Plant Cell Walls
ARC Centre of Excellence

Australian Government
Australian Research Council

Australian Academy of Science

Pulling Together a Winning Bid

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What Provided Our Bid With a Competitive Advantage?

- selection of CIs and PIs, hard-nosed approach
- map out research program by yourself or with a small group of high profile, friendly scientists, avoid workshops
- we had only four CIs; plus five international PIs; don't involve too many!
- remember the research must be seen as more than a series of DPs (must demonstrate scale and focus)
- identify heroic targets and how new approaches/technologies will enable them to be achieved; think quantum leap, not more of the same!
- the application: as a standard ARC style or as a strategic plan?
- opportunity for leveraging ARC funding (get cash commitments)
  - with industry
  - with international collaborators
  - with other local R&D funders (e.g. GRDC)

Industry Cash Always Helps: Push the leverage line!

- how to get industry partners to contribute decent $$$$$ up front?

- our program was related to renewable biofuels, human health, malting/brewing
  - build relationship
  - how much cash???
  - sell the potential advantages and low risks to industry partners
  - sell minimal overheads of Australian/ARC system

Leverage from Public Funding Bodies

- our application had 2.5 pages of research proposal in 214 pages total!
- research plan therefore had a degree of flexibility
- get agreement from international PIs to apply to their own funding bodies for support for joint Centre research programs
- success with BBSRC (UK) and GABI (Germany)
  - put new Centre $$$s on the table for collaborative research projects
  - conditional on this ARC cash being matched by PI through BBSRC/GABI etc.
  - double everyone's money!
  - no funds transferred offshore, in either direction
  - Director must trust PIs and be determined to make it happen
  - must demonstrate complementarity of skills and resources.

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The Application Itself

(Standard ARC Format or Strategic Plan?)

PART E: PROJECT DESCRIPTION

E1. PROPOSAL TITLE

Reduced Water Consumption in Commercial Malting Processes

E2. AIMS AND BACKGROUND

Objective

The overall aim of the project is to produce malting quality barleys with reduced (1,3;1,4)-β-glucan content that can be used to realize a 40% saving in water usage in the commercial production of malt. Within this overall aim, more specific objectives of the project are to:

- identify genes and other factors that regulate the synthesis of the cell wall polysaccharide (1,3;1,4)-β-glucan in cell walls of barley grain
- generate malting barley varieties in which grains have very low levels of (1,3;1,4)-β-glucan
- use these varieties to develop malting strategies that reduce water usage for the malting process by up to 40%, whilst not compromising final malt quality.

The successful outcome to the project will be barley varieties that can be successfully malted with a single steep, rather than the conventional two steeps currently employed. This will result in water savings of around 40% as compared to conventional malt production. Forward and reverse genetics approaches will be taken in addressing these aims. The Linkage Project will bring together resources, expertise and infrastructure in a range of disciplines directly applicable to the regulation of (1,3;1,4)-β-glucan biosynthesis in commercially important cereal crops. The availability of these resources will ensure that outcome-oriented postgraduate and postdoctoral training is provided to the highest international standards and in a multidisciplinary environment, while the outcomes of the Project will be delivered to grain producers and processors through protected Intellectual Property and direct links with large barley breeding programs in Australia.

Background

In commercial malting processes, barley grain is germinated under controlled conditions and mobilization of the starchy endosperm is allowed to proceed for approximately four days. During this period enzymes secreted from the aleurone layer and the scutellar epithelium, together with some that pre-exist in starchy endosperm cells, collectively degrade cell walls, starch and storage protein. The malt is dried and transported to the brewery, where starch degradation products and other endosperm components are extracted and further hydrolysed, prior to the fermentation of released sugars to ethanol.

The malting process is initiated by immersing the grain in water. This is known as steeping and the objective is to quickly raise the moisture content of the grain to

SECTION C : STRATEGIC PLAN

C1.1 GOALS AND OBJECTIVES

THE SCIENTIFIC OBJECTIVE

'How do plants regulate the synthesis, assembly and re-modeling of their cell walls?' during normal development, and in response to biotic stresses.

Plant walls are the world's largest renewable carbon resource, but their assembly and re-modeling regulatory mechanisms are not understood.

THE VISION

The Centre will build on existing strengths in the field of fundamental cell wall biology to:

- generate scale and focus at the scientific, technical and training levels
- enhance plant biotechnologies that underpin Australian industries valued at over $8 billion per annum, associated food industries valued at about $40 billion per annum, and massive emerging industries related to the production of renewable transport fuels, biomedicine and biocomposites.

JUSTIFICATION OF THE RESEARCH

WHY GRASSES?

Grasses represent the most important family of plants for humans. Foods made from rice, wheat, sorghum, barley, millets and sugar cane account for a high proportion of our daily 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 and barley are the most important food crops in Australia but others are important to our international partners; model systems will be used in the research program, including species of grasses for which genome sequences are available.

WHY CELL WALLS?

Cell walls determine the quality of most plant-based products in society. Textural, nutritional and processing properties of plant-based foods are heavily influenced by cell wall properties. Fibres for textiles, pulp and paper manufacture, timber products and now, for fuel and bio-composite manufacture, are largely composed of walls, or derived from them. Major drivers of many international research activities are the central role of plant cell walls as a renewable source of transport fuels, as functional foods to improve human health, and as a source of raw materials for industrial processes.

To achieve sustainable development in these key areas we require a complete understanding of wall assembly, structure and function at the molecular, genetic and biochemical levels, so that an informed and integrated approach can be applied to deliver beneficial outcomes.

INTERNATIONAL LEVERAGE

- An innovative feature of this program will be the development of collaborative projects with each of our PIs, under the framework of an international network of both public and private partners
- This international network will leverage ARC investments in Europe and North America, and capture world class multidisciplinary expertise not currently available in Australia.
- Strategic co-investment of some ARC funds will enhance our capabilities and provide access to overseas funding bodies for research, training and commercialization collaborations.

Potential exists to leverage an extra $1.5m per year for research activities.

THE GOALS

Goals of the ARC "Centres of Excellence" scheme		How this proposal will contribute to the Scheme's Goals	KPIs*
a	**highly innovative and potentially transformational research**	Internationally, no other group has the assembled expertise and experience to adopt the following research approach: • Define the precise mode of action of genes and enzymes that regulate plant cell wall synthesis • Define the fine chemical structure and physicochemical properties of wall polysaccharides in the grasses • Relate these to molecular architecture and cell wall function • Define the route and mechanism of wall polysaccharide assembly through the cell • Define the mechanisms of re-modeling used to meet changing functional requirements.	1 2 3
	achieve international standing in the fields of research	• Highly experienced public and private sector partners • Highly experienced Australian CIs and overseas PIs • Significant partner funding and resource commitments	3 4 5
	lead to a significant advancement of capabilities and knowledge	• Develop significant new capabilities, as measured by the attraction of new staff • Generate new important knowledge, evidenced by the achievement of KPIs	1 3
b	**link existing Australian research strengths**	• All major Australian plant cell-walls groups are partners • Expertise from all university teams is integrated • Significant research and management experience in field	3 7

***KEY PERFORMANCE INDICATORS (KPIS)**

1) Scientific
- 20 peer reviewed publications
- Two (2) in journals with a citation impact >5
- One (1) in journals with a citation impact >10

2) International standing
- Two (2) scientific reviews or commentaries in refereed journals.
- Four (4) invitations to present at scientific meetings
- One (1) invitation to be involved in an international review
- Ten (10) attendances at international scientific meetings
- Four (4) memberships of journal editorial panels

3) Capacity Building
- Build Centre to full staff capacity within 12 months
- Formalize arrangements with ACPFG/ CSIRO/ APPF by end of Yr 1.

4) Project Portfolio
- Develop four (4) bi-lateral projects
- 70:30 balance between short/medium and long term projects within the project portfolio

5) Funding
- Apply for international funding for new collaborative projects with partner organizations
- Yr 2 - $500k
- Yr 3 - $1m
- Yr 4 - $2m

6) Linkages and networks
- Four (4) exchanges of staff per year with international partners
- One (1) extended overseas visit to partner laboratory per candidature for PhD students
- 15 short term visitors attracted to Centre
- Two (2) overseas visits for postdoctoral scientists per annum
- Host at least two (2) long term visitors from overseas
- 1/3 of the PhD students to be from overseas

7) Staff, Training and Education
- Three (3) new PhD students each year
- Establish post graduate mentoring group
- 20 external seminars to community groups
- Four (4) media releases per year
- Three (3) internal scientific meetings per year
- One (1) major international meeting organized during the first three years
- Apply for one (1) ARC Fellowship per year.

TRACK RECORD

AUSTRALIAN SCIENTISTS

CIs Bacic, Burton and Fincher have many joint publications and have published with CI Gidley. CIs Bacic, Fincher and Gidley have each published more than 40 refereed papers in the last five years and each has published more than 140 papers with H indices of about 40. Their publications have been cited over 4,000 times in the literature and all are regularly invited to present their work at international scientific confere
integration of expertise from the teams of CIs Bacic, Fincher and Gidley essentially links all the m
walls groups in Australia and will provide the ARC Centre with decades of research and managem
in the field.

CD FINCHER	• research focused on the biology of cell walls in commercially important c • has characterized enzymes responsible for the hydrolysis and re-modeling constituents, and is now characterizing key polysaccharide synthases.
CI BACIC	• has established a concentration of expertise in complex carbohydrates (gly proteomics, metabolomics and other key platform technologies • has state-of-the-art analytical equipment and capabilities in the analysis o macromolecules that are amongst the most comprehensive in the world.
CI BURTON	• research focused on cell wall polysaccharide biosynthesis • brings high level skills in emerging techniques in functional genomics.
CI GIDLEY	• brings experience in linking polysaccharide structure with functionality in industrial applications. • has capabilities in physicochemical properties of polysaccharides, gelatio construction and characterization of polysaccharide composites as functio for walls, and behaviour during processing, digestion and absorption.
CURRENT ROLES	Should this application be successful, • CD Fincher will relinquish his duties as Deputy CEO of the ACPFG, but 10% of his time to maintain contact with other research activities. • CIs Bacic, Burton and Gidley will focus their research activities on the AI and contribute at least 40% of their time to the Centre.

COLLABORATING SCIENTISTS

Each PI is currently directing a large research group, centre or institute, has experience with manag
research groups with effective governance and management systems, and brings to the Centre spec
research expertise. In this context, we have intentionally invited a relatively small number of high
PIs to collaborate with us in the ARC Centre, based on the criteria in part C3.

PI BULONE	• is Director of the $9m Center for Biomimetic Fiber Engineering; which is evolutionary biological systems for new surface and fiber chemistries • is an expert in the isolation of membrane rafts (Program 3) • is one of few to express cDNAs for polysaccharide synthase enzymes and polysaccharide biosynthesis *in vitro*; indispensable expertise for Program • will submit applications to the Swedish Foundation for Strategic Research, the Swedish Research Council, other foundations and funding agencies that support fundamental, strategic and applied research (e.g. MISTRA, VINNOVA), and EU

OUTCOMES AND LINKAGES

IP	• IP may arise from research activities as has already occurred with our identification of the *CslF* and *CslH* genes as mediators of (1,3;1,4)-β-glucan synthases. • Quarantined, bilateral IP agreements will be acceptable to our partners; these will minimize the risk of IP leakage and will protect commercial interests in outcomes. Agreement to this has been a prerequisite for sign-on of our commercial partners. • PIs from Biomime, EBI, IPK, SCRI and the University of Dundee all have contacts with the private sector, and agree that the proposed bilateral framework system will adequately protect their IP interests, while adding to potential information available to them through the broader activities of the Centre.
Research Outcomes	• Research outcomes will be directly applicable to o human health and nutrition o the production of specialized biomaterials o malting and brewing industries o lodging resistance and yield security o disease resistance and yield security o emerging cellulosic bioethanol industries. • We have direct access to: o the largest barley and wheat breeding programs in Australia through our collaborators at the University of Adelaide, and o barley breeding programs in the UK and Europe, through our PIs. • These links provide a clear path for technology transfer to end-users, using either GM or non-GM approaches. The ARC Centre will be closely aligned with the commercialization, technology transfer, education and training, and public relations activities of ACPFG, which has commercialization agreements with a number of large national and international companies and can thereby enhance potential returns to Australian stakeholders. The Centre will markedly enhance Australia's capacity to participate in the current revolution in agricultural biotechnology, particularly as it relates to food security, human health and nutrition, and emerging bioethanol industries.

Delivery

Outcome area	Potential delivery Partner
Human health	CSIRO Food Futures Flagship
Biofuel production	EBI in the USA or by UD/SCRI in the UK
Malting and brewing	ABB Grain Ltd. for use in Australia or its Viterra parent company for evaluation in Canada
Disease resistance in agriculturally important crops	Cereal breeding programs co-located with the Centre in Adelaide, to SCRI in Europe, and to Viterra in Canada.
Stalk strength and lodging	Will be evaluated by DuPont-Pioneer; one of the largest maize companies in the world.
Use of wheat bran and triticale for bioethanol production, and the use of triticale for silage in animal production.	Australian Grain Technologies Pty. Ltd. Its part-owner, Limagrain, has a structure for testing and marketing research outcomes internationally.

Avoided superlatives
Not one reference in application
ARC demands 'stretch' KPIs

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