ARC Centre of Excellence

ARC CENTRE OF EXCELLENCE FOR INTEGRATIVE LEGUME RESEARCH

legumes: vital for life

LEGUME RESEARCH CENTRE

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We have shared values and culture in research, education and the public good.



Contents





- Did you know that the great Australian wattle is a legume?
- Soybean has the same number of genes as a human!
- Nodulation is a recent evolutionary advance – most likely appearing only 60 million years ago!
- Legumes are defined by pod production – not the shape of the flower!
- Understanding legumes leads the way to understanding all plants!

Our Centre

The ARC has established Centres of Excellence to create the scale and focus necessary to maintain and develop Australia's international standing in the designated Priority Areas of:

- Nano-Materials and Bio-Materials
- Genome/Phenome Research
- Complex/Intelligent Systems
- Photon Science and Technology

Through highly innovative research that addresses challenging and significant problems within the priority areas these Centres will build national research capability and produce outcomes of economic, social and cultural benefit to Australia. ARC Centres of Excellence are funded under *Backing Australia's Ability*, the Australian Government's 2001 innovation action plan. http://www.arc.gov.au/grant_programs/centre_excellence.htm Two Centres of Excellence have been established in each of the Priority Areas, and the CILR is one of the two Genome/Phenome centres

The ARC Centre of Excellence for Integrative Legume Research (CILR) is a partnership that brings together pre-eminent plant researchers located at four of Australia's leading research intensive universities: the University of Queensland, the Australian National University, the University of Melbourne and the University of Newcastle.

Our research focuses on **scientific discovery** and utilises comparative genomics on the internationally recognised model legumes *Lotus japonicus (Lj)* and *Medicago truncatula (Mt)* and also studies from pea and soybean.

The Centre has been established with a A$10 million Australian Research Council (ARC) grant over five years from 2003. Cash contributions from partner universities and state governments matching the ARC funding, combined with in-kind contributions of staff and facilities will generate a major A$28 million five-year cutting edge biological science research effort.

The Centre has three main objectives.

Our first objective is to understand how to control meristem differentiation and hence the general architecture of the plant. Knowledge of the control of meristem communication is the key to manipulating legumes for adaptation to the Australian environment and for the production of specialty chemicals produced only in particular organs of the plant.

Our second objective is to isolate and characterise the novel molecules involved in intercellular communication between meristems. These molecules will include secondary metabolites and regulatory signal peptides that may have potential as value-added products for human health.

Our third objective is to undertake a systems biology analysis of the model legumes describing the interacting gene networks, key metabolic pathways, and identify intellectual property for use in other legumes.

Why Legumes?

Legumes are very special plants.

Their roots are nodulated by the nitrogen-fixing soil bacteria, *rhizobia*. Legumes such as pea, chickpea, lupin and soybean, are of fundamental importance for agricultural systems, providing sustainable pasture production and cereal crop rotation capabilities (nitrogen fixation, mycorrhizal associations, deep rootedness). They are also the source of high quality products such as vegetable oils, protein and nutriceuticals (anti-oxidants, phytoestrogens and folate). Another special feature of legumes is that they possess complex biochemical pathways and produce biomedically important compounds (e.g., phytoestrogens, saponins, phyto-hemaglutinins, and anti-oxidants) that are absent in most other crop plants.

The value of world wide crop production of legumes exceeds A$200 billion per annum and Australia has a long record of outstanding legume research and its application to sustainable food production.

Our Research

Did you know that legumes are low glycemic index (GI) foods?

Low GI foods:

- ☑ keep blood glucose levels on an even keel
- ☑ help control appetite and hunger
- ☑ help weight control
- ☑ help diabetes control
- ☑ reduce insulin resistance
- ☑ improve heart health
- ☑ aid mental performance
- ☑ aid physical performance

Professor Jennie Brand-Miller, University of Sydney Nutritionist and author of international bestsellers ***The GI Factor*** *and* ***The New Glucose Revolution***

Our analysis of gene regulatory networks and associated signals within the plant which control cell formation and function will provide scientists with new knowledge of plant growth and development processes.

These will be the tools that can be applied to optimise legume productivity, quality, and environment adaptation.

This in turn will have direct impact on agricultural sustainability, environmental quality and potential value-added products for human health.

At the **University of Queensland Node** our research is focused on the autoregulation of nodulation in roots, interactions with *mycorrhizae* (fungus in the soil), signals that control embryo, meristem, leaf development and shoot branching.

Our research facilities include:

- Centrifuges (Beckman, Eppendorf, Sigma Instruments)
- CHEF DR instrument for pulsed field gel electrophoresis (Biorad)
- DNA quantitation instruments – spectrophotometer, fluorometer
- Gel electrophoresis equipment (Biorad)
- Glasshouse facilities including PC2, quarantine and controlled environment chambers
- High quality microscopes with associated digital camera, flourescence and computer systems
- LiCor DNA fragment analyser
- PC2 laboratories
- PCR cycling machines (Hybaid and MJR instruments)
- Plant growth cabinets (Conviron) and growth chambers for tissue culture (Conviron)
- Quantitative RT-PCR (ABI7700) facility
- Radioisotope facility

We also have ready access to powerful confocal microscopy, DNA sequencing through the Australian Genome Research Facility, NMR, mass spectrometry, crystallography and unlimited opportunities for close collaboration with the Queensland Bioscience Precinct.

Our Research

The Australian National University Node has specialist expertise in proteomics which will be used to analyse nodulation and identify novel short and long range signal molecules. The bioinformatics group has a background in both molecular biology and computer science and is able to combine both disciplines by applying modern information technology to the analysis of biological data. In addition, we will be able to screen plant-derived peptides for their biological activity, initially using a convenient *in vitro* assay for mammalian angiogenesis.

ANU research equipment in the Centre includes:

- -80°C Freezers
- Queue Cryostat
- Haraeus (Hara freeze)

Centrifuges/rotors

- Beckman Coulter Avanti J-301
- Sorvall RCRC centrifuges (x2)
- Beckman L8-80 Ultracentrifuge
- Beckman Coulter L 100 Ultracentrifuge
- Full range of rotors

Biomedical Resource Facility (JCSMR)

- DNA sequencing and fragment analysis
- Protein sequencing
- Peptide synthesis
- Gene Chip Microarray
- Chromatography and antibody purification
- Real time PCR
- Fluoroimage/phosphoimager/ chemiluminescence CCD

Proteomics Facility

- 2D protein electrophoresis (6 rigs)
- Protein gel image documentation and analysis
- Microarray spotting and analysis
- Real time PCR

Microscopy

- Confocal microsccope
- Leica TCS- SP2- UV confocal duel laser
- Light microscopy (several)
- Kyowa (Tokyo) dissecting microscope
- Scanning electron microscopy
- Cryo equipment
- Transmission electron microscopy

Mass Spectrometers and HPLCs

- Fisons MD800 GC/MS: MassLab 1.27, NIST library
- Thermo Finnigan Polaris Q GC/MS: Xcalibur 1.4, Wiley/NIST library
- Thermo Finnigan LCQ Deca X Plus LC/MS: Xcalibur 1.3, ProtemeX, Bioworks 3.1, DeNovoX
- Micromass QToF2 LC/MS ,MassLynx 1.5
- Bruker Omniflex MALDI ToF: FlexControl, Xmass, Biotools 2.2
- Shimadzu HPLCs
- Hewlett Packard 1090 HPLC: ChemStation A.09.03
- Melanie 4, Sequest 3.1, and Mascot software
- HP 5720A Gas Chromatograph

Controlled Environment Facility

- PC2 growth facilities and controlled environment chambers and laboratories

Transgenic tissue culture facility

- Bio-5satec PCR machine
- G24 Environmental Incubator Shaker (New Brunswick Scientific Co)

Access to:

- Glasshouses (3); additional Growth Chambers (5)
- a Fourier Transform Cyclotron Resonance (FTICR) Mass Spectrometer (Research School of Chemistry)
- a fully equipped Bioinformatics Group
- Micromass QTOF2 (R00002790) quadrupole-ion-trap mass spectrometer (Q-TOF) (University of Wollongong) to study larger complexes of biomolecules (eg. complexes of replication proteins and DNA; protein-protein interactions) with an extended mass range




Our **University of Melbourne Node** aims to provide critical insights into mechanisms of meristem differentiation and intercellular communication with a particular focus on floral meristems. Laboratories fully equipped for productive research in plant genomics and phenomics include:

- ABI 310 Genetic Analyzer
- Packard Instant Imager
- Stratagene Mx 3000 Real Time PCR machine
- BMG Fluostar Optima microplate reader
- Packard Spectracount
- Fluorescence Microscope with DP-70 Cooled CCD Digital Imaging SysteM
- PC2 Growth Room and Glass House.

In addition, the group has ready access to confocal and electron microscopy on the campus and high throughput DNA sequencing/microarray technology through the Australian Genome Research Facility.

Research at the **University of Newcastle Node** focuses on the genetic regulation of *in vitro* embryo formation (somatic embryogenesis) in the model legume *Medicago truncatula* utilising large scale microarray and proteome analyses. Our laboratories are well equipped to carry out a wide range of research in plant genomics and plant cell and molecular biology.

- PC2 molecular biology laboratory
- PC2 glasshouse and controlled environment growth rooms
- Tissue culture/transformation facility
- Radioisotope facility
- Centrifuges (Sorvall high speed, Beckman ultracentrifuge,microfuges)
- Microscopes (Zeiss Axiophot photomicroscope, dissecting and inverted fluorescence microscopes)
- UV/Vis spectrophotometers
- Standard PCR cycling, Real time PCR (DNA engine Opticon2)
- Gel electrophoresis equipment

We have routine access to confocal microscope, transmission and scanning electron microscopes, a Biomolecular Research Facility with DNA and Protein sequencers, microarray reader and Maldi-Tof mass spectrometry. We also have access to equipment in the ARC Centre of Excellence for Biotechnology and Development which is housed in the same building complex.

Legumes are everywhere!

Uses for peanuts include:

Food, animal feed, oil, imitation milk/cheese/ice-cream, wallboard, pet litter, detergents, polishes, inks, bleach, axle grease, shaving cream, soap cosmetics, linoleum, rubber, paint, explosives, shampoo, medicines.

Uses for soybean include:

Food, animal feed, petroleum replacement, bio-diesel, asphalt, waxes, lubricating oils, candles, concrete form releasing agent, hair care products, hand cleaners & lotions, hydraulic oils, fertilisers, nail polish remover, oil spill clean up, paint stripper, penetrant oils, dust suppressant, inks, wood & concrete sealants, spray foam insulation, engine lubricating oils.

Our People

Our Centre aims to strengthen agricultural research training for tomorrow's plant researchers; giving a systems biology approach to studying and using genetic networks for a specific phenotypic outcome. To this end we have offered scholarships to vacation, Honours, Masters and PhD scholars to encourage students into the new integrated, systems biology based, agricultural and innovative environmental sciences.

The Centre actively promotes graduate and postdoctoral personnel travel between node laboratories so as to ensure the breadth of training and co-operation between the partners.

Over 90 graduate students, post doctoral research fellows, research assistants and support staff are included directly in the Centre, with numerous other collaborating and visiting academic staff involved at different levels.

Part of the Centre's work is taking place within the context of significant public debate about the safety and desirability of genetically modified organisms (GMOs). We recognise and accept our responsibility to make a positive contribution to the debate, not only scientifically, but also from social, political and legal perspectives. Accordingly the Centre has appointed Associate Professor William Grey as the Centre's bio-ethics adviser and we have awarded several PhD scholarships in these areas.

The Centre's research is led by the Director, Deputy Director and nine other Chief Investigators who are profiled below.

Director

Prof Peter M Gresshoff

Expertise: Molecular genetics and genomics, soybeans, biotechnology, legume nodulation

Location: ARC Centre of Excellence for Integrative Legume Research,
The University of Queensland

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Deputy Director

Prof Barry G Rolfe

Expertise: Plant molecular genetics

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Chief Investigators

Dr Christine Beveridge

Expertise: Plant molecular developmental physiology

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The University of Queensland

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Assoc Prof Prem Bhalla

Expertise: Developmental cell biology and plant molecular biology, plant biotechnology

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The University of Melbourne

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Assoc Prof Bernard Carroll

Expertise: Plant molecular genetics, developmental biology

Location: School of Molecular and Microbial Sciences, The University of Queensland

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Dr Michael Djordjevic

Expertise: Microbial and plant molecular genetics, microbial proteomics

Location: Research School of Biological Sciences, The Australian National University

Phone: 61 2 6125 3088

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Dr Ulrike Mathesius

Expertise: Plant developmental genetics, legume nodulation and signal exchange

Location: School of Biochemistry and Molecular Biology, The Australian National University

Phone: 61 2 6125 2840

Email: ulrike.mathesius@anu.edu.au

Prof Chris Parish

Expertise: Animal cell systems

Location: John Curtin School of Medical Research, The Australian National University

Phone: 61 2 6125 2604

Email: christopher.parish@anu.edu.au

Assoc Prof Ray Rose

Expertise: Cell biology, developmental biology, molecular genetics

Location: School of Environmental and Life Sciences, The University of Newcastle

Phone: 61 2 4921 5711

Email: ray.rose@newcastle.edu.au

Assoc Prof Mohan Singh

Expertise: Molecular and developmental biology of plant reproduction, molecular immunology of allergens

Location: School of Agriculture and Food Systems, The University of Melbourne

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Email: mohan@unimelb.edu.au

Dr Georg Weiller

Expertise: Yeast molecular biology and bioinformatics

Location: Bioinformatics Laboratory, Research School of Biological Sciences, The Australian National University

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Email: weiller@rsbs.anu.edu.au

Our Partnership

The Centre is a partnership of four leading Australian universities

- The University of Queensland
- The Australian National University
- The University of Melbourne
- The University of Newcastle

CILR is headquartered at the University of Queensland in the John Hines Building on the St. Lucia campus. The Centre operates under a nodal structure with coordinated research undertaken in laboratories in all four partner universities.

The Centre is thriving on the strength and depth of the collaboration between the research laboratories in the partner universities and is actively seeking additional formal partnerships with industry and other peer research institutes in Australia and overseas.

The University of Queensland

The University of Queensland was founded in 1909 as the first university in Queensland and the fifth in Australia. The university ranks in the nation's top two or three institutions by most performance measures. Nationally, UQ is a founding member (along with ANU and The University of Melbourne) of the Group of Eight – a national coalition of leading research-intensive universities. Internationally, UQ is one of only three Australian members (including The University of Melbourne) of *Universitas 21*, a select alliance limited to 25 research-intensive universities dedicated to world-best practice.

The Australian National University

The Australian National University was established by Federal Parliament in 1946 with a mission to bring credit to the nation and be one of the world's great universities. The university is distinguished by its relentless pursuit of excellence, resulting in outstanding teaching and profound achievements in research. The university is located in Canberra, the national capital, as are a range of national institutions established to help nurture the identity, culture, intellect and economy of the nation.

The University of Melbourne

The legislation establishing the University of Melbourne was passed in 1853, making it older than all the universities in England except Oxford, Cambridge, Durham and London. Through the 'Melbourne Agenda', the University is committed to maximising its capacity to add intellectual, cultural and professional value to the City of Melbourne, and to serving Victoria and Australia by performing and being acknowledged as one of the finest of the world's institutions of higher learning.

The University of Newcastle

The University of Newcastle, established in 1965, has a student population of just over 20,000. The university offers over 150 undergraduate and graduate courses, delivered via five Faculties – Business and Law, Education and Arts, Engineering and Built Environment, Health, and Science and Information Technology. The university is an exceptional achiever in research with an international reputation for expertise in innovative approaches to teaching and learning. With campuses in both the Central Coast and Hunter regions of NSW, the university serves a community of around a million people.

Photographs and Images

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RESEARCH
is a partnership of

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

The UNIVERSITY of NEWCASTLE
AUSTRALIA

ANU
THE AUSTRALIAN NATIONAL UNIVERSITY

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