes that encode small RNA molecules. These may well hold the key to understanding how pathogens fine tune their genetic systems during infection. PhD student Beth Jose is developing state-of-the-art bioinformatics tools to illuminate genomic dark matter RNAs using the power of comparative analysis. This is crucial if we are to better combat pathogens, but the task is tricky because RNAs evolve very quickly, making small RNA identification akin to finding a needle in a haystack. Beth's new approach is already bearing fruit, and is a critical first step towards meeting the pathogen challenge head on.

ALANNAH RICKERBY

HARNESSING THE BRAVE NEW WORLD OF SYNTHETIC BIOLOGY

Understanding how biological systems evolved is critical if we are to control or alter them for biotech. PhD student Alannah Rickerby is looking at how DNA, the molecule at the centre of all life, evolved, to better understand whether other genetic systems might operate as well as natural systems. To do this, she is combining the emerging tools of synthetic biology and gene editing with the power of experimental evolution to see if she can create a genetic throwback - an organism that lacks T, the fourth letter in the genetic alphabet. If she can pull this off, it will help her understand whether there is anything special about T, which appears to have been a late addition to the DNA alphabet. This will enable us work out whether modern DNA is optimal for genetic storage, or whether other versions of DNA could be just as good. With IT giants now talking about storing online information in DNA, the implications of this work could be profound.

HELEN ASHMEAD

FROM BIC TO INDUSTRY

Former Callaghan Innovation funded BIC doctoral student Helen Ashmead has secured employment at Arotec Diagnostics Ltd, Wellington.

Helen completed her PhD under the supervision of BIC PI Professor Juliet Gerrard (now at the University of Auckland) on "Proteins as bulding blocks for biological nanomaterials". She defended her thesis in August 2016 and was awarded her PhD in September. Helen received the Callaghan Innovation graduate careers grant in July and now works developing methods for producing recombinant antigens to be used in autoimmune disease diagnostics.

Bethany Jose

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PROFESSOR EMILY PARKER

DR RENWICK DOBSON

PROFESSOR CONAN FEE

DR GRANT PEARCE

DR VOLKER NOCK

ASSOCIATE PROFESSSOR PAUL GARDNER

PROFESSOR JULIET GERRARD

PROFESSOR ANTONY FAIRBANKS

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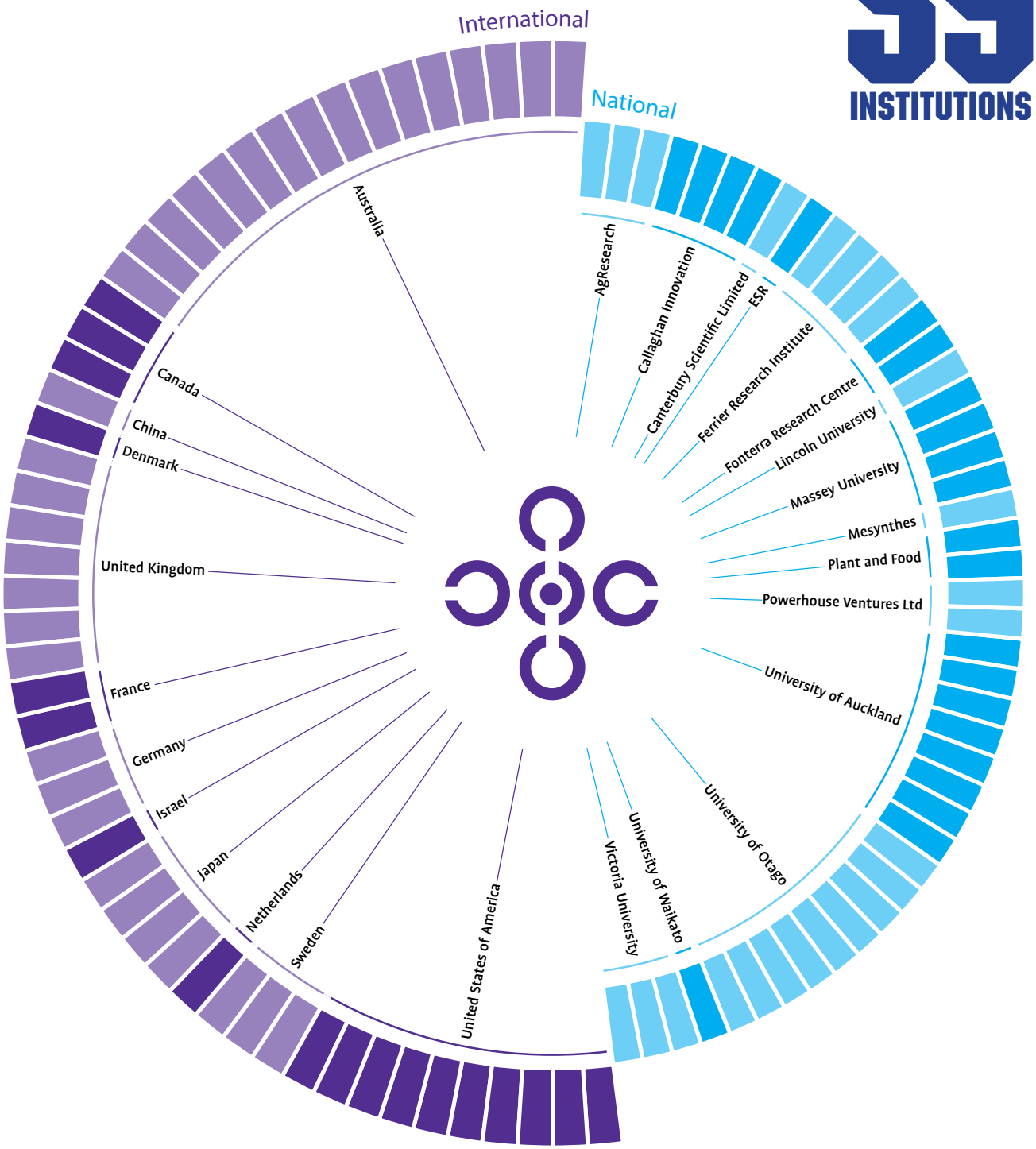

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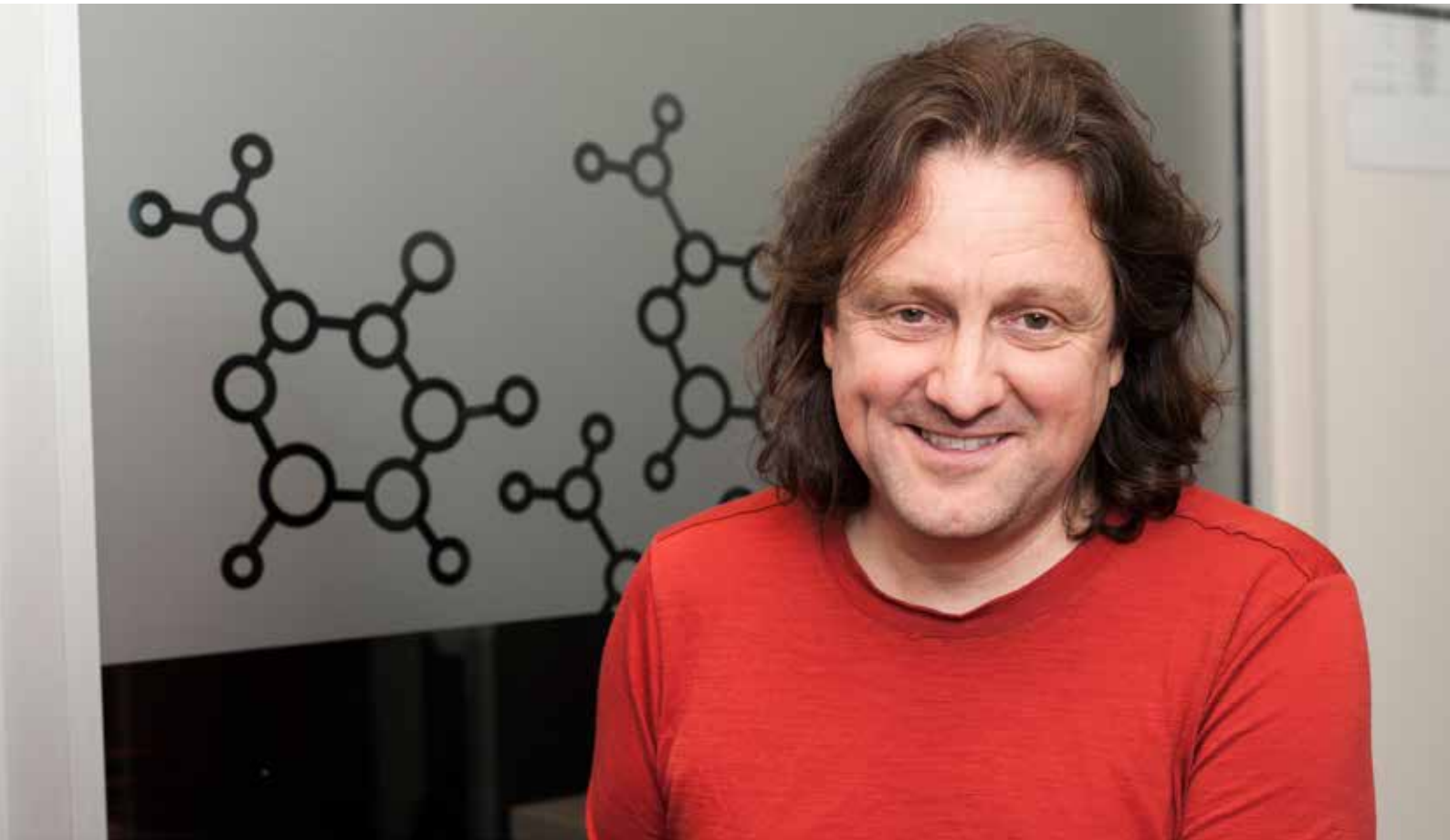

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Huber, T., Dimartino, S. and Fee, C.J. (2015) Cross-linked all-cellulose composite hydrogels made from aqueous NaOH/urea solutions. Sydney, Australia: 24th Annual Conference of the Australasian Society for Biomaterials and Tissue Engineering (ASBTE), 7-10 Apr 2016.

Poole, A.M. (2016) Exploring the origin of DNA: synthetic biology, experimental evolution & genomics. Speaker, Canterbury Omics 2016, Christchurch, NZ: October 2016

Poole, A.M. (2016) RNA evolution is dominated by rapid turnover, not molecular fossils. Keynote speaker, Society for Molecular Biology & Evolution 2016, Gold Coast, Australia: July 2016

Poole, A.M. (2016) Emergence of slippage-type 'editing' revealed by experimental evolution. Selected speaker, SMBE Satellite Meeting on RNA modification and Evolution, Valencia, Spain: May 2016.

Poole, A.M. (2016) From RNA to DNA. Invited speaker, LUCA, its contemporaries and their viruses, Fondation des Treilles, Provence, France: May 2016

Poole, A.M. (2016) Nuclear pore-like structures in a bacterium: what relevance to early cell evolution? Invited speaker, LUCA, its contemporaries and their viruses, Fondation des Treilles, Provence, France: May 2016

Poole, A.M. (2016) The RNA world and the origin of DNA. Invited seminar, University of Tokyo. Tokyo, Japan: March 2016

Poole, A.M. (2016) What can modern biology tell us about the RNA world? Organiser, 1st NZ Astrobiology Workshop, Kaikoura, NZ: Feb 2016.

Poole, A.M. (2016) The origin of RNA genes: big bang or continuous creation? Invited seminar, Analytical Genetics Meeting, Rotorua, NZ: Jan 2016.

Poole, A.M. (2015) Using experimental evolution to assess a possible early origin for DNA. Invited speaker, Pacifichem 2015, Honolulu, USA: Dec 2015

Poole, A.M. (2015) DNA, RNA, protein, time: using long term evolution experiments to study early evolution. Invited seminar, Massey University, Palmerston North, NZ: October 2015

Poole, A.M. (2015) DNA, RNA, protein, time: using long term evolution experiments to study early evolution. Invited seminar, University of Otago, Dunedin, NZ: September 2015

Poole, A.M. (2015) Cultivating a healthy disrespect for established boundaries. Keynote speaker, BioLive/ChemEd 2015, Wellington, NZ: July 2015

Poole, A.M. (2015) Probing the evolutionary origins of bacterial translation initiation using experimental evolution. Selected speaker, AbSciCon, Chicago, USA: June 2015

Poole, A.M. (2015) Emergence of RNA editing in a long term evolution experiment. Invited speaker, Company of Biologists Workshop, Eukaryo-/Archaeogenesis: Where Do We Stand? Steyning, UK: March 2015

Poole, A.M. (2015) DNA, RNA, protein, time: using long term evolution experiments to study early evolution. Invited seminar, Institut Pasteur, Paris, France: March 2015

Poole, A.M. (2015) DNA, RNA, protein, time: using long term evolution experiments to study early evolution. Invited seminar, Stockholm University, Stockholm, Sweden: March 2015

Poole, A.M. (2015) The 'Goldilocks Zone' for finding novel RNA genes is perversely narrow. Speaker, Annual NZ Phylogenetics Meeting, Portobello, New Zealand: Feb 2015

OTHER

Fee C.J., Huber T., Dimartino, S. (2015) "Separation Medium" – NZ patent application 715087

Current Grants

EXTERNAL RESEARCH INCOME CONTINUES TO BE SIGNIFICANT FOR THE INSTITUTE AND THE UNIVERSITY

Renwick Dobson, Growing up milks, AgResearch, $184,860 (2013–2016).

Renwick Dobson, Mapping the evolution of a key glycolytic enzyme, Marsden Fast-start, $266,956 (2011–2015).

Renwick Dobson, Not different, just better: The adaptive evolution of an enzyme, US Department of Defense, $397,591 (2011–2015).

Antony Fairbanks, Doctoral scholarship grant, Callaghan Innovation, $105,000 (2013–2016).

Antony Fairbanks, Doctoral Scholarship, Callaghan Innovation, $105,000 (2016-2018)

Conan Fee, Simone Dimartino, Mathieu Vilmay and Don Clucas, Three dimensional printed adsorptive media, MBIE Smart Idea Phase-1 and Phase-2, $1,835,528 (2013–2015).

Paul Gardner, Bioinformatic approaches to functionally characterise RNAs, Rutherford Discovery Fellowship, $800,000 (2011–2016).

Paul Gardner, Genome assembly, RNA-Seq mapping, genome annotation, identification significant difference between lethal & non-lethal, ESR, $5,000 (2014–2016).

Sally Gaw, Fate and behaviour of wastewater PCP's in constructed wetlands and on-site land application systems, NIWA, $30,000 (2013–2017).

Juliet Gerrard, Callaghan Innovation doctoral scholarship grant, Callaghan Innovation, $191,000 (2012–2015).

Juliet Gerrard, Enhanced protein functionalities, PGP, $567,300 (2012–2016).

Juliet Gerrard, Red Meat Combifoods, AgResearch, $96,720 (2011–2015).

Juliet Gerrard, Riddet Institute, $414,295 (2008–2015).

Juliet Gerrard, Self assembling peptides as tools to probe the quaternary assembly of proteins, AgResearch, $76,500 (2012–2015).

Juliet Gerrard, Celine Valéry, Peter Steel, Proteins as supramolecular building blocks for responsive materials and nanodevices, United States Department of Defense, $417,246 (2012–2015).

Richard Hartshorn, High strength protein biomaterials through photo-induced crosslinking, AgResearch, $51,150 (2010–2016).

Wanting Jiao and Emily Parker, New drugs for lung infections in cystic fibrosis, CMRF, $82,872 (2012–2015).

Wanting Jiao and Emily Parker, Novel strategies for antibiotic design: Targeting histidine biosynthesis in pathogens, Lottery Health, $85,500 (2013–2016).

Matthew Nicholson and Emily Parker, Fungal factories for manufacture of high value industrial bioproducts, MBIE, $953,186 (2014-2016).

Emily Parker, Investigating in inhibition of adenosine triphosphate phosphoribosyltranferase: A potential target for antimicrobial drug design, IRL, $50,000 (2012–2015).

Emily Parker, Retracing the evolution of enzyme regulation: Understanding the molecular mix-and-match that gives rise to sophisticated control of metabolism, Marsden, $639,130 (2012–2015).

Emily Parker, The evolution of biosynthesis pathways and metabolism, Subcontract on Vic Arcus led Marsden, $44,427 (2014–2017).

Emily Parker, Next generation enzymes for commercial applications, Subcontract on Vic Arcus led MBIE Smart Idea, $452,845 (2013–2017).

Emily Parker, Vurucidal action of naturally occurring enzymes found in waste stabilisation ponds, ESR, $17,000 (2014–2015).

Anthony Poole, How does complexity emerge in cellular systems? Rutherford Discovery Fellowship, $800,001 (2012–2017).

Anthony Poole, Rewiring Life: Addressing the origin of life and improving industrial processes by resurrecting an ancient pathway for DNA synthesis, RSNZ-JSPS Joint Research Project, $60,000 (2014–2016).

Karen Adair, Community dynamics of freshwater algal blooms, $15,000 (2015-2016)

Renwick Dobson, Riddet Institute, $68,520 (2016-2018))

Renwick Dobson, Laminar flow devices for measuring the diffusional coefficients of macromolecules and macromolecular interactions: towards devices for medical testing, Callaghan Innovation, $49,344 (2016 -2018)

Renwick Dobson, How do bacteria scavenge sialic acids from their human host? Marsden $770,000 (2016-2019)

Conan Fee, Riddet Institute, $54,480 (2016-2018)

Paul Gardner, CoRE Bio-Protection: Provide bioinformatics expertise to allow genomic comparisons and co-supervision of two students, $26,686 (2016)

Paul Gardner, CoRE Bio-Protection: To identify determinants of virulence and adaptation in the kiwifruit pathogen Pseudomaonas syringae pv. actinidiae (Project 3), $64,596 (2016)

Paul Gardner, CoRE Alan Wilson: Legacy Project: Phylongeny-informed comparative transcriptomics of bacteria and archaea, $15,000 (2015-2016)

Volker Nock, Using the Lab-on-a-Chip to understand the protrusive force exerted by pathogenic hyphae, Brian Mason Scientific and Technical Trust, $11,763 (2015-2017)

Volker Nock, Hyphae-on-a-Chip - A microfluidic platform for the study of protrusive forces in hyphal invasion, Marsden Fast-Start, $300,000 (2016-2019)

Emily Parker, CoRE Maurice Wilkins, $765,940 (2015-2017)

Emily Parker, Virucidal action of naturally occurring enzymes found in waste stabilisation ponds, ESR, $61,000 (2014-2017)

Grant Pearce, Effect of protein and lipid co-oxidation on food quality, Co-funding for doctoral student, BIC/AgResearch, $42,543 (2016-2019)

Anthony Poole, Phylongeny-informed comparative transcriptomics of bacteria and archaea, CoRE Alan Wilson, $15,000 (2015)

Anthony Poole, Postdoctoral fellowship, CoRE Alan Wilson, $164,000 (2015)

Antony Fairbanks, A new paradigm for organelle targeting, Marsden, $870,000 (2016-2019)

Alannah Rickerby

Grants Disbursed

BIC supports the development and growth of biomolecular interaction research by funding projects that support our aim to promote excellent, high impact, interdisciplinary and collaborative research. In 2014 we awarded more than $150k.

2015

Principal Investigator seed funding to establish new research projects, $27,000.

Renwick Dobson and Volker Nock, leveraged postgraduate scholarship funding co-funded by Callaghan Innovation, Laminar Flow Devices for Measuring the Diffusional Coefficients of Macromolecules and Macromolecular Interactions: Toward Devices for Medical Testing, $21,000 plus fees per annum for three years, (half funded by BIC).

Akshita Wason (Antony Fairbanks), strategic Postdoctoral Fellowship funding, Synthesis of Phosphorylated Glycoproteins, $8,000.

Katherine Donovan (Renwick Dobson), strategic Postdoctoral Fellowship funding, Viral capsid-like bacterial enzyme factories: Structure, function, evolution and mode of assembly and packaging, $16,000.

Amy Osborne (Ant Poole), strategic Postdoctoral Fellowship funding, Phylogeny-informed comparative transcriptomics of Bacteria and Archaea as a tool to study avoidance of non-coding RNA – mRNA crosstalk interactions $17,500.

Dorien Coray (Paul Gardner), strategic Postdoctoral Fellowship funding, RNA vs protein: investigating evolutionary robustness, $17,500.

Prasanna Ponnumallayan (Conan Fee), strategic Postdoctoral Fellowship funding, Gelation Properties of Self-Assembling Peptides, $10,700.

Principal Investigator travel funding: Grant Pearce, AUC Conference, $2,500; Antony Fairbanks, Pacifichem 2015, $3750; Renwick Dobson, AUC Conference and travel to the US, $5,000; Volker Nock, Micro TAS Conference, $4000; Anthony Poole, Pacifichem, $3,500; Emily Parker, Pacifichem, $3,500.

Unfunded postgraduate student support was awarded to Azadeh Taleb Hashemi, $7,275.00; Jenna Gilkes, $7,640.00; Pariya Noeparvar, $8,600.00; Rasika Kariyawasam, $4,250.00; Yu Bai, $7,640.00; Jordyn Smith, $7,050.00.

Flagship funding of $75,000 was disbursed.

2016

Grant Pearce, leveraged postgraduate scholarship funding co-funded by AgResearch, Effect of protein and lipid co-oxidation on food quality, $21,000 plus fees per annum for three years, (half funded by BIC).

Anthony Poole, full postgraduate scholarship funding, Using synthetic evolution to streamline translation, $21,000 plus fees per annum for three years.

Paul Gardner, full postgraduate scholarship funding, Evolving RNA-protein interactions, $21,000 plus fees per annum for three years.

Gabriel Visnosky, seed funding, Production of baculovirus biopesticides using insect cell culture: improving yields to allow commercialisation, $10,550

Mark Staiger, seed funding, Prevention of fungal invasion via pruning wounds in grape vines, $5,000

Volker Nock and Monica Gerth, seed funding, SlipChips for Bacterial Chemotaxis, $5,000

Renwick Dobson, seed funding, Function of SpoT: a bi-functional enzyme that controls bacterial adaptation, $5,000

Anthony Poole, strategic Postdoctoral Fellowship funding, Evolving RNA editing in the lab, $17,000.

Renwick Dobson, strategic Postdoctoral Fellowship funding, Biointeractions between milk proteins: a new role for β-lactoglobulin and interactions of lactoferrin, $17,000.

Paul Gardner, strategic Postdoctoral Fellowship funding, Robustness of RNA and protein function in the face of genetic change, $17,000.

Emily Parker, strategic Postdoctoral Fellowship funding, Tracing the evolutionary relationship of allosteric regulation mechanisms in metabolic enzymes, $17,000.

Principal Investigator travel funding, Volker Nock, MNE 2016 Micro- and Nano-engineering conference, $5,400; Emily Parker, Protein Society Symposium, GRC – Enzymes coenzymes and metabolic pathways conference, visits to US collaborators, $4,700; Renwick Dobson, QMB 2016, SMBE 2016 and visit to the Australian Synchrotron, $5,000; Grant Pearce, visit to the Australian Synchrotron, $1,000; Antony Fairbanks, 27th International Carbohydrate Symposium (ICS), $3,200.

Principal Investigator seed and targeted funding to establish new research projects, $75,000.

Unfunded postgraduate student support was awarded to Jenna Gilkes, $2,500.00; Pravesh Tyagi, $5,000.00; Mohammad Firoozinia, $2,500.00; Mehrnoush Tangestani, $5,000.00; Hamish Cleland, $3,000.00; Cameron MacDonald, $3,000.00; James Davies, $3,000.00; William Finnis, $3,000.00.

UC Summer Scholarships, co-funding of 14 projects of BIC Principal and Associate Investigators, $35,000.

Flagship funding of $75,000 was disbursed.

TO ENCOURAGE AND GROW RESEARCH THAT SUPPORTS OUR VISION