PHYTOGEN

A
NEWSLETTER
FOR
AUSTRALIAN
PLANT SCIENTISTS

Volume 8 Number 3
December 2006

PHYTOGEN

Volume 8: Number 3

INSIDE THIS ISSUE

A big thanks to all the scientists who contributed to this issue of Phytogen.

Editor's corner

Dear Fellow Society Members,

Thank you for all of your contributions, as we again have another excellent issue of Phytogen. The "state of affairs" collated by the new SA representative Chris Ford highlights the some of research occurring in plant sciences in SA. I certainly hope that you enjoy reading this and the other features of Phytogen.

This issue contains a fascinating look at the state of plant science in Australia (page 9). Our presidents, Steve Tyerman (outgoing) and David Day (incoming), commissioned Kate Fairley-Grenot to prepare this report. It highlights the importance of plant science in the Australian community and the trends in research funding. Importantly, the report brings out areas that we as members of the plant science community need to be aware of and work to improve such as promoting the opportunities of plant science to funding agencies.

Please keep the articles coming as it is your contributions that make Phytogen a success. A two year roster is in place for the "State of Affairs" and Queensland will feature in the next issue. Reports from local, national and international meetings relevant to plant science are welcomed; so please send reports to Andy Netting (anetting@unsw.edu.au) who is co-ordinating "From our Seed Banks".

I wish everybody a safe and happy festive season and a very productive and successful 2007.

Helen Irving

ASPS Office Bearers – 2007

President	David Day	University of Sydney
Honorary Secretary	Robyn Overall	University of Sydney
Honorary Treasurer	Peter Ryan	CSIRO Plant Industry
Public Officer	Marilyn Ball	Australian National University
Cell Biology	David McCurdy	University of Western Australia
Environment & Ecophysiology	Mark Hovenden	University of Tasmania
Genetics & Molecular Biology	Patrick Finnegan	University of Western Australia
Plant Development	Dennis Green	Charles Sturt University
Plant Microbe Interactions	Peer Schenk	University of Queensland
Plant Science Education	Chris Ford	University of Adelaide
Whole Plants	Charles Warren	University of Sydney
Student Representative	Jo Tregeagle	La Trobe University
FASTS Representative	Graham Farquhar	Australian National University
FPB representative	Jennifer Henry	CSIRO Publishing
Plants in Action	Brian Atwell	Macquarie University

President's Report

As the last report in my office as Honorary President I would like to focus on a major challenge that faces the Society, and to highlight the benefits to members that have accrued in recent years.

Our major challenge is to boost membership of the Society. The Treasurer's report details the decrease in membership that has occurred. Our ordinary membership has reduced from 328 to 184 in the last three years while student membership has increased, although it is rather ephemeral. At the beginning of my tenure as President I was aware of the trends in membership, and the executive and council resolved to turn this around by demonstrating and boosting the benefits to members. We also carried out a targeted membership drive late in 2005 where 10 different institutions were approached via members within those institutions. This has not resulted in a turn around of membership renewals, although feedback was received that indicated some reasons for declining membership.

What has changed over the last decade that would reduce the need for plant researchers and academics to be members of ASPS? There are several issues that can be developed from this question.

Is it possible that the reduced membership is an indicator of the general health of plant sciences? This question is currently being analysed for the benefit of members, and if it is found that the state of health is not particularly good we will need to lobby hard with our governments; State and Federal. It would seem to be unlikely however that all of the reduction in membership could reflect a decline in plant science effort at a National level.

It may be conjectured that there is no longer the impetus on individuals to be a member of a scientific society like there used to be several years ago. This is in spite of the fact that society membership is still positively recognised in institutional promotion committees as an indicator of service to the discipline. Assuming that plant scientists continue to provide service to their discipline at a similar fraction that they did a decade ago, the drop in membership in ASPS could be due to dilution of that service across a broader range of activities.

Greater specialisation and society-like activities are being undertaken by such entities as CRCs and Centres. These entities have many functions that can replace those traditionally carried out by a scientific society, and furthermore they consume time that would otherwise be at the disposal of society activities such as attendance at the annual meetings, public education and popular press publications. CRCs and Research Centres provide much needed investment in plant science research, but we need to ensure that membership of a broader society is not reduced because of more activities associated with such centres. Again we must examine the real benefits that membership of ASPS provides and if it is found wanting for a particular group we need to do something about it. Perhaps ASPS needs to be more involved in plant based CRCs and research centres.

Another possibility is that our members are engaged in other societies, eg Agronomy, Plant Pathology, Viticulture and Oenology, Plant Ecology etc. All can be claimed as firmly based in "plant science". Could it be that our broad claim on many plant science disciplines has had the effect that we are not considered specialised enough for any sub-disciplines in particular? There is also the likelihood that there are too many conferences in the different sub-disciplines resulting in ComBio becoming the last preference and even clashing with other conferences. We should be engaging with related societies such as the Australian Plant Pathology Society to encourage them to come in to ComBio.

The recognition of excellence in research and teaching has been a focus of ASPS in recent years and is a very important benefit to members, since without being a member one cannot entertain the prospects of winning an award. The Goldacre award remains the premier award in research for early career researchers and the Teaching Award is being recognised as a premier award for tertiary educators. These two awards alone are good reasons for membership and involvement in the society, particularly in these times where peer recognition of excellence counts toward career advancement and broader department and institutional recognition with the public and government. Involvement in a Society is also still recognised in institutional promotions as demonstration of good academic citizenship.

We now have even more to offer our membership with the Functional Plant Biology Best Paper award, and the R.N. Robertson fellowship, two new awards that have been well received. These awards are targeted at early career researchers, and we expect their value to only increase with time. Again both awards are only available to members.

Student members gain substantially by travel assistance to ComBio, various prizes for their presentations and a subsidised ticket to our annual dinner.

All these awards represent a significant time input by the council and executive of the ASPS and during the year they would constitute the majority of our time for the society. I would like to thank at this point all those who were involved in assessing the awards, including some of our Corresponding Members.

Perhaps the targeting of our benefits mainly to early career members is reflected by healthy student numbers. Perhaps we now need to focus on mid career members, and members at later stages in their career, because it is in this category where we seem to be taking the losses. We have recognition of excellence for these members in the form of the J.G. Wood and R.N. Roberston plenary lectures at ComBio, but perhaps we need to do more.

The Society is currently in a very healthy state financially, this is largely the result of remaining in the ComBio fold and through the excellent efforts of Peter Ryan, as Honorary Treasurer, in obtaining Sustaining Members. The Society has $85,000 in cash reserves. This is of no value with a declining membership and now is the time to use these funds to the benefit of members. It will be the task of the new council and executive to develop new benefits for members and to invest these funds in such a way that there will be no choice but for every plant scientist in Australia to feel obliged to join up and to be comfortable as a member of ASPS.

Finally it remains for me to thank the executive for their superb efforts and enthusiasm through the year and to the council members for their support of various initiatives. I wish to particularly thank John Patrick, who has been tireless in his efforts and support to the executive. Also Peter Ryan for keeping the Society in such an excellent financial position so that new initiatives can be undertaken in the future. I thank the outgoing council members: Brent Kaiser, John Harper, Eloise Foo, and Tim Colmer for their work for the Society. I also wish to thank the supporting subcommittees; Marilyn Ball (Public Officer), Graham Farquhar (FASTS representative), Brian Atwell (Plants in Action), Jennifer Henry (FBP); and last but not least the Phytogen Editors Helen Irving and Andy Netting.

I wish the new executive and Council all the very best for the coming year.

Steve Tyerman
President ASPS

ASPS Website

A feast of new information recently has been uploaded onto the ASPS website (http://www.plantsci.org.au/). Of particular note are:

1. **Council Members for 2006-2007**. The AGM endorsed David Day as President and Robyn Overall as Honorary Secretary along with a number of new Discipline Representatives. New Council members are welcomed and those departing thanked for their valuable contributions (click on the button 'Council Members').
2. **Minutes of the Annual General Meeting**. You will also find a report from the retiring President Steve Tyerman. Please note the Treasurer's Report indicating the healthy state of the ASPS finances as well as reports from Functional Plant Biology and Plants in Action (click on the button 'Council Members' and then "AGM reports').
3. **RN Robertson Travelling Fellowship** (click on the button 'Awards'). The named Fellowship recognises and celebrates the sustained contribution made by RN Robertson (Sir Bob) in nurturing young plant scientists in Australia spanning across four decades from the 1950's. The Australian Society of Plant Scientists is indebted to Hank Greenway and Joe Wiskisch who generated and championed the early development of the RN Roberston Travelling Fellowship. In this context, we call on your support to promote the scheme including garnering further sources of funds to reach the target of $100,000 (click on the button 'About ASPS' to locate the downloadable form).
4. **Goldacre and Teaching Awards**. Nominations for these prestigious awards will close on April 13, 2007. Please give thought to nominating a deserving recipient. Guidelines and selection criteria are outlined in the relevant web pages (click the button 'Awards').
5. **Corresponding/Life Members**. These members are listed together with criteria for their selection (see 'About ASPS'). ASPS members are encouraged to nominate candidates for these esteemed positions.
6. **ASPS Support for Workshops and Conferences**. As one initiative to promote plant science within the national research community, ASPS provides seeding support for members to run workshops and conferences. Guidelines and a downloadable application form are available on the website (click on the button 'Conferences').
7. **2007 Membership Renewal**. Deadline for renewal of ASPS membership is set at March 31, 2007. A downloadable form is available from the web (click the button 'Join ASPS'). Please note that form provides an opportunity to make a donation to the RN Robertson Fund if you have not already done so. In addition, please note that Functional Plant Biology has been joined by Beckmann Coulter, Corbett Research, Genesearch and Sapphire Biosciences as valued ASPS Sustaining members. If you know of any company that would be interested in becoming a Sustaining member, please contact Peter Ryan (peter.ryan@csiro.au) with the relevant information.
8. **FASTS**. This is an extremely active organization working on your behalf. To assist members assessing the prodigious output of information by the Federation, a link is available to the FASTS website from the "About ASPS" page.
9. **ASPS Promotional Material**. An ASPS Flier and an ASPS Poster are available on the website as downloadable pdf files (see About ASPS). ASPS member are encouraged to use this material to promote the Society within their institution or elsewhere.

John Patrick
ASPS Hon Sec

DISCIPLINE AND STATE PERSPECTIVES

Meetings of Sydney-based Ecophysiologists

This year has seen the continuation of a series of meetings of Sydney-based plant ecophysiologists. These meetings involve a handful of research presentations and plenty of time to discuss the finer points of ecophysiology over a refreshing beverage. In July we saw presentations from UTS ecophysiologists Sigfredo Fuentes, Cate Macinnis-Ng and Daniel Taylor. October saw three speakers from Forests NSW: Huw Morgan, Bhupinderpal Singh and Craig Barton.

On the behalf of all Sydney plant ecophysiologists I would like to thank Belinda Medlyn for organizing the meetings. The meetings wouldn't exist without Belinda's drive and organization. Thanks are also owed to Derek Eamus and UTS for supplying us with a suitable venue.

Meetings are very informal and friendly and we would strongly encourage any interested people to attend. Please e-mail Belinda Medlyn (b.medlyn@unsw.edu.au) if you would like to be added to the list of Sydney ecophysiologists and kept informed of upcoming meetings. The next meeting will probably be in March 2007.

Charles Warren

Melbourne Plant Group

This year has seen the continuation of the very successful Melbourne Plant Group meetings of the molecular based Melbourne scientists. The meetings are held Monday evenings at the School of Botany, University of Melbourne on a bimonthly basis and usually involve two short (~20 min) presentations; each from a different lab. There is plenty of opportunity for discussion with pizza and drinks between the talks provided by the generosity of the Plant Cell Biology Research Centre. This year there were five meetings with presentations from 10 labs across Melbourne.

The meetings are organised by John Golz (jgolz@unimelb.edu.au) and Ed Newbign (edwardjn@unimelb.edu.au). Please email John or Ed if you wish to be added to the mailing list.

POSTGRADUATE section

We are proud to announce that student members who have recently completed their PhD and had their thesis passed can submit a summary that features in Phytogen. The editors feel that this is an important opportunity for our postgraduate students to showcase their research.

Such successful student members are advised that the summary can be accompanied by a key image in suitable format and that they should submit their items to the editors of Phytogen by the first of April, August or December to appear in the April, September or December issues.

Plant Science in AUSTRALIA

The following summary of Plant-based Enterprise and Plant Science in Australia is intended as an updatable framework that can be used to support the on-going viability of both. It was compiled for the Australian Plant Science Council by Kate Fairley-Grenot (Member, ASPS). Dr Grenot is a former plant scientist (Sydney, Harvard), a Director of Wirra Wirra Vineyards, a Trustee of the Royal Botanic Gardens & Domain Trust, and an Honorary Associate of The University of Sydney.

Actions arising

This Summary indicates that Plant Science in Australia could be further strengthened by:

> Building the membership of plant-related societies, given the estimated 8,000 plant scientists in Australia

> Promoting networks with and within this '$900m' community

> Redressing a recent decline in expenditure on basic research

> Continuing to promote plant science opportunities to government and other funding providers

> Where appropriate, leveraging funds flowing in relation to current national issues (such as water, energy, security, health)

> Leveraging convergence opportunities (such as aquaculture), and structural opportunities, incl. shared infrastructure (such as NCRIS)

> Responding to current interest in bilateral developments (viz ISL Program, PMSEIC 2006), to ensure on-going world-class performance

> Giving immediate attention to human capital risk (viz SET Audit Initiatives 2007), building on existing career development initiatives

> Heightening awareness of the relationship between plant science and 'sustainability' agendas, and

> Continuing to monitor trends in both Plant Science and Plant-based Enterprise in Australia, to enable early attention to emerging weaknesses.

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1. Plant-based Enterprise in Australia

ABARE Australian Economy Overview, Farm Sector, Commodity Statistics 2005; DAFF Stocktake 2005

Summary

- *The combined turnover of plant-based industries in Australia is estimated at $60bn or 5% of GDP*
- *Plant industries show 'mature industry' dynamics: more crops, produced increasingly efficiently and at higher value, but making a diminishing contribution to the overall economy, using less people*

- *Export growth has been strong, but the fact that global production is growing at a faster rate than demand will continue to drive industry dynamics (downward price-pressure, cost-reduction), with implications for R&D budgets and priorities*
- *None-the-less, there is a large, experienced domestic 'catchment' for Australian plant science*
- *This 'catchment' does not naturally mitigate towards global scientific links.*

Plant-related industry is estimated at $60 bn or 5% of GDP:

- *Agricultural (all)* contribution to GDP is 3%
- Processed *food and beverage industry* contribution is a further 2.3%
- *Forestry* products a further 1%
- Biosecurity, environment, marine plants, tourism are additional.

The on-going success of plant industries is a key issue for regional economies:

- 386,000 people are employed in Australian agriculture (all), across 120,000 commercial farms & involving about 60% of the Australian land mass, 13,500 farm businesses
- there are a further 3,400 firms in food and beverage employing 187,000 people
- the forestry industry employs a further 86,000 people and contributes 7.5% to Australia's manufacturing output.

Innovation is an accepted driver in these industries:

- Stocktake 2005 estimates that agricultural R&D has driven 85% of the 2 – 4% per year production growth that has occurred in many sectors – particularly crops – over a sustained period
- Innovation is perceived as a key driver of future

Farm

Australian gross value of farm production in 2004-05 was $36.3 bn. The 2002-05 three year average was $35.2 bn, up 52% from $23.1bn ten years earlier. However, the contribution of farm gross product to national GDP dropped from ca. 3.5% to 2.5% over this period. Of the $36.3 bn, 51% or $18.5 bn was attributable to Crops ($7.4 bn grains and oil seeds, $11.1 bn other). Farm employment (crops *and* livestock) in 2004-05 was 312,000. The 2002-05 three year average was 319,000, down 11% from 360,000 ten years earlier. Contribution to Australian employment dropped from 4.7% to 3.4% over this period and the number of family workers has more than halved. The value of *(all)* Farm Exports was $27.7 bn in 2004-05, with the three year average increasing 57% over the preceding decade. The value of Crop Exports is estimated as 51% of Farm Exports at $14.1 bn (cf 46% of Farm Exports at $8.4 bn in 1994-95).

Food and beverage

The processed food and beverage industry (all) is Australia's largest manufacturing industry with turnover of $66 bn (excl spirits) in 2002-03, contributing around $16.6 bn (2.3%) to Australia's GDP and having grown ca. 11% over the preceding 3 years

Forestry

The value of Forestry Exports was $2.1 bn in 2004-05, with the three year average increasing 123% over the preceding decade. Crop + Forestry Exports together comprise 17% of all Australian Commodity Exports (the remainder being Livestock 14% and Mining 69%) and 10% of Total Goods & Services Exports (includes Merchandise & Services). This is the same as estimated for 1994-95. Land area used for Wheat has increased from 7.9 to 12 m ha over the past decade, and for Other Crops, from 7.5 to 8.5 m ha. Total farm area has stayed fairly constant, but cattle and sheep numbers have declined by 10% over the same period.

Other

The economic contribution of plant-based enterprise in relation to environment, marine industries and tourism is additional to that reported above.

2. Funds for Plant Science

Summary

- *Australia conducts an estimated '$900 million' of plant science annually*
- *Given '$60bn' of plant industry, this suggests an average research intensity of 1.5%*
- *Over 75% of funds are derived from the public purse*
- *Remaining competitive in public programs is critical to the future of plant science*
- *Rural R&D Corporation support has shifted away from pure and basic plant science (and infrastructure) in recent years*
- *On volume, it appears particularly important to sustain plant science within Universities and CSIRO*
- *Support from business support programs continues to strengthen, but slowly.*

The '$60bn+' of plant industry in Australia is supported by approx. $900 million of plant science (all sources), based on ABS statistics coupled with some 'broad-brush' assumptions, detailed below. This equates to an overall R&D intensity of 1.5% which is low, but not atypical for a mature industry. Over 75% of the total is 'public money', channeled through various mechanisms. If BERD alone is considered, the research intensity is 0.2%.

Australian Government support for science *and innovation*, by major program or program category 2005-06 was as follows:

Program or Program category (unmatched)	*$m*	*% Total*	*est. % Plants*
Block funding Higher Education	1,251	22.6	2.6
Other HE research & training	450	8.1	0.8
CSIRO	594	10.7	3.0
ARC	557	10.0	1.0
Non-Tax Concession business R&D&I support	484	8.7	0.87
Cooperative Research Centres	208	3.8	1.7
Rural R&D Corporations	207	3.7	2.4
Energy & Environment	64	1.2	0.3
Tax Concession	491	8.9	0.5
Other major Research Agencies	400	7.2	
NHMRC	432	7.8	
DSTO	330	6.0	
Other	71	1.3	
Total	5,538		13 est. 700m + BERD = $900m

DEST Science at a Glance 2006

25 year trend data for these components are available and show that:

- Support for higher education research and research training has doubled
- Summed support for major research agencies has been fairly constant
- Support for S&T Programs has grown from *ca* 10 to 40% of the current HE allocation, and
- Support for Business R&D&I has grown from *ca* 5 to 40% of the current HE allocation.

Rural R&D Corporations

Report on Survey of R&D Corporation Activities, DAFF 2000

When matching funds and purpose are taken into account, Rural RDCs are a dominant contributor, allocating over $460m to agricultural R&D in 2003-04 (Stocktake 2005). However, since inception, RDCs have undergone a significant shift *away from* pure and strategic basic research, towards development and extension, with diminishing support for core infrastructure:

R&D Category for new RDC Projects, summed for all Corporations (%):

Category	1994 – 95	96 -97	98-99
Pure & strat. basic	40	14	11
Applied	29	42	36
Development	11	13	17
Extension etc	20	31	36

ARC Programs
2004-05 ARC Annual Report
Meanwhile, plant science 'holds its own' in ARC Programs, winning an estimated 10% of funds. At $557m (the 2005-06 ARC total), this would equate to approximately $60 m (p.a.), which should be considered relative to the somewhat larger decline in RDC funding for pure and strategic plant science over the past decade.

	Discovery Projects		Fed Fellows	LIEF	Linkage Internal	Linkage Projects	
	% funded	$ m	% funded	% funded		% funded	$ m
Ag Vet Envt	24	5.4	17	33	33	44	11.7
Biol Sci	30	48.8	15	54	44	49	13.7
Earth Sci	32	19.2	9	56	38	56	4.9
Est 40% plants		*29.4*					*12.1*
All fields	*31*	*298*	*13*	*49*	*52*	*46*	*116*
% Total		10%					10%

Re '10%': 4 of 50 Research Centres; 3 of 24 Research Networks

3. Pattern of expenditure on Plant Science

Summary

- *Plant science is a widely distributed system with some clusters, and is at times subject to the need for proximity to field sites*
- *It is weighted towards applied research, extension and development, with higher education and some commonwealth sites conducting most of the pure and strategic basic research*
- *However, even these show an unusually high level of activity in the applied spectrum, relative to other life sciences (e.g. health and medical), perhaps due to the industry-linked nature of most funding sources, including CRCs and the Rural RDCs*
- *As a result, the 'front end' of the system has become lean and concentrated in pockets. Maintaining critical mass with state-of-the-art infrastructure at these nodes will be key to supporting plant science nationally into the mid-term*
- *Research groups within Higher Education become particularly relevant to determining the nature of infrastructure for high tech / frontier plant science and on-going collaboration will be essential*
- *State Government expenditure by Field shows strengths in NSW in biodiversity, ecological genetics, plant improvement, plant protection and environmental management. Qld government expenditure is strong in population and ecogenetics, plant development and protection. SA government strengths tend towards the applied technologies*
- *A relatively small amount of plant science in Australia is conducted within businesses themselves*
- *There is very limited philanthropic and overseas support, and*
- *There has been marked growth in the 'environmental' contribution to plant science totals over the past decade.*

$900 million
ABS Cat. No. 8104.0, 8109.0, 8111.0

While flow-of-funds has been considered above, this section maps plant science (in broad-brush terms) by sector, and is summarized as follows:

	Total R&D spend $	**Plant-related est. $**	**Plants as % total**
Higher Education (2004)	4.3b	**'300 m'**	**8%**
Government (2002-03)	2.5b	**'400 m'**	**16%**
Business (2004-05)	8.5b	**'190 m'**	**2%**
Unattributed		**'10m'**	
All Sectors	*15.3b*	***'900m'***	***6%***

Across all sectors, it is estimated that 6% of the total sector is in the plant sciences. *If* it is similarly assumed that 6% of total *world* R&D spend is plant-related, then the total world plant science spend would be est. AUD 70 bn, in which case Australia's total spend would be 1.3% of that occurring globally. [US National Science Foundation data for 1990 – 2002 show that R&D expenditure (summed for all fields) is increasing around the world, driven by both governments and industry (NSF Briefing to PCAST, March 2006). Total US and EU expenditure have tracked together over that period and are currently each >USD 200 bn. The OECD total is about USD 700 bn, with non-members showing the greatest recent growth (esp. China) and taking the world total to est. USD 800bn.]

Higher Education

ABS data provided via FASTS for 2000, 2002, 2004; ABS Cat 8111.0

The estimate that higher education expenditure on plant science was ca. 300 m in 2004 is based on the application of % estimates derived from six-digit SEO and RFCD data. The key codes that capture plant science have grown more slowly than overall HERD over the past few years: x 1.4 between 2000 and 2004, compared with overall growth of 1.5.

Higher Education RFCD Codes detailed 2000, 2002 & 2004 (Source ABS)						
		Expenditure $'000			Plants	Plants
Code	Description	2000	2002	2004	est. %	est. $
249901	*Biophysics*	*3,527*	*2,318*	*3,385*	*30*	*1,016*
27	BIOLOGICAL SCIENCES	325,686	410,155	450,955		
2701	BIOCHEMISTRY AND CELL BIOLOGY	73,173	108,245	96,531	45	43,439
2702	GENETICS	62,620	93,653	104,228	25	26,057
2703	MICROBIOLOGY	29,564	28,343	29,671	20	5,934
2704	BOTANY	23,656	30,821	38,306	100	38,306
2707	ECOLOGY AND EVOLUTION	60,850	64,334	75,446	30	22,634
2708	BIOTECHNOLOGY	26,751	27,790	33,654	20	6,731
2799	OTHER BIOLOGICAL SCIENCES	16,156	20,369	29,867	50	14,933
						158,034
29	ENGINEERING AND TECHNOLOGY	311,700	374,546	473,870		
2901	INDUSTRIAL BIOTECHNOLOGY AND FOOD SCIENCES	9,741	7,617	8,856	20	1,771
2911	ENVIRONMENTAL ENGINEERING	6,728	13,995	20,478	40	8,191
2914	MATERIALS ENGINEERING (Timber, Pulp ..)	24,410	25,018	37,084	10	3,708
2999	OTHER ENGINEERING AND TECHNOLOGY (Sensor ..)	17,774	21,786	28,100	10	2,810
						16,481
30	AGRICULTURAL, VETERINARY AND ENVIRONMENTAL SCIENCES	204,783	235,190	291,847		
3002	CROP AND PASTURE PRODUCTION	54,476	59,303	70,915	90	63,823
3003	HORTICULTURE	12,639	20,705	20,296	90	18,267
3006	FORESTRY SCIENCES	16,329	12,108	11,853	90	10,667
3008	ENVIRONMENTAL SCIENCES	31,559	44,279	57,564	50	28,782
3009	LAND, PARKS AND AGRICULTURE MANAGEMENT	4,117	6,359	5,430	80	4,344
						125,884
TOTAL		2,791,623	3,429,597	4,282,781		**301,414**

Detailed SEO Codes - 2000, 2002, 2004 - Higher Education (Source ABS)						
		Expenditure $'000			Plants	Plants
		2000	2002	2004	est. %	est. $
DIVISION 2 - ECONOMIC DEVELOPMENT		800,290	991,845	1,243,485		
6201	FIELD CROPS (wheat, field crops ..)	58,227	60,787	78,643	100	78,643
6202	HORTICULTURAL CROPS (Nursery, grape, veg ..)	18,445	21,732	22,956	100	22,956
6203	FORESTRY (native, hardwood ..)	16,223	11,410	12,082	100	12,082
6204	PRIMARY PRODUCTS FROM PLANTS	1,966	1,708	3,447	100	3,447
6205	SUSTAINABLE PLANT PRODUCTION SYSTEMS	14,006	20,142	28,567	100	28,567
6302	PASTURE, BROWSE AND FODDER CROPS	5,294	7,192	4,624	100	4,624
6605	PREVENTION AND TREATMENT OF POLLUTION	2,992	3,188	2,490	20	498
6701	PROCESSED FOOD PRODUCTS AND BEVERAGES	9,319	10,935	11,384	50	5,692
6702	FIBRE PROCESSING AND TEXTILES; FOOTWEAR AND LEA	699	1,604	2,595	50	1,297
6703	WOOD, WOOD PRODUCTS AND PAPER	2,534	6,367	7,963	80	6,371
						164,176
DIVISION 4 - ENVIRONMENT		160,603	221,074	297,010		
7703	MARINE ENVIRONMENT	26,999	29,389	36,711	25	9,178
7704	COASTAL AND ESTUARINE ENVIRONMENT	24,901	37,521	42,405	35	14,842
7705	URBAN AND INDUSTRIAL ENVIRONMENT	11,205	16,933	34,541	25	8,635
7706	HIGH COUNTRY (INCL. MOUNTAINS)	1,824	2,329	4,125	50	2,063
7707	FOREST AND WOODED LANDS	12,912	25,034	29,865	95	28,372
7708	FARMLAND (INCL. ARABLE LAND AND PERMANENT CROP	14,686	19,408	31,132	95	29,575
7709	SPARSELAND (INCL. PERMANENT GRASSLAND AND THE	5,236	6,570	7,716	90	6,944
7710	MINING ENVIRONMENTS	5,934	5,284	18,099	40	7,239
7711	ANTARCTIC AND SUB-ANTARCTIC AREAS	5,116	3,099	2,701	20	540
7799	OTHER (INCL. ISLANDS)	14,150	23,887	29,029	30	8,709
						116,098
TOTAL		2,789,753	3,429,597	4,282,781		**280,273**

Note: This analysis is not exhaustive, equivalent data are not readily available for the other sectors (gov't, BERD), and there are some reservations about data quality. However, at a macro-level, and for spot-questions by field of endeavor, findings seem to generally align with anecdotal evidence.

Government

ABS Cat 8109.0 2002-03

It is estimated that government expenditure on plant science was ca. $480 m in 2002-03 (new data due Oct 06). Government spend is heavily weighted towards applied research (54%), mainly comprising 'own funds', and distributed in a manner that is largely reflective of production patterns, suggesting a strong focus on 'extension' projects.

Expenditure by SEO by TOA (similar pattern by RFCD)

SEO	Total $m	Pure basic	Strat basic	**Applied**	Exp Dev
Plant prodn & primary plant products (est 80% plants)	377 '302'	19 (5%)	50	**254 (67%)**	54
Environmental Management (est. 20% plants)	473 '95'	20 (4%)	157	**259 (55%)**	37
Plant est.	'400'				
Total	2,482	152	603	**1,338**	389
Plants as %	16%				

Expenditure by SEO by SOF (similar pattern by RFCD)

SEO	Total $m	Own funds, Aust Gov	Own funds, State	Other govt, Aust Gov	Other State/ Local	Business	Joint govt bus	Univ	Other Aus	Overseas
Plant prodn & primary plant products	377	60	153	9	12	13	74	0.04	52	4
Environmental mgt(all)	473	230	127	23	21	1	0.8	.07	1	0.3
Total	2,482	1,206	594	117	76	128	143	7	163	48

Expenditure by SEO by LOC (similar pattern by RFCD)

SEO	Total $m	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Other
Plant prodn & primary plant products	377	66	68	76	32	51	6	7	71	0.8
Environmental mgt (all)	473	103	57	105	19	37	86	17	47	3
Total	2,482	538	545	403	322	197	118	50	297	11

Note: This section reports R&D spend only, in contrast to the overall Australian 'science and innovation' spend reported earlier in this document (5.8bn, incl. HE, tax concession & business support). PNP spend is low (< $1m) and has not been included

Business

Ref ABS Cat 8104.0 2004-05

It is estimated that business expenditure on plant science was ca. $190 m in 2004-05, based on both SEO or RFCD data. This comprises only 2% of total BERD, reflecting the fact that the science that supports plant industry is heavily subsidised:

SEO	Expenditure on R&D $ '000			Proportion of Total Expenditure %		
	2002-03	03-04	04-05	2002-03	03-04	04-05
Plant prodn & primary plant products (est. 80% plants)	76	100	108 '86'	1.1	1.3	1.3
Processed food & beverage (est. 25% plants)	253	288	320 '80'	3.6	3.8	3.8
Wood, wood products & paper (est. 70% plants)	82	111	108 '76'	1.2	1.5	1.3
Environmental mgt (est 20% plants)	38	50	62 '12'	0.6	0.7	0.7
Plant est.			'185'			
Total BERD	6,940	7,648	8,446			
Plants as %			2%			

RFCD Business	Expenditure on R&D $ '000			Proportion of Total Expenditure %		
	2002-03	03-04	04-05	2002-03	03-04	04-05
Biological sciences (est. 50% plants)	189	228	193 '97'	2.7	3.0	2.3
Earth sciences (est 10% plants)	121	147	120 '12'	1.7	1.9	1.4
Industrial biotech & food (est. 10% plants)	192	195	254 '25'	2.8	2.5	3.0
Agric vet & environmental (est. 25% plants)	197	223	225 '56'	2.8	2.9	2.7
Plant est.			'190'			
Total BERD	6,940	7,648	8,446			
Plants as %			2%			

5. Publications/Citations

Including exerpt of analysis by Professor Steve Tyerman, University of Adelaide, based on the ISI Web of Knowledge

Summary

- *Plant science publication data are encouraging and indicate an efficient and competitive system*
- *Plant science should be promoted and supported as both a domestic strength and as an internationally significant component of the Australian science system.*

Australia's plant science publication rate is keeping up with that of the US and UK, but China is accelerating very quickly, albeit from a low base:

- The total number of publications in general plant journals has been increasing with a doubling time of about 18 years. In comparison the doubling times are 27.5 (Australia, sig.), 27.7 (USA, not sig.) and 31.9 (UK, not sig.). China is spectacular with a doubling time of 2 years (sig.)
- The trend for the agriculture and agronomy journals is similar, and
- Australia is still in a growth phase of plant publications, but is lagging behind the growth of total publications in the general plant journals.

Plant science contributes strongly to the Australia's publication profile:

- A summary of Australian scientific publications over the period 2000 – 2004 suggests that 11% of all publications are plant-related:

Field of Research	*% Total*
Plant and animal sciences (take 50%)	5.5
Biology and biochem (take 33%)	2.5
Ecology / Environment (take 33%)	1.4
Agricultural science (take 33%)	1.1
Molec biol and genetics (take 25%)	0.7
Total	11.2

DEST 2006 At A Glance

- Publication growth rates in plant science are *similar* to those for all science in Australia
- When publications are reported as a percent of the world total, Australia's 1st, 4th, 8th categories (from a list of 25 categories used) are plant-related, and
- When citations are reported as a percent of the world total, Australia's 4th, 7th, 9th categories (from a list of 25 categories used) are plant-related.

Australia provides a very good ROI if calculated using publications as a measure of output:

- The 11% of Australian publications estimate above can be considered relative to the earlier finding, that plant science accounts for only 6% of Australian R&D spend

- Further, growth in publications in Australia has occurred with reduced real growth in R&D expenditure over the last decade
- That Australia provides very good *relative* value for the R&D investment in terms of plant/agriculture publications is also suggested by the international comparisons.

6. Human capital

Summary

- *Career paths for people with plant-related training are varied*
- *Plant science alone involves an estimated 8,000 Person Year Equivalents*
- *Growth in environment-related education has been an important aspect of maintaining human capital in plant-related disciplines*
- *As for many SET fields, plant-specific human capital is expected to erode into the mid-term unless action is taken to off-set stated recent declines in student numbers*
- *This will have flow-on effects for research capability given the strong reliance on postgraduates, particularly in the higher education sector.*

Employment

Plant industry

As noted in the opening section of this document, plant industries in Australia employ > 300,000 people, estimated as 50% of the 386,000 employed in agriculture, plus forestry 86,000, plus an allocation (>18,000) for other (environment, etc). This finding is particularly important with respect to spill over benefits in regional (rural and remote) economies.

People with plant-related education (all sectors)

DEST SET Audit Report 2006

There are 197,400 persons employed with natural and physical science *qualifications*, by industry (est. 2004-05 *cf* 1.1 million with engineering qualifications). These are distributed across sectors, highest concentration in education, and business services. Only 3% in agriculture. Growth rate is relatively high for the period 1996-97 to 2004-05, driven by high levels of employment growth in environmental studies, other natural sciences and biological sciences. Lower (but still >30%) projected growth for the period 2004-05 to 2012-13:

ASCED Field Category	Employment Growth 1996-97 to 2004 -05 (%)	Projected Growth 2004-05 to 2012-13 (%)
Environmental studies	97.3	44.7
Forestry studies	61.3	44.0
Other agric & environment	242	37.5
Horticulture & viticulture	72.9	34.5
Agric (gen.)	26.7	31.7
Biological sciences (gen)	70.3	33.8
cf total Engineering	7.1	13.5

Plant science

ABS Cat 8109.0, 8111.0, 8104.0

There are an estimated estimate is 8000 plant scientists in Australia (Person Year Equivalents), distributed as follows:

Sector	R&D $	Total PYE	$R&D per PYE	est. $ Plants	est. people Plants	Indicative composition		
Higher Ed	4.3b	56,809	76,000	'300m'	'4000'	27% acad	16% other	57% pgrad
Govt	2.5b	18,542	135,000	'400m'	'3000'	43% rschr	38% techn	18% other
Business	8.5b	41,656	204,000	'190m'	'1000'	55% rschr	31% techn	14% other
Total					'8000'			

These data indicate a reliance on postgraduate students, particularly for university-based research, and highlight different spending/people patterns across the sectors.

Education

Undergraduate and postgraduate enrolments in [Hort + Forestry + Enviro] over the decade to 2004 have been fairly stable *overall.* Enrolments for biological sciences (all) have also been stable, however, anecdotal comments regarding recent declines in plant science student numbers are noted and suggest that more accurate data are required for this group. Note that, in contrast to other fields (e.g. business studies), Australia has not developed a significant overseas market in natural science education, with associated structural and financial implications.

Undergraduate enrolments

DEST Higher Education Group aggregated data sets, SET Audit Report July 2006

Field	Type	1993	2000	2002	2004
Biological sciences (all)	Domestic	8,277	11,922	11,008	11,506
	Overseas	145	410	1,198	1,325
Horticulture, viticulture	Domestic	1,752	2,034	1,504	1,456
	Overseas	48	28	20	33
Forestry studies	Domestic	306	367	363	312
	Overseas	35	108	195	226
Environmental studies	Domestic	4,213	5,646	6,305	6,396
	Overseas	35	108	195	226
Elec eng	*Domestic*	*17,126*	*19,050*	*1,1466*	*10,232*
	Overseas	*1,651*	*3,428*	*3,483*	*3,974*

Postgraduate enrolments (Id)

Field	Type	1993	2000	2002	2004
Biological sciences (all)	Domestic	3,509	4,009	3,237	3,458
	Overseas	532	726	601	841
Horticulture, viticulture	Domestic	119	151	159	195
	Overseas	19	37	45	25
Forestry studies	Domestic	40	40	105	102
	Overseas	48	13	32	41
Environmental studies	Domestic	1,510	1,412	1,968	2,206
	Overseas	106	252	462	560
Elec eng	*Domestic*	*2,746*	*2,503*	*2,009*	*2,286*
	Overseas	*551*	*1,045*	*1,480*	*2,645*

VET

DEST SET Audit Report 2006

VET completions in the natural and physical sciences have dropped sharply since 2001:

Year	Diploma completions		Certificate completions	
	% of Total	Total number	% of Total	Total number
Natural & Physical sciences (all)				
1996	8.7	2,086	7.3	5,988
1999	9.1	2,431	6.7	11,546
2001	7.5	2,567	5.8	13,486
2002	1.2	483	0.4	864
2004	1.2	371	0.4	813
Agriculture, Environmental & Related Studies (all)				
1996	2.8	678	4.8	3,932
1999	3.1	839	5.3	9,206
2001	4.1	1,389	4.4	10,110
2002	2.3	951	5.1	12,552
2004	3.2	1,001	4.7	9,753

School education and student choice

DEST SET Audit Report 2006

School education is a near-term target area for DEST, based on the recent SET skills audit and associated Youth Attitude Survey findings, which suggest that there is diminishing interest in science as a career choice among students in Years 10, 11, 12.

Migration

Birrell, B et al (2004) Skilled Movements in the New Century: Outcomes for Australia, Monash Univ, via DEST Audit

Occupation	Stock (employed persons 2001)	Net flow over 5 yrs (No.)	Net flow (% stock)
Life scientists	5,227	793	15
Geologists & geophysicists	5,090	733	14
Computing professionals	126,546	17,495	14
Enviro & agr sci professionals	16,613	773	5
School teachers	256,035	1,851	1
Financial dealers & brokers	39,144	523	1

Disclaimer: This Report comprises a 'broad brush' analysis only. It is based on publicly available information and should not be relied on for investment decisions. No responsibility is taken for errors either by act or omission. Parties should refer to the original sources and develop their own assumptions before relying on these findings in any way. In the event of questions, please email grenot@bcpinv.com

Kate Fairley-Grenot

THE PLANT NUTRITION AWARDS

THE PLANT NUTRITION TRUST has been established to encourage and promote research and technology transfer in the mineral nutrition of plants, soil fertility and fertiliser and soil amendment technology, and includes areas where these impinge on other fields such as plant breeding.

THE TRUST invites applications for awards to assist in carrying out a study tour or to attend a conference or such other activity related to the stated objectives.

In 2007 The Alf Anderson award will be made to an outstanding early-career scientist working in the areas mentioned above. More than one award may be made, depending on the applications received.

In making an award an applicant's scholastic achievement and recent contribution to industry, research or technology transfer, and their potential for future contribution will be considered. The amount of each award will depend on circumstances but is likely to be under $2,000.

Applicants must be Australian citizens or permanent residents and be based in Australia,

Applications for the next round close on **23 February 2007**

Application forms can be obtained from:

Dr Peter Randall
CSIRO Plant Industry
GPO Box 1600
Canberra ACT 2601

Fax: (02) 6246 5000
e-mail: Peter.Randall@csiro.au

About the Plant Nutrition Trust - The Management Committee has included people associated with the Fertiliser Industry Federation of Australia, the Australian Institute of Agricultural Science, the Australian Society of Soil Science, the Australian Society of Plant Scientists and the Australian Soil and Plant Analysis Council. The funds come from surpluses from International conferences held in Australia and donations from The Sulphur Institute, ASPAC and individuals. **Further donations are welcome.**

Focusing on one state's research per edition

This edition:

The WAITE South Australia

Collated by Chris Ford
(the Council representative resident in SA)

Welcome to the feature article highlighting some of the research in plant science by ASPS members from the WAITE institute, South Australia.

The Salt focus group at the Australian Centre for Plant Functional Genomics

Group members: Jairus Bowne, Scott Carter, Olivier Cotsaftis, Damian Drew, Yusuf Genc, Marilyn Henderson, Andrew Jacobs, Deepa Jha, Alex Johnson, Inge Skrumsager-Møller, Jeremy Pinyon, Darren Plett, Alireza Rivandi, Stuart Roy, Gehan Safwat, Yuri Shavrukov, Katrina Smoult, Joanna Sundstrom, Mark Tester

Salinity is a major abiotic stress affecting crop plants in Australia with predictions that 13.7 million ha of agricultural land will be affected by dryland salinity by the year 2050 and a larger area by transient salinity.

As a broad generalisation, it has been found that crop plants which produce the highest yields in saline soils have the lowest concentrations of sodium (Na^+) accumulating in the shoots. Shoot accumulation of Na^+ is controlled mainly by the influx of the ion into the roots and its transfer from the root to the shoot. We, at the Adelaide node of the ACPFG salt group, hope that by understanding and altering these pathways it will be possible to modify our crop plants ensuring that they survive and produce viable yields on those areas of land affected by salinity. We hope to further identify the genes and cellular processes involved in salt tolerance, both in our current crops and in other resistant plant lines, so that these traits can be introduced into commercially available crops.

To achieve this goal we are taking two complementary approaches, the first of which is a forward genetic approach, where genetic loci and genes that are linked to Na^+ exclusion are being identified in crops plants (such as wheat, barley and maize) and in Arabidopsis. Already we have isolated a number of landraces of wheat and barley which have reduced Na^+ in the shoot, compared to standard Australian cultivars, and these have now been crossed with commercially available lines to investigate the benefits of such crosses. In addition we have also been using recombinant inbred lines created from crosses between different Arabidopsis ecotypes, from different genetic and

environmental backgrounds, to map traits for Na^+ exclusion from the shoot. Already we have identified 5 QTLs of interested and are currently investigating candidate genes that lie beneath the QTL.

The second approach in our lab is a reverse genetic approach, where candidate genes which confer salt tolerance which have been identified from a variety of organisms, not necessarily crop plants, are being inserted into both crops and Arabidopsis to investigate their effect on Na^+ exclusion.

A key aspect of the latter approach will be cell specific and temporal gene expression; the ability to express the candidate genes in specific cell types of a plant at a specific time. This is important as the expression of a gene may have beneficial effects in one part of the plant but at the same time be detrimental in another. Systems in both rice and Arabidopsis have been developed for the spatial and temporal regulation of genes involved in salt exclusion and already research carried out in our lab has shown the importance of cell specific expression of Na^+ transporters in the roots of both species which results in reduce Na^+ accumulation in the shoot.

Finally, an important factor in our research is the continued development of methodologies and techniques to allow us to continue our research. As such we are striving to improve methods for plant transformations, laser dissection, cell sorting and map based cloning.

All in all we find it a very exciting time in the salt group.

Members of the ACPFG salt focus group

Understanding the genetics of meiosis in cereals

The Genetics of Meiosis in Cereals research group is led by Dr Jason Able. We are located at the Waite Campus within the Waite Main Building. The research is principally funded through the Molecular Plant Breeding CRC and the GRDC. The group has a close affiliation with several members of the Australian Centre for Plant Functional Genomics (ACPFG), including Professor Peter Langridge. We also have excellent collaborative linkages both nationally with Professor German Spangenberg from DPI Victoria; and internationally with Professors Graham Moore and Peter Shaw at the John Innes Centre, Norwich, England. We are also in the process of strengthening our collaborations with Dr Glyn Jenkins who is at the University of Wales, Aberystwyth and Professor Zac Cande who resides at the University of California (Berkeley).

THE UNIVERSITY OF ADELAIDE AUSTRALIA

MPB CRC

GRDC Grains Research & Development Corporation

Our Research Themes

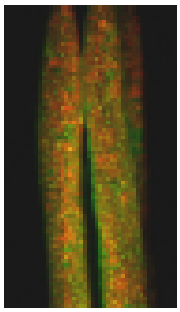
- Investigating recombination in bread wheat with the aim of being able to manipulate this process.
- Investigating the process of chromosome pairing and working towards understanding what genes control the pairing complex that is prevalent in the hexaploid wheat genome.
- Investigating the meiotic transcriptome (the 'meiome') in bread wheat, enabling the identification of candidate genes that are 'novel' and that have a role in meiosis in bread wheat.

The 'Able Group' is currently composed of young aspiring scientists either in their Honours year or completing their PhD candidature.

Current Members: Research Highlights

- **Scott Boden – PhD Candidate (commenced April 2006)**

Determining the role of TaASY1 in chromosome pairing and synapsis during prophase I of meiosis in bread wheat

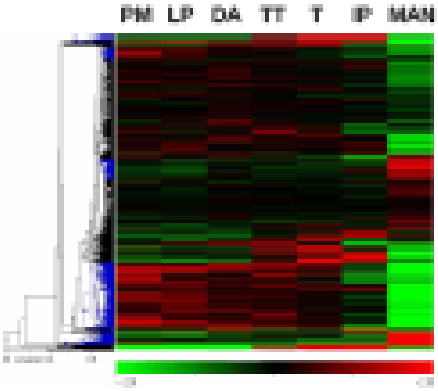


proTaASY1:GFP detection in wheat anther

Mutants of *ASY1* genes in *Arabidopsis* and rice have a severely reduced ability to successfully synapse homologous chromosomes during the progression of early prophase of meiosis I. We are attempting to use ASY1 from hexaploid bread wheat to better understand the molecular mechanisms controlling homologous chromosome pairing and synapsis. During meiosis in bread wheat, chromosomes strictly pair with their homologue even though homoeologues are present. This project also includes analysis of mechanisms controlling meiosis specific expression of *TaASY1* through promoter analysis. The project is using many protein based techniques as well as genetic techniques to address such objectives. This research is funded through both the MPB CRC and the GRDC (Project No. GRS103) under which Scott has been awarded a Grains Industry PhD Scholarship.

- **Wayne Crismani – PhD Candidate (commenced mid-2006)**

The bread wheat 'meiome': Working towards identifying the key players that have a role in homologous recombination



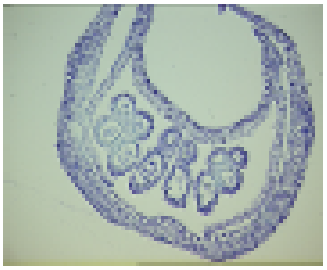
Hierarchical clustering of 1,350 meiotically-regulated transcripts

This research project is focussed on understanding the homologous recombination pathway in bread wheat. To date both microarray and Q-PCR platforms have been used to provide a starting point for this research. The microarray was a time course with seven meiotic time points. The data generated from this experiment has provided a source of new meiotic genes from which to conduct further research. From this pool of candidate genes, several have been selected that will be extensively characterised. Their selection was based on being meiotically regulated during the early stages of Prophase I as well as being novel transcripts that showed no similarities to any other sequence in the publicly available databases. A series of genetic and biochemical techniques will be employed to characterise these candidates.

- **Hayley Jolly – PhD Candidate (commenced 2007)**

Functional characterisation of candidate genes with a role in chromosome pairing in bread wheat

Through the use of genetic and proteomic technologies, several candidate genes from the abovementioned array will be characterised to determine their role(s) in the process of chromosome condensation and pairing during meiosis. The technologies typically employed throughout the study will include basic expression experiments (Southern and northern analysis), RNA *in situ* hybridisation, protein co-localisation, yeast-two-hybrids and western analysis. Investigating both wild-type and transgenic wheat plants with the candidate genes over-expressed or 'knocked-out', it is envisaged that we will have a better understanding of the pairing control process between homologous and homoeologous chromosomes. If successful, this project has the potential in allowing for the development of new controlled introgression strategies that will assist cereal breeders of the future.

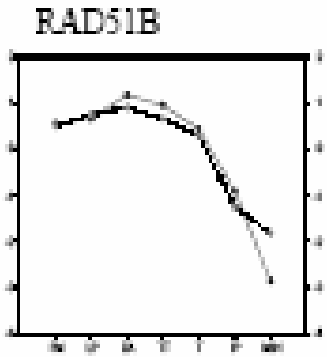


Cross-section of a spike at leptotene (Prophase I)

- **Kelvin Khoo – Honours Candidate (commenced 2007)**

Working towards a greater understanding of the role of RAD51 in bread wheat during meiosis

A large number of genes involved in the mediation of recombination have been characterised in the simple eukaryote, yeast. While limited, plant scientists have been able to draw some parallels from these characterised genes, elucidating orthologues in several plant species. We have

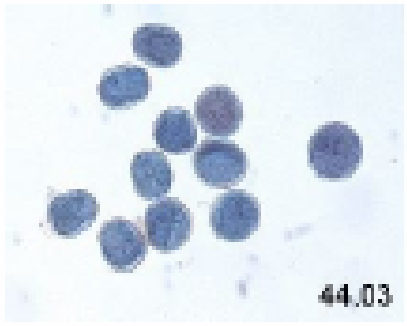


Correlation of microarray and Q-PCR for RAD51B (see Crismani et al. 2006 for further details).

Identified a RAD51 orthologue from bread wheat that shares high levels of similarity with RAD51 proteins from other organisms including moss, humans and mouse. Through genetic and protein approaches, we will gain an understanding of what role RAD51 has in bread wheat during meiosis. Expression analysis and identification of which chromosome group this gene resides on will be conducted. During this project we also aim to study the localisation of RAD51 using a series of wild-type control plants and wheat mutants that have been produced through genetic engineering. These mutants have been produced with our collaborators (Prof. Spangenberg *et al.*) at MPB CRC in Melbourne.

- **Caroline Bartel – Honours Candidate (commenced 2007)**

Functional analysis of TaSSRP1 transgenic wheat plants: Is there a role in recombination?



Non-viable pollen from barley transgenics. The pollen in this photo have been stained with trypan blue. This dye is taken up by the pollen grain when the integrity of the membrane has been compromised.

We aim to determine what role *TaSSRP1* has in the process of homologous recombination during meiosis in bread wheat. This analysis will be conducted on transgenic wheat plants that were produced with our collaborators in Melbourne (Prof. Spangenberg *et al.*). These plants have had the *TaSSRP1* gene either (a) over-expressed; or (b) knocked-out using RNAi. Techniques conducted throughout the Honours project will include expression analysis via northerns, RNA *in situ* hybridisation and Southerns. A proportion of the research will examine whether the reproductive structures (including pollen) have been altered as a result of *TaSSRP1* expression. It is envisaged that the outcomes of this project will lead to a better understanding of the role that *TaSSRP1* has in the process of recombination in wheat.

Key Papers

If you would like to know more about our research, we draw you attention to the following papers that are easily accessible on-line (or soon will be). Alternatively, if you are a student and would like to consider this avenue of research as a career path contact me at: jason.able@adelaide.edu.au, as we have a number of projects that are suitable for both Honours and PhD students ready to go.

- Able JA *et al.* (2007) *Trends Plant Sci.* 12 (2): (In Press)
- Crismani W *et al.* (2006) *BMC Genomics* 7: 267 (DOI: 10.1186/1471-2164-7-267)
- Able JA & Langridge P (2006) *Trends Plant Sci.* **11** (6): 261-263
- Whitford R *et al.* (2006) *Funct. Integr. Genomics* DOI: 10.1007/s10142-006-0026-3
- Dong C *et al.* (2005) *Funct. Plant Biol.* 32: 249-258
- Sutton T *et al.* (2003) *Plant J.* 36: 443-456

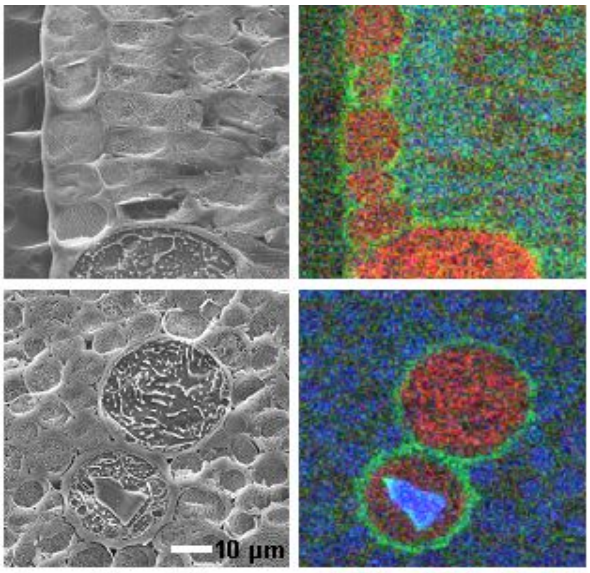
Plant Cell Physiology Group

School of Agriculture, Food and Wine, University of Adelaide
Roger Leigh (Head of Group), Matthew Gilliham (Senior Research Fellow)

We are a new laboratory group to the University of Adelaide (and Australia) having been established in October following Roger's appointment as Head of the School of Agriculture, Food and Wine. Roger moved from Cambridge in the UK where he was Professor of Botany at the University of Cambridge and Head of the Plant Sciences Department. Matthew obtained his PhD at Cambridge during this time and has since undertaken a Research Fellowship with Steve Tyerman, in Adelaide, and a Postdoctoral role with Mark Tester and Julia Davies in Cambridge.

The main focus of our research is concerned with uncovering the mechanisms, and the physiological significance, of the cell-specific nutrient storage seen within higher plants. To this end we use a large range of tools, integrating both whole plant and single cell based biochemical, (electro-) physiological and molecular assays.

Although it has been widely observed that plants often take up nutrients in excess of their immediate needs and store the extra in cell vacuoles, it is a less well known that the resulting nutrient storage pools in different plant cell-types are often compositionally distinct. For instance, phosphate and calcium (Ca) appear to never co-localise in the same leaf cell whereas magnesium, potassium, chloride and nitrate may share similar cellular locations but can be at very different concentrations in different cells. We have recently conducted a survey of leaves from over 30 phylogenetically distinct species and discovered two dominant distribution patterns of cell-specific Ca accumulation. In grasses, vacuolar Ca is present at high concentrations in epidermal cells but at much lower levels in mesophyll cells. In contrast, in the majority of eudicot species Ca is at a high concentration in the palisade and spongy mesophyll cells but not in epidermal cells. At present, the mechanisms behind these patterns in Ca distribution, and their physiological significance, are unclear. It is envisaged that such knowledge may ultimately allow the nutritional enhancement of crop plants (and consequently fortification of animal and human diets) without adversely affecting crop plant physiology.



Images taken with the cryo-SEM of a rough lemon leaf showing cell-specific ion accumulation

We are working closely on this project with Steve Tyerman and Brent Kaiser and our laboratories are all co-located at the Plant Research Centre at the Waite Campus. We have also continued our close collaborations with Mark Tester (also at the Waite) and Richard Storey at CSIRO, Merbein and we are in the process of establishing new local and national collaborations in related research matters.

Currently we are recruiting staff, PhD and Honours students for the above and additional research projects. If you are interested in research opportunities in our laboratory, collaborating with

us or would simply like further information please visit;

http://www.agwine.adelaide.edu.au/research/plant/plant_phys/pcp/index.html

We are excited about our upcoming years of research in Adelaide and the new opportunities Australia brings. We are also looking forward to meeting fellow members of the ASPS and to discussing our and other research with you all.

Grapevine biochemistry and molecular biology

Chris Ford; Matt Hayes; Vanessa Melino; *Crystal Sweetman, *Kathy Soole.

School of Agriculture, Food and Wine, The University of Adelaide and *School of Biological Sciences, Flinders University

One of the research programs underway in our laboratories focuses on the processes by which grape berries make and accumulate L-tartaric acid (TA). Despite differing from the commonly accumulating L-malic acid (MA) by just a single hydroxyl group, TA is made through an entirely separate pathway. Briefly putting on my Oenology lecturer's (hard) hat, I will explain why this acid is so important in wine and its production. During the earliest stages of development, grape berries accumulate tartaric and malic acids; as the berries ripen further they begin to accumulate sugars and decrease their levels of acidity. During berry ripening, malate is metabolised, but levels of tartaric acid remain constant per berry. At harvest and thereafter, winemakers must for a number of reasons maintain pH levels around the mid to low 3's, and they commonly do this by adding solid tartaric acid to the must (crushed grapes). In Australia, the hot climate results in well-ripened grapes; consequently acid levels drop significantly compared to those found in grapes ripened in 'old world' regions, and often up to 8 g/L of tartaric acid may be required to bring the pH down to desired levels. Across Australia, this adds up to something like $40 M per annum spent on *imported* tartaric acid in a hot year.

Given its undoubted importance in winemaking, it's perhaps surprising that little is known of tartaric acid's biogenesis, or of the ways in which its levels may be manipulated by cultural practices during grape growing. Tartaric acid has intrigued scientists for years, Louis Pasteur first made his discoveries of the chiral nature of compounds after studying tartrate crystals under the microscope, and between the 1960's and 80's in the USA and Japan, Frank Loewus and Kazumi Saito among others elucidated a number of pathways by which its formation from various precursors could occur. In grapevines, their results suggested that ascorbic acid undergoes a series of oxidation and cleavage steps to yield tartaric acid.

We are currently investigating the biochemical and molecular basis of tartaric acid biosynthesis, using a combination of genomics and enzymological approaches. We began in 2003, when Seth DeBolt joined my lab as a PhD student on a CRC Viticulture Scholarship. Our early work demonstrated that in addition to TA formation, grape berry tissue contains cells in which ascorbic acid is metabolised to form oxalic acid, resulting in formation of needle-shaped raphide crystals of calcium oxalate[1]. In collaboration with Prof. Doug Cook from UC Davis, with whom Seth spent several months during his candidature, we completed *in silico* analysis of berry transcript levels from over 50 fully-sequenced cDNA libraries. Candidate sequences of homologues to enzymes involved

with individual steps in the putative ascorbate-to-tartrate pathway were identified in grapevine libraries and expressed and characterised for their ability to promote the specific reactions in vitro. From this work we identified a number of potential candidates, with enzymatic activities corresponding to the proposed steps in the pathway. One of these candidate sequences encodes L-idonate dehydrogenase, previously not recorded in plants. We showed that the gene encoding this enzyme was absent from grapevines that lack TA synthetic capacity, thereby providing the first biochemical and molecular evidence for the basis of TA synthesis in plants[2].

Vanessa Melino, who began a GWRDC-supported PhD in mid-2005, is extending this research to study the metabolism of ascorbate during berry ripening, which we believe will illustrate some intriguing subtleties in the dynamic between its use as an in vivo antioxidant and as a precursor for biosynthesis of tartaric acid[3]. In addition, we are continuing to examine the synthesis of TA, with biochemical and molecular investigations of other candidate sequences. Matt Hayes, recently appointed to a post-doc position in the lab, is developing assays for a number of enzymes believed to play a role in the conversion of ascorbate to TA. We are also examining links between berry exposure to light during development and organic acid levels, and the collaboration with A. Prof. Kathy Soole at Flinders Uni. is enabling us to examine the links between organic acids and respiratory control during berry development. Crystal Sweetman, a recently appointed PhD student in Kathy's lab., is examining aspects of MA metabolism during berry development to enable us to compile a total picture of organic acid synthesis in this most important of horticultural crops.

Chris Ford

References

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2. DeBolt, S., Cook, D.R. and Ford, C.M. (2006) L-Tartaric acid synthesis from vitamin C in higher plants. Proc. Natl. Acad. Sci. (USA) **103**, 5608-5613.

3. DeBolt, S., Melino, V.J. and Ford, C.M. (2007) Ascorbate as a biosynthetic precursor in plants. Annals of Botany (in press).

Functional Plant Biology

Summer 2006 - 2007 Update

Another girl for Jennifer Henry!

FPB Editor Jennifer Henry is currently on maternity leave following the only slightly early arrival of her second daughter, April Bridget, on 6 November. Jennifer returns to work in late-April 2007 but until then, I will be looking after FPB. During this period we also welcome Danielle de Maio in production. Danielle comes to us with a Bachelor of Applied Science from RMIT and extensive journal production experience, most recently with *The Lancet* in London.

Goldacre Paper

We are pleased to announce that the 2005 Goldacre Paper, 'Rapid cell expansion and cellulose synthesis regulated by plasmodesmata and sugar: insights from the single-celled cotton fibre' by Yong-Ling Ruan, will be published in Issue 1 of the Journal. This issue is scheduled for online publication in mid-January 2007.

Forthcoming and recent Special Issues

We are currently receiving submissions for two exciting Special Issues of the Journal, scheduled for publication in early–mid-2007. The first will be a commemorative issue of papers arising from selected presentations at the international symposium held in memory of **Vincent R. Franceschi** at WSU in June 2006, guest edited by Gerry Edwards. The second will contain papers arising from presentations made in the **Carbohydrate Metabolism** symposium of the 8th International Congress of Plant Molecular Biology (Adelaide, August 2006), with Guest Editor Alison Smith. The issue will also feature papers from selected abstracts submitted for the symposium. Both Special Issues will feature mini-reviews and original research papers.

FPB published two Special Issues in 2006, Ecofizz II and Legume Genetics and Genomics, arising from the Ecofizz 2005 meeting and the International Conference of Legume Genomics and Genetics III, respectively. Both issues have attracted a high level of interest and it has been pleasing to see that papers from these issues have been heavily downloaded and are beginning to pick up citations.

New NCBI/Genbank service to authors

As a new service to authors, we are now alerting NCBI when we publish a paper containing a new Genbank accession number. This means that the paper will be automatically listed by NCBI and the DNA sequence reported as a Genbank accession publicly released at the time of publication. This is another example of the value added to papers by publishers such as **CSIRO** Publishing (see FPB Spring Update in the previous edition of Phytogen for a more extensive list of benefits).

Farewell to Dr Owen Atkin

After 6 years of excellent service, and a fabulous Evans review (**The hot and the cold: unravelling the variable response of plant respiration to temperature,** FPB 32/2, Feb 2005, with 13 citations already), Owen Atkin will retire from the Editorial Board of FPB at the end of 2006. Owen has been appointed as an Editor of New Phytologist. We thank him for his hard work for the FPB and wish him well in his new role.

That's all from FPB for 2006. Have an enjoyable summer break,

Amanda Ellery.
Managing Editor

From Our Seed Banks

Meeting reports provided by members from around the country

We welcome meeting reports from all local and international meetings. Please contact Andy Netting (co-ordinating editor) at anetting@unsw.edu.au for further details.

ComBio 2006, 24-28 September 2006

This was another example of a successful ComBio meeting. There were several streams of plant science talks – often two sessions competing for the attention of plant scientists. Some highlights:

- Peter Dodds presenting the 2006 Peter Goldacre Lecture on the recognition of haustorially expressed rust avirulence proteins in flax and the delineation of the molecular basis of plant pathogen interactions
- TJ Higgins presenting the RN Robertson Lecture on genetically modified legume grains for field performance and product quality where he expounded on the importance of testing heterologous expression of genes in a case by case basis.
- Stephen Long who presented the Annals of Botany lecture on mechanisms of plant response to atmospheric change where he introduced results from "free air concentration enrichment" (FACE) experiments. The FACE system allows predictions of climate change to be tested on open air field crops. FACE results indicate that fertilization effect of CO_2 is about half of the predicted levels while rising onzone levels could cause large crop yields.
- The ASPS dinner which was prepared by TAFE students and brought together many plant scientists for an enjoyable evening.
- The excellent poster sessions (prizes detailed below) and trade exhibits

Peter Dodds receiving the Peter Goldacre award from Jennifer Henry (Functional Plant Biology) and Steve Tyerman (president of ASPS).

- The student posters were excellent and the judges had a difficult task deciding upon the winners of the poster prizes and student oral presentation. They were: Christian Gruber - Portland Press Award; Elizabeth Dun - ASPS Best Oral Presentation; Iain McConnell; Megan Shelden and Jo Tilbrook – ASPS Poster prizes. The abstracts for these posters are presented below.

PLANT PROTEIN DISULFIDE ISOMERASE: ENZYME MECHANISM AND ACTIVITY

Gruber C.W.[1], Cemazar M.[1], Horibe T.[2], Renda R.[2], Anderson M.A.[2] and Craik D.J.[1]
[1]Institute for Molecular Bioscience, University of Queensland, QLD, Australia. [2]Department of Biochemistry, LaTrobe University, VIC, Australia.

We have isolated a protein disulfide isomerase (PDI) sequence from *Oldenlandia affinis*, a plant that produces knotted circular proteins called cyclotides. The PDI from this plant contains an unusual non-acidic C-terminal domain and an uncommon glutamine residue following the active site motif compared to other known PDI proteins. For the first time, to our knowledge, the biochemical properties of a plant PDI have been characterized by means of enzyme activity assay and biophysical methods. Additionally the plant enzyme was used for peptide folding analysis *in vitro* using RP-HPLC, MALDI-TOF mass spectrometry and NMR. PDIs are major folding catalysts in the eukaryotic endoplasmatic reticulum. They contain two highly conserved thioredoxin motifs (CXXC) in the active sites responsible for oxidation (formation), reduction (breakage) and isomerisation (shuffling) of disulfide bonds in substrate polypeptides. Furthermore, PDIs are important as chaperone in the secretory pathway. Novel information from this study could be important to protein folding applications in medicine and biotechnology. At the same time novel knowledge about physiological roles and evolution of this enzyme will be obtained. Recombinant full-length PDI was expressed soluble as 6xHIS fusion protein in *E.coli* and purified using metal affinity and size exclusion chromatography. Reduced and oxidized proteins were structurally characterized with circular dichroism and ^{1}H NMR. Isomerase and chaperone assays *in vitro* as well as analysis of redox properties suggest novel activities for this plant PDI protein compared to human PDI and human P5 proteins. Folding assays with small, disulfide-rich peptides gave a first insight into the function of the plant protein folding catalyst.

COMPUTATIONAL ANALYSIS OF FLOWERING IN PEA

Wenden B.[1,2], **Dun E.A.[2]**, Hanan J.[2,3], Weller J.[4], Beveridge C.A.[2] and Rameau C.[1]
[1]INRA Versailles, Station de génétique et d'amélioration des plantes, 78026 Versailles, France. [2]ARC Centre of Excellence for Integrative Legume Research, Brisbane, Queensland, Australia. [3]ARC Centre for Complex Systems, Brisbane, Queensland, Australia. [4]School of Plant Science, University of Tasmania, Australia.

Pisum sativum (garden pea) has been used as a model species for several decades to investigate the genetic and environmental control of flowering. Studies using a large series of non-allelic flowering mutants led to the development of a model incorporating photoperiod and photoperiod response genes, two mobile flowering signals, and genes controlling a response threshold. The outcome of interactions in this potentially complex network determines the node of floral initiation. Computational approaches allow unbiased testing of the model hypotheses and their consistency with experimental data. We are therefore developing a hypothesis-driven computational model of the genetic regulatory network that controls the node of floral initiation in pea and its response to photoperiod. The approach entails developing a semi-quantitative rule-based description of the hypotheses. The model will be used to identify key experiments required to test the accuracy of hypotheses about the regulation of floral initiation in pea.

CHARACTERISATION OF THE CARBONIC ANHYDRASE ACTIVITY ASSOCIATED WITH THE PHOTOSYSTEM II TRANSMEMBRANE PROTEIN COMPLEX

McConnell I.L., Wydrzynski T. and Hillier W.
Research School of Biological Sciences, The Australian National University, Canberra, ACT, 0200, Australia.

Photosystem II (PSII) is a membrane imbedded, pigment-protein complex that catalyses the photosynthetic oxidation of water into molecular oxygen. The complex consists of over 25 protein subunits with a total molecular mass of > 220 kDa. Several of the subunits are extrinsic hydrophilic proteins and attach to the lumenal side of the PSII complex. Recent reports have suggested that carbonic anhydrase (CA) activity is associated with both the intrinsic and extrinsic parts of the PSII complex and that bicarbonate may be a cofactor for the water oxidizing process. However, bicarbonate is not an alternative substrate in the water oxidizing process. [W.Hillier, I. McConnell, M.R. Badger, A. Boussac, V.V. Klimov, G.C. Dismukes & T. Wydrzynski (2006) *Biochemistry* 45, 2094-2102]. CA catalyses the equilibrium reaction: $CO_2 + H_2O$ <--> $HCO_3^- + H^+$. The CA enzymes are ubiquitous, ancient enzymes that occur across all domains of life. There are at least four separate classes of CA, based their primary structures. Due to the very low CA activity in PSII samples, we have used measurements employing a very sensitive equilibrium method incorporating isotopic 18O labelling and Membrane Inlet Mass Spectrometry (MIMS). Preliminary data indicate that the PSII-associated CA activity is variable but may have two kinetic components. We report our analysis of this apparently novel class of CA activity with reference to other studies.

IDENTIFICATION AND CHARACTERISATION OF AQUAPORINS IN THE GRAPEVINE, *VITIS VINIFERA*

Shelden M.C.[1, 2], Kaiser B.N.[1, 2] and Tyerman S.D.[1, 2]
[1]Cooperative Research Centre for Viticulture, Plant Research Centre, Hartley Grove, Urrbrae, SA 5064. [2]Discipline of Wine and Horticulture, Plant Research Centre, Waite Campus, University of Adelaide, Urrbrae, SA 5064.

Plant aquaporins belong to a large superfamily of proteins, the Major Intrinsic Proteins (MIPs). In many plant species the expression of aquaporin genes and their regulation has been linked to water stress, and recently it has been hypothesised that aquaporins may play a role in embolism repair. The aim of this project is to identify and characterise aquaporin genes from grapevine, and ultimately assess the role of aquaporins in embolism and embolism recovery. We have screened a *Vitis vinifera* cv. Cabernet Sauvignon cDNA library for aquaporin cDNAs encoding members of the Plasma membrane Intrinsic Protein (PIP) and Tonoplast Intrinsic Protein (TIP) subfamilies. We have isolated 9 full length and 5 partial aquaporin cDNAs. Sequence analyses of the full length cDNAs reveal 5 of these are homologous to the PIP2 subfamily, and two each to the PIP1 and TIP subfamilies. Functional expression in *Xenopus* oocytes showed PIP2 members have significantly higher water permeability compared to PIP1 aquaporins. VvPIP2;1 showed very high water permeability which was reduced by acidic cytosolic pH, as has been reported for other members of the PIP2 family. Of particular interest is VvPIP2;2 which has high sequence homology with the walnut AQP JrPIP2, recently postulated to be involved in embolism refilling. Using both semi quantitative PCR and qPCR we have shown tissue specific expression of aquaporin genes. Currently we are using qPCR to look at expression of these genes in response to water stress in the water conducting pathway of the petioles of grapevine.

HYDRAULICS AND CELLULAR VIABILITY OF GRAPE BERRIES DURING DEVELOPMENT

Tilbrook J.[1, 2] and Tyerman S.D.[1, 2]
[1]CRC for Viticulture. [2]University of Adelaide.

Berries of *Vitis vinifera* L. cv Shiraz can undergo weight loss during later stages of ripening while other varieties such as Chardonnay and Sultana are less prone to this phenomenon. To examine the contribution of xylem to water flow into or out of the berry during ripening we have measured the hydraulic characteristics of Shiraz, Chardonnay and Sultana berries using the pressure probe and the Xyl'em^{TM}system. We examined the flow characteristics into and out of the berries at different stages of development. For flow **into the berries** there was a gradual reduction in hydraulic conductance (L_o) for all varieties after veraison, where Shiraz and Chardonnay showed similar values and Sultana had much higher values. We also determined the L_o for flow **out of the berries** for Shiraz and Chardonnay. Here we observed a ten fold higher L_o for Shiraz that was similar to L_o for flow in to the berry at the equivalent stage of development. This indicates that Shiraz and Chardonnay have contrasting hydraulics. Chardonnay is able to rectify flow in some way so that the system acts like a valve preventing flow out of the berry. For Sultana this comparison could not be done because very negative pressures had to be applied which caused cavitation. The cell membranes of the berry are likely to play a role in these phenomena so we examined the changes in cell leakiness using vital stains at key stages in development. Two stains were used, fluorescein diacetate (FDA) and propidium iodide (PI). Both stains showed loss of cell membrane integrity during later stages, but PI showed a sudden accessibility of DNA that then subsided just after the peak in berry weight.

Plant Nutrition Trust Awards 2006

Report from Peter Randall

In 2006, three scientists were successful in obtaining Plant Nutrition Awards.

Joanne Castelli is a Research Associate in the School of Biomedical, Biomolecular and Chemical Sciences at The University of Western Australia, and was supported to attend the 13th International Symposium on Iron Nutrition and Interactions in Plants held in Montpellier, France. Joanne presented a poster on her work with David Day and Martha Ludwig with the title "*Gm*YSL1, a putative iron chelate transporter in symbiotic soybeans".

Joanne summed up the value of her trip - "The experience, contacts and ideas for further research I have gained from attending this conference will be invaluable for my continuing work…".

Clayton Butterly is a PhD student at the Waite campus, University of Adelaide working with Petra Marschner, Jeff Baldock and Ann McNeill. He received support to present his work on "Drying and wetting cycles and phosphorus dynamics" at two conferences (3rd International symposium on phosphorus dynamics in the soil-plant continuum held in Uberlandia, Brazil; and the World Congress of Soil Science in Philadelphia, USA). He also spent time in the Lab of Professor Mary Firestone at UC Berkeley and visited Rothamstead Research Institute in the UK.
Clayton wrote "The overseas travel has helped me to develop contacts, linkages and also receive discussion and feedback on my (PhD) project. The interaction with researchers and other postgraduate students was invaluable".

Geoffrey Anderson of the Department of Agriculture and Food, WA travelled to the World Congress of Soil Science in Philadelphia, USA and presented a poster paper, based on his published work with Ian Fillery, with the title "Sulfate sorption by agricultural soils in Western Australia".

In addition to the 2006 winners (above), **Jason Condon**, who lectures at Charles Sturt University and was the recipient of the Sam Tisdale award of the Plant Nutrition Trust in 2005. His award assisted him to travel to Viet Nam in January 2006 to spend a 5 month sabbatical leave at the College of Agriculture and Applied Biology, Can Tho University, Can Tho City in the Mekong Delta region. Jason gave seminars, lectured to students, talked to colleagues and worked on a project on nutrient levels and the survival and production of Artemia, an aquatic organism farmed in ponds and used to feed intensively farmed shrimp.
Jason reported that his experience in Vietnam had been one of the highlights of his career to date. It gave him the opportunity to work with and understand Asian cultures, meet many scientists from a wide range of institutions in Asia and Europe and to create an awareness in Viet Nam of the expertise available in Australia and in Charles Sturt University. His visit has opened several opportunities for further collaboration with Can Tho University.

Plant Nutrition Trust Report – Joanne Castelli (2006 Alf Anderson Award Recipient)

I was very pleased to receive the Alf Anderson Award for 2006 from the Plant Nutrition Trust in order to attend the 13th International Symposium on Iron Nutrition and Interactions in Plants. The conference was held in Montpellier, France, from the 3rd to the 7th of July this year, and was attended by scientists from around the world from a broad range of disciplines. The goal of the conference was a better understanding of the effects of the interactions between soils, microbes, plants, animals and human beings on the iron nutrition of plants. The themes of the sessions reflected this goal and were divided into topics of iron chemistry and the environment, iron and plant/microbe interactions, plant iron uptake and regulation, iron distribution and compartmentation within plants, plant iron metabolism, the diagnosis of iron deficiency and its correction by agronomical or breeding methods, plant iron and human nutrition, and iron-trace elements interactions and phytoremediation of contaminated sites.

At the conference I presented a poster entitled "*Gm*YSL1, a putative iron chelate transporter in symbiotic soybeans". My work aims to characterise iron transport proteins from the root nodules of symbiotic soybeans and to elucidate the roles of these transporters in the maintenance of iron homeostasis in the plant.

Iron is required for plant growth but in many soils is limited in its availability. Low soil iron leads to decreased plant yields and nutritional quality. Conversely, in other environments, plants may accumulate iron to toxic levels. Iron transporters in plants are often able to take up other metals, some of which are also toxic. Knowledge of these iron acquisition, transport and storage mechanisms is important for future breeding and engineering of plants to take up more iron, or to exclude toxic metals. Iron deficiency is one

of the most common nutrient deficiencies in the world, and increasing the ability of consumable plants to take up iron has the potential to beneficially impact human health.

Iron is a component of symbiotically important proteins, so is essential for the nitrogen fixation process that occurs in the root nodules of symbiotic legumes. The two partners of the symbiosis have individual as well as associated requirements for iron. The *Gm*YSL1 protein may have a role in provision of iron to the developing nodule and/or for transport of iron chelates for storage within the nodule. My supervisor, Dr Martha Ludwig, also attended the conference and presented a poster of work we have recently done characterising another putative iron transporter family in soybean, *Gm*CCC. This protein may function in storage of iron for ready delivery to the nodule at times of high demand.

Ours is a novel study of plant iron transporters, since the cDNAs have been isolated from symbiotic soybeans, and little is known about iron transport in legumes. These findings have implications for the future breeding of iron efficient legumes and other plants. We were pleased to see that our research is on a par with other laboratories specialising in iron transport proteins and membrane transporters, and that we are doing some original work involving new technologies in the area of localisation of proteins and transcripts in soybean.

The experience, contacts and ideas for further research I have gained from attending this conference will be invaluable for my continuing work on the roles of these transporters, their interactions and their regulation.

IP Roots & Branches

Ownership and Inventorship of Patents

Ownership and inventorship of a patent are two quite different issues. Generally, ownership of a patent is determined by the contractual relationships of the inventor to their employer or research group. Inventorship is another matter. A recent decision has highlighted the rights of an inventor to claim ownership of patent rights from an employer. The clear identification of inventors and ownership at the very early stages of development, along with preparation of appropriate assignments can minimise difficulties down the track.

Inventorship is often regarded personally as a right, a favour or is based on some other political decision. Inventorship has nothing to do with such things and is a legal issue based only on facts. Inventors must have made an inventive contribution to a piece of work in a patent application. This sounds like a tautology, so we have prepared the following notes and questionnaire to assist in addressing this important issue. The answers to these questions should help identify the inventor as making a unique, intellectual and essential contribution to the invention; please feel free to use it.

Who is an inventor?

- An inventor is a person who has made an **inventive** contribution to the invention as defined in at least one of the claims of a patent application
- Authorship on a publication relating to the invention does not necessarily equate with inventorship
- Involvement in experiments alone is not enough for inventorship.
  - Inventorship does not necessarily lead to any ownership or proprietary rights to the invention.
  - Inventorship is a matter of fact and not favour.
  - Incorrect identification of inventors can invalidate a patent.

The following questions/answers can assist in determining inventorship and are indicative of who is really an inventor or not; and can assist in deciding who is or is not an inventor:

1. Would the invention have occurred without that person's contribution?
   No: possibly an inventor.
   Yes: not an inventor.
2. Did that person solve a problem not recognised by the other inventors?
   Yes: possibly an inventor.
   No: not an inventor.
3. Did that person solve a recognised problem that the other inventors were unable to solve?
   Yes: possibly an inventor.
   No: not an inventor.
4. Did that person produce a result or advantage not contemplated by the other inventors?
   Yes: possibly an inventor.
   No: not an inventor.

EXAMPLE ONE

You are working on a project at University A and have isolated and determined the N-terminal sequence of a protein of possible clinical interest. You publish these results; but do not make the protein in question.

University B learns of your work and, using your N-terminal sequence, clones the cDNA encoding the protein, and thus characterizes the full-length protein sequence.

Are you an inventor?

Answer: No. Notwithstanding the ability to use "your" N-terminal sequence to ultimately clone the cDNA molecule, the fact that you did not DIRECTLY contribute to the identification of the cDNA, or demonstrate a conception of the cDNA claimed in the patent, you are NOT an inventor.

EXAMPLE TWO

You are working at University A and develop an assay for identifying compounds which could be used to treat cancer and publish your method and results.

University B learns of your new method and uses it to identify a compound which proves to be useful in the treatment cancer.

Are you a co-inventor of the compound identified using your method?

Again, because you made no direct contribution to the identification of the compound and would have no concept of all the compounds that could be identified using your assay, you would have no claim to inventorship.

As an aside, if such a new assay procedure is devised, patent protection should be sought. Although you will have no ownership to products identified using this assay, you may be entitled to receive royalties from University B for using your assay.

EXAMPLE THREE

This time you are working with a research group and develop a new method of forming derivatives of TAXOL. The method is highly successful, but is neither published or patented and only used "in house" by your research group to make TAXOL derivatives for testing and experimentation. You group develops TAXOL-A, TAXOL-B and TAXOL-C derivatives using the method. One of your colleagues then leaves the group and begins work at University B. This ex-colleague uses "your" new method and develops TAXOL-D. University B then applies for a patent with claims to the method of forming derivatives of TAXOL, and claims to TAXOL-D.

In this case, you should be named as co-inventor because the patent includes claims to the method you developed and applied to make a range of compounds. You did not make TAXOL-D and cannot be considered an inventor of that compound.

Of course, such a patent application includes claims having different inventors. This is not a problem. But, such applications must be carefully monitored during examination. If the claims to TAXOL-D are deleted (perhaps this TAXOL was lacking novelty) then your co-inventor must be deleted from the application as the only remaining claims in the application are to "your" method and you will remain as the sole inventor. Similarly, if the claims to your method are rejected by the examiner and only claims to TAXOL D remain in the application, then you should be deleted as an inventor in the application as you did not directly contribute to conception of this TAXOL derivative.

SUMMARY

- Care must be taken in naming inventors.
- Any inventor must have a firm and clear idea of the CLAIMED invention.
- Any patent application should be carefully monitored for changes to claim scope and possible shifts in inventorship.

Questionnaire for inventor

- Briefly describe what the invention is about.
- Briefly describe the problem the invention particularly solves and how it solves this problem.
- Why is the invention an improvement over current state-of-the-art technology ?
- Briefly describe your own particular contribution to the invention.
  - was this contribution a routine part of your daily work ?
  - could another person have contributed equally to the invention ?
- Do you have any evidence of your contribution to the invention (laboratory notebook records, discussions with colleagues, written notes, seminars etc ?). Please provide details.
- Who would you expect to be listed as an author on a publication including this invention? Please provide details.

  a) Yourself ?
  b) Anyone else ? What did they contribute to the invention ?

Mark Wakeham
Patent and trade mark attorney, FB Rice & Co
mwakeham@fbrice.com.au

Did you know….?

- ***ASPS Website.*** The ASPS website is regularly updated. We'd like to remind you that if you wish to advertise jobs, PhD scholarships, conferences, books, etc. you can contact Lidia Mischis via advertise@plantsci.org.au. To cover the costs involved, the society has introduced a small charge of $30 for members and $70 for non-members ***FOR EMPLOYMENT ADS ONLY***. Advertising conferences and books (edited by society members or containing chapters written by society members) are ***FREE OF CHARGE***.
- ***RN Robertson travelling fellowship.*** The named Fellowship recognises and celebrates the sustained contribution made by RN Robertson (Sir Bob) in nurturing young plant

scientists in Australia spanning across four decades from the 1950's. The Australian Society of Plant Scientists is indebted to Hank Greenway and Joe Wiskisch who generated and championed the early development of the RN Roberston Travelling Fellowship.

- ***Goldacre and Teaching Awards.*** Nominations for these prestigious awards will close on April 13, 2007. Guidelines and selection criteria are outlined in the relevant web pages (click the button 'Awards').

- ***Postgraduate section in Phytogen***. A Postgraduate section will be established in Phytogen where student members are encouraged to publish summaries of their PhD theses. The summaries can be submitted once the thesis has been approved (see page 8).

- ***Student Travel Funds.*** Funds are set aside each year to sponsor student travel to our annual conference (next year in Sydney), and contribute to their professional development in plant science. Support will vary from year to year depending on the Society finances, location of meeting and number of applications. The Treasurer will apply a formula in calculating individual entitlements and takes these factors into account. Applicants must be financial members of ASPS and presenting a paper or poster at the ComBio meeting.

- ***Society funding for Workshops and Conferences.*** The society has a total of $10,000 available each year to provide seeding money and sponsorship for up to four conferences organised by members. The amount available to assist each conference will be about $2500. For more details see the website: http:/www.plantsci.org.au and take the link to conferences.

- ***Corresponding and Life memberships.*** Life Membership recognises an outstanding and sustained contribution to the Society by along standing ASPS member who, through their professional activities, has substantially enhanced the international profile of Australian plant science research. Corresponding Members are high profile overseas colleagues who have contributed substantially to plant science research within Australia. If you know of a deserving recipient for Life or Corresponding Membership, please consider putting a nomination forward. The procedure to follow is outlined on the ASPS website (see: http://www.plantsci.org.au/ and click on "About ASPS" where there is also a list of Life and Corresponding members).

Botany

There should be no monotony
In studying your botany;
It helps to train
And spur the brain--
Unless you haven't gotany.

It teaches you, does Botany,
To know the plants and spotany,
And learn just why
They live or die--
In case you plant or potany.

You learn, from reading Botany,
Of wooly plants and cottony
That grow on earth,
And what they're worth,
And why some spots have notany.

You sketch the plants in Botany,
You learn to chart and plotany
Like corn or oats--
You jot down notes,
If you know how to jotany.

Your time, if you'll allotany,
Will teach you how and what any
Old plant or tree
Can do or be--
And that's the use of Botany!

--Berton Braley
Science News Letter
March 9, 1929

Contributed by John Harper

TWIGS & BRANCHES

Some News & Comments from the Plant Science World

ABA receptors – multiple proteins with multiple functions. There have been two recent reports on proteins that bind ABA and in doing so modify their behaviour. These proteins thus qualify as a receptor as they bind to a hormone and relay its message. Razem *et al* (*Nature* **439**: 290-4) show that the nuclear protein FCA binds ABA at its C-terminus and so inhibits FCA interaction with other proteins such as FY which delays flowering. Then Shen *et al* (*Nature* **443**: 823-826) showed that the H subunit of the Mg-chelatase (ABAR) which is critical for chlorophyll synthesis and plastid-nucleus signaling also bound to ABA. Molecular genetics reveals that plants underexpressing ABAR have ABA-insensitive phenotypes and overexpressors have ABA hypersensitive phenotypes. Perhaps the most interesting feature of these recent findings is not only that hormones can act directly on the receptor protein and modify its function but that the effects are mediated by direct protein-protein interactions – a very short relay message. Also it begs the question – how many more ABA receptors are there? Should we be looking for more examples of multi-function / multi-domain proteins that control regulatory pathways?

Levels of xylem ABA alter depending on watering schedule. Drying of root systems enhances xylem ABA levels resulting in decreased stomatal conductance. Dodd *et al* (*Funct. Plant Biol.* **33**(12): 1081-1089) grew tomato plants with the roots in separate soil columns. They compared xylem ABA levels of well watered plants with 50% watered plants that were watered on one or both sides. Plants that were watered alternatively had double ABA in their xylem to those watered on one side resulting in further reduction is stomatal aperture. Are the alternatively watered roots able to release more ABA?

Salt stress regulatory networks. Jiang and Deyholos (*BMC Plant Biology* 2006 **6**:25) undertook a microarray of Arabidopsis roots following hydroponic exposure to 150 mM NaCl. Over 20% of the transcriptome changed. They identified several underappreciated families including transporters (MATE, LeOPTI-like) and signaling molecules (PERK kinases, MLO-like receptors) and transcription factors (ZIM, WRKY and NAC families).

Quicker way to identify transformants. Floral dip transformation is a quick easy method but selection can be awkward and usually takes 7-10 days. Harrison *et al* (*BMC Plant Methods* 2006 **2**:19) developed a 3.25 day procedure to identify transformants with commonly used markers (e.g. kanamycin, phosphoinothricin and hygromycin B). The rapid identification reduces contamination and also as it is easily discernible (e.g. green expanded cotyledons versus pale unexpanded) it should result in fewer false positives.

Helen Irving

UPCOMING CONFERENCES

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International Conference on Plant Vascular Biology

Academica Sinica, Taipei, Taiwan
7 – 11 May 2007

http://sym.abrc.sinica.edu.tw/~plant2007/

Plant Biology Annual Meeting
July 7-11, 2007, in Chicago.

This will be a joint congress of the American Society of Plant Biologists, the Botanical Society of America, the American Fern Society, the Phytochemical Society of North America, and the American Society of Plant Taxonomists.

ComBio2007

Sydney Convention Centre 22 to 26 September 2007
For further updates visit:
http://www.asbmb.org.au/combio2006