

Plant Cell Walls

ARC Centre of Excellence

2015



**South Australian node:**

Waite Campus
School of Agriculture, Food and Wine
The University of Adelaide
Urrbrae SA 5064

**Victorian node:**

Plant Cell Biology Research Centre
School of Botany
The University of Melbourne
Parkville VIC 3010

**Queensland node:**

Centre for Nutrition and Food Sciences
Queensland Alliance for Agriculture and Food
Innovation
The University of Queensland
St Lucia QLD 4072



Plant Cell Walls
ARC Centre of Excellence



Australian Government
Australian Research Council



Government of South Australia
Department of Further
Education, Employment,
Science and Technology

**ARC Centre of Excellence in Plant Cell Walls, 2015**

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and J Sawade (B-Smarter Pty Ltd)

Cover image:

Barley plants growing in controlled environment room at The Plant Accelerator®, Adelaide.
Source: J Sawade, B-Smarter

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Director's Report



On behalf of all our staff and students at the Universities of Adelaide, Melbourne and Queensland, I am pleased to present to the Australian Research Council the Report of activities in the ARC Centre of Excellence in Plant Cell Walls for 2015. The beginning of 2015 coincided with my appointment as the new Director of the Centre, replacing Professor Fincher in this role. I was excited by the opportunity to take over the responsibility of a Centre that is a major international player in the field of Plant Biology, thanks to the leadership of my predecessor and the members of the Executive Management Committee and Project Leadership Team, obviously, to the quality of the research performed by all our staff members and students.

The past year has witnessed the culmination of several scientific areas of high priority, which has led to the highest number of high-impact publications since the launch of the Centre. All targets were exceeded in terms of publication outputs and citations. 2015 also provided the opportunity to revise our strategic plan to further increase focus and delivery of major outputs. Our strategy is to capitalise on the current most successful projects to build the legacy of the Centre while, at the same time, shaping the future of cell wall research by further consolidating the promising and exciting areas that have been identified. Beyond its fundamental scientific outputs, the leadership team of the Centre continuously evaluates potential for translation of its research into opportunities for the Australian agri-food sector.

The many research highlights that marked 2015 included advances in our understanding of polysaccharide biosynthesis and assembly in model plant species, insights into the role of cell walls in plant-pathogen interactions and the molecular mechanisms that underlie the beneficial health effects of plant cell walls in food. Powerful approaches were developed and used for the detailed analysis of the intricate interactions that take place between cell wall components to determine the impact these interactions have on physical properties of the wall. These data are being exploited in collaboration with the IBM Collaboratory to develop the

first 3D multi-scale model of the plant cell wall. The key advances made by the Centre during 2015 have attracted attention in the media through our outreach activities and spontaneous solicitations by University and independent communication groups. Details of research and outreach activities are outlined in the Research Highlights and Key Performance Indicator sections of the report.

In 2015, the Centre hosted several international scientists that worked in our laboratories for extended sabbatical periods as well as some of our Partner Investigators from Europe. These visits have provided important new ideas and feedback on the Centre projects and elicited additional collaborative activities. The annual retreat was held at the Wirrina Cove Conference Centre in South Australia in early November. It was a great success, both scientifically and socially. Professor Aidan Byrne, Chief Executive Officer of the ARC, participated actively in the discussion that followed his presentation of the different ARC funding schemes and their outcomes. Members of our restructured Scientific Advisory Committee presented exciting lectures and research perspectives in the cell wall field. A high level of interaction occurred between staff and students and direct feedback was given to the leadership team of the Centre on the research strategy and progress. The outcome of the discussions that followed is reflected in the lines of research presented in the activity plan for 2016.

Chief Investigators and Affiliates of the Centre have secured additional income through successful ARC DP, LP and LIEF grants, and grants from other funding agencies. Activities with the Centre's Partner Organisations have contributed to the further development of our joint projects and the attraction of additional funds through the Centre's leverage strategy for international collaborations. Several high-impact publications with our overseas collaborators were published in 2015, others are in preparation at the time of writing this report. Collaborations have been extended to other national players in Plant Biology, such as members of the ARC Centre of Excellence in Plant Energy Biology and other scientists linked to the Chief Investigators and Affiliates of the Centre at each node. Altogether, the Centre activities and collaborative work that took place during 2015 have further contributed to the high quality training that we provide to our postgraduate students and postdoctoral scientists.

In summary, the Centre's highest outputs were obtained in 2015 and we expect to reach, or even exceed, a similar level of performance during 2016 by focusing on our selected strategic areas and further capitalising on the technical and research capacities established in the previous years.

A handwritten signature in black ink, appearing to read 'Vincent Bulone'.

Vincent Bulone
7 March 2016

The Centre

Overview

Our mission

To advance fundamental scientific understanding of plant cell wall biology to enable sustainable biomass production for:

- Food Security
- Human Health
- Energy Biomass Conversion

The scientific question

The ARC Centre of Excellence in Plant Cell Walls addresses the fundamental question: How do plants regulate the synthesis, assembly, re-modelling and degradation of their cell walls during normal development and in response to the environment? As plant cell walls are the world's largest renewable carbon resource and the basis of a healthy human diet, understanding the regulatory mechanisms controlling wall biology and physico-chemical properties are crucial drivers to many new areas of international research in plant science.

Why cell walls?

Cell walls determine the quality of most plant-based products used in modern human societies. Textural, nutritional and processing properties of plant-based foods are heavily influenced by wall properties. Fibres for textiles, pulp and paper manufacturing, timber products, and biofuel and bio-composite manufacturing are largely composed of, or derived from, cell walls. As the largest source of renewable carbon, plant cell walls have a critical future role in transport fuels, food security, functional foods to improve human health, and as raw materials for industrial processes.

The vision

The Centre builds on existing national strengths in the field of fundamental cell wall science to

- Generate scale and focus at the scientific, technical and training levels.
- Enhance plant biotechnologies that underpin Australian industries valued at over \$8 billion p.a., associated food industries valued at about \$40 billion p.a., and emerging industries related to the production of renewable transport fuels, biomedicines and biocomposites.

Why grasses?

The research activities of the Centre are focused on cell wall biology in the grasses. Grasses represent the most important family of plants for humans. Foods derived from rice, wheat, maize, sorghum, barley, millet and sugarcane account for a high proportion of global caloric intake. Forage and fodder grasses support the production of domesticated livestock, while switchgrass, *Miscanthus* spp. and other perennial grasses show great promise as biomass energy crops. Wheat, sugarcane and barley are the most important food crops in Australia and there are a growing number of grass model systems for which full genome sequences are available.



Governance

Governance of the ARC Centre of Excellence in Plant Cell Walls is overseen by a Governing Board chaired by the Deputy Vice Chancellor (Research) (or proxy) of the University of Adelaide as Administering Institution of the Centre. The Centre's Executive Management Committee (EMC), chaired by the Centre Director (CD), monitors progress towards the Centre's performance targets, takes advice from a Scientific Advisory Committee (SAC), and implements scientific direction and related policy and review. The Project Leadership Team (PLT), established in 2012, continues to assist in directing the day-to-day research activities and in facilitating communication throughout the Centre. Overall financial control and external reporting responsibility resides with the Administering Institution. Reporting to the EMC, under direction of the CD, the Centre's Administrative Group manages and monitors Centre budget and resources, internal funds disbursements, reporting and acquittal.



The Governing Board

Since commencing as Pro Vice-Chancellor – Research Strategy for the University of Adelaide in 2015, Professor Julie Owens now Chairs the Governing Board as permanent proxy for the Deputy Vice Chancellor (Research) (DVCR) of The University of Adelaide. Other members include:

- Professor Robert Henry, proxy for DVCR, University of Queensland
- Professor Ian Woodrow, proxy for the DVCR, University of Melbourne
- Professor Ian Small, Chair, Scientific Advisory Committee (SAC)
- Professor Robbie Waugh (James Hutton Institute, UK), Partner Organisation representative
- Centre Director, Professor Vincent Bulone.

The 2015 meetings were held in August and late November following the two SAC meetings, with the first after mid-year to allow the new Centre Director time to establish, review and develop plans for the future (addressed in later sections). The second meeting was held after the ARC Expression of Interest process for new CoE applications. Key discussion items for the 2015 meetings included

- Clarification of the role that 'Fellows' (ARC FF, DECRA, strategic university appointments, etc) play in a maturing Centre. A new internal title of 'Affiliate' was defined, along with corresponding expectations and inclusion of some of their outputs in KPI reporting. Our nominated Affiliates were Prof Stefan Persson (a "Research at Melbourne Accelerator Program" appointment), Dr Josh Heazlewood (UM) and Dr Matt Tucker (UA), ARC Future Fellows, Dr Caitlin Byrt (UA) ARC DECRA Fellow and Emeritus Prof Geoff Fincher (UA Adjunct Prof)
- The successful implementation of the Mid-Term Review recommendations.
- Application for new grants and partnerships, securing future funding, and managing outputs in the last two years of the Centre
- Strategic and financial planning and the need to focus on key deliverables entering into the last two years of the Centre.
- The usual business of SAC reports, KPI progress, outreach and finances.

Executive Management Committee & Project Leadership Team

The Australian-based membership of the Executive Management Committee (EMC) comprises the CD, CIs and Executive Officer. The Centre's next tier of management, the Project Leadership Team (PLT) provides for a more direct communication of project and program issues and developments through postdoctoral researchers actively involved in projects. Since 2012/13 the PLT have joined the EMC in the regular fortnightly management meetings by video or teleconference.

The EMC/PLT meetings provide a regular forum to review and discuss research activities, manuscript/publication progress, grant applications, upcoming meetings, strategic planning, IP, media & outreach, etc. The PLT involvement in these meetings continues to enable direct communication of relevant issues and information to Centre Management. Under advice from the Executive Officer, the PLT also assist in facilitating the collection of data relevant to managing KPI performance across the Centre.

The PLT also take responsibility for much of the agenda planning, speaker/topic selection and the inclusion of professional development workshops at each of our Centre Scientific Meetings. Independently, the PLT typically meet on a bimonthly basis, increasing as required ahead of our Centre Meetings and Annual Retreat. The Executive Officer and relevant nodal administrative support provide the logistics planning and support for the Centre Scientific Meetings.

The term for a PLT member is generally 2–2.5 years. Rotations in 2015 saw Sarah Wilson, Deirdre Mikkelsen, Alan Little and Gleb Yakubov complete their terms and be replaced by Allison van de Meene, Mauricio Rincon Bonilla, Neil Shirley and Purnima Gunness, respectively. In December, Kim Johnson replaced John Humphries who transitioned to a non-Centre role at UM. The EMC acknowledge the valuable contributions made by all outgoing personnel, and welcomes the new and ongoing membership in their important communication roles across nodes, and between management and research personnel.

The Scientific Advisory Committee (SAC)

The SAC contributes to the development of strategies and vision for the future relative to the proposed goals of the Centre and by serving as a vehicle for creating linkages between academia, industry and government. The SAC advises CIs on the following:

- Ambition and clarity of Centre goals;
- Capability of the Centre to achieve these goals, in the context of available expertise, facilities and resources;
- Effectiveness of collaboration, internally and with international partners;
- Centre's public image, i.e., its national and international reputation and its ability to attract high quality staff and students.

2015 saw a refinement of SAC membership to reflect the subtle shift of some Centre research toward translational activities, and to bring in new expertise, particularly in the areas of growth at the UQ node on the nutritional focus of dietary fibres related to carbohydrate polymer interactions. The Centre acknowledges the valuable contributions made since inception by outgoing members Professor Paul Gleeson (UM) and Professor Daniel Cosgrove (Penn State, USA); and we look forward to working with Professors Peter Ellis (UK) and Ken Keegstra (USA) over the next two years.

The 2015 meetings were held on 1 June by teleconference, and in November as part of the 2015 Centre Retreat, which most SAC members were able to attend. Based on information provided in October and from the presentations and discussions at the Centre Retreat, the SAC noted that the citation data and the improvements in publication outputs clearly indicated the impact the Centre is having at the international level. The SAC again praised the PLT structure and its participants on enhancing the Centre and its ability to meet its goals. The SAC's main focus for 2015 however, was to assist and advise the CD and CIs on the review of the Centre Strategic Plan to renew focus on high impact targets. The SAC and CIs agreed that the identification, completion and dissemination of a range of achievable outcomes by 2017, whilst maintaining progress on future opportunities and research, is essential. Further detail provided in the Research Highlights introduction and 2016 Activity Plan sections.

Scientific Advisory Committee



Professor Ian Small, Chair

Professor and Chief Investigator, ARC Centre of Excellence in Plant Energy Biology, The University of Western Australia

Professor Small's PhD at Edinburgh University was followed by a career with France's National Agronomy Research Institute (INRA). In 2005, 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. His research interests include the study of gene expression and metabolism relating to energy systems in plants. In August 2014, Professor Small was awarded an Australian Laureate Fellowship from the ARC.



Professor Marilyn Anderson

Professor of Biochemistry, La Trobe University; Associate Professorial Fellow, The University of Melbourne

After graduating with a PhD in Biochemistry at La Trobe University, Professor Anderson spent seven years working on diabetes at the University of Miami and oncogenes at Cold Spring Harbor Laboratory. She is a founding scientist of Hexima Ltd, and was appointed Chief Science Officer in 2009 and a Director in 2010. She is a Fellow of the Australian Academy of Science, of the Australian Academy of Technological Sciences and Engineering, and of the Australian Institute of Company Directors.



Professor Deborah Delmer

Professor Emeritus of Biology at the University of California, Davis, USA

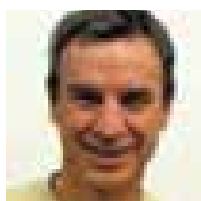
Professor Delmer received her PhD from UC San Diego and has held faculty positions at Michigan State University, The Hebrew University and UC Davis. She has served as President of the American Society of Plant Biologists and in 2004 was elected to membership in the US National Academy of Sciences. From 2002 – 2007 she served as Associate Director for Food Security for the Rockefeller Foundation, involved in policy relating to the role of biotechnology in developing world agriculture.



Professor Peter Ellis (joined mid 2015)

Professor of Carbohydrate Biochemistry, Diabetes & Nutritional Sciences Division, King's College London, UK

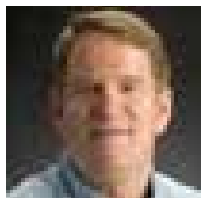
Professor Ellis has a specific interest in the functionality of dietary polysaccharides (starch and non-starch polysaccharides (NSP)) with respect to the bioavailability of nutrients, and prevention and treatment of disease, e.g., diabetes, coronary heart disease and arthritis. Much of the work focuses on the rheological behaviour of water-soluble NSP in the gastrointestinal tract and also the properties of supramolecular structures (starch, plant cell walls), particularly in relation to the kinetics of nutrient absorption (e.g., glucose) and the so-called 'glycaemic index'.



Dr Herman Höfte

Research Director and Group Leader, Institut Jean-Pierre Bourgin, Institut National de la Recherche Agronomique (INRA) – AgroParisTech, Versailles, France

Dr Herman Höfte received his PhD at the University of Ghent (Belgium), and carried out postdoctoral research at the University of San Diego, California. His current research interests are the synthesis and assembly of plant cell walls using molecular genetic approaches in the model plants *Arabidopsis* and *Brachypodium*. He is the Adjunct Director of the Institute Jean-Pierre Bourgin at INRA, Versailles and has published over 100 articles in internationally refereed journals.



Professor Kenneth Keegstra (joined mid 2015)

Scientific Director, Great Lakes Bioenergy Research Center and University Distinguished Professor, Department of Biochemistry & Molecular Biology and Department of Plant Biology, Michigan State University, USA

Professor Keegstra is a renowned plant biologist and an expert in plant cell wall biochemistry and biofuels. He has extensive management and scientific experience, having served for 14 years as director of the DOE-funded Plant Research Laboratory at MSU and as faculty member in the Botany Department at the University of Wisconsin–Madison for 15 years. In 2014, he was elected to the National Academy of Sciences for his work in investigating the biogenesis of chloroplasts and the biosynthesis of plant cell walls.

Key Centre personnel

Chief Investigators



Professor Vincent Bulone, University of Adelaide

Director (from January 2015)

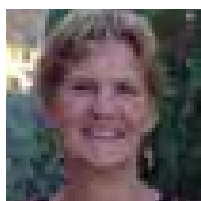
Professor Bulone's research is focused on cell wall polysaccharide structure and metabolism in higher plants, oomycetes and fungi. Capitalising on his long standing and renowned experience in the area of plant and microbial Glycoscience, Vincent brings novel research capabilities of strategic importance and maintains his strong links with Partner Organisation, KTH (Sweden).



Professor Tony Bacic, University of Melbourne

Deputy Director & Chief Investigator: Cell Biology and Biochemistry of Walls

Professor Bacic has established a concentration of expertise in complex carbohydrates (glycomics), proteomics, metabolomics and other key platform technologies. His capabilities for analysis of wall-related macromolecules are amongst the most comprehensive in the world. His research expertise is in the structure, function and biosynthesis of cell wall polysaccharides/glycoproteins and the role of the cell wall in mechano-sensing.



Professor Rachel Burton, University of Adelaide

Chief Investigator: Molecular Genetics of Wall Synthesis

Professor Burton's research is focused on cell wall polysaccharide biosynthesis. She brings experience and high-level skills in the adoption and application of emerging techniques in functional genomics and molecular biology, particularly associated with cereal grain development.



Professor Mike Gidley, University of Queensland

Chief Investigator: Cell Wall Organisation and Molecular Architecture

Professor Gidley brings experience in linking polysaccharide structure with physico-chemical properties, functionality in walls and industrial applications. He has capabilities in construction and characterisation of cellulose/polysaccharide composites as functional models for the assembly and deconstruction of walls, and in studies of the mechanisms underlying nutritional and health properties of plant cell walls.

Associate Investigators



Professor Diane Mather, University of Adelaide

Professor Mather is an experienced applied plant breeder who advises on the delivery of research outputs through plant variety development. She supervises and advises PhD students and postdoctoral researchers on the choice and development of populations, and on designing and performing genetic experiments.



Professor Robert Gilbert, University of Queensland

Professor Gilbert's expertise is in the development of biosynthesis-structure-property relationships for plant cell wall polymers and relating them to the underlying genetics. His input to the concomitant mathematical interpretation of these data to develop causal relations between the genetics and growth conditions controlling the molecular architecture of cell wall polymers, and between this architecture and properties of interest, is essential.



Associate Professor Jason Stokes, University of Queensland

Associate Professor Stokes has expertise in the integration of polymer, colloidal, interfacial and material science principles in developing relationships between fundamental characteristics of plant cell wall systems and their properties. His input is leading to an understanding of how structure at different scales influences properties and utilisation of cell walls in diverse applications.

Partner Investigators



Professor Robbie Waugh, The James Hutton Institute, UK

Professor Waugh holds a Personal Chair in Crop Genomics at the James Hutton Institute. Professor Waugh and colleagues make the most comprehensive barley genetic resources in the world available to the Centre and contribute to projects on the genetics and evolution of polysaccharide synthases, and on cell wall changes during plant-pathogen interactions.



Professor Claire Halpin, University of Dundee, UK

Professor Halpin was the Director of the Cell Wall Lignin program within the £26 million BBSRC Sustainable Bioenergy Centre at the University of Dundee. Her expertise in lignin synthesis is complementary to the Centre's expertise in wall polysaccharides and enables collaborations on manipulation of lignin biosynthesis in barley straw.



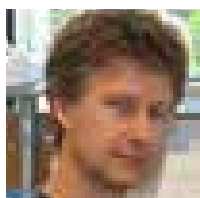
Dr Vic Knauf, Arcadia Biosciences Inc., USA

Dr Knauf is the Chief Technical Officer with Arcadia Biosciences, who develop agricultural products to capitalise on opportunities that benefit the environment and enhance human health. He provides specialised expertise in TILLING (Targeting Induced Local Lesions in Genomes), a method that allows directed identification of mutations in a specific gene.



Professor Christopher Somerville, Energy Biosciences Institute, USA

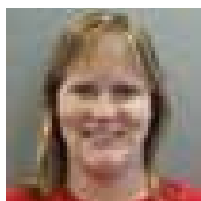
Professor Somerville is the Director of the Energy Biosciences Institute based at UC Berkeley, the largest biofuels research centre in the world. Collaborations with the Centre involve development and application of biophysical models of plants, metabolic profiling of fungi for biomass conservation, meteorological data and economic metrics to support biomass production opportunities in Australia.



Dr Patrick Schweizer, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Germany

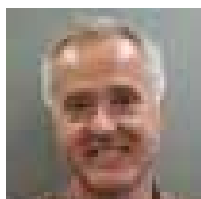
Dr Schweizer is the Leader of the Plant Genome Resources Center at the \$54m Leibniz Institute of Plant Genetics and Crop Plant Research (IPK). His collaborations with the Centre advance knowledge in plant-microbe interactions and disease-resistance mechanisms at the cell wall level.

Project Leadership Team



Dr Helen Collins, University of Adelaide

Dr Collins has expertise in cereal biochemistry. She received her PhD from the University of Adelaide in 2003 in malting research as part of the South Australian Barley Breeding Program. Since then, she has been working on cell walls in grain and their relationship to dietary fibre and, more recently, on the germination of barley. She is currently employed as a research scientist on a Centre-associated ARC Linkage Project investigating the physiology and genetics of barley grain germination.



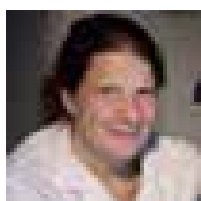
Dr Neil Shirley, University of Adelaide (joined April 2015)

Dr Shirley is a bioinformatician with expertise in transcriptomic analysis. He received his PhD in organic chemistry in 1987 from the University of Adelaide, then worked as a postdoctoral fellow at Flinders University for two years. He returned to the University of Adelaide in 1991 at the Special Research Centre for Basic and Applied Plant Molecular Biology with Professor Bob Symons and Professor Peter Langridge. He joined the Australian Centre for Plant Functional Genomics in 1999, then joined the Centre of Excellence in 2011.



Dr John Humphries, University of Melbourne (term ended December 2015)

Dr Humphries is a plant developmental biologist with expertise in molecular biology and plant cell signalling. He received his PhD from the University of Adelaide in 2006, then worked as a postdoctoral researcher at the University of California, San Diego, studying cell division in maize. He joined the Centre of Excellence at the University of Melbourne in 2011.



Dr Allison van de Meene, University of Melbourne (joined March 2015)

Dr van de Meene is a plant cell biologist/microscopist with over 15 years' experience studying plant cell biology. She obtained her PhD from the University of Melbourne in 2002, then worked as a postdoctoral research scientist at Arizona State University studying photosynthetic mechanisms in bacteria. She moved to the UK to lead the Bioimaging Unit at Rothamsted Research, where she undertook research on a range of organisms and processes involved in growing healthy crops before moving back to Melbourne and joining the Centre of Excellence in 2012 to work on cell wall biosynthesis.



Dr Kim Johnson, University of Melbourne (joined December 2015)

Dr Johnson is a plant developmental biologist with research expertise in molecular and cell biology, and mechanical regulation of plant growth. She received her PhD from The University of Melbourne in 2004, then worked as a postdoctoral research scientist at The University of Edinburgh (UK, 2004–2008) and the John Innes Centre (UK, 2009–2012) before returning to the University of Melbourne as a postdoctoral research scientist in 2012.



Dr Purnima Gunness, University of Queensland (joined May 2015)

Dr Gunness is a biologist with research expertise in *in vivo*, *ex vivo* and *in vitro* digestion of lipids; the structure and role of bile salts in lipid digestion; interactions of bile salts with polysaccharides; and sensory sciences. She was awarded her PhD in Nutrition and Food Sciences from the University of Queensland, then joined the Centre of Excellence as a postdoctoral research fellow in 2012.



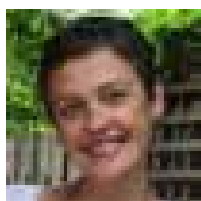
Dr Mauricio Rincon Bonilla, University of Queensland (joined June 2015)

Dr Rincon Bonilla is a postdoctoral chemical engineer with experience in the areas of adsorption and diffusion in nanoporous materials; and expertise in diffusion processes, poroelasticity and the use of theoretical and Finite Element simulation tools. He joined the Centre in 2014 following his PhD at the School of Chemical Engineering of the University of Queensland and is currently working jointly with IBM research in Melbourne to develop multiscale computational models of the plant cell wall.



Dr Alan Little, University of Adelaide (term ended April 2015)

Dr Little is a plant pathologist with expertise in molecular biology, plant cell walls and plant-pathogen interactions. He received his PhD from The University of Adelaide and CSIRO Plant Industry in 2004, undertook postdoctoral research in the Molecular Plant Breeding CRC and worked as a research scientist at the Plant Genomics Centre (Adelaide).



Dr Sarah Wilson, University of Melbourne (term ended March 2015)

Dr Wilson is a cell biologist who uses imaging technology, particularly Transmission Electron Microscopy, to reveal high resolution details of carbohydrate synthesis and deposition in plant cell walls. She received her PhD at The University of Melbourne in the field of phycology, focusing on the developmental biology of red algae. Dr Wilson has been working as a postdoctoral research fellow at the University of Melbourne since receiving her PhD in 2001.



Dr Gleb Yakubov, University of Queensland (term ended May 2015)

Dr Yakubov is a physical chemist with research expertise in surface forces, molecular biophysics and scanning probe microscopy. He received his PhD from the University of Mainz and The Max Planck Institute for Polymer Research (Germany) and has worked as a research scientist and technical project leader at Unilever R&D (UK).



Dr Deirdre Mikkelsen, University of Queensland (term ended June 2015)

Dr Mikkelsen has expertise in fermentation microbiology and molecular microbial ecology techniques. She received her PhD in Microbiology from the University of Queensland in 2005. She worked at the Advanced Water Management Centre (UQ), until moving to the Centre for Nutrition and Food Sciences in 2006. Since then, she has worked on modelling plant cell walls of cereals and grasses, developing molecular microbiology techniques to investigate gut microbe–dietary fibre interactions, and investigating the fermentability of cell wall components.

2015 ARC Centre of Excellence in Plant Cell Walls Staff

Executive Officer	Mr	David	Mathew	UA
Centre Administrative Group	Mrs	Emma	Drew	UA
(<3 FTE, UM & UQ provide partial support)	Ms	Cassie	Watts (part-time)	UM
	Ms	Andrea	Gallo (part-time)	UM
	Ms	Ann	Dunn (part-time)	UQ
	Ms	Liz	Eden (part-time)	UQ
Affiliate Research Fellows	Dr	Matthew	Tucker	UA
	Dr	Caitlin	Byrt	UA
	Prof.	Geoff	Fincher	UA
	Prof.	Staffan	Persson	UM
	Dr	Josh	Heazlewood	UM
	Dr	Andrea	Watt	UM
Postdoctoral Researchers	Dr	Natalie	Betts [#]	UA
	Dr	Helen	Collins [#]	UA
	Dr	Suong	Cu [#]	UA
	Dr	Alan	Little	UA
	Dr	Neil	Shirley	UA
	Dr	Rohan	Singh	UA
	Dr	Monika	Doblin	UM
	Dr	Natalie	Gilka (to Feb)*	UM
	Dr	John	Humphries (to Dec)*	UM
	Dr	Kim	Johnson	UM
	Dr	Edwin	Lampugnani	UM
	Dr	Allison	Van de Meene	UM
	Dr	Sarah	Wilson (to Dec)*	UM
	Dr	Bernadine	Flanagan	UQ
	Dr	Deirdre	Mikkelsen	UQ
	Dr	Barbara	Williams	UQ
	Dr	Gleb	Yakubov	UQ
ECR Postdoctoral Researchers	Dr	Yves	Hsieh (to Dec)*	UA
	Dr	Wei	Zeng	UM
	Dr	Sushil	Dhital	UQ
	Dr	Purnima	Gunniss	UQ
	Dr	Patricia	Lopez-Sanchez	UQ
	Dr	Marta	Martinez-Sanz	UQ
	Dr	Mauricio	Rincon Bonilla	UQ
Research Staff	Ms	Main (Grace)	Ang (to March)*	UA
	Ms	Sophia	Dimitroff	UA
	Mr	Pastor	Jullian	UA
	Dr	Bianca	Kyriacou	UA
	Ms	Shi Feng	Khor [#]	UA
	Ms	Natalie	Kibble	UA
	Mr	Jelle	Lahnstein	UA
	Mr	Chao	Ma [#]	UA
	Ms	Kylie	Neumann	UA
	Dr	Lisa	O'Donovan	UA
	Mr	Jake	Parker	UA
	Mr	Julian	Schwerdt	UA
	Dr	Hwei Ting (Ashley)	Tan (to Aug)*	UA
	Mr	Kuok	Yap	UA
	Mrs	Cherie	Beahan	UM
	Mr	Andrew	Cassin (to Nov)*	UM
	Mrs	Kristina	Ford	UM
	Ms	Kelsey	Picard	UM
	Dr	John	Belward	UQ
	Dr	Gabriele	Netzel (to April)*	UQ
	Dr	Francesca	Sonni	UQ
	Dr	Dongjie	Wang	UQ
	Dr	Dagong	Zhang	UQ

* Left or changed roles during the year

[#] Part funded on 'bolt-on' grants

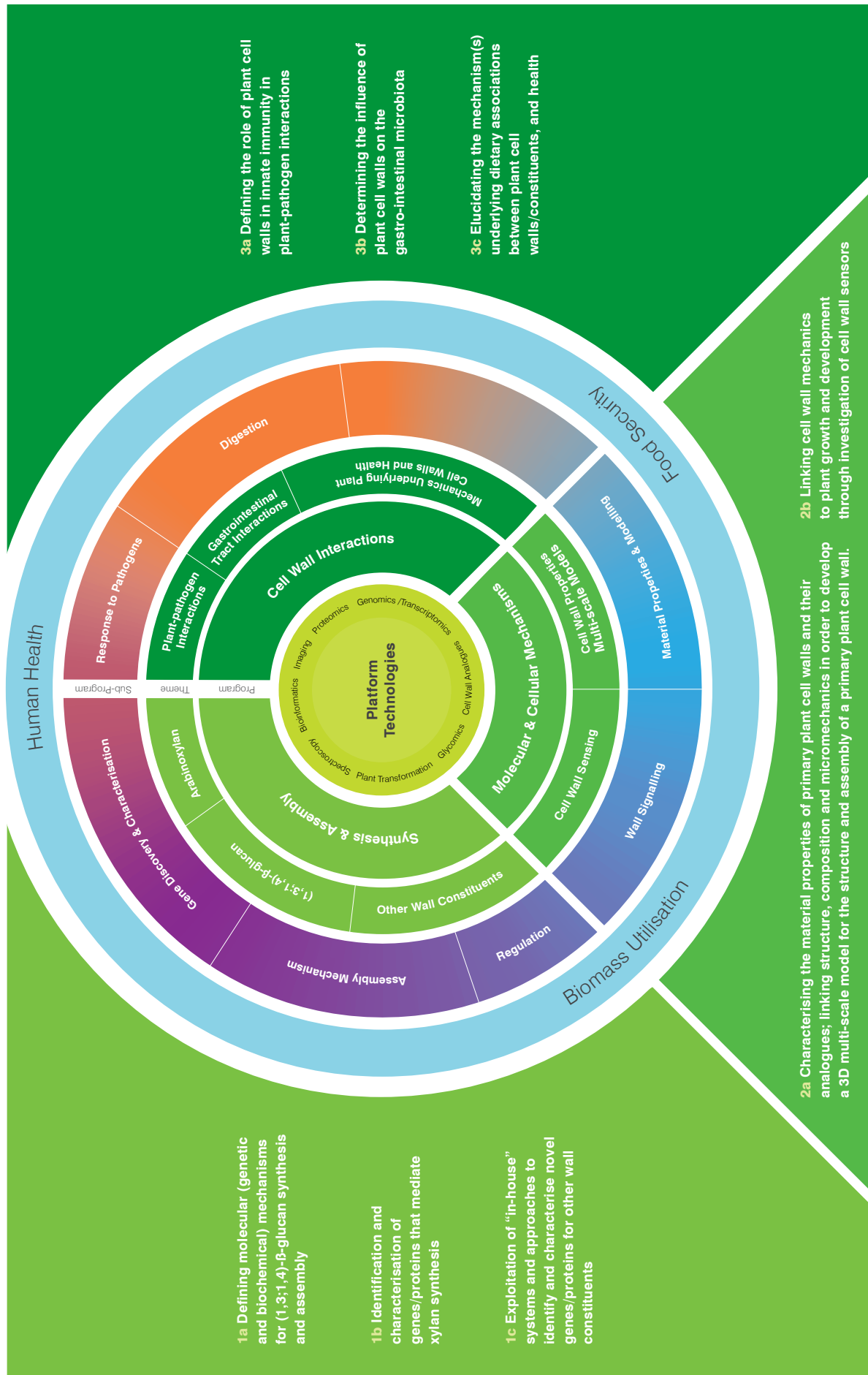
Research Report

Major funding provided by:



Australian Government
Australian Research Council

The Scientific Questions

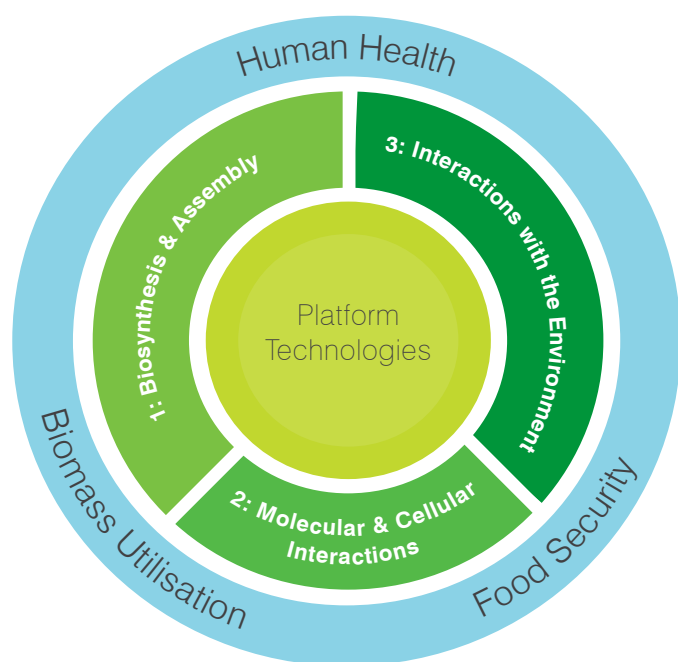


Research Highlights

Since the Centre was established in 2011, our mission has been to advance the fundamental scientific understanding of plant cell wall biology with particular focus on grasses and cereals. The overarching aim of the Centre is to understand *how plants regulate the synthesis, assembly, re-modelling and degradation of their cell walls during normal development and in response to the environment*.

This fundamental knowledge, considered a 'holy grail' in Plant Sciences, is linked with socially, environmentally and commercially important applications in areas such as *food security, human health, and biomass utilisation* for renewable energy production.

The Centre activities are integrated in three interconnected programs underpinned by state-of-the-art Platform Technologies, implemented and made available across all three geographic nodes to maximise synergistic interactions and outputs that would not be possible to reach through individual 'traditional' research groups.



Early in 2014, our Strategic Plan was revised and updated in line with progress to date, new opportunities and important advances in plant cell wall biology internationally. After Mid-Term evaluation of the Centre, and following the commencement of the new Centre Director in early 2015, our Strategic Plan was further revised to ensure that activities are better integrated and highly focused on High Impact Targets (HITs). The objective is to capitalise on the strengths that have been established through the Centre's initial years of activities to reinforce its reputation as a world leader in cell wall biology through ground-breaking, multidisciplinary research. The key HITs identified through our revised Strategic Plan are integrated in our three programs, as follows:

- Cell Wall Biosynthesis and Assembly, with focus on MLG and xylan biosynthesis, and the identification of key molecular determinants of the structure and formation of novel wall components;

- Molecular and Cellular Mechanisms, with focus on cell wall structure, properties, and sensing by the plant, to establish the first 3D multiscale model of primary walls;
- Interactions of Cell Walls with their Environment, with focus on (i) plant cell surface interaction with fungal pathogens to decipher mechanisms that can be exploited for crop protection and food security; (ii) cell wall interaction with the gastrointestinal tract to understand how specific carbohydrate epitopes positively impact health and to exploit this knowledge in plant selection and processing for nutritionally-enhanced foods.

Addressing these fundamental questions with a high potential for translation, these activities comprehensively address the ARC priorities in research impact.

Each of the focus activities benefit from unique partnerships with Partner Organisations that provide complementary, specialised expertise and proprietary biological and technological resources, making this network of investigators a unique entity at the forefront of plant cell wall biology. For example, our privileged partnership with IBM Research Australia is central to the development of multi-scale models of primary cell walls, and for establishing structural models of enzymes involved in wall assembly and reconstruction identified in Program 1. Partnership with the James Hutton Institute provides access to barley genetic resources that are unique in the world. Infection models of barley available at Partner Organisation IPK are central to the success of our program on plant cell wall interactions with the environment (Program 3). These few examples illustrate the benefits of our privileged partnership with these and other renowned organisations. Further details are provided in the next pages on each of the HITs and the 2015 achievements.

Many of these advances would not be possible without successful research proposals with our Partner Investigators. In 2015, as for previous years, ARC funds have been matched by funds from the Biotechnology and Biological Sciences Research Council (BBSRC, UK), the German Plant Genome Research Program (GABI) and the Swedish Research Councils (VR and FORMAS), for example. Publications are continuing to emerge from these international collaborations and significantly contribute to our KPIs. All of our publication target KPIs were reached and/or well exceeded in 2015 (see also KPI section).

Similarly, at the national level we have leveraged Centre facilities and expertise through strategic alliances that have translated into significant additional funding for the Centre in the form of Discovery Projects, LIEF and Linkage Projects (see Research Funding and Collaboration section).

Collaborative projects undertaken with both national and international partners are listed in the table on page 42, together with a list of the scientists who visited the Centre to work in our laboratories in 2015.

Program 1: Biosynthesis and Assembly

The plant cell wall is an extremely complex structure that sits at the periphery of every plant cell. It provides strength and protection against the environment, and constitutes a reservoir of signalling and storage molecules to support growth and development. Cellulose, a major component of the cell wall, consists of glucose residues that are polymerised into long glucan chains, which in turn assemble to form microfibrils with high tensile strength. The remainder of the cell wall comprises the matrix polysaccharides, i.e., the non-cellulosic glycans and pectins, as well as structural proteins and enzymes. In addition, lignin is common in the walls of differentiated cell types such as xylem cells.

The Centre is particularly interested in the non-cellulosic polysaccharides that are specific to the cell walls of cereals and other grass species (the commelinid monocots), namely mixed-linkage glucan ((1,3;1,4)- β -glucan), abbreviated as 'MLG', and heteroxylan. Variations in the amounts and fine structure of these polymers influence the properties and function of the cell walls, both in the plant and for agro-industrial applications. The mechanisms that control the biosynthesis and deposition of MLG and heteroxylan in the plant cell wall have not yet been fully elucidated. We are using economically important cereal plants such as barley, wheat and rice together with model species to understand what genes are involved in the synthesis of these polysaccharides, how and where they are synthesised and assembled, and what genes and proteins regulate their biosynthesis.

Program 1 focusses on understanding the biosynthesis and assembly of MLG and heteroxylan in cereals, as well as other, novel cell wall components that affect cell wall properties.

HIT 1.a: MLG biosynthesis

Unravelling the mechanisms of MLG synthesis

Understanding the mechanism for synthesis and assembly of MLG is a key step to control its levels and fine structure in cereals to improve human health and nutrition. Significant evidence has accumulated in the Centre from mutant analyses and heterologous expression experiments indicating that the *Cellulose synthase-like (Csl) F* and *CslH* genes encode the catalytic subunits of the MLG synthase enzyme. These genes, together with *cellulose synthase (CesA)* and other *Csl* genes, are members of the large glycosyltransferase (GT) 2 family, which comprises various eukaryotic polysaccharide synthases. Our studies of the CslF6 and CslH1 proteins have revealed that they have a different sub-cellular distribution within the cell and produce MLG with different fine structures. Our working model of the molecular pathway for the synthesis of MLG by each enzyme is shown in Figure 1.

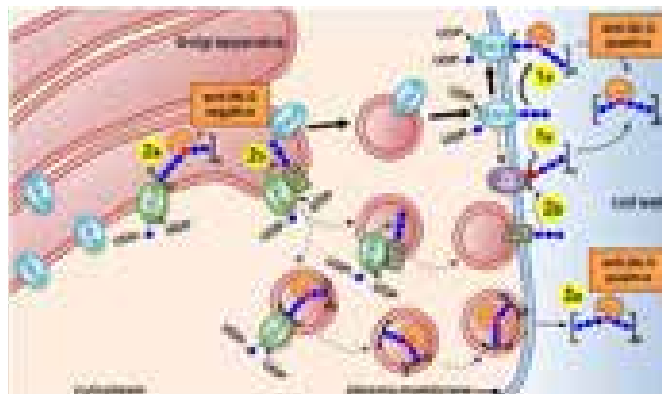


Figure 1: Updated model of the mixed-linkage glucan (MLG) synthesis pathway. CSLH1 and CSLF6 proteins are located in the Golgi apparatus (GA) and plasma membrane (PM) respectively, as their final sub-cellular destinations. (1) CSLF6 is the major MLG synthase (thick arrows) and is proposed to act similarly to CesAs, synthesising MLG chains *de novo* that are recognised by a MLG-specific antibody at the cell surface (scenario 1a). A less likely but possible alternative is that CSLF6 produces cello-dextrins (short chains of (1,4)-linked glucose residues, represented by blue circles), that are joined together by an as yet unidentified protein (Prt X) via a single β -(1,3)-glucosidic linkage (shown in red), creating the MLG motifs that are recognised by the MLG-specific antibody (scenario 1b). (2) CSLH1 has a minor, if any, role in MLG synthesis (dashed arrows) in most cells. Akin to CSLF6, it can catalyse the formation of both glucosidic linkages and produce MLG chains. However, this event is rare in most cell types that are actively synthesising primary walls. It is therefore not easily detectable (dashed anti-MLG, scenario 2a). MLG chains produced in the GA by CSLH would pass through the endomembrane system and be delivered to the PM for incorporation into the wall. Alternatively, CSLH could be involved in producing cello-dextrins that remain bound to either proteins or lipids (P/L) that pass through the endomembrane system to reach their final destination at the PM; these cello-dextrins could contain either solely β -(1,4)-linked glucose residues or have a single β -(1,3)-linked glucose residue with a total DP <7, which makes them undetectable by the MLG antibody. These oligosaccharides could then be joined together by an unknown protein (Prt X) (scenario 2b) using a mechanism similar to CSLF6 shown in scenario 1b. Modified from Wilson et al. (2015) *Plant Cell* 27: 754 (cover feature).

CsIF6 genes encode the predominant synthase responsible for the biosynthesis of MLG in cereals. As such, the *CsIF6* gene is a major target for functional characterisation to determine which regions of the protein contribute to its specificity and regulation. One approach developed in the Centre is to identify *CsIF6* mutants in *Brachypodium distachyon*, a temperate grass that is used as a model worldwide for the study of cell wall biosynthesis and biomass production. As well as having a fully sequenced genome, important advances have been made in the development of efficient transformation protocols and mutant collections, including sequence-indexed T-DNA insertion lines and TILLING (Targeting Induced Local Lesion In Genomes) populations. Several independent *CsIF6* and *CsIH* mutants have recently been obtained from the USDA Brachypodium Genome Resources collection and the Institut National de la Recherche Agronomique (INRA, Institut Jean-Pierre Bourgin, Versailles, France) and are currently undergoing molecular characterisation. In future, we plan to use fluorescently-tagged versions of wild-type and mutant *CsIF/H* variants to test their ability to functionally complement the *csIf6/cslh1* mutants.

To gain further insight into the 3D structure of plant GT2 polysaccharide synthases, we are utilising the recently published crystal structure of the bacterial cellulose synthase subunit BcsA (Morgan *et al.* (2013) *Nature* 493:181-6). In close collaboration with IBM Research Australia, we have built homology and *ab initio* models of several GT2 proteins. Molecular dynamics simulations have been performed using the IBM Blue Gene/Q supercomputer housed at the Victorian Life Sciences Initiative (VLSI) to equilibrate protein structures and assess their stability. Biochemical experiments have been performed to validate these models in an iterative manner. Such models have guided the design of *CsIF/H* variant binary vector constructs that have been transiently expressed in the *Nicotiana benthamiana* leaf system to identify which regions in these proteins are responsible for the observed differences in activity. Complementary to these gene characterisation approaches, proteomic analyses have been performed on *Lolium multiflorum* suspension cultured cells to reveal potential interacting protein partners and sites of CSLF6 post-translational modifications (PTM). Samples were prepared by co-immunoprecipitation of CSLF6 interacting partners with a CSLF6-specific antibody, using detergent-solubilised membrane fractions as the source of proteins. Further experiments are underway to verify whether any of these interactors and/or PTMs play a functional or regulatory role in MLG biosynthesis. These data are being combined with information obtained from a genome wide association scan (GWAS) for grain MLG content in barley and QTL for high MLG content in durum wheat to determine which genetic factors control the levels (and fine structure) of MLG in these grasses.

Functional analysis of a GT2 protein from the moss *Physcomitrella patens*

Professor Alison Roberts is a distinguished scientist from the University of Rhode Island who has worked for many years on cellulose synthase complexes in plants. Her work has involved analysis of the occurrence, expression and function of *CesA* and *CsI* genes in algae and seedless land plants. In 2015, she spent time in the Centre working on a novel GT2 gene from the moss *Physcomitrella patens*, which was thought to be involved in the biosynthesis of MLG or a related polysaccharide. She has cloned candidate GT2 genes into expression vectors and used the Centre's in-house protein expression systems to determine the biochemical activity of the corresponding gene products. Whilst expression of the related proteins in yeast expression systems did not result in a detectable polysaccharide product in the walls of the yeast, expression of one of the PpGT2 genes in the *N. benthamiana* leaf expression system was accompanied by the formation of a polysaccharide of about 20 kDa. This polysaccharide was not detected in the control plants transformed with a null construct. The chemical structure of this novel polysaccharide is under investigation.

Hit 1.b: Xylan biosynthesis

Analysis of mutants of *Plantago ovata* mucilage

Several plant models are used to increase our fundamental understanding of heteroxylan biosynthesis. Psyllium is the common name of several species within the genus *Plantago*, whose seeds are used commercially for the production of mucilage as a source of dietary fibre. Seed mucilage from *Plantago ovata* is composed predominantly of heteroxylan, so this species was selected to identify novel molecular players involved in heteroxylan biosynthesis through a mutagenesis approach. The first set of gamma radiation-induced *P. ovata* mutants with an altered seed mucilage phenotype (M3 generation) have been characterised at the morphological and molecular levels. Upon imbibition, the seed mucilage of one mutant is more compact and released more slowly than its wild-type counterpart, whereas the mucilage of a second mutant is loose and readily dispersed (Figure 4). Chemical and immuno-labelling analyses have shown that the xylan of these mutants is different to that of the wild-type mucilage. An RNA-seq approach is being used to identify the genetic lesions within these and other mutant lines.

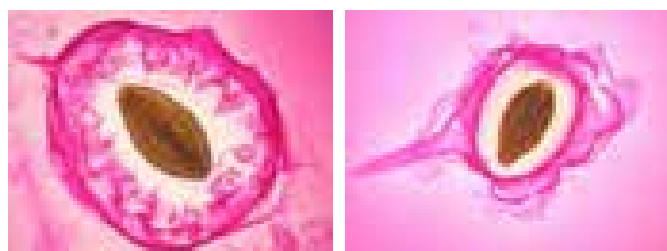


Figure 4: Ruthenium red staining of extruded *Plantago ovata* seed mucilage of wild-type (left) and a mutant (right)

Xylan biosynthesis in *Asparagus officinalis*

Biochemical analysis of the xylan synthase complex (XSC) in the immature spears of *Asparagus officinalis* has continued to reveal its protein composition and the role of each protein during xylan synthesis. Five genes associated with the synthesis of the xylan backbone, namely *IRX9*, *IRX9-LIKE* (*L*), *IRX10*, *IRX14A* and *IRX14B* have been cloned and characterised using the *N. benthamiana* leaf transient expression system. Co-expression of *AoIRX9*, *AoIRX10* and *AoIRX14A* yields xylan xylosyltransferase (XylT) activity in extracted microsomes equivalent to native asparagus spear microsomal membrane preparations, suggesting that a functional XSC was reconstituted *in planta*. The use of fluorescently tagged proteins revealed that co-expression of the three IRX proteins results in location to the Golgi apparatus, compared with singly-expressed IRX proteins being detected predominantly in the endoplasmic reticulum. In addition, multicolour Bimolecular Fluorescence Complementation (mcBiFC) showed that IRX proteins are able to form dimers and that the IRX9, IRX10 and IRX14 proteins most likely interact to form a complex *in vivo* (Figure 5). Site-directed mutagenesis experiments have confirmed that the *AoIRX10* and *AoIRX14* isoforms have xylan XylT activity. Conversely, IRX9 proteins appear to play a structural and regulatory role within the XSC, potentially recruiting IRX10 and IRX14 to form a catalytically active complex in the Golgi. Future experiments will focus on further defining the roles of each protein, and how the side-chain enzymes act on the growing xylan chain formed by the complex.

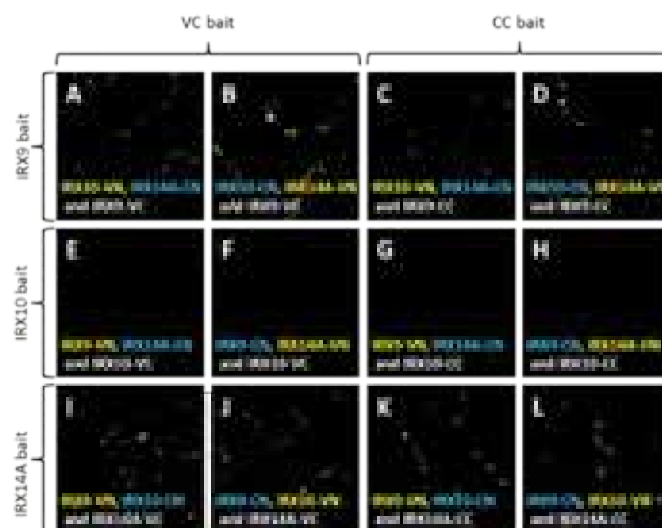


Figure 5: Using multicolour Bimolecular Fluorescence Complementation (mcBiFC) to elucidate protein-protein interactions in the xylan synthase complex (XSC). mcBiFC was used to test if IRX9, IRX10 and IRX14A can hetero-dimerise *in planta*, by expressing split VENUS and split CFP constructs in *N. benthamiana*. The COOH-terminal half of either VENUS (VC) or CFP (CC) was fused to a protein of interest and expressed in the presence of two other proteins carrying either the NH2-terminal half of the VENUS (VN) or CFP (CN). Signal in either the yellow or blue spectrum indicates an interaction between the respective proteins. First we tested which proteins can interact with IRX9 (A-D) by using it as a bait by fusing IRX9 to either VC (A-B) or CC (C-D) and expressing it in the presence of IRX10 and IRX14A. A signal was observed in all four tests indicating an interaction between IRX9 and IRX14A only. No interaction was detected between IRX9 and IRX10. We then tested which proteins can interact with IRX10 (E-H) by using it as a bait by fusing IRX10 to either VC (E-F) or CC (G-H) and expressing it in the presence of IRX9 and IRX14A. No signal was detected between any of the proteins, indicating that IRX10 does not directly interact with either IRX9 or IRX14A. Finally, we tested which proteins can interact with IRX14A (I-L) by using it as a bait and fusing IRX14A to either VC (I-J) or CC (K-L) and expressing it in the presence of IRX9 and IRX10. A signal was observed in all four combinations indicating an interaction between IRX14A and IRX9 only. No interaction was detected in between IRX14 and IRX10. Twelve independent tests indicate that IRX9 and IRX14A are able to form hetero-dimers with each other but not with IRX10. From Zeng et al. (2016).

HIT 1.c: Novel wall constituents

Evolutionary analysis of the GT2 gene family in the grasses

The GT2 family is a large family of enzymes implicated in the biosynthesis of many plant cell wall polysaccharides including cellulose, MLG, heteromannan and xyloglucan. Functional characterisation of the GT2 clades remains incomplete and is complicated by their ancient origin and significant diversification within the family. Phylogenetic analyses were performed to reconstruct a large scale evolutionary history of the family within the Poaceae (grasses). Bayesian methodologies were used to estimate evolutionary rates and revealed significant disparity between many of the clades, highlighting differing evolutionary histories for their associated polysaccharide products. Additionally, an analysis was made to determine how natural selection has operated across the family, revealing specific amino acids that have been driven by evolution away from the consensus. Four subclades in Cesa and CslF clades were shown to have undergone major shifts in selection pressure, suggesting a change in protein function. Homology models of CSLF6 were constructed and refined using molecular dynamics simulations. Amino acids under strong selection were mapped onto the model, revealing how selection has operated on CSLF6 during its evolution.

The CsIM gene family

A detailed phylogenetic analysis of the Cesa superfamily (Schwerdt et al., 2015) was used to trace the evolutionary origins of the Cesa and Csl gene families and to identify particular responses to selection pressure. The CslE, H and J genes have accumulated the greatest number of changes, making them the most responsive members to selection pressure. Heterologous expression, followed by enzymatic hydrolysis of carbohydrates and HPLC analysis, have shown unequivocally that CslJ genes encode a third type of MLG synthases found in most, but not all, cereals. A detailed phylogenetic dissection of the closely related CslJ, CslE and CslG genes has revealed a new dicot-specific family that we have named CsIM, and experiments have begun to examine their function. Heterologous expression of the genes from grapevine and tomato in *N. benthamiana* has given rise to an unusual phenotype exhibiting greatly expanded cells in the infiltrated leaf tissue (Figure 6). Biochemical analyses are underway to identify the role of CsIM proteins in polysaccharide biosynthesis.

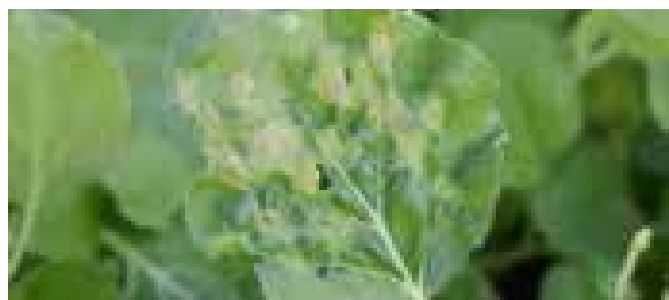


Figure 6: CsIM infiltration causes a visible phenotype in *N. benthamiana* leaf.

Program 2: Molecular and cellular mechanisms

Plant cell walls are natural biocomposites whose unique material properties are determined by molecular interactions during and after wall polymer assembly. Program 2 aims to elucidate the mode of assembly of the polysaccharides whose biosynthesis is investigated in Program 1, as well as their interaction with cellulose. Interactions between wall components are studied in model systems, and combined with rheology and micromechanics to infer the intrinsic properties of primary cell walls and their structural determinants. The ultimate objective is to develop a 3D multi-scale model for the structure and assembly of primary cell walls and to exploit this knowledge to improve cell wall properties for end use applications, such as nutrition and health purposes. The data obtained in this Program are a key to better understanding the interaction of plant cell walls with their environment and how plant cell walls are deconstructed during digestion in the gut, which is the main focus of Program 3.

HIT 2.a: Cell wall properties

Measuring adhesive forces between cellulose nanofibres

A novel technique was developed to measure the adhesive interactions between cellulose nanofibres using lateral mode force spectroscopy in the Atomic Force Microscope (AFM) (Figure 7). This approach is a critical advance in experimental determination of fibre-fibre interactions as the method can be applied directly to fibre networks, eliminating the need to isolate fibres, and allows characterisation of the distribution of contact configurations. The technique has been validated for model electrospun fibres, i.e., fibres of homogenous lateral sizes spun using electric force, and cellulose nanofibre webs, where the measured adhesion force corresponds to van der Waals' and hydrogen bonding energies, respectively.

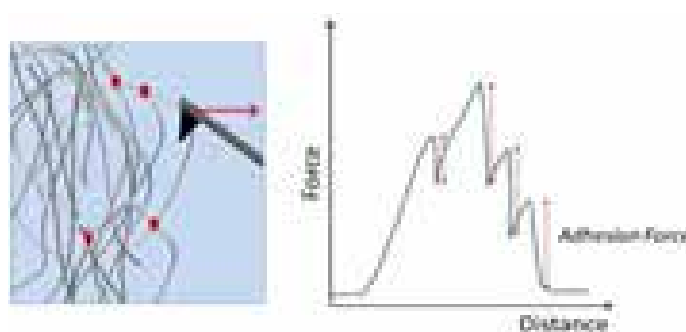


Figure 7: Measurement of adhesion forces by AFM. Lateral force spectroscopy in the AFM is used to pull fibres out of the network and record the force-distance data. From the force-distance curve, sharp drops in the measured force are observed corresponding to fibre detachment events. The magnitude of these drops gives the adhesion force.

Interaction of cell wall matrix polysaccharides with hierarchically structured cellulose

The combination of small angle neutron and X-ray scattering (SANS and SAXS) data of native hydrated bacterial cellulose pellicles has led to the development of a core-shell model to characterise the multi-scale structure of pure and composite cellulose hydrogels (Figure 8). The model proposes that cellulose microfibrils are composed of a crystalline impermeable core surrounded by a partially hydrated paracrystalline shell. Cellulose microfibrils interact with each other and with bound water by hydrogen bonding, creating larger structures known as cellulose ribbons. Due to the presence of microfibrillar sub-structures within the ribbons, solvent accessibility towards the inner region of ribbons is limited. Thus, cellulose ribbons can be modelled as core-shell structures with distinct solvent accessibility. In the case of composites based on bacterial (*Gluconacetobacter*) cellulose that mimic plant cell walls, arabinoxylan has been shown to be preferentially located within the ribbons' shell, whereas xyloglucan is present within the ribbons' core, where it interacts with individual cellulose microfibrils thereby affecting the cellulose crystallisation process and promoting the creation of smaller and more I β -rich cellulose crystals.

Interactions between cellulose and pectin have also been investigated using the *Gluconacetobacter* model. The cell wall biosynthetic process is mimicked by producing bacterial cellulose in the presence of media with different viscosities determined by the pectin content. The combination of SAXS and SANS has revealed the existence of distinct pectin domains: (i) non-interacting pectin domains that fill the pores found in the network structure of cellulose hydrogels and are removed after washing the composites; (ii) pectin domains that directly interact with the cellulose microfibrils and remain bound to the cellulose even after washing. Unlike xyloglucan, the bound pectin does not seem to interfere in the crystallization process of cellulose.

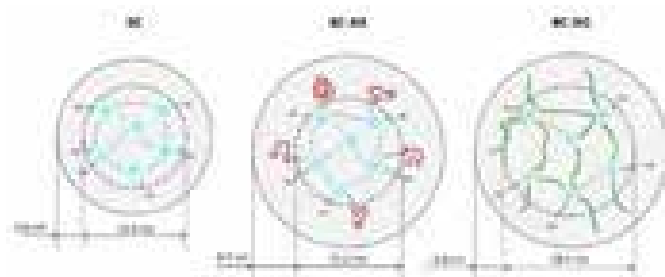


Figure 8: Schematic representation of the ribbon structure of hydrated (D₂O soaked) bacterial cellulose and its composites with plant cell wall polysaccharides based on the fitting parameters obtained by our core-shell model applied to SANS experimental data.

Modelling poroelasticity and aggregation of cellulose-hemicellulose networks

The primary cell wall is a highly hydrated composite structure. Its ability to dissipate energy through water redistribution plays an important role in maintaining wall integrity against external mechanical stresses acting over time scales comparable to its poroelastic time. To understand the mechanics of this process, xyloglucan-cellulose and arabinoxylan-cellulose composites were engineered and used for compression/relaxation/oscillation analyses. Interpretation of these data requires a model capable of accounting for the relationship between the

elastic properties of the gel and water diffusion. Moreover, cellulose fibres have the ability to reorient and aggregate upon compression, eliminating any residual stress but producing a structure that is harder to continue compressing.

A simple approach was proposed for the incorporation of reorientation/aggregation effects into the poroelastic theory: a yield pressure is introduced in the stress-strain constitutive equations assuming fibre-fibre adhesion forces are counteracted by continual pressure build up during compression, avoiding aggregation. However, once compression stops and fluid pressure falls below the yield pressure, aggregation occurs over a time scale that is similar to the poroelastic time (Figure 9).

The characterisation of these hydrogels using the current model shows that, at different levels of hydration, xyloglucan can significantly modify hydrogel stiffness with little variation in permeability. Arabinoxylan, on the other hand, binds weakly to cellulose and its mechanical effect is purely viscous, as it only modifies the permeability either by increasing tortuosity (the magnitude of twists in twisted structures), or by directly modifying apparent viscosity. Compared to previous studies, these results suggest the presence of arabinoxylan and/or xyloglucan in the cell wall has significant local anisotropic effects, increasing in-plane extensibility while simultaneously boosting out-of-plane stiffness.

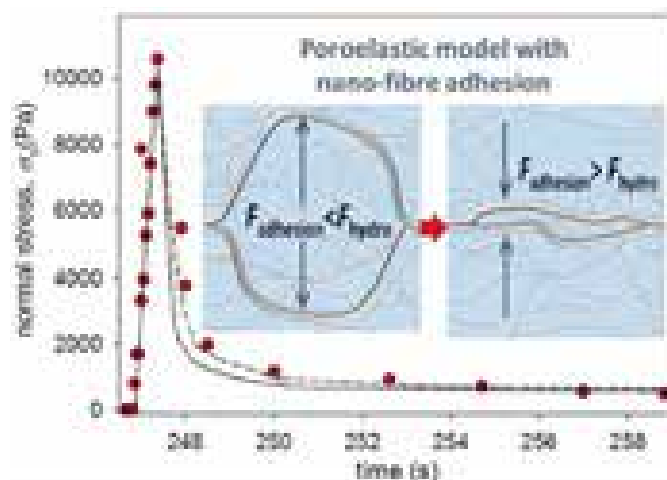


Figure 9: Cellulose networks under compression tend to aggregate and develop compressional stiffness.

This effect is enhanced by xyloglucan, which modifies network architecture, and arabinoxylan, which affects matrix permeability by effectively increasing the viscosity of the trapped fluid. A mathematical model of poroelasticity was developed that incorporates internal aggregation to investigate these effects. Here, the adhesion force between fibres is counteracted by the hydrodynamic pressure of the interstitial fluid. However, once this pressure is dissipated, aggregation occurs. The time required for fibre aggregation is therefore given by the characteristic poroelastic time of the system.

Relating the viscoelasticity to friction response of hydrogels

A rheological technique was used to characterise the viscoelasticity of cellulose hydrogels and relate it to the friction response between pairs of surfaces (Figure 10). This study gives insight into the relationship between cell wall mechanics and functionality during growth processes. The interaction between water and the hydrogel microstructure determines the viscoelastic response, which in turn affects the forces required to initiate and maintain sliding between pairs of hydrogels. Low water permeability leads to high static friction, which could contribute to the critical yield stress (P_{th}) in the Lockhart equation:

$$\frac{d\sigma}{dt} = \varphi(P - P_{th})^n$$

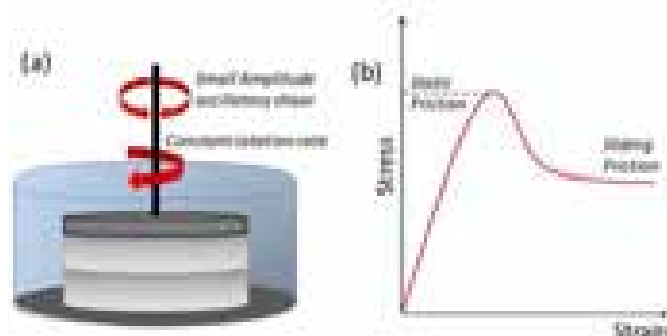


Figure 10: (a) Rheological characterisation of hydrogel pairs. Small amplitude oscillatory shear to determine viscoelasticity. Constant angular velocity to measure friction response. **(b) Typical friction curve with shear stress against shear strain during rotation of the top plate at a constant velocity.** The maximum stress is labelled as the 'static friction' and represents the force required to initiate sliding. The force required to maintain sliding is labelled as the 'sliding friction'.

In silico mesoscopic model of the plant cell wall (collaboration with IBM, Australia)

A 3D mesoscopic model of the primary cell wall is being built by capitalising on our privileged partnership with IBM Australia, using molecular dynamics and dedicated powerful computing capacity. In the *in silico* cell wall, each constituent is considered on a supramolecular length-scale (coarse-grained detail) and the model parameters are fine-tuned according to information coming from either atomistic simulations or experiments. For example, AFM and Raman spectroscopy provide data on the mechanical properties of individual cellulose microfibrils ($E \sim 80$ GPa), while atomistic simulations inform us of the nature, intensity and range of microfibril-microfibril interactions. These data are incorporated into a bead-spring chain model of the cellulose microfibril, and a system consisting of thousands of bead-spring chains is allowed to spontaneously self-assemble. By setting up the phase volume and initial orientation appropriately, the resulting structure turns

out to be remarkably similar to actual micrographs of cell wall material and cellulose hydrogels (Figure 11). These *in silico* networks can be subjected to uni- and biaxial deformations, shear, and compression to compare mechanical behaviour against that of actual cellulose hydrogels. The results show that *in silico* cellulose networks display the correct qualitative mechanical behaviour, highlighting that it is not microfibril extensibility that gives the network its characteristic stiffness, but mostly contact point density and the ratio between cellulose fibre bending and contact energy.

The next step will be to incorporate xyloglucan chains, which is challenging as these much more flexible polymers are affected significantly by thermal fluctuations. Moreover, their interaction within the cellulose network is still a subject of debate. The various hypotheses available will be explored to identify which ones produce *in silico* structures that match the experimental data obtained on the mechanics of cellulose-xyloglucan hydrogels.

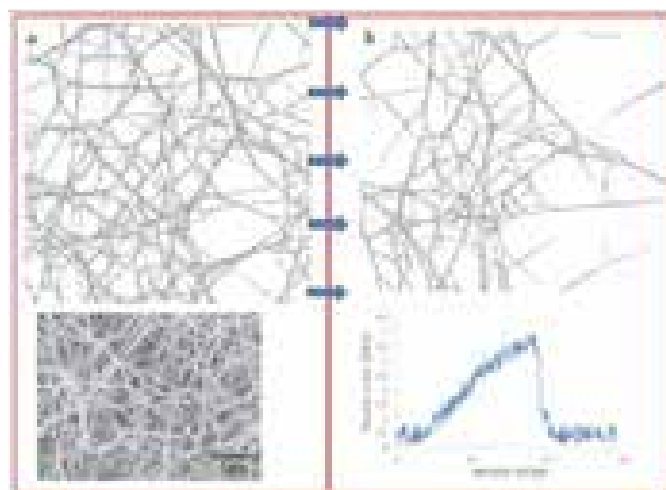


Figure 11: Coarse-grained model of the cellulose network in the cell wall. The *in silico* model (a, top) is informed by data obtained from atomistic simulations or experiments. The resulting structure resembles closely the topology observed in SEM micrographs of cellulose hydrogels (a, bottom). Simulation of uniaxial tension (b, top) produces stress-strain curves qualitatively matching those obtained with cellulose hydrogels (b, bottom).

HIT 2.b: Cell wall sensing

The role of the *Defective Kernel1 (DEK1)* gene in regulation of leaf cell morphology

Plant cells can sense the integrity of the wall and feed this information back to the cytoplasm to regulate production of new polysaccharides and wall-modifying enzymes. In collaboration with Dr Gwyneth Ingram (ENS, Lyon, France), we are investigating the function of a novel cell wall integrity sensor, DEFECTIVE KERNEL1 (DEK1), a large modular protein located at the cell wall-plasma membrane-cytoplasmic interface. On the cytoplasmic face is a calpain-like cysteine protease that is uncoupled from DEK1 by intramolecular proteolysis and can transmit information to downstream cytoplasmic substrates, presumably by altering their structure and/or activity. Extensive characterisation of plants that over-express the active cytoplasmic calpain-like domain alone has been initiated, as well as characterisation of plants with reduced DEK1 expression. In leaves, plants with altered DEK1 show dramatic changes in leaf shape, cell expansion, cell wall thickness and cell wall polysaccharide composition in the epidermal cell layer. These data suggest that DEK1 targets are likely to be regulating biosynthesis and modification of pectins during growth.



Figure 12: A putative cell wall sensor, Defective Kernel 1 (DEK1), regulates leaf shape in *Arabidopsis* as shown by the changes in plant morphology when levels of DEK1 are increased (left) or decreased (right) compared with wildtype (middle).

Hydroxyproline-rich glycoproteins in 1000 plant species

A bioinformatics approach is being used to characterise the role of another class of putative sensing and signalling molecules in the wall, the hydroxyproline-rich glycoproteins (HRGPs). HRGPs are a diverse and heterogeneous family of glycosylated proteins that have been categorised into three general classes: arabinogalactan-proteins (AGPs), extensins (EXTs) and proline-rich proteins (PRPs), spanning a continuum from highly glycosylated AGPs to minimally glycosylated PRPs. HRGPs, as intrinsically disordered proteins, represent a significant bioinformatics challenge as their core proteins have strong amino acid biases but relatively low sequence similarity. A motif and amino acid bias (MAAB) bioinformatics pipeline that is stringent, consistent and flexible has been generated to identify and classify HRGPs. The pipeline was used to investigate HRGPs in genomic datasets (www.phytozome.net) and the 1000 plant species (1KP) project (www.onekp.com). The 1KP initiative is an international multi-disciplinary consortium led by Professors Gane Ka-Shu Wong and Michael Deyholos (University of Alberta, Canada) that has generated large-scale gene sequencing data. These data are being used to investigate the HRGPs across major evolutionary milestones, including the transition to land plants and eudicot evolution. In future, the 1KP data will be used to investigate two important classes of AGPs in more detail, the Fasciclin-Like AGPs (FLAs) and AG-peptides.

Program 3: Interactions of cell walls with their environment

Program 3 aims to elucidate two important questions of plant cell wall surface interactions with their environment:

1. How does the plant cell wall interact with the cell surface of fungal pathogens during infection and how does it react to the presence of a pathogen?
2. How does the plant cell wall interact with the gastrointestinal tract before being deconstructed into components that have positive impacts on health?

The fundamental information gained from this research can be exploited in the longer term for enhancing plant resistance to crop pathogens and for improving plant cell wall properties for human health. Other applications can be envisaged from the information gained on cell wall deconstruction into simple components, e.g., for ethanol production through fermentation of simple sugars released during cell wall carbohydrate degradation.

HIT 3.a: Plant-pathogen interactions

Identification of key components in the barley cell wall papillae and their association with penetration resistance against fungal pathogens

In plants, cell walls are one of the first lines of defence for protecting cells from successful invasion by fungal pathogens and are a major factor in basal host resistance. For the plant cell to block penetration attempts, it must adapt its cell wall to withstand the physical and chemical forces applied by the fungus. We have demonstrated that barley papillae induced during infection with the powdery mildew fungus, *Blumeria graminis* f. sp. *hordei* (Bgh), contain significant levels of callose, cellulose and arabinoxylan (Figure 13). Higher concentrations of callose, arabinoxylan and cellulose are found in effective papillae, i.e., papillae that are able to confer resistance against the pathogen by blocking its penetration, compared with ineffective papillae.

Research is currently being undertaken to identify key genes involved in the cell wall-based penetration resistance. In doing so, members of the *Glucan synthase-like (HvGs)* gene family have been characterised and a single gene has been identified whose silencing results in a loss of callose in the papillae and an increased rate of successful fungal penetration. In addition, through a collaboration with our partner investigator Dr Patrick Schweizer (IPK Gatersleben, Germany), a *CsID* gene has been identified through gene silencing resulting in a loss of cellulose in the papillae and an increased rate of successful fungal penetration. The identification of the genes controlling cell wall deposition during the defence response will enable the improvement of papillae composition for the generation of novel crop lines with greater disease resistance.

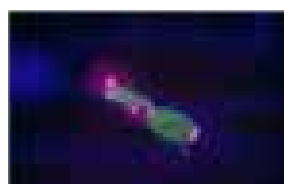


Figure 13: Local accumulation of arabinoxylan (red label) in the barley leaf epidermis. A papilla forms beneath the powdery mildew appressorium (green label) in an attempt to stop fungal colonisation.

HIT 3.b: Interactions with the gastrointestinal tract

Mechanism underlying lipid reduction by cereal soluble dietary fibres

In vivo studies in pigs have revealed that the mechanism by which cereal soluble dietary fibres (oat MLG and a wheat arabinoxylan-rich fraction) lower blood lipids is not by increasing the excretion of bile acids (BAs) in the faeces as previously reported in the literature. Furthermore, *in vitro* experiments using ^{13}C NMR and SAXS show that there is no strong binding between the polysaccharides and bile acid micelles.

The previously proposed mechanism was that these viscous polysaccharides prevent the re-absorption of BAs by binding to them in the small intestine (SI), thus breaking the enterohepatic cycle and causing excess excretion of BAs in the faeces. The liver compensates for this loss by synthesising more BAs from its sole precursor, cholesterol. The depletion of liver cholesterol causes an increase in its synthesis and that of LDL-cholesterol (LDL-C) receptors, which promotes the uptake of circulating cholesterol from LDL causing a reduction in blood cholesterol.

In our experiments however, the concentrations of blood triacylglycerides (TAG) and total bile acids (TBA) significantly decreased after four weeks on a high fibre diet, but there was no change in total cholesterol (TC), LDL-C or HDL-C levels compared with animals on the control diet. The decrease in blood TBA seems to have resulted from a decrease in circulating BAs in the gall bladder and SI which in turn reduced the digestion of TAG in the SI, as quantified by a reduction in fatty acids digestibility at the different sites of the SI (Figure 14a). We suggest that arabinoxylan in the SI might reduce the rate/extent of TAG digestion by limiting the emulsification of TAGs, thereby reducing the need for BAs which, after adaptation to the diet, results in a lower total level of BAs. This capacity of arabinoxylan to hinder digestion can be attributed to its network-forming property as seen in confocal microscopy (Figure 14b) and peak broadening of BAs signals in ^{13}C NMR spectroscopy.

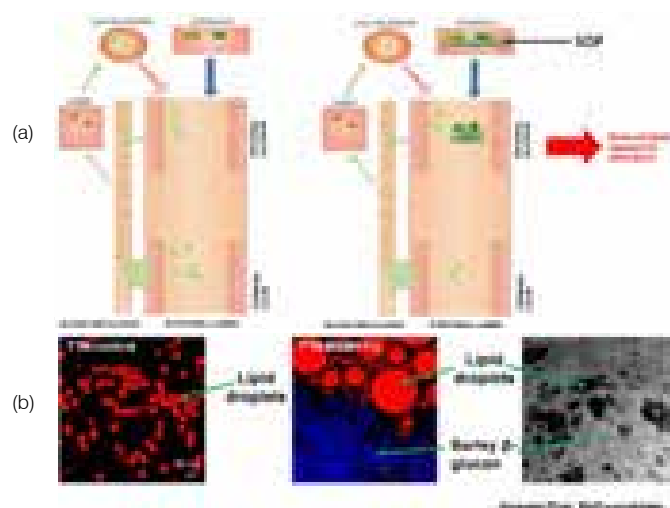


Figure 14: (a) Reduction in synthesis and circulation of bile acids in absence (left) and presence (right) of SDF leading to reduction in blood lipids. (b) Confocal microscopy images representing hindrance of lipid droplets by high molecular weight barley β -glucan.

HIT 3.c: Mechanisms underlying plant cell walls and health

Intactness of cell wall structure controls the *in vitro* digestion of starch in legumes

An intact cell wall from legumes was found to be sufficient to prevent entry of a hydrolytic enzyme, α -amylase, and its concomitant degradation of starch within a legume cell. Intact cells were isolated from a range of legumes after thermal treatment at 60°C (starch not gelatinised) or 95°C (starch gelatinised) followed by treatment with pancreatic α -amylase. It was found that intact cells isolated at either temperature were impervious to amylase. However, application of mechanical force damaged the cell wall and made starch accessible to digestive enzymes. The access of enzymes to the entrapped swollen starch may therefore be the rate-limiting step controlling hydrolysis of starch in cooked legumes, and suggests that a single cell wall could be sufficient to provide an effective delivery of starch to the large intestine with consequent nutritional benefits as 'resistant starch'. The present results also demonstrate the more general principle that plant tissues with intact plant cells can act as an efficient barrier to digestive enzyme action, providing a potential route to controlled delivery of functional nutrients to the large intestine where fermentation by the resident microbiota will allow the release of cell contents. However, the relative fragility of isolated cells suggests that some strengthening of the wall structure may be needed to guarantee that intact cells survive to the large intestine. A parallel study showed that cellulose efficiently binds α -amylase, preventing its action on starches, a finding that may help to explain why diets high in insoluble fibre are associated with a reduced risk of diabetes. The binding of α -amylase to cellulose is also seen in the association of α -amylase with the external surfaces of isolated legume cells (Figure 15).

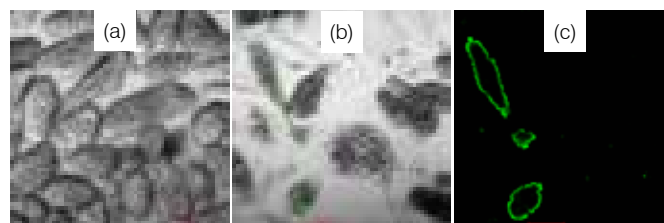


Figure 15: Chickpea cells isolated at 95°C (a) Isolated cells incubated with FITC labelled α -amylase for 4 h (b, c) The green fluorescence in B (reflective mode) and C (confocal mode) represents the location of α -amylase. Enzymes were unable to diffuse inside the intact cells. Most of the enzyme is associated with the surface of cells, consistent with binding to cellulose. Dhital *et al.* (2015) *Carbohydrate Polymers* 123: 305. Scale bar = $100\ \mu\text{m}$.

Interaction of bacteria with plant cell walls and other substrates

The interaction between bacteria, plant cell wall components and other dietary substrates play an important role in determining the end-products of fermentation and maintaining a healthy state of the host's gastro-intestinal tract. The association between bacteria and the different food remnants in pig digesta was investigated to understand the extent to which close association or colonisation is required for their fermentation. Only one direct association was observed, between bacteria belonging to the *Eubacterium rectale*/*Clostridium coccoides* cluster and cellulose remnants (Figure 16A). Other cereal cell wall components, such as arabinoxylan (B), ferulic acid (C) and lignin (C) had no direct bacterial associations. Similarly, no associations were observed for meat protein (D) and endogenous mucin (not shown). Degradation of these un-associated substrates likely takes place via indirect methods, such as bacterial enzyme secretion. These results provide novel insights into the mechanisms of fermentative processes within the large intestine.. Further investigations will concentrate on the effects of the cereal soluble dietary fibres, arabinoxylan and mixed linkage glucan, on the bacterial community profiles and end-products of fermentation through *in vivo* and *in vitro* studies.

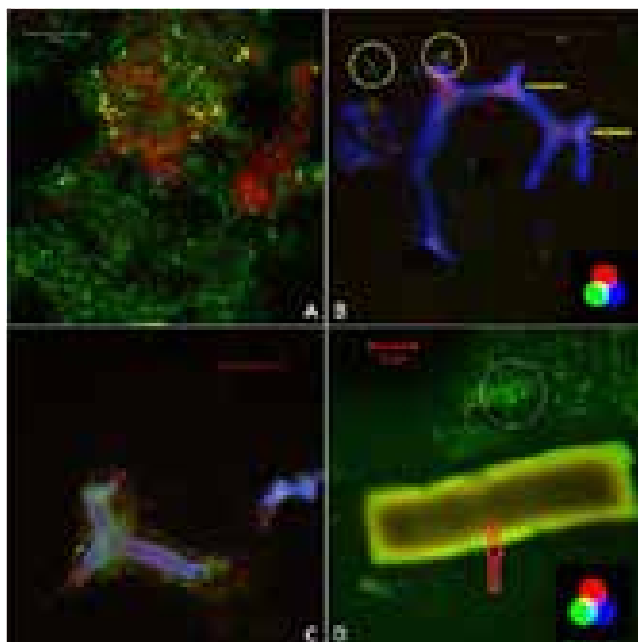


Figure 16: Visualisation of bacterial-food remnant associations in pig digesta pigs by fluorescence in situ hybridisation and histological staining. (A) P4B staining for cellulose (red) combined with bacterial hybridisation with the EUB338Mix FITC probe (green) and the genus specific Erec482 Cy5 probe (yellow). (B) Small intestine digesta sample hybridised with EUB338Mix-FITC probe and the α-L-arabinofuranosidase-Mix-n-Stain™ CF™ 660R fluorophore, where the arabinoxylan exhibits red fluorescence at the cell junctions (arrowed) and the bacteria have green fluorescence (circled). (C) A composite image showing caecal digesta sample hybridised with EUB338Mix-FITC probe to visualise bacterial cells (green) and stained with the lignin peroxidase-Mix-n-Stain™ CF™ 660R fluorophore conjugate to visualise lignin, while ferulic acid autofluoresces (at ~420 nm). (D) Eosin Y staining of meat protein particles in caecal digesta (arrow), combined with bacterial visualisation with a EUB338Mix-FITC probe (green), indicating no direct association between the protein remnants (arrow) and the bacteria (circled).

Soluble plant cell wall fibres affect protein digestion and overall gut intestinal tract fermentation

We are gradually unravelling the complex interactions between dietary plant cell walls and their effects on digestion (of meat, for example), mean retention time within the stomach and small intestine, and fermentation in the large intestine. Any detrimental effect on bacterial profiles of a moderate increase in dietary meat intake was offset by the addition of wheat arabinoxylan in the diet (Figure 17). Protein digestibility was slowed while mean retention time was reduced: these factors are associated with efficiency of digestion and feelings of satiety, respectively, which have important implications for the prevention of obesity. These findings indicate mechanisms by which plant cell walls impact positively on human health.

The addition of arabinoxylan to a diet containing moderately increased protein (red meat) was also associated with a positive shift in the large intestinal beneficial bacterial community. This shift was related to arabinoxylan's highly fermentable nature, and was associated with the formation of a positive end-product profile (increased short-chain fatty acids and decreased ammonia). These combined findings add to the health benefits of solubilised wheat arabinoxylan, showing the potential for enhancing the nutritional value of wheat grains and derived food products.

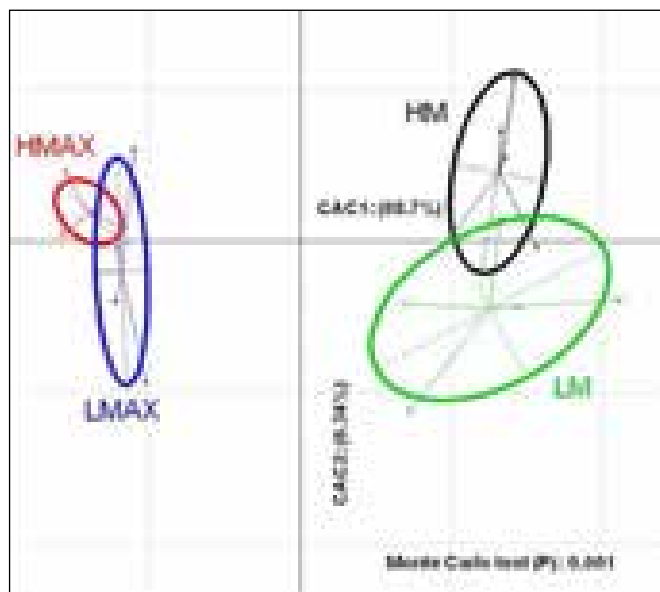


Figure 17: Correspondence analysis of bacterial profiles of pigs given different diets with HM, high meat; HMAX, high meat and AX; LM, low meat; LMAX, low meat and AX.

HIT 3.d: Cell wall engineering

Agricultural by-products as a source of fermentable cell walls for the production of ethanol

Plant cell walls are an abundant source of sugar that can be fermented into ethanol for use as transport fuel. However, the food versus fuel dilemma has necessitated the exploration of non-food sources of plant biomass. We have investigated two agro-industrial residues available in Australia that do not impinge on food supply: *Agave* plants, which can grow on marginal lands with minimal inputs; and grape marc, the waste residue of skins, seeds and stems left over during wine production.

The chemical composition of plant biomass influences the processing methods required for optimal conversion to bioethanol. Whole leaf tissue, juice (stem and leaf) and fibrous bagasse from two *Agave* species were characterised. The leaf biomass, discarded during tequila production, was particularly attractive as a ligno-cellulosic raw material because it had significantly lower lignin content relative to other common biofuel feed stocks. Juice from the leaves and stem was rich in fermentable sugars (fructose, glucose and sucrose) and soluble fructans, hydrolysis of which could double the amount of fermentable sugars. Experimentation with endogenous (Figure 18) and novel fermenting organisms, including *Kluyveromyces marxianus* and *Candida akabanensis*, increased ethanol yields by 50% over commercial *Saccharomyces* strains. Direct fermentation of leaf and stem juice from a whole plant was modelled to yield up to 15,350 L/ha of ethanol, rivalling current bioethanol feed stocks without the use of expensive pre-treatments.

In contrast, grape marc carbohydrates are rich in the phenolic polymer lignin, which intertwines with cellulose and non-cellulosic polysaccharides in a biocomposite that necessitates pre-treatment to allow enzyme penetration. Marc from the white wine variety Sauvignon Blanc contained approximately 37% (w/w) free fermentable sugars, compared with less than 5% (w/w) in marc from the red variety (Cabernet Sauvignon), reflecting the leaching of sugars, tannins, anthocyanins and flavours that occur during maceration in red wine production. These factors make marc an unfavorable feedstock for bioethanol production, but a valuable source of polyphenols and nutrients for animal feed and fertiliser.



Figure 18 Carbohydrate and ethanol tolerance of native microbes present in *Agave tequilana* stem juice.



Kendall Corbin with harvested agave leaf

Platform Technologies

The Centre activities are underpinned by multiple high-end technology platforms that provide a whole range of complementary technologies implemented by highly qualified dedicated technicians and research assistants at each node. Examples of the most significant recent outputs from these Platform Technologies that are relevant to multiple HITs are provided below.

Proteomics of *N*-glycosylated plant proteins

N-glycosylation of plant proteins has been shown to be important for protein folding, correct subcellular location and secretion, enzyme catalytic activity as well as plant pathogen interactions. Previous plant *N*-glycosylation profiling studies have primarily relied on removal of the *N*-glycans to ease the identification of the peptide, at the cost of losing information on site-specific glycan microheterogeneity. Current mass spectrometry (MS)-based ionisation and fragmentation techniques allow the comprehensive sequencing of intact glycopeptides revealing both the peptide and glycan sequences as well as the *N*-glycosylation site position. A method was developed for the enrichment of *N*-linked glycopeptides from plants, followed by liquid chromatography-electrospray ionisation-tandem mass spectrometry (LC-ESI-MS/MS) analysis using higher-energy collision dissociation product dependent electron transfer dissociation (HCD-pd-ETD) fragmentation for peptide identification, glycan site attachment and glycan sequence (Figure 19).

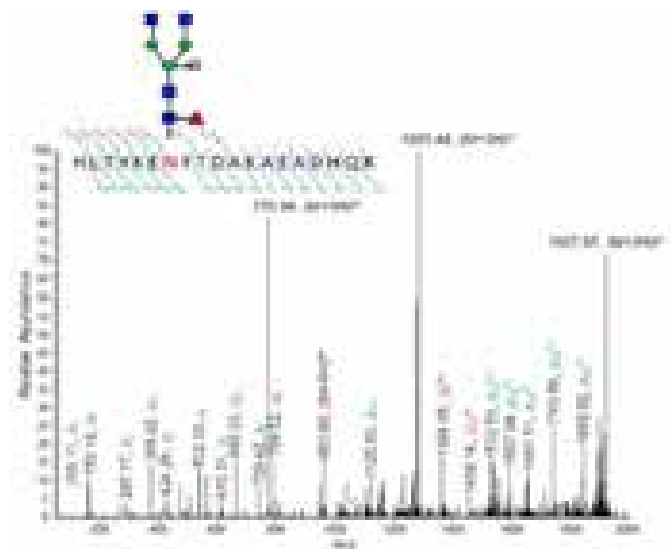


Figure 19: Example of an ETD fragmentation of a glycopeptide from AoIRX9 (see HIT 1.b), revealing the peptide HLTYKENFTDAKAEADHQR with a complex *N*-linked glycan comprising of HexNAc₄Pent₁Deoxy1Hex₃.

New preparative fast protein liquid chromatography system

In the past, manual purification of heterologously expressed enzymes has involved gravity columns and syringes and has taken up to an entire day. In August 2015, with the purchase of the ÄKTA start chromatography system, this process has been streamlined to 30 minutes with added benefit of monitoring the process in real-time. This flexible system is capable of affinity, ion-exchange and desalting chromatography with fraction collection based on time or peak area.

Nickel and cobalt affinity chromatography have been used to isolate His-tagged proteins from crude lysates of induced cultures. In addition, ion-exchange chromatography has been used to determine the integrity of purified enzymes and to remove any contaminants such as thrombin, DNase and lysozyme that are used during cell lysis and sample preparation. The system is semi-automated so other tasks can be completed in between chromatography runs. This new addition to our suite of high performance liquid chromatography instruments has afforded greater control and greater throughput of enzyme sample preparations.

NMR spectroscopy for rapid quantification of starch molecular order

A method was developed to rapidly quantify starch molecular order (Figure 20). Starch molecular order is a key determinant of the functional parameters of starch such as digestibility. It can be used, for instance, to study the mechanisms by which cell walls interact with starches and thereby control both blood glucose responses and the beneficial delivery of 'resistant' starch to the large intestine.

A partial least squares (PLS) model was developed using 115 different starch samples with molecular order values calculated from iterative fitting of ¹³C Cross Polarisation (CP) with Magic Angle Spinning (MAS), solid-state ¹³C-NMR spectra. The predictive error (RMSEP) of the PLS model (5.91%) compares favourably to that of the current spectral fitting method (6.28%). Using this model, a predictive macro was developed that gives instant results. Another advantage is that no amorphous standard sample is required and there is no need for iterative fitting. The predictive macro works in complex systems including cell walls. For example, using the macro it is possible to quantify molecular order of starch even in sorghum that has been cooked and undergone *in vitro* fermentation.

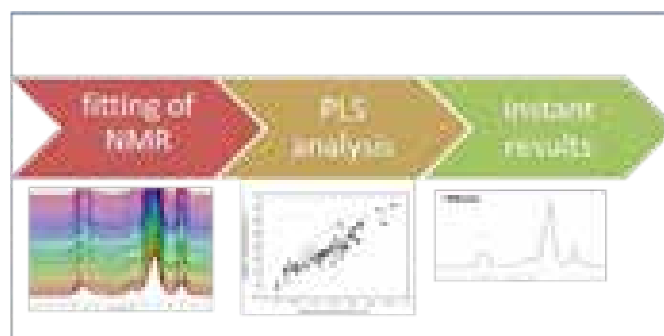


Figure 20: A predictive macro has been developed to instantly calculate starch molecular order from solid state ¹³C NMR spectra. Flanagan *et al.* (2015) *Chemical Communications* 51: 14856.



Activity Plan for 2016

Research

In 2016, the activities will focus on the key projects that have been prioritised in the revised strategic plan, taking into account the recommendations made by the Scientific Advisory Committee at the end of 2015. Our strategy is to capitalise on the current most successful projects to build the legacy of the Centre while, at the same time, shaping the future of cell wall research by further consolidating the exciting areas that have been identified through the past years of research. Potential for translation in agricultural crops and plant-based food will be given particular attention where appropriate. The main lines of research for 2016 comprise the:

- In-depth biochemical characterisation of the CSL F and H proteins involved in mixed-linkage glucan biosynthesis.
- Elucidation of the fundamental molecular and biochemical processes underlying xylan biosynthesis in model plant species.
- Functional analysis of additional genes and proteins recently identified as playing a role in primary cell wall biosynthesis, e.g. uncharacterised members of the CesA superfamily.
- Analysis of the contribution of DEK1 and proteoglycans in the regulation of cell wall development and properties.
- Refinement of molecular and supramolecular models of cell wall components to establish a 3D multiscale model of a primary cell wall that relates cell wall structure to material properties.
- Detailed analysis of glycosyltransferases responsible for the formation of papillae that are effective in blocking the penetration of the fungal pathogen *Blumeria f. sp. hordei* in barley tissues.
- Analysis of the molecular mechanisms that underlie the beneficial health effects of plant cell walls in food, with emphasis on the interactions between cell wall components and the gastrointestinal tract as well as bio-accessibility of phytonutrients and bio-processing of plant polysaccharides in the gastrointestinal tract.

Grant Funding

Early 2016 will see the commencement of CI Bulone's successful DP15 grant in collaboration with Prof. Marilyn Anderson at LaTrobe University. Centre Affiliate Staffan Persson's LE15 spinning disk confocal microscope has been commissioned at the beginning of 2016 and will be used in Centre research. UM researcher Monika Doblin will commence her UM Faculty of Science Research Grant Support Scheme project that will maintain focus on core Centre-related research.

Centre CIs and AIs will be awaiting the outcome of a number of applications submitted to the LP16 Linkage Project round, and all CIs are involved in Discovery and/or LIEF applications at the time of compiling this report. These applications and other funding opportunities will play an important role to ensure that the critical mass at each node is maintained throughout 2016 and beyond.

Opportunities to exploit the Centre's successful partnerships will be pursued with grant applications with PIs to attract funds in the Partners' regions. CI Bulone, through his ongoing links with Partner Organisation KTH in Sweden, was successful in European Commission & Swedish Research Council grants that will commence in 2016. CI Gidley was also successful in his application involving PO Arcadia Biosciences for UQ seed funding. This collaboration also brought a new partner, Ardent Mills, into Centre-related research. Further funding opportunities in Australia and the USA will be pursued as a result. Other external funding opportunities being actively pursued at the start of 2016 include: SA State Government and Bio-Innovation SA discussions with UA on large initiatives that would

involve Centre investigators and have links to Centre research; an NHMRC project application and the establishment of other non-Centre initiatives will also be pursued that will benefit the Centre with access to resources and potential new affiliations. Travel grants will also be actively pursued to assist conference related travel for students and postdocs.

Staffing, Students and visitors

Entering its last two years in 2016, the Centre will continuously adjust to both the revised research focus described previously and the need to secure future funding for continuity of key personnel whilst ensuring core Centre aims are achieved. Staff departures from the UA and UM nodes in late 2015 have been compensated by:

- A cross-nodal postdoctoral appointment of Dr Wei Zeng between UM and UA to strengthen work on xylan synthesis and further stimulate interactions between the UA and UM nodes.
- A replacement postdoctoral appointment at UA to compensate for the recent employment of Dr Yves Hsieh at KTH (junior lecturer position)
- The growth of new research groups under Affiliates Persson & Heazlewood at UM and Tucker and Byrt at UA, strengthening the Centre's overall capacity through their networks and student co-supervision opportunities.
- Dr Andrea Watt's return (from France) for the last year of her Victorian Postdoctoral Research Fellowship to study changes in cell wall mechanics as a result of altered DEK1 activity. She also brings expertise in Atomic Force Microscopy (AFM).

PhD student commencements on core Centre work will reduce and we will also have a large number of completions in 2016. A renewed focus on the shorter MSc-Research, Honours and MSc-Coursework projects will maintain overall student numbers in the Centre.

We have continued to develop collaborative ventures with international scientists, which will continue through 2016 with a combination of laboratory exchange visits and collaboration meetings, a few of which are already planned. Among these are visits from the Max Planck Institute (golm) to Affiliate Staffan Persson, and to Future Fellow Matthew Tucker from the Universities of Freiburg and Hohenheim. The aforementioned UQ Collaboration and Industry Exchange Fund projects will result in visits from Partner Organisation Arcadia Biosciences and others.

We expect that at least one PI will visit the Centre during 2016, and we are also planning for extended stays of at least one international SAC member around our Centre Retreat in October. The exchanges and collaborations with KTH in Sweden will continue in 2016 with the recent appointment of former UA postdoc Yves Hsieh to a faculty position, and former UA postgraduate student Ashley Tan undertaking a 1 year postdoc in Stockholm.

Administration and governance

The SAC membership changes from 2015 have been implemented and the PLT membership will remain stable for 2016. The Variation to Funding Agreement (VFA) will be finalised for the changed contribution of the Energy Bioscience Institute.

We will again hold two Centre Scientific Meetings in Melbourne (February) and Brisbane (May) and the 3-day Centre Retreat in Adelaide in October. The two SAC and Governing Board meetings are being scheduled to capitalise on their timely advice into the Centre Meetings.

The commercialisation options of our patent portfolio, under consideration by an external partner, will be decided on in early 2016. We will implement a strategic plan for IP management beyond the life of the Centre.



Centre Interactions

The Centre again held a Scientific Meeting at each of its three nodes during 2015, the last being a 3-day Centre Retreat coinciding with the face-to-face meeting of the Scientific Advisory Committee (SAC). The Centre Meetings and Retreats continue to be of great importance in generating and sustaining a strong culture of collaboration and integration within the Centre at all levels, from students to CIs to support staff, and with visiting SAC, Partner Investigators and/or invited visitors.

Our 2-day Centre Meetings provide the opportunity for students and research staff to present their work; and to interact formally and informally with colleagues from other nodes and with visitors to the Centre. The Meetings also provide the opportunity for participation in specialist workshops and professional development training sessions. The 3-day Centre Retreat added to the interactions with the presence of the Scientific Advisory Committee. The SAC benefit by hearing first-hand what is happening at the Centre, enhancing their capacity to report immediately to the EMC.

Centre Meeting 1, February 2015 Hosted by the UQ Node, Brisbane

The Queensland meeting provided new Centre Director Vincent Bulone with his first opportunity to address all staff and students collectively on his vision for the current Centre, future possibilities and opportunities, and the process to review the Centre's Strategic Plan accordingly.

Held at the St Lucia Campus of UQ, this meeting took the focus back to student presentations in sessions introduced and chaired by relevant PLT members or investigators. The Guest speaker was Affiliate. Staffan Persson, recent UM appointment and Affiliate to the Centre, who spoke on microtubule-based guidance of cellulose synthesis. Professors Alison and Eric Roberts from Rhode Island, who were on sabbatical from July 2014 to June 2015, also attended the meeting and participated in mentoring discussions with students. The final session involved technology platform-based interactive discussions aimed at providing non-host-node personnel a better understanding of the broader capacities of the Centre and to stimulate discussion on integration of technologies into new areas of work across the Centre. Dr Bernadine Flanagan facilitated a discussion of nuclear magnetic resonance (NMR) technologies at UQ and Dr Gleb Yakubov chaired a session on vibrational spectroscopy of polysaccharides.



Attendees of the UQ meeting.

Centre Meeting 2, May 2015 Hosted by the UM Node, Melbourne

With the review of the Strategic Plan underway, the Melbourne meeting was focussed primarily on the three largest, trans-nodal high impact targets (HITs). These were the areas that had been identified as requiring more focus in the Centre's remaining time. Each was introduced by the relevant CI or PLT member, and comprised 3–4 talks covering both ongoing and new work, and how each is currently positioned in relation to its stated goals. Interactive discussions were chaired at the end of each session.

The final session was a series of interactive workshops of HIT participants (students and staff) to discuss future plans and directions in order to reach specific goals/targets during 2016–17. The outputs of these discussions were incorporated in the revision of the Strategic Plan in the weeks immediately following this very productive and worthwhile meeting.



Interactive discussion in one of the UM meeting's HIT sessions

Centre Retreat, November 2015 Wirrina Resort, South Australia

With four of our Scientific Advisory Committee present for the week and the review of the Centre Strategic Plan complete, the Retreat focus was a review of the streamlined HITs. In addition to HIT overviews and highlight presentations, work plans for the last two years of the Centre were discussed. The full 3-day agenda also included meetings and mentoring sessions between students, postdocs, support staff and the PLT with the attending SAC members. Invited visitors for the meeting, PI Dr Vic Knauf from Partner Arcadia Biosciences (USA) and Dr Carolyn Schultz from UA, also participated.

We were pleased that we were also able to have a range of guest speaker talks in the agenda. These included presentations by SAC members Marilyn Anderson (*fungal cell walls*), and Ken Keegstra (*Xyloglucan: a journey over the Years*); and also from visitors Carolyn Schultz (*It's not easy being HYP in the green plant lineage*) and Vic Knauf (*Commercialisation opportunities and challenges*).

The Retreat Dinner presentation this year was an anticipated highlight of the meeting. We were fortunate that ARC CEO Professor Aidan Byrne was able to join us and provide some fascinating insights into the Australian research environment and its future. Although scheduled for 45 minutes, Professor Byrne held forth for nearly 2 hours of, at times, intense debate on aspects of the ARC funding cycles and processes. Everyone, from students to our international visitors, was appreciative of the frankness and honesty of the presentation and the manner in which sometimes controversial questions and topics were addressed.

The SAC were provided time to deliberate over their experience and later, a full review of our Strategic Plan and the status, progress and future of some projects was undertaken with the EMC and PLT. Key recommendations were made to ensure we remain focussed on the deliverable outcomes expected of the Centre. The meeting was recognised by the SAC and visitors as highly successful and a key step in ensuring our continued success.



Professor Aidan Byrne (ARC CEO) speaking at the 2015 Centre Retreat

Education and Public Awareness

Education

Students and teaching

In 2015, the Centre reduced the number of 1-year postgraduate students in order to focus on existing higher degree by research (HDR) students to ensure timely completion. The Centre supervised and mentored 51 students at the three nodes:

- 41 HDR students, including PhD and MSc-Research students;
- 3 Honours and MSc-Coursework students, each a full-time load with the Centre;
- 7 students visiting from overseas labs, including HDR students.

Teaching and lecturing by Centre staff in undergraduate and MSc-Coursework programs continued in 2015.

The Centre had eight student degrees conferred in 2015. These included five PhDs, one Honours student from UQ and two MSc-Coursework students from UA and UM.

- Dr Kendall Corbin (UA) researched the viability of biofuel production from industrial waste biomass.
- Dr Bradley Hocking (UA) studied cell wall – calcium interactions in grape development.
- Dr Anton Pluschke (UQ) worked on the impact of soluble dietary fibre on elements of digestive physiology.

Dr Dorrain Low (UQ) studied phytonutrient bioaccessibility and metabolism *in vitro* and *in vivo*.

- Dr Bin Zhang (UQ) researched structure-digestibility relationships of starch.

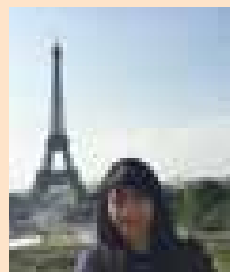


Dr Pluschke (left) and Dr Low

Student Scholarship success

The Norma Hilda Schuster (nee Swift) scholarships support students enrolled in the Faculty of Science at the University of Melbourne who are undertaking undergraduate studies (Hons) or graduate research (MSc-Research / PhD) that is significantly aligned to the field of biochemistry. The scholarships, which have a value up to \$5,000, are awarded by a selection committee based on academic merit and are tenable for one year. **Yin Ying Ho**, **Jessica Zhao** and **Edgar Liu**, UM post-graduate students, were each awarded this prestigious scholarship in 2015.

Dhika Amanda and **Edgar Liu** successfully applied to the University of Melbourne Botany Foundation Travel Award and the School of BioSciences Travel Grant. Both PhD students used these funds to attend the 26th International Conference on Arabidopsis Research (ICAR), which was held in Paris, France, July 5-9, 2015.



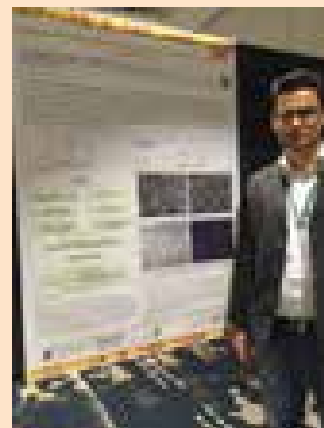
Dhika Amanda (left) and Edgar Liu.

Edgar Liu (UM) continued his success with the award of the John S. Turner Postgraduate Scholarship. The scholarship is awarded to a student undertaking a PhD in the areas of plant physiology, plant ecology or conservation plant biology.

Matt Aubert (UA) won a GRDC Grains Industry Research Scholarship to provide additional funds into his research on barley grain development.

Ghanendra Gartaula (UQ) won a \$500 Australasian Grain Science Association Travel Award to attend the 65th Australian Cereal Chemistry conference in Coogee in September.

Grace Dolan received a UQ travel Award for \$5000 to visit Prof. Daniel Cosgrove in Penn State University for three months. There, she will perform groundbreaking nano-pulling experiments on cell wall material using a technique developed by Grace and Dr Gleb Yakubov (UQ).



Grace Dolan (left) and Ghanendra Gartaula

The average completion time for a PhD student (total to 2015) is 4.3 years, slightly above the key performance indicator (KPI) of 3.5–4 years. This extra time is in part due to the transition in thesis format to 'submission by publication', requiring students to submit their thesis in the format of three journal papers. However, staff and students are becoming more familiar with this protocol and we expect completion times to decrease over the coming years. The 1-year Honours and MSc-Coursework students all completed their research components within the required time frame.

As the Centre is due to complete its activities in 2017, there were only four new HDR students in 2015: one MSc-Research student under CD Bulone, two PhDs with Affiliate Matthew Tucker, and one PhD at UQ with CI Gidley. The Centre plans to increase its load of 1-year students from 2016 to ensure that work can focus on Centre-related projects.

Current students had a great deal of success with scholarships and travel grants (see sidebar stories, previous page). Staff were also recognised for their achievements and the calibre of their research.

- Dr Sushil Dhital (UQ) was awarded the Australian Nutrition Trust Fund Travelling Fellowship to investigate the binding of enzymes on non-substrate food polymers with Prof Peter Ellis at King's College London in 2016.
- CI Burton and AI Stokes were both promoted to full professorships at UA and UQ, respectively. Their new positions commenced at the beginning of 2016. Congratulations!

There were again many visits by Centre staff and students to international laboratories, with a definite focus on China. Highlights include:

- Wai Li Lim (UA) visited IPK University in Gatersleben (Germany) for three months to perfect her results using their MALDI-Mass spectrometry imaging equipment.
- Dr Purnima Gunness (UQ) visited Ghuangzhou (China) for 1.5 weeks to share information, visit research facilities and learn new techniques.
- Dr Wei Zeng (UM) visited the South China Agricultural University and South China Botanical Garden to present research and to develop research collaborations.
- Dr Yves Hsieh (UA) visited KTH in Stockholm (PO) on two separate occasions to learn techniques and develop collaborative projects before taking up a position on their faculty in 2016. Collaborations with the Centre will continue.
- Dr Barbara Williams (UQ) visited the China Agricultural University in Beijing to present research and to receive instruction in the use of the automated gas recording system to monitor microbial fermentation of plant cell wall components.
- Dr Matthew Tucker (Affiliate, UA) visited the Chinese Academy of Sciences and the Shanghai Jiaotong University to discuss scientific collaborations.
- Dr Marta Martinez-Sanz (UQ) presented her research at the institute of Agrochemistry and Food Technology in Spain.

Success in China

Dr Purnima Gunness (UQ) was invited by The Ministry of Agriculture Aquatic Products Processing Laboratory, National Aquatic Product Processing Technology R & D Center and National Tilapia Industry Technology System to visit the Academy of Fishery Sciences, South China Sea Fisheries Research Institute (SCSFRI) during October 2015.

Purnima presented a seminar on *Mechanisms behind the effects of soluble dietary fibres on blood lipids*. She described the work being done in Australia to study these mechanisms *in vivo*, *in vitro* and *ex vivo*, and the main findings that soluble dietary fibres from cereals can lower blood lipids by impacting on bile acid levels.



The seminar was attended by more than 40 people including students, scientific and technical personnel. An animated discussion after the presentation emphasised the point that cereals should be included in our daily diet! Finally, Purnima visited the research laboratories and gave suggestions on potential investigations on the non-starch polysaccharides that the SCSFRI is extracting from red marine algae.

Purnima's hosts were thrilled and thanked her for "*the interesting and exciting discussions after her brilliant presentation*".



Dr Purnima Gunness in China (middle)

http://www.scsfri.ac.cn/xsjl/201510/t20151029_18992.html

2015 ARC Centre of Excellence in Plant Cell Walls - students

Student, PhD			
Mr	Matthew	Aubert	UA
Mr	Md Jamil	Chowdhury	UA
Ms	Kendall	Corbin *	UA
Mr	George	Dimitroff	UA
Ms	Riksfardini	Ermawar	UA
Mr	Christopher	Hakachite	UA
Mr	Bradley	Hocking *	UA
Ms	Juanita	Lauer-Smith	UA
Ms	Wai Li	Lim	UA
Ms	Sarah	Moss	UA
Ms	Jana	Phan	UA
Mr	Ali	Saleh Hassan (Al-Jibouri)	UA
Ms	Laura	Wilkinson	UA
Ms	Dhika	Amanda	UM
Ms	Melissa	Bain	UM
Ms	Deborah	David	UM
Mr	Ting Ting	Guo	UM
Ms	Yin Ying	Ho	UM
Ms	Nadeeka	Jayawardana	UM
Mr	Edgar	Liu	UM
Mr	Andrew	Lonsdale	UM
Ms	Joan	Narciso	UM
Mr	Xingwen	Wu	UM
Mr	Rewati	Bhattarai	UQ
Ms	Si-Qian	Chen	UQ
Ms	Grace	Dolan	UQ
Ms	Guangli	Feng	UQ
Mr	Ghanendra	Gartaula	UQ
Mr	John	Gorham	UQ
Mr	Lucas	Grant	UQ
Ms	Mingxia	Han	UQ
Ms	Dongjie	Liu	UQ
Ms	Dorrain	Low *	UQ
Mr	Oliver	Meldrum	UQ
Ms	Anh	Phan	UQ
Mr	Anton	Pluschke *	UQ
Mr	Vishal	Ratanpaul	UQ
Mr	Long	Yu	UQ
Ms	Honglei	Zhai	UQ
Mr	Bin	Zhang *	UQ
Student, MSc (Research)			
Ms	Trang	Pham	UA
Student, MSc (Coursework)			
Ms	Haoyu (Mia)	Lou	UA
Ms	Jia (Jessica)	Zhao	UM
Student, Honours			
Ms	Hui Shan (Vivian)	Lam	UQ

Student, Visiting or Externally Supervised			
Mr	Guillermo	Gimenez (UK)	UA
Ms	Weibke	Weissgerber (Ger)	UA
Ms	Wen	Shan (Ch)	UM
Ms	Laura	Alves (Fra)	UQ
Ms	Juliette	Aubertin (Fra)	UQ
Ms	Flavie	Crecy (Fra)	UQ
Ms	Dehui	Lin (Ch)	UQ

* HDR completion

Student and ECR Conference attendance

Exposure of students and ECRs to top international researchers through attendance at conferences and meetings is essential to their professional development.

Twelve HDR students and four ECRs attended local, national and international conferences throughout the year.

- ECR Purnima Gunness (UQ) was invited to speak about the diffusion kinetics of bile salts across the intestinal mucosa using the Ussing chamber system at the Nutrition Society of Australia and New Zealand's 2015 Annual Scientific Meeting in Wellington. UQ student Lucas Grant also attended this meeting, presenting his work on a poster.

UA student Jamil Chowdhury attended the Australian Plant Pathology Society Conference in Fremantle. He was asked to act as a session chair as well as to present his research on barley infection by *Blumeria graminis*.

- UM student Yin Ying Ho spoke at ComBio 2015 on her work mapping the catalytic subunit of CSLF6.
- ECR Patricia Lopez-Sanchez (UQ) attended the 10th Annual European Rheology Conference in Nantes to present her work on fluid phase effects on cellulose composites.
- UQ student Rewati Bhattarai presented a talk on how food structure affects digestibility of macronutrients at the 65th Australian Grain Science Conference.
- ECR Marta Martinez-Sanz (UQ) spoke at the Asia-Oceania Conference on Neutron Scattering about her work on cellulose hydrogels.

A further eleven posters were presented at other international and national conferences. Further details are presented in the appendix.

Public awareness

The Centre is involved in public awareness campaigns through a range of outreach, media and sponsorship programs across each node.

Outreach programs

The Centre participates in Outreach programs for primary and secondary schools, universities and the community generally. Feedback from students, in particular, is overwhelmingly positive, and introduces them from a young age to the fun and passion of a career as a scientist. Developing materials suitable for lay people of all ages is a valuable learning experience for Centre students and staff.

Schools Outreach

With the closure of the *Get into Genes* (GiG) program in South Australia in 2014, the UA node has re-focussed its Outreach efforts. Two staff members work within the Scientists in Schools program to deliver exciting science programs to primary children that may lay outside the expertise of their teachers, often tying in with National Science Week celebrations. Two students also regularly volunteer within the University of Adelaide's Compass program to support primary school teachers.

The UA node has been heavily involved with high school students in 2015. The lab hosted a Year 11 Primary Industry Centre for Science Education (PICSE) Industry Placement Scholarship Student; and a group of elite Year 12 students, who toured the university as a reward for their hard work! Both programs required the development of an intense day's demonstrations by UA staff and students, whose efforts were much appreciated by the visiting students. Laura Wilkinson (UA) also volunteered to "Meet a STEM professional" through the CSIRO's ASSETS program, which provides high-performing senior school students with opportunities to explore career options in science, mathematics and engineering.

Staff at the UM node gave seminars and demonstrations to high school students about bioinformatics and microscopy, and also hosted tours of campus facilities. CI Gidley was invited to speak at the Australian Institute of Food Science and Technology Summer School.

Tertiary Outreach

At all three nodes, Centre personnel participated in Open Days, Careers Nights and Postgraduate Student Information Sessions. Dr Rohan Singh (UA) also hosted a workplace visit from Plant Biotechnology undergraduates to demonstrate how biotechnology is applied in a research situation. Teaching of undergraduate and MSc-Coursework programs continues to provide a source of 1-year postgraduate students for the Centre.

Community Outreach

The success of the new community demonstrations developed in 2014 were repeated in 2015, with very well received demonstrations by Centre staff at the Royal Adelaide Show and *Science Alive!*, the National Science Week activity supported by the UA's School of Agriculture, Food & Wine. Centre staff were increasingly invited in 2015 to give radio interviews to discuss current scientific issues.

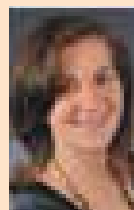
International Student Visits

Wai Li Lim (UA) spent two months at IPK Gatersleben (Germany) to use mass spectrometry imaging to visualise the distribution of sugars, such as glucose, fructose, sucrose and fructans, in transgenic barley grain overexpressing CSLF6, which contained high levels of MLG compared with wild type during grain development. Wai Li also measured the relative amount of sugars in grains using the MALDI-TOF spectrometry and determined the carbon:nitrogen ratio in transgenic and wild type grain. This work is part of a Go8/DAAD collaboration project under CI Burton, and was followed with a visit to Adelaide by Dr Andrea Matros and Manuela Peukert to learn microscopy techniques.

"I was very fortunate to be given the opportunity to visit the lab in IPK and to learn to use the mass spectrometry imaging technique. During my visit in IPK, Andrea and Manuela were great support for me. Under their supervision, I was able to observe fructan distribution during grain development using MALDI-MSI and to generate important data needed for my PhD project." – Wai Li Lim



Ms Wiebke Weissgerber visited UA from Prof. Klaus Pillen's laboratory at the Martin Luther University in Halle, Germany. She was working on resistance to the powdery mildew fungus *Blumeria graminis* in barley obtained from the extensive collections of wild barley races held at the University. A resistance locus that contains several members of the germin gene family is thought to encode proteins involved in defence against pathogen attack. In the locus, the germin genes are concatenated; eight extremely similar genes arrayed one after the other along the genome. She was successful in profiling the gene expression of almost all of the germin genes in the locus and was able to demonstrate they were not responsible for the disease resistance trait.



Mr Guillermo Garcia Gimenez, from the James Hutton Institute in Dundee, visited UA for four months in 2015. He undertook analysis of the genetic elements controlling the expression of the *HvCslF6* gene, examining its promoter for sequences that may be unique to *HvCslF6*. Primary *CesA* genes are sometimes co-expressed with *HvCslF6*. Guillermo used a promoter deletion series for the *HvCslF6* gene prepared by Mr George Dimitroff to determine key elements that activate gene expression in regenerating protoplasts. These data will inform a screen of known barley transcription factor binding sites to determine candidates for transcription factors controlling MLG synthesis in barley.



Industry liaison and participation

Our CIs and Affiliates have continued to be active in local and national initiatives:

CD Bulone conducted a whirlwind round of introductions as the new Centre Director for key members of the South Australian Government, including SA Chief Scientist Dr Leanna Read; and a variety of industry groups, such as the GRDC and the *Journal of Integrative Plant Biology*.

- CI Bacic was invited to present a keynote seminar at the prestigious Gordon Research Seminar Series on Plant Cell Walls in Boston (USA).
- CI Gidley met with senior personnel at PepsiCo to discuss a collaboration relating to the current ARC Linkage grant.
- CI Burton and CD Bulone were involved in discussions to establish the collaboration between UA and the Shanghai Jiaotong University to create a SJTU/UA Centre for Agriculture and Health.
- CI Gidley was invited to present his research to the scientific and broader communities in London and Cambridge.
- CI Bacic gave overviews of Centre work to staff at two Chinese institutions: South China Botanical Gardens and the South China Agricultural University.
- CD Bulone was invited to meeting of the Nano3Bio Consortium in Paris.
- Affiliate Staffan Persson was invited to give several talks at international conferences, such as the 4th International Symposium on Plant Reproductive Development; the 1st Molecular Plant International Symposium: from Model Species to Crops; the 5th Symposium on International Collaborative Laboratories: Front Lines of Plant Cell Research; ComBio 2015; and the 11th international Congress of Plant Molecular Biology.

Marketing and communications

The Centre's website continued to receive high traffic in 2015. We received a total of over 62 000 visitors — 27 000 unique — who viewed more than 600 000 pages on our site. Although our host data shows over 200 000 of these 'hits' originated from automatic sources (spiders or robots), over 400 000 hits were recorded from non-automatic sources. Most of the page views were from the USA with Australia, France, Russia, Ukraine, China, Germany and the UK also rating highly. About 17% of all the page visits were over two minutes duration, which is an indicator that information was being sought. Our Annual Reports were the most downloaded documents, and the news blog was the most frequented page.

Our Facebook page was up to 107 'likes' by the end of 2015 and our Twitter page had 356 followers.

In August, we released a long-anticipated video on our refreshed website. The video was produced in to capture what the Centre had set out to achieve, and provides visual insight into the tools and techniques we use. The voices of many Centre staff and students were used to support new imagery collected across our three nodes and some partner facilities.

In addition, the Centre provided sponsorship for the highly successful Australian Barley Technical Symposium, a regular international conference held in Sydney in 2015.

Travel diary of Dr Daniel Oehme (IBM)



While in the US for the Gordon Research Conference – From Genomes to Function (July 12-17, 2015 at Bentley University, Waltham, Massachusetts), I was lucky enough to be invited to visit with Professor Candace Haigler and Dr Yara Yingling at North Carolina State University, and Professor Jochen Zimmer at University of Virginia (August 26-27).

The focus of our discussions in North Carolina was computer modelling of the CESA/CSL proteins to understand how these proteins function. We spoke about many aspects of the in silico models of these proteins, including how the number of transmembrane helices differs between plants and bacteria, the positioning of the flexible catalytic loop, how these plant proteins might oligomerise, and the composition of the CESA rosette that produces cellulose in plants.

In Virginia, dialogue was more directed to the crystal structures of the bacterial CESA (BcsA) protein that Professor Zimmer has produced, which have revolutionised the plant cell wall field. We discussed some of the limitations of the models, more theories about the function of BcsA and some of the future structures they will be releasing. I was also given advice in relation to the modelling I was performing with the plant CSLF6 and bacterial CSL proteins.

All in all, it was a very educational trip and a great experience to visit these leading experts in the field. Hopefully we will be able to work with them all sometime in the future.

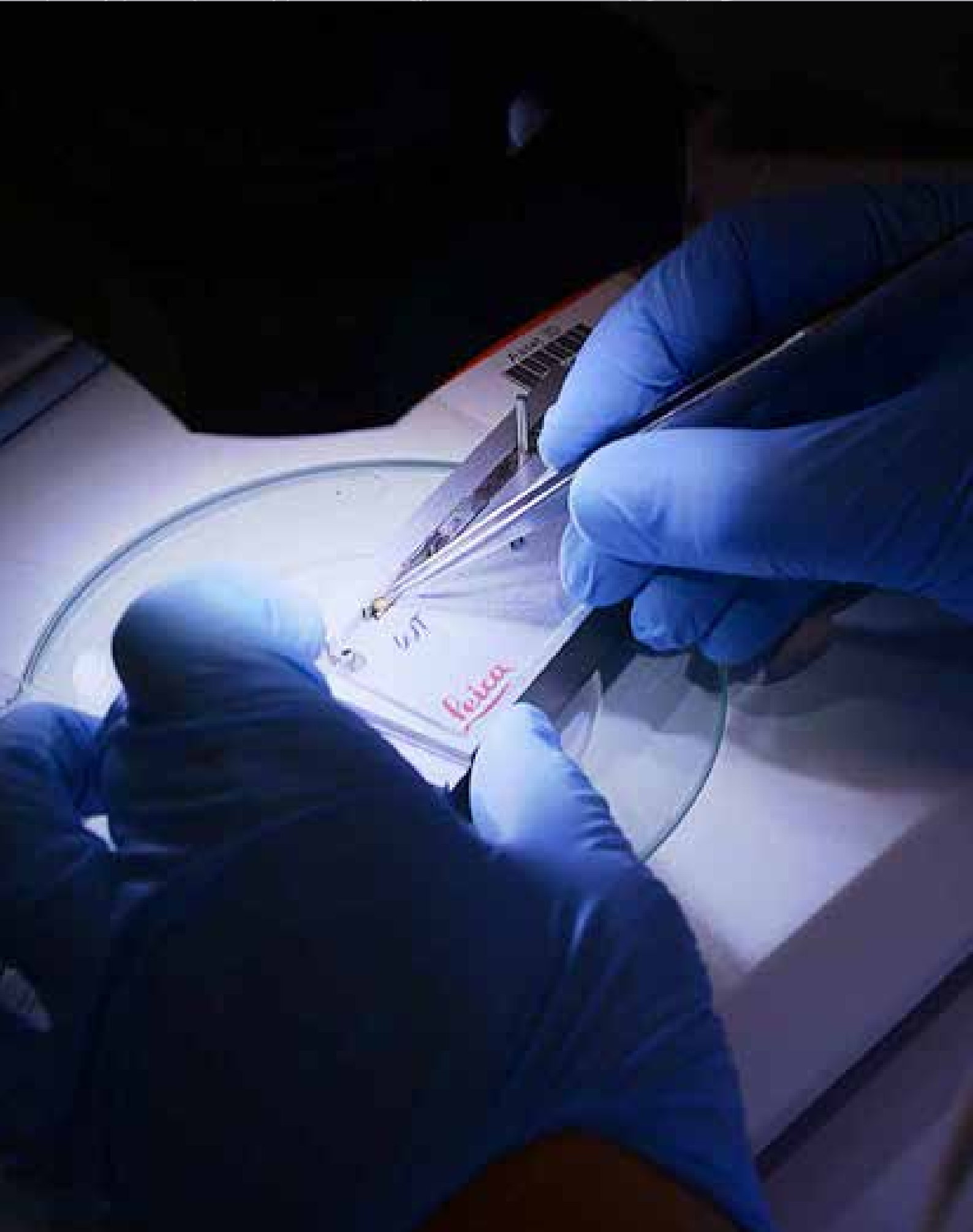
Visit from Prof. Jiayang Li

The University of Melbourne node hosted a visit from Prof. Jiayang Li in late September. Jiayang Li is a Professor in the Institute of Genetics and Developmental Biology, Chinese Academy of Science, President of the Chinese Academy of Agricultural Sciences and the Chinese Vice-Minister of Agriculture.

Prof. Li presented a seminar to the Centre staff and students on his research on molecular mechanisms in plant development and biosynthetic pathways of grain starch, cell walls and other compounds of higher plants, with special emphasis on traits for the improvement of crop yield and quality. He also held individual discussions with staff and students to assess the possibilities for collaborative projects.

His lab is particularly interested in cloning and characterising key genes that control rice tiller numbers, tiller angle, plant height, and panicle size, which determine plant architecture and affect rice grain yield. Prof. Li's lab has made immense progress in the molecular design of new elite rice varieties, with ideal properties such as high yield, good quality, nutrient use efficiency, and resistance to biotic stresses, by pyramiding the desired properties through molecular marker-assisted selection and transgenic approaches.





Key Result Areas & Performance Measures

Many of the Performance Measures (PMs) agreed with the ARC have been detailed in the preceding sections of this report, particularly in relation to media, research training and mentoring. In the following section, we provide further highlights and address progress in other Key Result Areas (KRAs) with particular emphasis on publications, training, and links with scientific colleagues and end users. The full details behind the summaries and highlights are included in the Appendix. Performance measures (PM) in **green** in the following KRA tables provide further context to the required PMs. Some KRA performance measures are also addressed in other sections of the Report and are indicated by page number. The highlighted KRAs are addressed under "Research Collaborations and Funding" in pages 40–43.

1. Research Findings

p36, 37

- a** Total number of research outputs
- b** Quality of Centre attributed research outputs
- c** Number of invited talks/papers/keynote lectures given at major international meetings
- d** Number and nature of commentaries about the Centre's achievements
- e** Citation data for publications

2. Research Training and Professional Education

p37, 38; and 29–30

- a** Number of attended professional training courses for staff and postgraduate students
- b** Number of Centre attendees at all professional training courses
- c** Number of new postgraduate students working on core Centre research and supervised by Centre staff
- d** Number of new postdoctoral researchers recruited to the Centre working on core Centre research
- e** Number of new Honours and MSc-Coursework students working on core Centre research and supervised by Centre staff
- f** Number of postgraduate completions and completion times, by students working on core Centre research and supervised by Centre staff
- g** Number of Early Career Researchers (within 5 years of completing their PhD) working on core Centre research
- h** Number of students mentored (including Summer Scholars, Honours, MSc-Coursework, PhD & visiting/co-supervised)
- i** Number of mentoring programs

3. International, national and regional links and networks

p38, 39

- a** Number of international visitors and visiting fellows
- b** Number of national and international workshops held/organised by the Centre
- c** Number of visits to overseas laboratories and facilities
- d** Examples of relevant interdisciplinary research supported by the Centre

4. End-user links

p39, and 32–33

- a** Number of government, industry and business community briefings
- b** Number and nature of public awareness programs
- c** Currency of information on the Centre's website
- d** Number of website hits
- e** Number of public talks given by Centre staff

5. Organisational support

a&b	Contributions from Collaborating Organisations	p41
c&d	Contributions from Partner Organisations	p46
e	Other research income secured by Centre staff	
f	Number of new organisations collaborating with, or involved in, the Centre	p40–43
g	Level and quality of infrastructure provided to the Centre	

6. Governance

- a** Breadth, balance and experience of the members of the Advisory Committee
- b** Frequency, attendance and value added by Advisory Committee meetings
- c** Vision and usefulness of the Centre strategic plan
- d** The adequacy of the Centre's performance measure targets
- e** Effectiveness of the Centre in bringing researchers together to form an interactive and effective research team
- f** Capacity building of the Centre through scale and outcomes

7. National benefit

- a** Contribution to the National Research Priorities and the National Innovation Priorities
- b** Measures of expansion of Australia's capability in the priority area(s)

8. Centre-specific KPIs

a	Attracting international funding into Centre collaborative projects	p40–43
b	Developed joint projects with international collaborators	
c	New commercial applications for Centre outcomes identified	p41
d	Document new technologies and file patent applications as appropriate	

KRA 1: Research Findings

Performance Measure 1. Research Findings	Actual 2015	Target 2015	Total 2011–2015*	Target 2011–2015
a. Total number of research outputs (CoE attributed) Total outputs including non-CoE attributed	72 85	35	178 251	165
b. Quality of CoE attributed research outputs (Impact Factors based on 5 year rolling average)				
– IF > 9	8	6	17	27
– IF > 6	15	15	33	68
– IF > 3	40	14	95	70
Impact Factor < 3 and other output (book chapters, web journals, etc)	9		33	
c. Number of invited talks/papers/keynote lectures at major international meetings Total # national and international conference invited lectures Total # national and International conference talks	23 24 38	20 0 0	105 134 183	67
d. Number of commentaries about the Centre's achievements (including internet & social media)				
– Media releases	180	25	442	150
– Articles (newsprint, radio & television)	24	14	61	84
	156	11	304	44
e. Average citations per 2011–12 CoE attributed paper Total # citations for CoE attributed papers in the KPI range	42 1593	12		

KPI 1–4, Outputs, Personnel and Linkages

Publications and citations (PMs 1a, b & e)

Centre attributed research outputs nearly doubled from last year, totaling 72 publications in 2015 with over 10 already accepted for publication in 2016. Thirteen additional publications were produced by Centre personnel on related, but non-core research.

Importantly, the Centre also met all of our impact factor (IF) targets in 2015. There were eight publications in journals with IP > 9, including *The Plant Cell*, *Nature Genetics* and *Trends in Plant Science*. There were also fifteen articles in journals with IF > 6, from all three Research Programs and Platform Technologies. These figures indicate that the adjustments and refinements to our strategic plan implemented in 2014 were effective, yielding a greater number of high impact publications.

Encouragingly, our citations continue to increase. For the 38 Centre attributed papers published in 2011 and 2012, we have received a total of 1593 citations. This average of 42 citations per paper is more than triple the target of 12.

Highlights from 2015 include a publication in *The Plant Cell* defining the subcellular location of (1,3;1,4)- β -D-glucan synthesis and assembly; international collaborations that have yielded two publications in *Cell*; and two articles in *Critical Reviews in Food Science and Nutrition* that describe the digestion of starch and cell wall fibres.

The March volume of *The Plant Cell* contained an editorial feature article highlighting the work of Monika Doblin and colleagues at the UM Node on "Determining the sub-cellular location of synthesis and assembly of the cell wall polysaccharide (1,3;1,4)- β -glucan in grasses".



The cover photo for the July 2015 edition of *New Phytologist* was from the cereal cyst nematode infection response work of Centre Honours Student Jessica Aditya and Affiliate Matthew Tucker.

Conferences and Meetings (PM 1c)

Centre personnel were invited to present 22 talks at international meetings in 2015.

- Four of these presentations were at the prestigious Gordon Research Conference in Plant Cell Walls held in Boston, USA, with talks given by CI Bacic, CI Burton, past-CD Geoff Fincher and A/Prof. Monika Doblin.
- Dr Alan Little and Jamil Chowdhury from the UA node were invited to speak and to chair sessions at the Australasian Plant Pathology Society Conference in Western Australia in September.
- CD Bulone gave five plenary lectures in Japan, China and Poland.
- New affiliate Staffan Persson also gave invited presentations in China and Japan, as well as at the 11th International Congress of Plant Molecular Biology in Brazil.

A further 23 talks and 19 posters were presented at other international, Australian and local meetings by Centre staff and students.

Media (PM 1d)

Centre research figured prominently in the media in 2015, with 180 items appearing in local, national and international forums.

The main media releases in 2015 were as follows:

How insights into the structure of cellulose microfibrils could help generate more resilient crops. These results were generated through *in silico* modelling from the IBM Collaboratory led by Melbourne researchers Daniel Oehme and Monika Doblin. This story was featured in 97 web articles from locations in the USA, UK, Singapore, India, Canada, Italy and South Africa.

- Promotion of two published journal articles by recently completed PhD student Kendall Corbin. Her research into bioethanol production from agro-industrial waste residues was featured in five media releases that were picked up by local and national newspapers, radio and internet sites.
- The involvement of previous CD, Geoff Fincher, in an international team that discovered genes involved in early barley domestication. This work was disseminated by national radio and newspapers, and through international web sites in the USA and Canada.

How plants adapt their cell wall in response to salt stress, through the involvement of Affiliate Staffan Persson in an international collaboration. Media promotion of this research, which was published in *Cell*, appeared in Australia, Germany, India and the USA.

- Results from Affiliate Dr Matthew Tucker and AI Dr Diane Mather, which described how β -glucan in barley can affect resistance to nematode pests in the field. This news was well-represented in regional South Australian news and radio.
- Dr Barbara Williams appeared on the popular ABC television *Checkout*, de-bunking the pseudoscience around nutrient extraction and the Nutribullet fad.

Seven Adelaide staff and students were also involved in eight Radio Adelaide interviews throughout the year, on topics ranging from "Reflections of a PhD completing student"; "Diversity and equity in science"; "Improving barley for efficient malting"; and "Growing our own biofuels".

Although not included in our KPIs, the Centre received a massive amount of indirect exposure through the worldwide interest generated by CD Bulone's Swedish laboratory's development of 'fishy sunscreen': a new, carbohydrate-based microfilm of crustacean chitosan with UV protective properties conferred by substitution with microsporines from fish and algae. This story generated over 300 media articles, from sources as prominent as the *Wall Street Journal*, *Scientific American*, *New Scientist* and the American Chemical Society's *Chemical and Engineering News*.

KRA 2: Research Training and Professional Education

Performance Measure 2. Research Training	Actual 2015	Target 2015	Total 2011–2015*	Target 2011–2015
a. Number of attended professional training courses for staff and postgraduate students	40	6	137	30
b. Number of Centre attendees at all professional training courses	52	10	267	46
c. Number of new postgraduate students working on core Centre research and supervised by Centre staff (including PhD & MSc-Research)	4	5	42	37
d. Number of new postdoctoral researchers recruited to the Centre working on core Centre research	0	3	29	30
e. Number of new Honours and MSc-Coursework students working on core Centre research and supervised by Centre staff	1	6	31	30
f. Number of postgraduate completions and completion times, by students working on core Centre research and supervised by Centre staff	5	5	13 MSc(R)=2.3yr; PhD=4.3yr	17
g. Number of Early Career Researchers (within 5 years of completing their PhD) working on core Centre research	7	6	*7.2 avg/yr	5
h. Number of students mentored (including Summer Scholars, Honours, MSc-Coursework, PhD & visiting/co-supervised)	51	21	*48.2 avg/yr	21
PhD or Masters by Research	41	0	34	
i. Number of mentoring programs	6	6	32	30

KPI 1–4, Outputs, Personnel and Linkages

(* where totalling is inappropriate averaging across each year is applied)

Professional training and development (PMs 2a, b & i)

Centre staff and students attended 40 different training courses in 2015. The training was split evenly between personal or professional development, research management and technique- or instrument-specific material, and included several student courses run by the University of Adelaide. Andrew Lonsdale was involved delivering training for Software Carpentry Instructors (University of Melbourne), while CI Gidley presented courses at the Food Science Summer School run by the Australian Institute of Food Science and Technology (University of Queensland). In addition to these voluntary courses, staff at the three nodes attended mandatory safety and compliance training as required.

Mentoring programs proved popular at our Centre meetings and annual retreat. Sessions for students, technical staff and junior academic staff were regularly scheduled to provide opportunities to speak with visiting academic and industry partners that attended our meetings. Students in particular relished the opportunity to learn about alternative career paths in other countries and proven techniques for navigating postgraduate research difficulties!

Centre personnel: students and Early Career Researchers (PMs 2c–h)

Students continued to be a main focus within the Centre in 2015. Many of the details within this KRA have been covered earlier in the Education section (p29) and the personnel table (p31).

Staff supervised 51 students across the three nodes, five of whom were PhD students who successfully completed their degrees. With much attention on these and other senior PhD students due to finish in 2016, the Centre chose not to take on large numbers of single-year Honours and MSc-Coursework students, although their numbers have risen again in 2016.

PM 2d (new postdoctoral researchers working on core Centre research) was not met in 2015, although our cumulative performance against this measure is on track. With the Centre approaching its last years, it is likely that, with the exception of filling vacancies, new full-time positions will not be created. However, joint appointments to Centre research and associated 'bolt-on' projects will ensure Centre aims continue to be addressed.

KRA 3: International, national and regional links and networks

Performance Measure 3. International, national and regional links and networks	Actual 2015	Target 2015	Total 2011–2015*	Target 2011–2015*
a. Number of international visitors and visiting fellows	24	18	138	78
b. Number of national and international workshops held/organised by the Centre	4	3	9	13
c. Number of visits to overseas laboratories and facilities	20	15	107	72
d. Examples of relevant interdisciplinary research supported by the Centre	15	9	*16.4 avg/yr	9

(* where totalling is inappropriate averaging across each year is applied)

Visits to and from the ARC Centre of Excellence in Plant Cell Walls (PMs 3a&c)

In 2015, the Centre hosted 24 visitors from Europe, Asia, the USA and Australia. Four of these stayed for at least a month:

- Dr Runxuan Zhang from the James Hutton Institute in Dundee, Scotland, visited in April to collaborate with UA researchers on work during barley grain germination that has since been published in *Plant Physiology*.
- Ms Ye Shan (exchange Master student) from Zhejiang A&F University Lin'an, China, learned molecular biology techniques at the UM node for 2.5 months.
- Professors Alison and Eric Roberts (USA) completed their 12-month sabbaticals in Adelaide with a short visit to the University of Melbourne node. Since their return, they have hosted a student to learn techniques in their home laboratories in Rhode Island, USA.

Centre staff also had a busy year travelling, with 20 national and international visits to other laboratories. Some of these have been described in detail earlier in the Education section (p29), especially Wai Li Lim's 3-month trip to Germany to learn new spectroscopy techniques. Other visits included:

- Seven visits by five staff members to China and Taiwan to learn various techniques and to build research collaborations
- CI Gidley's trip to England, where he gave two invited lectures at King's College, London and the University of Cambridge
- Dr Yves Hsieh had two trips to KTH in Stockholm to perform research and to facilitate the transfer of technology between the two laboratories
- Dr Marta Martinez-Sanz spoke about her research at the Institute of Agrochemistry and Food Technology in Valencia, Spain.

Hosted or organised workshops (PM 3b)

After a busy year in 2014 organising the 5th International Conference on Plant Cell Wall Biology (PCWB2014), Centre staff returned to a less hectic schedule of workshop and conference organisation in 2015.

CI Bacic assisted on the organising committee for ComBio 2015 in Melbourne. CD Bulone contributed to organising or scientific committees for three international meetings:

- 11th Carbohydrate Bioengineering Meeting (CBM 11) in Espoo, Finland
- Okinawa Institute of Science & Technology (OIST) Mini Symposia in Japan
- 4th International Polysaccharide Conference (EPNOE) in Warsaw, Poland

Following from the success of last year's Glycomics workshop that followed the October Centre meeting, two workshops were held in Adelaide following the Centre Retreat in November. An overview of liquid chromatography techniques was organised by Jelle Lahnstein, while an introduction to bioinformatics was run by Julian Schwerdt.

KRA 4:End-user links

Performance Measure 4. End-user links	Actual 2015	Target 2015	Total 2011–2015*	Target 2011–2015
a. Number of government, industry and business community briefings	38	12	118	51
b. Number and nature of public awareness programs	12	3	*12.2 avg/yr	3
c. Currency of information on the Centre's website				
d. Number of website hits	27669	500	75488	2000
e. Number of public talks given by Centre staff	15	9	37	42

(* where totalling is inappropriate averaging across each year is applied)

The reach of the Centre into the government, industry and public forums continued in 2015 with over 50 presentations to government, industry, scientific and public audiences. In particular, our website reached a massive number of people, with over 27 000 unique visitors (refer to Marketing and Communications section for more detail).

Highlights from PMs 4 b,c & d have been described earlier in the Public Awareness section (p32). Centre CIs, staff and students have given 38 government, industry, business community or research sector briefings during 2015 (PM4a; see Appendix p63 for details). Some examples of government and industry briefings include:

- The introduction of the new Centre Director to the South Australian Department of Development and to BioInnovation SA
- Discussion on future opportunities for the Centre by CD Bulone with:
 - SA Chief Scientist, Dr Leanna Read
 - External stakeholders in industry and government, including The Hon D Ridgway MLC, Shadow Minister for Agriculture, Food & Wine, in a meeting hosted by the Vice Chancellor of the University of Adelaide, Prof. Warren Bebbington
 - Key program leaders from the GRDC
- CI Bacic gave two presentation to senior management in South China, at the Agricultural University and at the Botanical Garden of the Chinese Academy of Sciences

Centre-funded interdisciplinary research (PM 3d)

As outlined in previous sections and detailed in the following Research Collaborations section (from p42), we continue to establish many co-funded collaborations with both national and international partners. In 2015, the Centre hosted over 20 funded projects and participated in many more projects at the local, national and international levels.

Centre investigators have also led or participated in over 60 unfunded research collaborations since 2011. Many of these collaborations involve an in-kind intellectual contribution by Centre CIs and/or a direct Centre involvement undertaken in our laboratories by Centre personnel as 'cash spent in-house' contributions. More than half of the funded collaborations involve universities and many involve government and industry institutions from across the world in addition to our Collaborating Universities and International Partner Organisations.

Details on externally funded research grants, active in 2015 and related to the Centre's work, are found in the Research Collaborations and Funding section from p42.

- CI Gidley presented briefings to senior personnel at PepsiCo in New York and at CSIRO Food and Nutritional Sciences in Sydney
- Affiliate Matthew Tucker's seminars in China to faculty members of the Chinese Academy of Sciences and Shanghai Jiao Tong University
- Dr Monika Doblin led investment discussions with Finistere Agtech and with BASF CropDesign in Melbourne
- CD Bulone, CI Burton and Affiliate Matthew Tucker were involved in round table discussions during the establishment of a collaborative partnership between the University of Adelaide and Shanghai Jiao Tong University

Centre personnel also gave 14 talks in public forums, both in Australia and overseas (PM 4e, see Appendix p63 for details). Highlights include: CI Gidley's presentation to the Cambridge University community on "*The alpha and beta of human nutrition*"

- Prof. Geoff Fincher's seminar describing the Centre to staff at the Carlsberg Laboratories in Copenhagen
- A series of eight radio interviews by senior staff and students from the Adelaide Node.

Research Funding and Collaborations

The remaining four Key Result Areas (KRA) of the Funding Agreement between the ARC and the Administering Organisation include some performance measures (PMs) that have been addressed in preceding sections of this Report. This section covers KRAs 5e–g from Organisational Support and 8a & 8b from *Centre-specific KPIs*.

Performance Measures relating to securing other income for the Centre					
		Actual 2015	Target 2015	Total 2011–2015*	Target 2011–2015
Performance Measure 5e Research income (grants and other) secured by Centre staff (Australian CIs)	i Grant income for Centre-based research (Australian)	2,761,117	-	7,076,186	-
	ii Other income secured, but not specifically linked to, Centre research*	540,000	-	4,568,176	-
	Subtotal	3,301,117	400,000	11,644,362	4,737,000
Performance Measure 8a Cash funding specifically available to PIs in their own regions		424,963	850,000 [#]	4,917,893	> 3,000,000
Total collaborative funding expected under Key Result Areas 5 & 8		3,726,080	> 1,250,000	16,562,255	> 7,737,000

*Not including Australian Phenomics Facility and Metabolomics Australia EIF & NCRIS major infrastructure funding awarded to CIs Bacic and Fincher(2011-2016), and Burton 2014/15 for APPC)

• Includes LIEF and other grants on which Centre investigators are co-CIs.

[#] The Performance Measure specifies "identify new sources of international funding and submitted multiple applications". Any funding received therefore, is set against an assumed cash target based on \$850,000, as in previous years

In the table above, the research funding PMs are addressed as the combination of:

- Research grants to Centre CIs and staff for Centre-based research (PM 5e, i);
- Other grants awarded to Australian Centre staff for infrastructure and research that are not specifically linked to the Centre's core activities (PM 5e, ii); and,
- Cash funding specifically available to PIs in their own regions (PM 8a).

The Centre benefits from all these activities through increased numbers of associates and collaborators and through access to new and improved infrastructure.

PM 5e: Research income secured by Centre staff

The Centre has continued to secure additional funds from new grants that commenced during 2015. The ongoing and new grant income for Centre based research in Australia totalled \$2,761,117 for 2015, including approximately \$1M on new activities. These include new grants linked to the Centre research through new Affiliates and also the fellowships and grants awarded to our postdoctoral fellows as highlighted in the 2014 Report. Highlighting the Centre's impact internationally was the number of new grants as well as partnerships commencing from long standing international collaborations, including the provision of cash from international partners for these new activities. Grant highlights under PM 5e for 2015 included:

- **UA node:** Commencement of an ARC Future Fellowship to Matthew Tucker and a DECRA to Caitlin Byrt; Dr Tucker also received a Go8-DAAD project and a University of Adelaide Priority Partner Program grant for collaborations in Germany and a collaboration grant with North Carolina State University.
- **UM node:** Affiliate Staffan Persson's Discovery Project granted in 2014 commenced; and the LIEF award for a spinning disk confocal microscope was approved and procurement initiated. Prof. Persson also received a Herman Slade foundation grant.
- **UQ node:** Al Jason Stokes commenced a Discovery grant and obtained industry funds for a Linkage Project. CI Gidley commenced two Australian Pork CRC projects and received both UQ and international partner cash for work on UQ Collaboration and Industry Engagement Fund projects (including a cash component from Partner Organisation, Arcadia Biosciences).

Further detail is presented in the table at the end of this section.

In addition, further new research income was secured by Centre investigators for activities not directly linked to Centre research, including CI Bacic's involvement in a successful LIEF to improve 3D electron microscopy at UM that will benefit Centre research in future. In total, the income reported under PM 5e for 2015 is \$3,301,117, which greatly exceeds the \$400,000 target initially set in our Funding Agreement with the ARC.

PM 5f: Number of new organisations collaborating with, or involved in, the Centre

Under PM 5f, the Centre should engage with at least one new organisation per year. 2015 again saw numerous new funded and unfunded collaborations commence. Formal projects involving new partners in 2015 included:

- Linkages with the ARC CoE Plant Energy Biology through the joint involvement with DECRA recipient Caitlin Byrt and her work on cell wall changes that alter plasma membrane function.
- UQ node research with Glaxo Smith Kline and Ardent Mills (USA).
- UA node collaborations with North Carolina State University (USA), and University of Hohenheim (Germany).

Centre investigators continue to engage formally and informally with many Australian and international institutions and companies. Parties to informal collaborations provide in-kind and service contributions as well as mechanisms for staff and student exchanges. Some have again resulted in joint publications. It has also been pleasing to see some long-term informal collaborations resulting in formal Linkage and other collaborative projects over the last few years. One example is the UA node collaboration with La Trobe University that resulted in the award of an ARC Discovery Project to commence in 2016 under CD Bulone.

PM 5g: Level and quality of infrastructure provided to the Centre

Our Centre has been provided with excellent infrastructural resources across its three nodes in Australia. Over the substantial initial investments made at the Centre's commencement, each Collaborating University has continued to invest in resources utilised by Centre investigators and students. These include cash contributions to external infrastructure grants and through 'internal' equipment rounds, where Centre investigators collaborate with other campus partners in competitive bids.

Other large and ongoing initiatives that the Universities continue to support and that are essential to the Centre's activities include the Bio21 Institute and at the IBM Collaboratory in Melbourne; Bioplatforms Australia through UM; The Plant Accelerator and Adelaide Microscopy through UA; and the Australian Institute for Bioengineering and Nanotechnology at UQ.

PM 8a: Attracting international funding to PIs in their own regions

Centre participation has helped to leverage a total of \$4,917,893 since 2011 for ongoing collaborative research with its Partner Investigators in Europe. These large projects are entering their final years with only final payment of \$334,963 budgeted for receipt in 2015. Approximately \$90,000/year of new funding for collaborations between KTH in Sweden and the Centre commenced in 2015 with the arrival in Adelaide of former PI Vincent Bulone as Centre Director.

The target for 2015–2017 was not quantified in the original ARC Funding Agreement, but the expectation of identifying new funding opportunities and writing new joint applications was expressed. CD Bulone's continuing part-time work with KTH was successful in late 2015 with new large grant awards that will flow in 2016. Although the Centre was not a direct joint applicant, there will be benefits through access to critical expertise. Collaboration discussions continue with PIs Waugh and Halpin in the UK and PI Schweizer (Germany), and new applications are possible.

PM 8b: Developed joint projects with international collaborators

2015 saw the commencement of a PhD student jointly funded between the Centre and Scottish Partner Organisations (University of Dundee and the James Hutton Institute). The scholarship is administered through the UK but the student spent the first of their annual laboratory visits to the Adelaide Node in 2015. During 2015, collaborations with KTH were expanded and saw two extended laboratory visits by a Centre postdoc to CD Bulone's laboratory in Sweden to learn and develop techniques beneficial to both partners. A recently completed Centre student took up a postdoctoral secondment at KTH to contribute to complementary research activities. Joint publications will flow from these collaborations in 2016.

Although not resulting in additional funding to Partner Organisation Arcadia Biosciences (ABS), their joint involvement in CI Gidley's successful UQ Seed Funding project has brought in increased commitments from a new partner, Ardent Mills.

Centre investigators published seven joint papers in 2015 with co-investigators from international Partner Organisations: James Hutton Institute, University of Dundee, The Energy Biosciences Institute and DuPont Pioneer (from work completed prior to their withdrawal from the Centre). Numerous other publications involved international collaborations (detail in the Key Result Areas section) and several other manuscripts are in preparation or have been submitted. Some of these collaborations and publications are not directly Centre-related.

PM 8c&d Commercial applications and patent management

The Centre manages a portfolio of polysaccharide synthase patents (3 families) that are based on IP developed by the Centre and by our scientists prior to establishment of the Centre. The patent applications have been filed in Australia, New Zealand, the USA, Japan and Europe. In 2015, further polysaccharide synthase family patents were submitted.

While the Administering Organisation (UA) continues to monitor the passage of these applications through the various stages in the different countries, the Centre has also engaged independent expert patent advice for the management and commercialisation of its IP. Although decisions were still pending at the end of 2015, the Centre has been actively engaged with Arcadia Biosciences on the future management of the human health and related patents held by the Centre.

Performance Measures 5e and 8a. Research Collaborations and Funding: Australian grant income and grants to PIs in their own regions

Centre Lead CI	Project / Program	Sponsor	Funding Type	New collaborator	2015 Awarded
Performance Measure 5e : Other research income secured by Centre staff — linked to Centre research (2015)					
Stokes	DP150104147: Engineering biomimetic lubrication with mucin (2014–2017)	ARC	ARC Discovery		\$ 90,000
Persson	DP150103495: To delineate two components that are part of a protein-complex, synthesise cellulose and protect the complex against environmental stress function	ARC	ARC Discovery		\$ 143,000
Fincher	LP130100600: Physiology and genetics of barley grain germination in the malting and brewing industries	ARC	ARC Linkage		\$ 225,000
			Linkage - Industry Ptnr		\$ 250,000
			Linkage - Industry Ptnr		\$ 150,000
Stokes	LP140100952: Enabling the design of superior healthy snack foods and beverages through innovative assessment of oral processing and mucosal film interactions	ARC	ARC Linkage		\$ 185,000
			Linkage - Industry Ptnr		\$ 75,000
Heazlewood	ARC Future Fellowship — Heazlewood	ARC	Future Fellowship		\$ 205,760
Tucker	ARC Future Fellowship — Tucker	ARC	Future Fellowship		\$ 193,026
Byrt	ARC Discovery Early Career Research Awards — Byrt ** in conjunction with ARCCoEPEB	ARC	DECRA	Y	\$ 118,000
Persson	LE150100011: Spinning disk confocal microscope with dual stages	ARC	ARC LIEF		\$ 346,439
Burton	GRDC Scholarship — Phan	GRDC	Scholarship		\$ 15,000
Tucker	GRDC Scholarship — Aubert	GRDC	Scholarship		\$ 20,815
Bacic	Novel fining agents to heat stabilise wine	GWRDC	Grant		\$ 196,954
Tucker	Sarah Moss, CSIRO Plant Industry: Role of auxin in grape berry development	CSIRO	Scholarship		\$ 5,347
Bacic	Julius Career Award — Biosynthesis of lignin and lignin-like molecules in cotton (Tony Bacic as contributing investigator)	CSIRO	Scholarship		\$ 50,000
Gidley	Predicting the effects of fibre, grain digestion rate and the ileal brake on voluntary feed intake	Pork CRC	Pork CRC Project		\$ 50,000
Gidley	Measurement of grain enzyme diffusion rates and grain threshold particle size calculator	Pork CRC	Pork CRC Project	Y	\$ 25,000
Persson	Understanding how plants can sustain biomass production under saline growth conditions	HSF	Hermon Slade Foundation		\$ 25,500
Johnson	"Victorian Postdoctoral Research Fellowship Investigating the developmental pathways that regulate seed nutritional content and plant architecture for agricultural applications. "	VPRF	Government		\$ 100,000
Burton	Go8 / GAAD — Subcellular localisation of oligofructans and related metabolising enzymes involved in nutrient import during barley grain development	Go8	Uni/ Government		\$ 10,000

Centre Lead CI	Project / Program	Sponsor	Funding Type	New collaborator	2015 Awarded
Tucker	DAAD/Go8 — Genetic control of germline initiation in flowering plants	Go8	Uni/ Government	Y	\$ 10,500
Tucker	University of Adelaide–NC State Starter Grant program (2015)	UA	Collaborating Uni	Y	\$ 10,000
Tucker	University of Adelaide Priority Partner program	UA	Collaborating Uni		\$ 4,700
Yakubov	Creating saliva-mimetic polysaccharide-protein complexes to control oral lubrication for applications in oral care, foods and biomedical treatment of dry-mouth.	UQ	UQ Collaboration and Industry Engagement Fund		\$ 75,000
Yakubov	Stribeck behaviour of industry relevant polysaccharide solutions and their interaction with saliva.	GSK	Int Industry	Y	\$ 38,000
Gidley	Design rules for nutritionally functional starches	Arcadia/ Ardent Mills	Industry Partners	Y	\$ 28,076
		UQ	UQ Collaboration and Industry Engagement Fund		\$ 75,000
Gidley	ANSTO Collaboration (0.5 FTE CoE postdoc)	ANSTO	Industry		\$ 40,000
					\$ 2,761,117
Performance Measure 5e : Other research income secured by Centre staff — not directly linked to Centre research (2015)					
Bacic (co CI)	LE150100004: An automated 3D electron microscopy facility	ARC	ARC LIEF		\$ 540,000
					\$ 540,000
Performance Measure 8a : Attracting international funding to PIs in their own regions (2015)					
Waugh	JHI–CoE PCW joint project — Regulation of (1,3;1,4)-β-glucan synthesis in the grasses	BBSRC	BBSRC Nov'11 start 493798 GBP 3yrs		\$ 247,963
Halpin/ Waugh	JHI–BBSRC Scholarship	BBSRC	RESAS Scholarship		\$ 87,000
Bulone	KTH / CoE PCW / UA collaborations support	KTH	KTH Grant		\$ 90,000
					\$ 424,963
Total research grant funding attracted by Centre investigators (2015)					\$ 3,726,080



Partner Organisations

Bioplatforms Australia Pty Ltd was the only Partner Organisation (PO) under the Collaboration Agreement that contributed cash to the Centre in 2015. The Government of South Australia and Arcadia Biosciences (USA) remain POs, but their respective cash contributions have not been extended beyond the first three years of the Centre activities. The Energy Biosciences Institute (USA) contributions are spent 'in-house' and not transacted to the Centre. The Royal Institute of Technology (KTH) (Sweden) ceased cash contributions in 2012 (per Agreement) but in 2015 increased cash support for the Centre through a grant to new CD, Prof Bulone. The James Hutton Institute (UK), the University of Dundee (UK) and IPK Gatersleben (Germany) are in-kind only contributors and DuPont-Pioneer (USA) withdrew from the Centre in 2014.



Arcadia Biosciences contributed US\$120,000 cash per year over the first three years of Centre activities, as stipulated in the Collaboration Agreement. Cash support ceased during 2014. However, Arcadia Biosciences continues to engage with the Centre by providing valuable in-kind support and patent advice. Partner Investigator Vic Knauf participates in our regular teleconferences to provide feedback on the Centre's translational activities. He contributed a lecture to our 2015 Annual Retreat and participated to the discussions on the IP strategy of the Centre and its approach to translational research. Potential for new project opportunities and joint communication activities of Centre outputs involving research supported by the company are regularly discussed. In 2015, Arcadia commenced a new project with CI Gidley at the UQ Node looking at 'Design rules for nutritionally functional starches'. Arcadia brought partner company Ardent Mills to this UQ 'seed-funding' project.



The South Australian Government supported the Centre by contributing \$500,000 cash until June 2014. We gratefully acknowledge this contribution and the capacity it provided to the South Australian node for the support of students, for facilitating student and ECR mentoring, and for the development of scientific exchanges between nodes and with our International Partner Organisations. The cash contribution was also used for the procurement of new laboratory equipment. Despite the end of the financial support received by the South Australian Government, we continue to regularly engage with the SA Chief Scientist and senior Department of State Development representatives to discuss opportunities for new funding applications.



Bioplatforms Australia (BPA) has continued to provide its cash support in 2015 for analyses performed through their 'omics' technology platforms (genomics/transcriptomics/metabolomics) and associated informatics, primarily through the University of Melbourne node.



Support from the **Royal Institute of Technology (KTH)**, Sweden, has continued since the appointment of Vincent Bulone as Centre Director in January 2015. Cash to be spent at KTH is provided for the support of a part-time postdoctoral scientist involved in joint projects with the Centre. CD Bulone remains affiliated with KTH, which facilitates the development of joint activities with the Centre and the mentoring of the KTH postdoctoral fellow. Research activities undertaken at KTH for the Centre well exceed the in-kind expectations.



The Energy Biosciences Institute (EBI) and PI Chris Somerville have maintained their engagement with Centre research through in-kind contributions supporting metabolomics

profiling projects with the Melbourne node and Bioplatforms Australia. However, cash contribution ceased during 2015. A Variation to Funding Agreement is being prepared at the time of writing this report to formalise the change in financial commitment of EBI. Despite the cessation of cash contribution, scientific collaborations remain and a visit of PI Somerville and EBI postdoctoral fellows has been discussed and will be organised depending on availability.



The James Hutton Institute (JHI), (formerly the Scottish Crop Research Institute), and **The University of Dundee** are in-kind only contributors. These POs continued to be productive collaborators through PIs Robbie Waugh and Claire Halpin, and postdoctoral researcher Kelly Houston, co-supervisor of a joint University of Dundee/UA PhD student. The core in-kind contribution comprised research on association mapping in barley. The remaining annual in-kind support from JHI includes collaboration with PI Waugh and associated

travel and related costs to support visits to the Centre. In 2015, several postdoctoral researcher and PhD student exchanges took place. Details of the leveraged grants are described in the earlier Research Highlights and Research Collaborations and Funding sections. Joint publications in 2015 are listed in the KPI table summarising the Centre publication output.



IPK Gatersleben is an in-kind contributor to the Centre through PI Patrick Schweizer. Dr Schweizer was successful in 2012 in securing GABI funding for the multi-institutional BARLEY-FORTRESS project with the ARC Centre as a major partner. Collaborations through this project have continued with German PhD students and IPK researchers undertaking stays at the Adelaide laboratories in 2015 to implement various collaborative projects. One UA student also visited IPK Gatersleben to apply in situ imaging mass spectrometry to grain compositional analysis. The collaborative work, underpinned by the complementary expertise of PI Schweizer in fungal pathogen research, has continued with joint publications submitted at the end of 2015.



Dupont-Pioneer Dupont-Pioneer formally withdrew from the Centre as an International Partner Organisation at the end of 2014. However, Dupont collaborators contributed to the preparation of 2 joint papers that were published in 2015.

Key Result Area 1: Performance Measures a & b

Research Outputs: Publications

Impact Factors (IF) are the five-year impact factors sourced from Thompson Reuters ISI Web of Knowledge Journal Citation Reports, 2015. Authors from the **Adelaide node**; the **Melbourne node**; the **Queensland node**; **Associate Investigators**; and **Partner Organisations** are indicated in bold colour.

Research Program	2015 Publications: ARC CoE Attributed (counted towards Performance Measure)	Impact Factor
1	Pourkheirandish M, Hensel G, Kilian B, Willcox, G, Senthil N, Chen G, Sameri M, Sakuma S, Dhanagond S, Sharma R, Mascher M, Himmelbach A, Gottwald S, Azhaguvel P, Nair S, Tagiri A, Yukuhiro F, Nagamura Y, Kanamori H, Matsumoto T, Middleton CP, Wicker T, Walther A, Waugh R , Fincher GB , Stein N, Kümlehn J, Sato KK and Komatsuda T. (2015) Evolution of the grain dispersal system in barley. <i>Cell</i> 162 : 527.	35.5
1	Ebert B, Rautengarten C, Guo X, Xiong G, Stonebloom S, Smith-Moritz AM, Herter T, Chan LJ, Adams PD, Petzold CJ, Pauly M , Willats WGT, Heazlewood JL and Scheller HV. (2015) Identification and characterization of a Golgi-localized UDP-xylose transporter family from Arabidopsis. <i>The Plant Cell</i> 27 : 1218.	10.5
1	Wilson SM , Ho YY , Lampugnani ER , van de Meene AML , Bain MP , Bacic A and Doblin MS . (2015) Determining the subcellular location of (1,3; 1,4)- β -D-glucan synthesis and assembly. <i>Plant Cell</i> 27 : 754.	10.5
1	Schwerdt JG , MacKenzie K, Wright F, Oehme D , Wagner JM , Harvey AJ, Shirley NJ , Burton RA , Schreiber M, Halpin C , Zimmer J, Marshall DF, Waugh R and Fincher GB . (2015) Evolutionary dynamics of the cellulose synthase gene superfamily in grasses. <i>Plant Physiology</i> 168 : 968.	8.0
1	Worden N, Wilkop TE, Esteve VE, Jeannotte R, Lathe R, Vernhettes S, Weimer B, Hicks G, Alonso J, Labavitch J and Persson S . (2015) CESA TRAFFICKING INHIBITOR inhibits cellulose deposition and interferes with the trafficking of cellulose synthase complexes and their associated proteins KORRIGAN1 and POM2/CELLULOSE SYNTHASE INTERACTIVE PROTEIN 1. <i>Plant Physiology</i> 167 : 381.	8.0
1	Draeger C, Ndinyanka FT, Gineau E, Mouille G, Kuhn BM, Moller I, Abdou MT, Frey B, Pauly M , Bacic A and Ringli C. (2015) Arabidopsis leucine-rich repeat extensin (LRX) proteins modify cell wall composition and influence plant growth. <i>BMC Plant Biology</i> 15 : 155.	4.7
1	Ermawar RA , Collins HM , Byrt CS , Henderson M , O'Donovan LA , Shirley NJ , Schwerdt J , Lahnstein J , Fincher GB and Burton RA . (2015) Genetics and physiology of cell wall polysaccharides in the model C4 grass, <i>Setaria viridis</i> spp. <i>BMC Plant Biology</i> 15 : 236.	4.7
1	Tan H-T , Shirley NJ , Singh RR , Henderson M , Dhugga KS , Mayo GM, Fincher GB and Burton RA . (2015) Powerful regulatory systems and post-transcriptional gene silencing resist increases in cellulose content in cell walls of barley. <i>BMC Plant Biology</i> 15 : 62.	4.7
1	Hill CB, Taylor JD, Edwards J, Mather D , Langridge P, Bacic A and Roessner U. (2015) Detection of QTL for metabolic and agronomic traits in wheat with adjustments for variation at genetic loci that affect plant phenology. <i>Plant Science</i> 23 : 143.	3.9
1	Houston K , Burton RA , Sznajder B, Rafalski AJ , Dhugga KS , Mather DE , Taylor J, Steffenson BJ, Waugh R and Fincher GB . (2015) A genome-wide association study for culm cellulose content in barley reveals candidate genes co-expressed with members of the CELLULOSE SYNTHASE A gene family. <i>PLOS ONE</i> (10.1371/journal.pone.0130890).	3.7
1	Marcotuli I , Houston K , Waugh R , Fincher GB , Burton RA , Blanco A and Gadaleta A. (2015) Genome wide association mapping for arabinoxylan content in a collection of tetraploid wheats. <i>PLOS ONE</i> (10.1371/journal.pone.0132787).	3.7
1	Song L, Zeng W , Wu A, Picard K , Lampugnani ER , Cheetamun R, Beahan C , Cassin A , Lonsdale A , Doblin MS and Bacic A . (2015) Asparagus spears as a model to study heteroxylan biosynthesis during secondary wall development. <i>PLoS ONE</i> (10.1371/journal.pone. e0123878).	3.7
1	Ermawar RA , Collins HM , Byrt CS , Betts NS , Henderson M , Shirley NJ , Schwerdt J , Lahnstein J , Fincher GB and Burton RA . (2015) Distribution, structure and biosynthetic gene families of (1,3;1,4)- β -glucan in <i>Sorghum bicolor</i> (L.) Moench. <i>Journal of Integrative Plant Biology</i> 57 : 429.	3.4
1	Hsieh YS , Zhang Q, Yap K , Shirley NJ , Lahnstein J , Nelson CJ, Burton RA , Millar AH, Bulone V and Fincher GB . (2015) The genetics, transcriptional profiles and catalytic properties of the UDP-arabinose mutase family from barley. <i>Biochemistry</i> 55 : 322.	3.0
1	Wong SC , Shirley NJ , Little A , Khoo KHP, Schwerdt J , Fincher GB , Burton RA and Mather DE . (2015) Differential expression of the <i>HvCslF6</i> gene late in grain development may explain quantitative differences in (1,3;1,4)- β -glucan concentration in barley. <i>Molecular Breeding</i> 35 : 1.	2.6

Research Program	2015 Publications: ARC CoE Attributed (counted towards Performance Measure)	Impact Factor
2	Oehme DP , Downton MT, Doblin MS , Wagner J , Gidley MJ and Bacic A . (2015) Unique aspects of the structure and dynamics of elementary Iβ cellulose microfibrils revealed by computational simulations. <i>Plant Physiology</i> 168 : 3.	8.0
2	Herve C, Simeon A, Jam M, Cassin A , Johnson KL , Salmean AA, Willats WGT, Doblin MS , Bacic A and Kloareg B. (2015) Arabinogalactan proteins have deep roots in eukaryotes: identification of genes and epitopes in brown algae and their role in <i>Fucus serratus</i> embryo development. <i>New Phytologist</i> (10.1111/nph.13786).	7.8
2	Emanuelle S , Hossain MI, Moller IE, Pedersen HL, van de Meene AM , Doblin MS , Koay A, Oakhill JS, Scott JW, Willats WG, Kemp BE, Bacic A , Gooley PR and Stapleton DI. (2015) SnRK1 from <i>Arabidopsis thaliana</i> , an atypical AMPK. <i>Plant Journal</i> 82 : 183.	7.0
2	Galletti R, Johnson K , Scofield S, San-Bento R, Watt AM, Murray J and Ingram G. (2015) Defective Kernel 1 protein promotes and maintains plant epidermal differentiation. <i>Development</i> 142 : 1978.	6.7
2	Bonilla MR , Lopez-Sanchez P , Gidley MJ and Stokes JR . (2016) Micromechanical model of biphasic biomaterials with internal adhesion: application to nanocellulose hydrogel composites. <i>Acta biomaterialia</i> 29 : 149.	6.6
2	Mikkelsen D , Flanagan BM , Wilson SM , Bacic A and Gidley MJ . (2015). Interactions of arabinoxylan and (1, 3;1, 4)-β-glucan with cellulose networks. <i>Biomacromolecules</i> 16 : 1232.	6.4
2	Liu Z, Persson S and Sánchez-Rodríguez C. (2015) At the border: the plasma membrane–cell wall continuum. <i>Journal of Experimental Botany</i> (10.1093/jxb/erv019).	6.3
2	Chiu TY, Lao J, Manalansan B, Loqué D, Roux SJ and Heazlewood JL . (2015) Biochemical characterization of Arabidopsis APYRASE family reveals their roles in regulating endomembrane NDP/NMP homeostasis. <i>Biochemical Journal</i> 472 : 43.	4.7
2	Lin D , Lopez-Sanchez P and Gidley MJ . (2015). Binding of arabinan or galactan during cellulose synthesis is extensive and reversible. <i>Carbohydrate Polymers</i> 126 : 108.	4.6
2	Lopez-Sanchez P , Schuster E, Wang D , Gidley MJ and Strom A. (2015). Diffusion of macromolecules in self-assembled cellulose/hemicellulose hydrogels. <i>Soft Matter</i> 11 : 4002.	4.3
2	Martínez-Sanz M , Lopez-Sanchez P , Gidley MJ and Gilbert EP . (2015) Evidence for differential interaction mechanism of plant cell wall matrix polysaccharides in hierarchically-structured bacterial cellulose. <i>Cellulose</i> 1 : 23.	4.3
2	Oehme D , Downton M, Doblin MS , Wagner J , Gidley MJ and Bacic A . (2015) Gaining insight into cell wall cellulose macrofibril organisation by simulating microfibril adsorption. <i>Cellulose</i> 22 : 3501.	4.3
2	Cu S , Collins HM , Betts NS , March TJ, Janusz A, Stewart DC, Skadhauge B, Eglinton J, Kyriacou B , Little A , Burton RA and Fincher GB . (2015) Water uptake in barley grain: physiology, genetics and industrial applications. <i>Plant Science</i> 24 : 260.	3.9
2	Johnson KL , Ramm S, Kappel C, Ward S, Levser O, Sakamoto T, Kurata T, Bevan MW and Lenhard M. (2015) The <i>Tinkerbell</i> (<i>Tink</i>) mutation identifies the dual-specificity MAPK phosphatase INDOLE-3-BUTYRIC ACID-RESPONSE5 (IBR5) as a novel regulator of organ size in Arabidopsis. <i>PLoS ONE</i> (10.1371/journal.pone.0131103).	3.7
2	Lopez-Sanchez P , Cersosimo J, Wang D , Flanagan B , Stokes JR and Gidley MJ . (2015). Poroelastic mechanical effects of hemicelluloses on cellulosic hydrogels under compression. <i>PLoS ONE</i> (10.1371/journal.pone.0122132).	3.7
3	Aditya J , Lewis J, Shirley NJ , Tan H-T , Henderson M , Fincher GB , Burton RA , Mather DE and Tucker MR . (2015) The dynamics of cereal cyst nematode infection differ between susceptible and resistant barley cultivars and lead to changes in (1,3;1,4)-β-glucan levels and <i>HvCsIF</i> gene transcript abundance. <i>New Phytologist</i> 207 : 135.	7.8
3	Dhital S , Warren FJ, Butterworth PJ, Ellis PR and Gidley MJ . (2015). Mechanisms of starch digestion by α-amylase—structural basis for kinetic properties. <i>Critical Reviews in Food Science and Nutrition</i> (10.1080/10408398.2014.922043).	6.0
3	Padayachee A , Day L, Howell K and Gidley MJ . (2015). Complexity and health functionality of plant cell wall fibres from fruits and vegetables. <i>Critical Reviews in Food Science and Nutrition</i> (10.1080/10408398.2013.850652).	6.0
3	Corbin KR , Hsieh YSY , Betts NS , Byrt CS , Henderson M , Stork J, DeBolt S, Fincher GB and Burton RA . (2015) Grape marc as a source of carbohydrates for bioethanol: chemical composition, pre-treatment and saccharification. <i>Bioresource Technology</i> 193 : 76.	5.3
3	Shelat KJ, Nicholson T, Flanagan BM , Zhang D, Williams BA and Gidley MJ . (2015) Rheology and microstructure characterisation of small intestinal digesta from pigs fed a red meat-containing Western-style diet. <i>Food Hydrocolloids</i> 44 : 300.	4.6

Research Program	2015 Publications: ARC CoE Attributed (counted towards Performance Measure)	Impact Factor
3	Wang D , Ho L, Faith J, Ono K, Janle EM, Lachcik PJ, Cooper BR, Jannasch AH, D'Arcy BR, Williams BA , Ferruzzi MG, Levine S, Zhao W, Dubner L and Pasinetti, GM. (2015) Role of intestinal microbiota in the generation of polyphenol-derived phenolic acid mediated attenuation of Alzheimer's disease β -amyloid oligomerization. <i>Molecular Nutrition & Food Research</i> 59 : 1025.	4.6
3	Dhital S, Gidley MJ and Warren FJ. (2015) Inhibition of α -amylase activity by cellulose: kinetic analysis and nutritional implications. <i>Carbohydrate Polymers</i> 123 : 305.	4.6
3	Yamassaki FT, Lenzi RM, Campestrini LH, Bovo F, Seyfried M, Soldara-Silva A, Stevan-Hancke FR, Zawadzki-Baggio SF, Pettolino FA, Bacic A and Maurer JB. (2015) Effect of the native polysaccharide of cashew-nut tree gum exudate on murine peritoneal macrophage modulatory activities. <i>Carbohydrate Polymers</i> 125 : 241.	4.6
3	Zhang B, Dhital S, Flanagan BM , Luckman P, Halley PJ and Gidley MJ . (2015). Extrusion induced low-order starch matrices: enzymic hydrolysis and structure. <i>Carbohydrate Polymers</i> 134 : 485.	4.6
3	Gilbert MS, Pantophlet AJ, Berends H, Pluschke AM , van den Borne JJ, Hendriks WH and Gerrits WJ. (2015). Fermentation in the small intestine contributes substantially to intestinal starch disappearance in calves. <i>The Journal of Nutrition</i> (10.3945/jn.114.208595).	4.4
3	Phan ADT, Netzel G, Wang D, Flanagan BM , D'Arcy BR and Gidley MJ . (2015). Binding of dietary polyphenols to cellulose: structural and nutritional aspects. <i>Food Chemistry</i> 172 : 388.	3.9
3	Corbin KR, Byrt CS , Bauer S, DeBolt S, Chambers D, Holtum JAM, Karem G, Henderson M, Lahnstein J, Beahan CT, Bacic A, Fincher GB, Betts NS and Burton RA . (2015) Prospecting for energy-rich renewable raw materials: Agave leaf case study. <i>PLOS ONE</i> (10.1371/journal.pone.0135382).	3.7
3	Low DY , D'Arcy B and Gidley MJ . (2015) Mastication effects on carotenoid bioaccessibility from mango fruit tissue. <i>Food Research International</i> 67 : 238.	3.4
3	Low DY, Williams BA , D'Arcy BR, Flanagan BM and Gidley MJ . (2015) <i>In vitro</i> fermentation of chewed mango and banana: particle size, starch and vascular fibre effects. <i>Food & Function</i> 6 : 2464.	3.0
3	Mönch S, Netzel M, Netzel G , Ott U, Frank T and Rychlik M. (2015). Folate bioavailability from foods rich in folates assessed in a short term human study using stable isotope dilution assays. <i>Food & Function</i> 6 : 241.	3.0
3	Williams BA, Zhang D , Lisle AT, Mikkelsen D , McSweeney CS, Kang S, Bryden WL and Gidley MJ . (2015). Soluble arabinoxylan enhances large intestinal microbial health biomarkers in pigs fed a red meat-containing diet. <i>Nutrition</i> (10.1016/j.nut.2015.10.008).	3.0
3	Zhang D, Williams B, Mikkelsen D , Li X, Keates HL, Lisle AT, Collins HM, Fincher GB , Bird AR, Topping DL, Gidley MJ and Bryden WL. (2015) Soluble arabinoxylan alters digesta flow and protein digestion of red meat-containing diets in pigs. <i>Nutrition</i> (10.1016/j.nut.2015.03.006).	3.0
3	Betts NS , Fox GP, Kelly AM, Cruickshank AW, Lahnstein J, Henderson M , Jordan DR and Burton RA . (2015) Non-cellulosic cell wall polysaccharides are subject to genotype \times environment effects in sorghum (<i>Sorghum bicolor</i>) grain. <i>Journal of Cereal Science</i> 63 : 64.	2.7
3	Karp A, Artaxo Netto PE, Berndes G, Cantarella H, El-Lakany H, Moellwald Duque Estrada TE, Faaij A, Fincher GB , Huntley BJ, Ravindranath NH, Van Sluys M-A, Verdade LM and Youngs H. (2015) Environmental and Climate Security (pp 138-183). In Souza, G. M., Victoria, R., Joly, C., & Verdade, L. (Eds.). (2015). <i>Bioenergy & Sustainability: Bridging the gaps</i> (Vol. 72, p. 779). Paris: SCOPE. ISBN 978-2-9545557-0-6	book
PT	Endler A, Kesten C, Schneider R, Zhang Y, Ivakov A, Froehlich A, Funke N and Persson S . (2015) A mechanism for sustained cellulose synthesis during salt stress. <i>Cell</i> 162 : 1353.	35.5
PT	Ming R, VanBuren R, Wai CM, Tang H, Schatz MC, Bowers JE, Lyons E, Wang ML, Chen J, Biggers E, Zhang J, Huang L, Zhang L, Miao W, Zhang J, Ye Z, Miao C, Lin Z, Wang H, Zhou H, Yin WC, Priest HD, Zheng C, Woodhouse M, Edger PP, Guyot R, Guo HB, Guo H, Zheng G, Singh R, Sharma A, Min X, Zheng Y, Lee H, Gurtowski J, Sedlazeck FJ, Harkess A, McKain MR, Liao Z, Fang J, Liu J, Zhang X, Zhang Q, Hu W, Qin Y, Wang K, Chen L-Y, Shirley N , Lin Y-R, Liu L-Y, Hernandez AG, Wright CL, Bulone V , Tuskan GA, Heath K, Zee F, Moore PH, Sunkar R, Leebens-Mack JH, Mockler T, Bennetzen JL, Freeling M, Sankoff D, Paterson AH, Zhu X, Yang X, Smith JAC, Cushman JC, Paull RE and Yu Q. (2015) The pineapple genome and the evolution of CAM photosynthesis. <i>Nature Genetics</i> 47 : 1435.	32.4
PT	Emanuelle S, Doblin MS , Stapleton DI, Bacic A and Gooley PR. (2015) Molecular insights into the enigmatic metabolic regulator, SnRK1. <i>Trends in Plant Science</i> (10.1016/j.tplants.2015.11.001).	14.7
PT	Uboldi AD, McCoy JM, Blume M, Gerlic M, Ferguson DJ, Dagley LF, Beahan CT , Stapleton DI, Gooley PR, Bacic A and Masters SL. (2015) Regulation of starch stores by a Ca^{2+} -dependent protein kinase is essential for viable cyst development in <i>Toxoplasma gondii</i> . <i>Cell Host & Microbe</i> 18 : 670.	13.1
PT	Gornik SG, Febrimarsa, Cassin A, MacRae JI, Ramaprasad A, Rchiaz D, McConville MJ, Bacic A , McFadden GI, Pain A and Waller RF. (2015) Endosymbiosis undone: stepwise elimination of the plastid in the dinoflagellate <i>Hematodinium sp.</i> <i>Proceedings of the National Academy of Sciences (USA)</i> 112 : 5767.	10.6

Research Program	2015 Publications: ARC CoE Attributed (counted towards Performance Measure)	Impact Factor
PT	Wijetunge CD, Saeed I, Boughton BA, Spraggins JM, Caprioli RM, Bacic A , Roessner U and Halgamuge SK. (2015) EXIMS: an improved data analysis pipeline based on a new peak picking method for EXploring Imaging Mass Spectrometry data. <i>Bioinformatics</i> 31 : 3198.	8.1
PT	Tiong J, McDonald G, Genc Y, Shirley N , Langridge P and Huang CY. (2015) Increased expression of six ZIP family genes by zinc (Zn) deficiency is associated with enhanced uptake and root-to-shoot translocation of Zn in barley (<i>Hordeum vulgare</i>). <i>New Phytologist</i> 207 : 1097.	7.8
PT	Flanagan BM , Gidley MJ and Warren FJ. (2015). Rapid quantification of starch molecular order through multivariate modelling of ¹³ C CP/MAS NMR spectra. <i>Chemical Communications</i> 51 : 14856.	6.8
PT	Warren FJ , Perston BB, Galindez-Najera SP, Edwards CH, Powell PO, Mandalari G, Campbell GM, Butterworth PJ and Ellis PR. (2015) Infrared microspectroscopic imaging of plant tissues: spectral visualization of <i>Triticum aestivum</i> kernel and Arabidopsis leaf microstructure. <i>The Plant Journal</i> 84 : 634.	5.9
PT	Zhang B , Dhital S and Gidley MJ . (2015). Densely packed matrices as rate determining features in starch hydrolysis. <i>Trends in Food Science & Technology</i> 43 : 18.	5.5
PT	Martínez-Sanz M , Gidley MJ and Gilbert EP . (2015). Application of X-ray and neutron small angle scattering techniques to study the hierarchical structure of plant cell walls: a review. <i>Carbohydrate Polymers</i> 125 : 120.	4.6
PT	Yakubov GE , Zhong I, Li M, Boehm MW, Xie F, Beattie DA, Halley PJ and Stokes JR . (2015) Lubrication of starch in ionic liquid-water mixtures: soluble carbohydrate polymers form a boundary film on hydrophobic surfaces. <i>Carbohydrate Polymers</i> 133 : 507.	4.6
PT	Azadi M, Nguyen AV and Yakubov GE . (2015). Attractive forces between hydrophobic solid surfaces measured by AFM on the first approach in salt solutions and in the presence of dissolved gases. <i>Langmuir</i> 31 : 1941.	4.5
PT	Pyke J, Callahan D, Kanokia K, Bowne J, Sahani S, Tull D, Bacic A , McConville MJ and Roessner U. (2015) A tandem liquid chromatography–mass spectrometry (LC–MS) method for profiling small molecules in complex samples. <i>Metabolomics</i> 1 : 11.	4.0
PT	Ford KL , Zeng W , Heazlewood JL and Bacic A . (2015) Characterization of protein N-glycosylation by tandem mass spectrometry using complementary fragmentation techniques. <i>Frontiers in Plant Science</i> 6 : 674.	4.0
PT	Parsons HT and Heazlewood JL . (2015) Beyond the Western front: targeted proteomics and organelle abundance profiling. <i>Frontiers in Plant Science</i> 6 : 301.	4.0
PT	Boughton BA, Thinakaran D, Sarabia D, Bacic A and Roessner U. (2015) Mass spectrometry imaging for plant biology: a review. <i>Phytochemistry Reviews</i> 1 : 44.	4.0
PT	Yu L , Xue C, Chang Y, Hu Y, Xu X, Ge L and Liu G. (2015). Structure and rheological characteristics of fucoidan from sea cucumber <i>Apostichopus japonicus</i> . <i>Food Chemistry</i> 180 : 71.	3.9
PT	Gibbins HL, Proctor GB, Yakubov GE , Wilson S and Carpenter GH. (2015). SlgA binding to mucosal surfaces is mediated by mucin-mucin interactions. <i>PLoS ONE</i> (10.1371/journal.pone.0119677).	3.7
PT	Malone JM, Morran S, Shirley N , Boutsalis P and Preston C. (2015) EPSPS gene amplification in glyphosate-resistant <i>Bromus diandrus</i> . <i>Pest Management Science</i> (10.1002/ps.4019).	2.9
PT	Mok L, Wynne JW, Ford K , Shiell B, Bacic A and Michalski WP. (2015) Proteomic analysis of <i>Pteropus alecto</i> kidney cells in response to the viral mimic, Poly I:C. <i>Proteome Science</i> 13 : 25.	2.1
PT	Yakubov GE , Branfiled T, Bongaerts J and Stokes JR . (2015) Tribology of particle suspensions in soft rolling-sliding contacts. <i>Biotribology</i> 3 : 1.	new
PT	Fernández-Niño SM, Smith-Moritz AM, Chan LJ, Adams PD, Heazlewood JL and Petzold CJ. (2015) Standard flow liquid chromatography for shotgun proteomics in bioenergy research. <i>Frontiers in Bioengineering and Biotechnology</i> 3 : 44.	

2015 Publications: ARC CoE not attributed (and not counted in 2015 Performance Measure)		Impact Factor
Dhital S , Dabit L, Zhang B, Flanagan B and Shrestha AK (2015). <i>In vitro</i> digestibility and physicochemical properties of milled rice. <i>Food Chemistry</i> 172 : 757.		3.9
Heazlewood JL , Schrimpf SP, Becher D, Reidel K, Tholey A and Bendixen E. (2015) Multi-Organism Proteomes (iMOP): advancing our understanding of human biology. <i>Proteomics</i> 15 : 2885.		3.8
Lao J, Sharma M, Sharma R, González Fernández-Niño SM, Schmutz J, Ronald PC, Heazlewood JL and Schwessinger B. (2015) Proteome profile of the endomembrane of developing coleoptiles from switchgrass (<i>Panicum virgatum</i>). <i>Proteomics</i> 15 : 2286.		3.8
Luo Y, Doering A, Scholl S, Zhang Y, Irani NG, Di Rubbo S, Neumetzler L, Krishnamoorthy P, Van Houtte I, Mylle E, Bischoff V, Vernhettes S, Winne J, Friml J, Stierhof YD, Schumacher K, Persson S and Russinova E. (2015) V-ATPase-activity in the TGN/EE is required for exocytosis and recycling in Arabidopsis. <i>Nature Plants</i> (10.1038/nplants.2015.94).		new jnl
Mok L, Wynne JW, Grimley S, Shiell B, Green D, Monaghan P, Pallister J, Bacic A and Michalski WP. (2015) Mouse fibroblast L929 cells are less permissive to infection by <i>Nelson Bay orthoreovirus</i> compared to other mammalian cell lines. <i>Journal of General Virology</i> 96 : 1787.		3.5
Mönch S, Netzel M, Netzel G , Ott U, Frank T and Rychlik M. (2015). Folate bioavailability from foods rich in folates assessed in a short term human study using stable isotope dilution assays. <i>Food & Function</i> 6 : 241.		3.1
Pathan M, Keerthikumar S, Ang CS, Gangoda L, Quek CY, Williamson NA, Mouradov D, Sieber OM, Simpson RJ, Salim A, Bacic A , Hill A, Stroud DA, Ryan MT, Agbinya JI, Mariadasson JM, Burgess A and Mathivanan S. (2015) Funrich: An open access standalone functional enrichment and interaction network analysis tool. <i>Proteomics</i> 15 : 2597.		3.8
Schneider R and Persson S . (2015) Another brick in the wall. <i>Science</i> 350 : 156.		35.3
Schneider R and Persson S . (2015) Connecting two arrays: the emerging role of actin-microtubule cross-linking motor proteins. <i>Frontiers in Plant Science</i> 6 : 415.		4.0
Shrestha AK, Blazek J, Flanagan BM , Dhital S , Larroque O, Morell MK, Gilbert EP and Gidley MJ . (2015). Molecular, mesoscopic and microscopic structure evolution during amylase digestion of extruded maize and high amylose maize starches. <i>Carbohydrate Polymers</i> 118 : 224.		4.3
Van Sluyter SC, McRae J, Falconer R, Smith PA, Bacic A , Waters EJ and Marangon M. (2015) Wine protein haze: mechanisms of formation and advances in prevention. <i>Journal of Agricultural and Food Chemistry</i> 63 : 4020.		3.3
Würschum T, Tucker MR , Maurer HP and Leiser WL. (2015). Ethylene inhibitors improve efficiency of microspore embryogenesis in hexaploid triticale. <i>Plant Cell, Tissue and Organ Culture (PCTOC)</i> 122 : 751.		2.1
Zhang Y, Persson S , Hirst J, Robinson MS, van Damme D and Sánchez-Rodríguez C. (2015) Change your Tplate, change your fate: plant CME and beyond. <i>Trends in Plant Science</i> 20 : 41.		14.7

Key Result Area 1: Performance Measure c

Research Outputs: Invited keynote lectures/talks/papers/posters and participation at major international meetings

(Including Key Result Area 3, PM b : National & international workshops held/organised by the Centre)

Meeting / Conference Name	Location	Attendee	Additional Role	Invitation	Presentation	Poster	Presentation Title
Hosted International Workshop							
11 th Carbohydrate Bioengineering Meeting (CBM 11)	Espoo, Finland	Bulone, Vincent	Organising Committee				
Okinawa Institute of Science & Technology (OIST) Mini Symposia; Unraveling the mysteries of cellulose: From biosynthesis & biological diversity to biomaterials	Okinawa, Japan	Bulone, Vincent	Co-organiser				
4 th International Polysaccharide Conference (EPNOE)	Warsaw, Poland	Bulone, Vincent	Scientific Committee				
ComBio 2015	Melbourne	Bacic, Tony	Organising Committee				
International and National Meetings / Conferences							
The 5 th symposium on International Collaborative Laboratories - ~Front Lines of Plant Cell Wall Research~	Nara, Japan	Bulone, Vincent	Speaker	Y	Y		Biochemistry of plant glucan synthases associated with the plasma membrane
		Heazlewood, Josh	Speaker	Y	Y		Nucleotide sugar transport: delivering the cell wall blocks
		Persson, Staffan	Speaker	Y	Y		Going off the rail: new components that affect microtubule-based guidance of the cellulose synthase complex
10 th Annual European Rheology conference	Nantes, France	Lopez-Sanchez, Patricia	Speaker		Y		Fluid phase effects on the rheology of cellulosic hydrogel composites.
Okinawa Institute of Science & Technology (OIST) Mini Symposia; Unraveling the mysteries of cellulose: From biosynthesis & biological diversity to biomaterials	Okinawa, Japan	Bulone, Vincent	Speaker	Y	Y		Biochemistry of cell wall polysaccharide biosynthesis in plants: emphasis on cellulose
		Hsieh, Yves	Attendee				
International Dietary Fibre Symposium	Paris, France	Gidley, Mike	Speaker		Y		Dietary fibre polysaccharides in the digestive tract: physical properties and health implications
Asia-Oceania Conference on Neutron Scattering	Manly, Australia	Martinez-Sanz, Marta	Speaker		Y		Characterisation of hierarchically-structured cellulose hydrogels by small angle neutron scattering
International Symposium: From Ecosystems to Modern Agriculture	Lanzhou, China	Bulone, Vincent	Speaker	Y	Y		Cellulose biosynthesis in higher plants: fundamentals and applications
Society of Experimental Biology (SEB)	Prague, Czechoslovakia	Fincher, Geoff	Speaker		Y		Plant cell walls and resistance to pathogens: changes in plant cell wall composition in response to fungal and nematode infections
26 th International Conference on Arabidopsis Research, ICAR 2015	Paris, France	Amanda, Dhika	Attendee			Y	The regulation of growth and cell wall deposition by DEFECTIVE KERNEL1 (DEK1) in <i>Arabidopsis thaliana</i>
		Liu, Edgar	Attendee			Y	Structural and functional investigation of fasciclin-like arabinogalactan proteins in <i>Arabidopsis thaliana</i>

Meeting / Conference Name	Location	Attendee	Additional Role	Invitation	Presentation	Poster	Presentation Title
Gordon Research Seminar in Plant Cell Walls Research: From Structure to Sustainability	Boston, MA, USA	Bacic, Tony	Keynote	Y	Y		A 'down-under' perspective of walls
Gordon Research Conference in Plant Cell Walls — From Genomes to Function	Boston, MA, USA	Fincher, Geoff	Keynote				Evolutionary dynamics of cell wall polysaccharide synthesis in the grasses: from genomics to molecular mechanisms of (1,3;1,4)- β -glucan synthases
		Burton, Rachel	Speaker	Y	Y		Is your Cs/ really what you think it is?
		Doblin, Monika	Speaker, Session Chair	Y	Y		Further insights into the molecular mechanism of (1,3;1,4)- β -glucan synthesis in grasses
		Bacic, Tony	Attendee	Y	Y		
Gordon Research Conference on Applied and Environmental Microbiology — Microbes that Influence, Sustain and Protect Our Planet	South Hadley, MA, USA	Mikkelsen, Deirdre	Attendee			Y	<i>In vitro</i> fermentation of native and isotopically labelled cellulose by porcine faecal inoculum and identification of cellulolytic microbiota by DNA stable isotope probing
Global Biotechnology Congress 2015	Boston, MA, USA	Burton, Rachel	Speaker		Y		The deconstruction of seed mucilages
Symposium on Sustainability, Genetics, and New Technologies	Melbourne, Australia	Fincher, Geoff	Speaker	Y	Y		The toolbox: modern plant breeding methods
The 4 th International Symposium on Plant Reproductive Development	Shanghai, China	Persson, Staffan	Speaker	Y	Y		Going off the rail? New components that affect microtubule-based guidance of the cellulose synthase complex
		Bulone, Vincent	Speaker	Y	Y		Biochemistry of cell wall polysaccharide biosynthesis in plants
The 1 st Molecular Plant International Symposium: From Model Species to Crops	Shanghai, China	Bulone, Vincent	Attendee				
		Persson, Staffan	Speaker	Y	Y		A mechanism for sustained cellulose synthesis during salt stress
Investigating Interactions — Symposium celebrating the research career of Professor Jeremy Sanders	Cambridge, UK	Gidley, Mike	Keynote	Y	Y		The alpha and beta of human nutrition
Australasian Plant Pathology Society Conference (APPS)	Fremantle, Australia	Chowdhury, Md Jamil	Speaker, Session Chair	Y		Y	Down-regulation of the <i>Glucan synthase-like 6</i> gene (<i>HvGs6</i>) in barley leads to decreased callose accumulation and increased susceptibility against <i>Blumeria graminis</i> f. sp. <i>hordei</i>
		Little, Alan	Speaker, Session Chair	Y		Y	Differential accumulation of callose, arabinoxylan and cellulose in non-penetrated versus penetrated papillae on leaves of barley infected with <i>Blumeria graminis</i> f. sp. <i>hordei</i>
17 th Australasian Research Management Society (ARMS) 2015 Conference	Singapore	Mathew, David	Attendee				
ComBio 2015	Melbourne, Australia	Burton, Rachel	Attendee				
		Doblin, Monika	Attendee				
		Ho, Yin Ying	Speaker		Y	Y	Post-translational modifications of CSLF6, the catalytic subunit of grass (1,3;1,4)- β -glucan synthase
		Johnson, Kim	Speaker		Y		The regulation of growth and cell wall deposition by DEFECTIVE KERNEL1 (DEK1) protein in <i>Arabidopsis thaliana</i>
		Lampugnani, Edwin	Attendee			Y	A glycosyltransferase from <i>Nicotiana</i> pollen mediates (1,5)- α -L-arabinan synthesis
		Lim, Wai Li	Attendee			Y	Barley grain fructan metabolism is altered by overexpression of <i>CsIF6</i> , a (1,3;1,4)- β -glucan synthase gene

Meeting / Conference Name	Location	Attendee	Additional Role	Invitation	Presentation	Poster	Presentation Title
		Lonsdale, Andrew	Attendee			Y	Machine learning approaches for the prediction of leaderless secretory proteins in <i>Arabidopsis thaliana</i>
		Pham, Trang	Attendee			Y	Establishment of an <i>in vitro</i> growth system for characterisation of the <i>Blumeria graminis</i> f. sp. <i>hordei</i> cell wall
		Phan, Jana	Attendee			Y	Using <i>Plantago ovata</i> as a model system to unravel the mechanism of xylan biosynthesis
		Tucker, Matthew	Speaker	Y	Y		Communication between the generations in plants: dissecting the role of small RNAs, hormones and cell wall composition in reproductive cell specification
		van de Meene, Allison	Attendee			Y	Investigation of the structure and biosynthesis of plant cell walls using endosperm-derived <i>Lolium multiflorum</i> suspension cultured cells
		Bulone, Vincent	Speaker, Session Chair		Y	Y	Cell wall polysaccharide biosynthesis in oomycete pathogens: a target for crop protection
		Bacic, Tony	Session Chair				
		Little, Alan	Speaker	Y	Y		Differential accumulation of callose, arabinoxylan and cellulose in nonpenetrated versus penetrated papillae on leaves of barley infected with <i>Blumeria graminis</i> f. sp. <i>hordei</i>
		Persson, Staffan	Speaker, Session Chair	Y	Y		Controlling biomass production — a framework for intracellular trafficking of the cellulose synthase in Arabidopsis
AACC International Starch round table	Minneapolis, USA	Gidley, Mike	Speaker		Y		Non-substrate interactions in digestion
American Association of Cereal Chemists International (AACCI)	Minneapolis, USA	Gidley, Mike	Speaker		Y		Cereal cell wall polysaccharides in the digestive tract
4 th International Polysaccharide Conference (EPNOE)	Warsaw, Poland	Bulone, Vincent	Keynote	Y	Y		Structure and biosynthesis of essential eukaryotic cell wall polysaccharides
11 th International Congress of Plant Molecular Biology	Iguazu Falls, Brazil	Persson, Staffan	Speaker	Y	Y		Systems approaches to understand secondary wall synthesis
The Nutrition Society of Australia and New Zealand 2015 Annual Scientific Meeting	Wellington, NZ	Gunness, Purnima	Speaker	Y	Y		Large intestinal bacterial community and the effect of mango, purified pectin, and low fibre diets
		Grant, Lucas	Attendee			Y	Understanding how cereal soluble dietary fibres reduce blood lipids: study of bile salt diffusion across intestinal mucosa using the Ussing chamber system

Meeting / Conference Name	Location	Attendee	Additional Role	Invitation	Presentation	Poster	Presentation Title
National Meetings / Conferences							
Australian Institute of Food Science and Technology Summer School	Melbourne, Australia	Gidley, Mike	Speaker	Y	Y		Plant cell wall polysaccharides in the digestive tract: physical properties and health implications
20 th Lorne Proteomics Symposium	Lorne, Australia	Ford, Kristina	Speaker		Y		Identification of N-linked glycosylation on plant glycoproteins
		Lonsdale, Andrew	Attendee			Y	Bioinformatics approaches to the proteomics of secreted proteins in <i>Arabidopsis thaliana</i>
Research Bazaar Conference	Melbourne, Australia	Lonsdale, Andrew	Attendee				
Joint Academic Microbiology Seminars (JAMS) 4 th Annual Symposium	Sydney, Australia	Mikkelsen, Deirdre	Attendee				
17 th Australian Barley Technical Symposium	Manly, Australia	Cu, Suong	Speaker		Y		Quantitative trait loci associated with kernel hardness and malting quality traits in the Admiral × Navigator mapping population
		Collins, Helen	Speaker		Y		Morphological and genetic changes in barley grain during malting
65 th Australasian Grain Science Conference	Coogee, Australia	Feng, Guangli	Attendee			Y	Bacterial mediated enzymatic metabolism of wheat arabinoxylan under <i>in vitro</i> large intestine fermentation conditions
		Gartaula, Ghanendra	Attendee			Y	Breakage of cross-links of ferulic acid and the swelling capacity of arabinoxylans
		Bhattarai, Rewati	Speaker		Y		Food structure affects enzymic hydrolysis of macronutrients <i>in vitro</i>
2 nd Annual Centre for Advanced Imaging Symposium	Brisbane, Australia	Flanagan, Bernadine	Speaker	Y	Y	Y	NMR spectroscopy of foods before and after digestion and fermentation
Combine Student Symposium 2015	Sydney, Australia	Lonsdale, Andrew	Attendee			Y	Machine learning approaches for the prediction of leaderless secretory proteins in <i>Arabidopsis thaliana</i>
Australian Bioinformatics And Computational Biology Society (ABACBS) Conference 2015	Sydney, Australia	Lonsdale, Andrew	Attendee			Y	Machine learning approaches for the prediction of leaderless secretory proteins in <i>Arabidopsis thaliana</i>
Laboratory Management & Laboratory Design Conferences 2015	Melbourne, Australia	Kibble, Natalie	Attendee				
State, Regional or Other Meetings							
Women in Science and Engineering (WISE) Forum	Adelaide, Australia	Wilkinson, Laura	Attendee				
ARC Centres Directors and Managers Forum	Canberra, Australia	Mathew, David	Speaker		Y		Strategic-planning & governance in a developing Centre
AFW Postgraduate Symposium 2015	Adelaide, Australia	Lim, Wai Li	Speaker		Y		Overexpressing CsIF6 gene in transgenic barley alters fructan metabolism

Key Result Area 1: Performance Measure d

Research Outputs: Number and nature of commentaries about the Centre's achievements

The Centre collates information on any media interest generated by our press releases or activities. The data below details only the newsprint, radio and television and special interest and professional association newsletters. Not presented is the volume of online exposure through 'web-logs' and similar social media outlets.

Topic/Trigger for media interest	KPI classification	Media Type	Media Outlet or Publication	Section or Program	State/Country	Issue Date
Biofuels: introduction (Burton)	Media Release	Radio	Radio Adelaide	Harvest Radio	SA	11-Feb-15
Unlocking plant cell walls (Bulone)	Media Release	Radio	Radio Adelaide	Harvest Radio	SA	27-May-15
Reflections of a PhD completing student (Dimitroff)	Media Release	Radio	Radio Adelaide	The Sound of Science	SA	24-Jun-15
Curiosity driving genetic research (Phan)	Media Release	Radio	Radio Adelaide	The Sound of Science	SA	17-Jun-15
Diversity and equity in science (Burton)	Media Release	Radio	Radio Adelaide	The Sound of Science	SA	03-Jun-15
Improving barley for efficient malting (Collins, Cu)	Media Release	Radio	Radio Adelaide	The Sound of Science	SA	10-Jun-15
Seeds for the future (Tucker)	Media Release	Radio	Radio Adelaide	The Sound of Science	SA	10-Jun-15
Growing our own biofuels (Burton)	Media Release	Radio	Radio Adelaide	Barometer	SA	11-Oct-15
Liquid biofuels (Fincher, Burton)	Article	Internet/Web	UA eScience		Australia	Feb-15
No rest for retired CoE Director (Fincher)	Article	Internet/Web	BionewsSA		SA	July-15
β-glucan, a healthy grain fibre, helps barley crops to resist pests (Tucker, Mather)	Media Release		University of Adelaide		Australia	23-Mar-15
	Media Release		Brand South Australia		SA	23-Mar-15
	Media Release		Newsmaker		Australia	20-Mar-15
	Article	Internet/Web	ABC Online		Australia	23-Mar-15
	Article	Radio	ABC South East SA, News		SA	23-Mar-15
	Article	Radio	ABC Eyre Peninsula and West Coast, News		SA	23-Mar-15
	Article	Radio	ABC Riverland SA, News,		SA	23-Mar-15
	Article	Radio	ABC Eyre Peninsula and West Coast, Rural Report		SA	23-Mar-15
	Article	Newsprint	Stock Journal, Adelaide	General News	SA	23-Mar-15
	Article		Phys-Org		UK	23-Mar-15
Where is the dietary fibre β-glucan made (Doblin)	Media Release		Scimex		Australia	19-Mar-15
	Media Release	University Press	University of Melbourne		Australia	20-Mar-15
Supercomputer unlocks the secrets of plant cells to create more resilient crops (Doblin, Oheme)	Media Release		Scimex		Australia	24-May-15
	Media Release		University of Melbourne/ IBM		Vic	24-May-15
	Article	University Press	University of Melbourne		Australia	24-May-15
	Article	Internet/Web	Agrimarketing		USA	24-May-15
	Article	Internet/Web	Controlled Environments		USA	24-May-15
	Article	Internet/Web	eWallstreeter		USA	24-May-15
	Article	Internet/Web	Brightsurf		USA	24-May-15
	Article	Internet/Web	Science Newsline		USA	24-May-15
	Article	Internet/Web	Noodls		USA	24-May-15
	Article	Internet/Web	IT online		USA	24-May-15
	Article	Internet/Web	Growing Alabama		USA	24-May-15
	Article	Internet/Web	USA gNet		USA	24-May-15

Topic/Trigger for media interest	KPI classification	Media Type	Media Outlet or Publication	Section or Program	State/Country	Issue Date
	Article	Internet/Web	Customs today		USA	24-May-15
	Article	Internet/Web	Ag Professional		USA	24-May-15
	Article	Internet/Web	LiveNews.co.nz		NZ	30-May-15
	Article	Internet/Web	Noodles		UK	23-May-15
	Article	Internet/Web	Life Sciences		India	22-May-15
	Article	Internet/Web	4RFV International News		UK	22-May-15
	Article	Internet/Web	Video Based Tutorials		USA	22-May-15
	Article	Internet/Web	Siggraph News		USA	22-May-15
	Article	Internet/Web	Digital Producer		USA	22-May-15
	Article	Internet/Web	ITBusinessNet.com		USA	22-May-15
	Article	Internet/Web	Renewable Energy World	Finance	USA	22-May-15
	Article	Internet/Web	Count On News 2		USA	22-May-15
	Article	Internet/Web	NewsWest 9		USA	22-May-15
	Article	Internet/Web	KXXV-TV News Channel 25		USA	22-May-15
	Article	Internet/Web	FOX 42		USA	22-May-15
	Article	Internet/Web	KFMB-TV CBS-8		USA	22-May-15
	Article	Internet/Web	WFXS, MyFoxWausau		USA	22-May-15
	Article	Internet/Web	WLOX-TV		USA	22-May-15
	Article	Internet/Web	Kcentv.com		USA	22-May-15
	Article	Internet/Web	KEYC-TV CBS-12 / FOX-12		USA	22-May-15
	Article	Internet/Web	NBC Right Now KNDO-TV		USA	22-May-15
	Article	Internet/Web	WSAV.com		USA	22-May-15
	Article	Internet/Web	The State Journal		USA	22-May-15
	Article	Internet/Web	NBC Augusta 26		USA	22-May-15
	Article	Internet/Web	KFVS 12		USA	22-May-15
	Article	Internet/Web	Ticker Technologies		USA	22-May-15
	Article	Internet/Web	12 News KBMT and K-JAC		USA	22-May-15
	Article	Internet/Web	WKRG News 5		USA	21-May-15
	Article	Internet/Web	NBC4i		USA	21-May-15
	Article	Internet/Web	WJTV News Channel 12		USA	21-May-15
	Article	Internet/Web	WDAM - Channel 7		USA	21-May-15
	Article	Internet/Web	Mediawebsite.net	Apparel Search	USA	21-May-15
	Article	Internet/Web	WBOC.com		USA	21-May-15
	Article	Internet/Web	Spoke		USA	21-May-15
	Article	Internet/Web	mediawebsite.net	TravelJourno -	USA	21-May-15
	Article	Internet/Web	mediawebsite.net	Denton Record-Chronicle	USA	21-May-15
	Article	Internet/Web	PR Newswire		USA	21-May-15
	Article	Internet/Web	IBM - United States		USA	21-May-15
	Article	Internet/Web	Benzinga		USA	21-May-15
	Article	Internet/Web	Mediawebsite.net	Northwest Cable News	USA	21-May-15
	Article	Internet/Web	Barchart.com		USA	21-May-15
	Article	Internet/Web	Mediawebsite.net	Worcester Telegram & Gazette	USA	21-May-15
	Article	Internet/Web	Mediawebsite.net	Dallas Morning News	USA	21-May-15
	Article	Internet/Web	Mediawebsite.net	PublicityInsider.com	USA	21-May-15
	Article	Internet/Web	sMediawebsite.net	Dallas South New	USA	21-May-15
	Article	Internet/Web	Pittsburgh Post-Gazette		USA	21-May-15
	Article	Internet/Web	Market Intelligence Center		USA	21-May-15
	Article	Internet/Web	InvestorPoint.com		USA	21-May-15
	Article	Internet/Web	Marketplace	The Numbers	USA	21-May-15
	Article	Internet/Web	Stock - AZCentral.com		USA	21-May-15

Topic/Trigger for media interest	KPI classification	Media Type	Media Outlet or Publication	Section or Program	State/Country	Issue Date
	Article	Internet/Web	Morningstar News		USA	21-May-15
	Article	Internet/Web	Ag Professional		USA	29-May-15
	Article	Internet/Web	Asian Scientist		Singapore	28-May-15
	Article	Internet/Web	Comunicati Stampa.net		Italy	27-May-15
	Article	Internet/Web	Free Online		Italy	27-May-15
	Article	Internet/Web	A-Zeta.it		Italy	26-May-15
	Article	Internet/Web	Informazione.it		Italy	27-May-15
	Article	Internet/Web	Comunicati.net		Italy	26-May-15
	Article	Internet/Web	USAgNet		USA	26-May-15
	Article	Internet/Web	Ag Connection	Ohio, Missouri, Wisconsin, Iowa, Michigan, Sth Dakota, Kansas, New York, Indiana, Penn, Kentucky, Minnesota & Nebraska	USA	26-May-15
	Article	Internet/Web	Growing Alabama		USA	26-May-15
	Article	Internet/Web	IT-Online		S Africa	25-May-15
	Article	Internet/Web	ScienceNewsline		USA	23-May-15
	Article	Internet/Web	e! Science News		Canada	23-May-15
	Article	Internet/Web	Bright Surf		UK	23-May-15
	Article	Internet/Web	Health Medicine Network		USA	22-May-15
	Article	Internet/Web	EurekAlert!		USA	22-May-15
	Article	Internet/Web	Science Daily		USA	22-May-15
	Article	Internet/Web	EnvironmentGuru.com		USA	21-May-15
	Article	Internet/Web	Seed World		USA	23-May-15
	Article	Internet/Web	Controlled Environments Magazine		USA	22-May-15
	Article	Internet/Web	Agri Marketing		USA	22-May-15
	Article	Internet/Web	CIO.in		India	22-May-15
	Article	Internet/Web	Computer World Singapore		Singapore	22-May-15
	Article	Internet/Web	CIO-Asia		Singapore	22-May-15
	Article	Internet/Web	Mis Asia		Singapore	22-May-15
	Article	Internet/Web	PC Advisor		UK	22-May-15
	Article	Internet/Web	CIO Australia		Australia	21-May-15
	Article	Internet/Web	Nanotechnology Now		USA	22-May-15
	Article	Internet/Web	NzHealthTec.com		USA	22-May-15
	Article	Internet/Web	AP		USA	21-May-15
	Article	Internet/Web	Phys.org		USA	21-May-15
	Article	Internet/Web	e! Science News		Canada	21-May-15
	Article	Internet/Web	The Melbourne Newsroom		Australia	21-May-15
	Article	Internet/Web	Noodls.com		Australia	21-May-15

Topic/Trigger for media interest	KPI classification	Media Type	Media Outlet or Publication	Section or Program	State/Country	Issue Date
Plant Cell Walls - 'nutribullet debunking' (Williams)	Article	Television	ABC Television	The Checkout	Australia	02-Jul-15
Tequila plant shows promise for biofuel (Burton)	Media Release	Newspaper	<i>Adelaidean</i>		National	06-Oct-15
	Media Release	Internet/Web	Scimex	Online News	National	06-Oct-15
	Article	Radio		AM Radio	NSW	06-Oct-15
	Article	Radio		AM Radio	VIC	06-Oct-15
	Article	Radio		AM Radio	QLD	06-Oct-15
	Article	Internet/Web		AM Radio	WA	06-Oct-15
	Article	Internet/Web		AM Radio	TAS	06-Oct-15
	Article	Internet/Web		AM Radio	SA	06-Oct-15
	Article	Internet/Web		AM Radio	NT	06-Oct-15
	Article	Internet/Web		AM Radio	NSW	06-Oct-15
How Biofuels could power SA economy - video story (Corbin, Burton)	Media Release	Internet/Web	Adelaide Now	Feature Advertorial	SA	02-Dec-15
Wine leftovers converted to ethanol (Corbin, Burton)	Media Release	Newspaper	<i>Adelaidean</i>		SA	21-Aug-15
	Media Release		Scimex		SA	21-Aug-15
	Article	Newsprint	<i>Advertiser</i>	General News	SA	21-Aug-15
	Article	Newsprint	AAP Newswire		Australia	21-Aug-15
	Article	Newsprint	<i>Courier Mail</i> Brisbane		Qld	21-Aug-15
	Article	Newsprint	<i>The Australian</i>		Australia	21-Aug-15
	Article	Newsprint	<i>The Gawler Bunyip</i>		SA	21-Aug-15
	Article	Newsprint	<i>The Penola Pennant</i>		SA	21-Aug-15
	Article	Radio	ABC Radio National	PM and syndicated to >50 regional stations	Australia	21-Aug-15
	Article	Radio	ABC FM	PM and syndicated to >20 regional stations	Australia	21-Aug-15
	Article	Radio	5AA	Evenings	SA	21-Aug-15
	Article	Radio	ABC news		Australia	21-Aug-15
	Article	Internet/Web	ABC Online	Online News	Australia	21-Aug-15
	Article	Internet/Web	Brand South Australia	Online News	Australia	21-Aug-15
	Article	Internet/Web	getwineries.com.au	Online News	Australia	21-Aug-15
	Article	Internet/Web	The Sydney News	Online News	Australia	21-Aug-15
	Article	Internet/Web	Wine Biz	Online News	Australia	21-Aug-15
	Article	Internet/Web	Terutalk	Online News	Australia	21-Aug-15
	Article	Internet/Web	Finans	Online News	Denmark	21-Aug-15
Barley research expected to help beer brew better (Burton)	Article	Newsprint	<i>The Advertiser</i>		SA	27-Mar-15
	Article	Newsprint	<i>NewsMaker</i>		Australia	27-Mar-15
	Media Release		University Of Adelaide		Australia	28-Mar-15

Topic/Trigger for media interest	KPI classification	Media Type	Media Outlet or Publication	Section or Program	State/Country	Issue Date
Using AFM and the CellHesion® module to study plant cells at the University of Queensland (Stokes, Yakubov)	Article	Professional Organisation Newsletter	JPK Instruments	Nanotechnology for Life Science	Germany	Jan-15
Barley domestication (Fincher)	Media Release		Uni Adelaide		SA	
	Article	Internet/Web	Phys.org		USA	31-Jul-15
	Article	Internet/Web	e! Science News		Canada	31-Jul-15
	Article	University Press	University Of Adelaide		SA	31-Jul-15
	Article	Internet/Web	ABC News	ABC Rural online	SA	31-Jul-15
	Article	Radio	ABC News	Country Hour	SA	31-Jul-15
	Article	Internet/Web	Sky News Australia (Licensed by Copyright Agency)	News > Health	Australia	31-Jul-15
	Article	Internet/Web	9News (Licensed by Copyright Agency)		Australia	31-Jul-15
	Article	Internet/Web	Queensland Country Life		Qld	31-Jul-15
	Article	Newsprint	<i>The Land</i>		Australia	31-Jul-15
	Article	Newsprint	<i>Stock Journal</i>		SA	31-Jul-15
	Article	Newsprint	<i>Stock and Land</i>		Australia	31-Jul-15
	Article	Newsprint	<i>The Australian Dairy Farmer</i> (Licensed by Copyright Agency)		Australia	31-Jul-15
	Article	Newsprint	<i>North Queensland Register</i>		Qld	31-Jul-15
	Article	Internet/Web	Farm Weekly		Australia	31-Jul-15
	Article	Internet/Web	The Lead South Australia		Australia	30-Jul-15
	Article	Internet/Web	ARCHway	Research Highlights	ACT	05-Aug-15
Plants also suffer from stress (Persson)	Media Release		UM Newsroom		Vic	03-Sep-15
	Media Release		Max Planck Institute for Molecular Plant Physiology		Germany	14-Sep-15
	Article	Internet/Web	Market Research Store		USA	07-Sep-15
	Article	Internet/Web	Labonline		Australia	04-Sep-15
	Article	Internet/Web	Newshunt		India	06-Sep-15
	Article	Internet/Web	Yahoo News		Australia	06-Sep-15
	Article	Internet/Web	NewsUnited		USA	06-Sep-15
ARC Discovery Grant success (Bulone)	Media Release		Adelaidean / UA Website	News	SA	30-Oct-15
The sticky business of pollen counting (Lampugnani)	Article	University Press	UM Pursuit	News	Australia	16-Dec-15
Nutrition in the future (Yakubov)	Article	Radio	SBS radio	SBS Radio 40 years / Future Fears: Obesity	Australia	23-Sep-15

Key Result Area 3: Performance Measures a & c

International visitors and visiting fellows, and Centre personnel visits to overseas laboratories and facilities

The Centre tracks all visitors to its facilities across the three nodes and also those visits by Centre personnel to other research laboratories, domestic and international. Although not recorded, the Centre also regularly liaises with international partners and collaborators by video conference.

Name	Institution / Facility	Country	City	Host	Purpose of Visit
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Visits to national and international collaborators and institutions by Centre CIs and Researchers

Williams, Barbara	China Agricultural University	China	Beijing	Dr. Yang Hongjian	Instruction in use of AGRS; Presentation to group concerning gut fermentation (4 days)
Mikkelsen, Deirdre	UNSW	Australia	Sydney	A/Prof. Mike Manefield and Dr Sabrina Beckmann	Learn about and carry out ultracentrifugation and gradient fractionation of stable isotope labelled DNA samples (2 weeks)
Martinez-Sanz, Marta	Institute of Agrochemistry and Food Technology	Spain	Valencia		Scientific collaboration discussions & seminar
Hsieh, Yves	Royal Technological University (KTH)	Sweden	Stockholm		Establish collaboration projects/technology transfer from KTH (4 weeks)
Bulone, Vincent & Mathew, David	ARC CoE Translational Photosynthesis	Australia	Canberra	Prof. Murray Badger & Adele Doust	Centres of Excellence scheme discussions, site visit
Gidley, Mike	ANSTO	Australia	Sydney	Dr Elliot Gilbert	Scientific collaboration discussions
Fincher, Geoff	Royal Technological University (KTH)	Sweden	Stockholm		Senior academic selection committee participation, site visits
Fincher, Geoff	Carlsberg Breweries	Denmark	Copenhagen	Prof. Birger Lindberg-Møller	ARC Linkage project meetings, manuscript preparation
Bacic, Tony	University of Wageningen	Netherlands	Wageningen	Prof. Sacco de Vries	Scientific collaboration discussions & seminar
Hsieh, Yves	ThermoFisher	Taiwan		Dr Eric Wu	Glycan sequencing
Fincher, Geoff	Carlsberg Breweries	Denmark	Copenhagen	Prof. Birger Lindberg-Møller	Consultancy in research capacity development
Hsieh, Yves	Royal Technological University (KTH)	Sweden	Stockholm	A/Prof. Qi Zhou & Francisco Vilaplana	Undertook <i>in vitro</i> and <i>in vivo</i> polysaccharide synthesis, linkage analysis of oligosaccharide products and structural assignment using 2D NMR (7 weeks)
Gidley, Mike	King's College	UK	London	Prof. Peter Ellis	Invited seminar and discussions with SAC member
Gidley, Mike	University of Cambridge	UK	Cambridge	Prof. Paul Dupree	Invited seminar and technical discussions
Zeng, Wei	South China Agricultural University	China	Guangzhou	Prof. Aimin Wu, Dr Changcao Peng, Dr Siming Gan, Prof. Shucai Zeng	Scientific collaboration discussions & seminar
Zeng, Wei	South China Botanical Garden	China	Guangzhou	Prof. Yueming Jiang and Prof. Hongxia Qu	Seminar given
Gunness, Purnima	South China Sea Fisheries Research Institute	China	Ghuangzhou	Prof. Xianqing Yang	Dissemination of research on lipid-reducing properties of plant cell walls, site visits and technique training. (1.5 weeks)
Tucker, Matthew	Chinese Academy of Sciences (CAS)	China	Beijing	Prof. Weicai Yang	Scientific collaboration discussions
Tucker, Matthew	Shanghai Jiaotong University, (SJTU)	China	Shanghai	Prof. Dabing Zhang	Scientific collaboration discussions & seminars (3 days)

Extended training visits to national and international collaborators and institutions by Centre Students

Lim, Wai Li	IPK University	Germany	Gatersleben	Dr Andrea Matros and Manuela Peukert	Use of MALDI-mass spectrometry imaging (3 months)
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Name	Institution / Facility	Country	City	Host	Purpose of Visit
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Visiting Fellows/Students to Centre Nodes

Roberts, Alison	University of Rhode Island	USA	Rhode Island	UA node	Sabbatical visit (1 year from mid-2014, 6 weeks at UM)
Roberts, Eric	Rhode Island College	USA	Rhode Island	UA node	Sabbatical visit (1 year from mid-2014, 6 weeks at UM)
Zhang, Runxuan	James Hutton Institute (JHI)	Scotland	Dundee	Tucker	Data presentation, GO annotation and network analysis, manuscript preparation
Shan, Ye	College of Forestry	China	Lin'an	Zeng	Molecular biology training, research collaboration (2.5 months)

Visits to Centre facilities by international and national researchers

Roberts, Jeremy	Nottingham University	UK	Nottingham	Bulone, Burton	Scientific & collaboration discussions
Waugh, Robbie	James Hutton Institute (JHI)	Scotland	Dundee	UA node	Scientific & collaboration discussions, project updates, student mentoring
Sato, Kazuhiro & Minoru Murata	Okayama University	Japan	Okinawa	Bulone	Introductory meeting, potential collaborations with CoE
Gao, Caixia	Chinese Academy of Sciences	China	Beijing	Little	Visited prior to the Genomic Editing workshop
Mylne, Josh	ARC CoE PEB / UWA	Australia	Perth	Tucker	Potential joint collaboration planning, seminar given. Jointly hosted with PEB UA Node
Harris, John	SARDI	Australia	Adelaide	Burton, Khor	Training in β -glucan assay and related techniques
Xu, Wenliang	Huazhong Normal University	China	Wuhan	Zeng, Bacic	Scientific & collaboration discussions
Lucas, Bill	UC Davis	USA	California	Bulone, Tucker	Scientific & collaboration discussions
Li, Jiayang	Vice-minister of Agriculture, China and Institute of Genetics and Developmental Biology, CAS	China	Beijing	Bacic, Doblin	Scientific & collaboration discussions, presented seminar
Whelan, Jim	La Trobe University	Australia	Melbourne	Bulone	Centre collaboration and facilitating formalising relations between LTU and UA
Keegstra, Ken	Michigan State University (MSU)	USA	Michigan	UA node	Post-Retreat visit to UA Node labs, mentoring discussions with students and post docs
Knauf, Vic	Arcadia Biosciences	USA	California	UA node	Post-Retreat visit to UA Node labs, mentoring discussions with students and post docs. Commercialisation opportunities and future collaborations
Zhang, Yehui	Sericultural & Agri-Food Research Institute, Guangdong Academy of Agricultural Sciences	China	Adelaide	Bulone	Australia China Young Scientist Exchange Program (YSEP) discussions involving W Zhang (Flinders University, Adelaide)
Matros, Andrea & Peukert, Manuela	IPK University, Gatersleben	Germany	Adelaide	Burton	Learn microscopy techniques
Griesser, Hans with Bryan Coad	University of South Australia	Australia	Adelaide	Bulone	Scientific & collaboration discussions
Anderson, Marilyn	La Trobe University	Australia	Melbourne	Bulone	Planning Workshop — ARC Discovery grant
Sun, Prof	Beijing Technology and Business University	China	Beijing	Wang	Scientific & collaboration discussions

Internodal laboratory visits for technique training &/or collaboration

Rincon Bonilla, Mauricio	UM Node & IBM		Melbourne	Oehme	Development of a coarse-grained molecular dynamics model of the plant cell wall. (3 weeks)
Phan, Jana	UQ Node		Brisbane	Yu, Yakubov	Mucilage extrusion video technique, collaboration planning

Key Result Area 4: Performance Measures a & e

End-User Links: Government, industry and business briefings; public talks and scientific seminars & lectures

The Centre collates information on briefings to end-users such as government, industry, business and students. Many of these briefings lay the foundations for future collaborations and partnerships, others serve to attract high calibre students to the Centre. In this table, the Centre also captures seminars provided to scientific peers.

Presenter	Key Audience/Client	Event	Host	Location	Month	Title/Activity
Government Briefing						
Bulone, Vincent	External stakeholders in industry and government, including Hon. D Ridgway MLC, Shadow Minister for Agriculture, Food and Fisheries; Mr A Pederick MP, Member for Hammond	Vice-Chancellor's Boardroom Lunches: Future opportunities for the ARC CoE PCW	Prof. W Bebbington (UA)	Adelaide	May	
Bulone, Vincent	SA Department of Development	New Centre Director introduction	Andrew Dunbar	Adelaide	Oct	
Bulone, Vincent	Bioinnovation SA, Dr Meera Verma	New CEO introduction	ARC CoE PCW	Adelaide	Nov	
Bulone, Vincent	SA Department of Development	Chief Scientist meeting	Dr Leanna Read	Adelaide	Dec	
Industry Briefing						
Bulone, Vincent	GRDC	Meet key program leaders	GRDC	Canberra	Feb	
Bulone, Vincent	CoE Translational Photosynthesis	Directors & COOs meeting and site visit	Prof. Murray Badger & Adele Doust	Canberra	Feb	
Bulone, Vincent	<i>Journal of Integrative Plant Biology</i>	Brief overview of Centre and new role at the Editorial Board meeting			Jun	
Bulone, Vincent	Nano3Bio Consortium	Project meetings	Nano3Bio	Paris	May	
Gidley, Mike	CSIRO Food and Nutritional Sciences	Briefing on CoE to senior personnel	Prof. Martin Cole	Sydney	Mar	
Wilkinson, Laura	Playford Trust Board Meeting	Present the outcomes of 2014 research as a Playford Trust/Coopers Scholarship recipient	Playford Trust and Coopers Brewery	Adelaide	Apr	
Fincher, Geoff	Carlsberg Board of Trustees	Update on the ARC CoE PCW	Carlsberg Breweries	Copenhagen	Jun	
Bulone, Vincent; Burton, Rachel & Tucker, Matthew	SJTU / UA collaboration	SJTU/UA Centre for Agriculture and Health Workshop	The University of Adelaide	Adelaide	Aug	
Bacic, Tony	South China Botanical Garden	Presentation to members and management		Guangzhou, China	Sept	
Bacic, Tony	South China Agricultural University	Presentation to research management		Guangzhou, China	Sept	
Doblin, Monika	Finistere Ventures, San Diego, USA (Ag-Tech focused subsidiary of AVAC, Canada), led by Arama Kukutai (Managing Director)	Overview of School of BioSciences and discussion on Finistere's interests in the agricultural biotechnology space	UM	Melbourne	Sep	

Presenter	Key Audience/Client	Event	Host	Location	Month	Title/Activity
Doblin, Monika	CropDesign/BASF. Dr C Reuzeau (Senior Manager Technology Acquisition and Collaborations, ASIA Pacific Region, Dr S Tresch (Team Leader, Global Research Herbicides, BASF SE)	Investment opportunity discussions	UM & Bio21	Melbourne	Sept	
Gidley, Mike	PepsiCo	Meetings with senior technical personnel holding global portfolio responsibilities	Dr Stefan Baier	New York, US	Oct	
Other						
Bulone, Vincent & Mathew, David	Australian Research Council	Introductory meetings with CEO, Executive Director and Program staff	Aidan Byrne, Fiona Cameron	Canberra	Feb	
Fincher, Geoff	UA Faculty of Sciences, academic and research personnel	Faculty of Sciences Information Session: Strategies for winning ARC DECRA awards	Research Office	Adelaide	Nov	
Public Talk						
Burton, Rachel	General public	Harvest Radio	Radio Adelaide	Adelaide	Feb	Introduction to biofuels
Fincher, Geoff	Australian Academy of Technological Sciences and Engineering (SA Branch)	Periodic meeting	ATSE - SA	Adelaide	Mar	Plant cell walls: from biofuels to human health
Gidley, Mike	UQ Open Seminar	Open Seminar	UQ	Brisbane	Apr	Plant cell walls in the digestive tract
Bulone, Vincent	General public	Harvest Radio	Radio Adelaide	Adelaide	May	Unlocking plant cell walls
Fincher, Geoff	Carlsberg Breweries	Carlsberg Laboratories seminar series	Carlsberg Breweries	Copenhagen	Jun	Australian Research Council Centre of Excellence in Plant Cell Walls
Burton, Rachel	General public	The Sound of Science	Radio Adelaide	Adelaide	Jun	Diversity and equity in science
Burton, Rachel	General public	Barometer	Radio Adelaide	Adelaide	Oct	Growing our own biofuels
Collins, Helen & Cu, Suong	General public	The Sound of Science	Radio Adelaide	Adelaide	Jun	Improving barley for efficient malting
Tucker, Matthew	General public	The Sound of Science	Radio Adelaide	Adelaide	Jun	Seeds for the future
Phan, Jana	General public	The Sound of Science	Radio Adelaide	Adelaide	Jun	Curiosity driving genetic research
Dimitroff, George	General public	The Sound of Science	Radio Adelaide	Adelaide	Jun	Reflections of a PhD completing student
Fincher, Geoff	Research Info Sessions	UA community (open)	Research Branch	Adelaide	Aug	Insights into the ARC assessment process
Gidley, Mike	Cambridge University community	Public talk as part of week long symposia	Cambridge University Dept Chemistry	UK	Aug	The alpha and beta of human nutrition
Fincher, Geoff	Lyceum Club			Melbourne	Nov	Plant cell walls: emerging roles in human health and renewable biofuels production
Tucker, Matthew	PSC Frontier Seminar Series	Chinese Academy of Science Faculty	Centre for Plant Stress, Shanghai, China	Shanghai	Nov	Intercellular cross-talk and differentiation during plant reproduction

Presenter	Key Audience/Client	Event	Host	Location	Month	Title/Activity
Science/Educational Seminar						
Lonsdale, Andrew	Students, families, teachers of Yr 11 Biology students	Career opportunities talks	Parade College, Bundoora, Vic	Bundoora	Oct	<i>Bioinformatics and my research in the CoE</i>
Bacic, Tony	UM and MPI academics and researchers	MPI Student Exchange Program	Prof. Staffan Persson (UM)	Melbourne	Nov	<i>PCBRC/metabolite and cell wall platform introduction</i>
Williams, Barbara	Department of Ruminant Nutrition & Microbiology, China Agricultural University	Departmental Seminar	Dr Yang Hongjian	Beijing	Jan	<i>Digestive health: the functional role of your gut microbiota</i>
Martinez-Sanz, Marta	Institute of Agrochemistry and Food Technology Seminar	Seminar	Spanish Council for Scientific Research	Spain	Jan	<i>Scattering techniques and their application to investigate the interaction mechanisms in plant cell walls</i>
Bacic, Tony	University of Wageningen	Departmental Seminar	Prof. Sacco de Vries	Wageningen	Mar	<i>Grass cell walls: biosynthesis and role in mechano-sensing</i>
Bulone, Vincent	School of Agriculture, Food & Wine, UA	School Research Day	UA	Adelaide	Oct	<i>Cell wall polysaccharide biosynthesis in plants and oomycetes</i>
Betts, Natalie	School of Agriculture, Food & Wine, UA	School Research Day	UA	Adelaide	Oct	<i>RNAseq of individual barley grain tissues during very early germination</i>
Phan, Jana	UA Faculty of Sciences	3 minute thesis competition	UA Faculty of Sciences	Adelaide	Aug	<i>Mutant weeds have got your back</i>
Gidley, Mike	King's College London	Departmental Seminar	Prof. Peter Ellis	London, UK	Sep	<i>CoE projects in cell wall modelling and digestive tract effects</i>
Gidley, Mike	University of Cambridge	Departmental Seminar	Prof. Paul Dupree	Cambridge, UK	Oct	<i>CoE projects in cell wall modelling and digestive tract effects</i>
Fincher, Geoff	Yerevan State Uni, Armenia	Departmental Seminar		Armenia	Nov	<i>Research and technological capabilities in the ARC CoE PCW</i>
Fincher, Geoff	MSc students	Lecture	Copenhagen University	Copenhagen	Oct	<i>Applications of Cell Wall Biology in Malting and Brewing</i>
Bacic, Tony	M(Biotech) students	Lecture	University of Melbourne	Melbourne	Oct	<i>Glycomics: another "-omics"!</i>
Tucker, Matthew	Faculty, Chinese Academy of Science	International Seminar Series	Chinese Academy of Science, IGDB	China	Nov	<i>Intercellular cross-talk and differentiation during plant reproduction</i>
Tucker, Matthew	Faculty, SJTU	International Seminar Series	Shanghai Jiao Tong University,	China	Nov	<i>Intercellular cross-talk and differentiation during plant reproduction</i>
Betts, Natalie	UA postgraduates	Waite Postgraduate Symposium	UA	Adelaide	Jul	<i>From post-grad to post-doc: the long way around</i>
Hakachite, Christopher	UA postgraduates	Waite Postgraduate Symposium	UA	Adelaide	Jul	<i>Analysis of genes responsible for cereal cyst nematode resistance in barley</i>
Lim, Wai Li	UA postgraduates	Waite Postgraduate Symposium	UA	Adelaide	Jul	<i>Barley grain fructan metabolism is altered by overexpression of CslF6, a (1,3;1,4)-β-glucan synthase gene</i>
Singh, Rohan	Plant Biotechnology undergraduates	Workplace visit & workshop	UA	Adelaide	Aug	<i>How biotechnology is applied in a research situation</i>

Notes

