# CILR Annual Report

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Research in the Centre will provide critical insights into mechanisms of organ differentiation and intercellular communication.
The ARC Centre of Excellence for Integrative Legume Research (CILR) is a partnership that brings together leading plant researchers located at the University of Queensland, the Australian National University, the University of Melbourne and the University of Newcastle. The director of the Centre is Professor Peter Gresshoff (who is also Professor of Botany in the School of Life Sciences at UQ). The Centre aims to drive further development of the genomics and phenomics of legumes, providing the critical mass of human, intellectual and infrastructure resources to function as a world-class research centre.

The Centre has been established with 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 $28 million five-year biological science research effort.

Research in the Centre will provide critical insights into mechanisms of organ differentiation and intercellular communication, utilising comparative genomics on the internationally acknowledged model legumes Lotus japonicus (Lj) and Medicago truncatula (Mt). New knowledge of plant growth and development processes through mechanistic analysis of organ induction will provide the tools 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.

The Centre’s research initiatives have significant intellectual property commercialisation potential, and this will augment Australia’s international standing in scientific discovery and directly benefit the Australian economy.

The Centre’s internal organisational linkages are outlined in the chart in Figure 1.
Figure 1

CILR ORGANISATION CHART

Centre Advisory Board
Partner University, Government and Industry Representatives

Scientific Expert Advisory Committee
Centre Director
Chief Operating Officer

PA to the Director
Finance Clerk
Education & Outreach Manager

Centre Management Committee

Chief Investigators
Research staff
Graduate students

Research Program* 1
Research Program* 2
Research Program* 3
Research Program* 4
Research Program* 5
Research Program* 6

*Research Programs
1. Meristem formation in somatic embryogenesis
2. Communication between meristems
3. Discovery of peptide signalling molecules
4. Legume root nodule meristems and their regulation
5. Shoot apical and floral meristems and their regulation
6. Gene networks in the intact plant
The first year of our Centre saw an incredible amount of integration of research and discovery programs based on previous scientific momentum of the partners. Considerable effort was applied to developing common and synergistic research fields. We started to learn more about the complexities of research areas in each of our nodes and contributed constructively to new perspectives of analysis and interpretation. Indeed ‘the whole became more than the sum of its parts’.

After the initial euphoria of the Centre award in December 2002, we held our first Annual Symposium at the UQ Moreton Bay Research Station on Stradbroke Island in late February 2003. The meeting was structured along ‘Gordon Conference’ lines to facilitate interaction, creativity and planning (and also some fun). All Chief Investigators, postdoctoral researchers, graduate and honours students, and key technical staff were invited to participate in the three day meeting. All scientific attendees presented overviews of their research and discussed how these would fit into the Centre’s mission and research goals, focussing on meristems, their control and communication.

Additionally we were privileged to be joined by Professor Doug Cook (UC Davis and member of our Scientific Expert Advisory Committee) who proved to be a valuable contributor by providing an international benchmarking focus in the nodulation and plant genomics area and expert facilitation of research discussion. Representatives of commercial companies in both biotechnology and seed production attended to provide a ‘real world’ perspective. Professor Peter Langridge, from the Australian Centre for Plant Functional Genomics (also a member of our SEAC), attended and provided valuable linkage between our two centres of molecular plant research.

The Annual Symposium initiated the now-established pattern of quarterly Chief Investigator meetings that deal more specifically with internodal linkages, research coordination and definition of research priorities. During 2003, three such meetings were held in Melbourne, Newcastle, and Canberra. These meetings are restricted to the Chief Investigators, the Chief Operating Officer and guests, usually representing new linkages. Their benefit is easily measured by the increasing quality and depth of discussion, coupled with the transition from abstract research plans to actual seamless research facilitation.

While the focus of the Centre is on the development and interaction of meristematic growth centres in plants, coupling analyses at the DNA, RNA, protein and metabolite level with the phenotypic characteristics, the Centre is excellently positioned to establish innovative linkages with other legume research programs. In 2003 links were established with two leading plant research groups in Australia; (1) Professor Jim Reid and Dr John Ross at the University of Tasmania (known for their flowering and hormonal analyses of pea) and (2) Professor Craig Atkins at the University of Western Australia (known for his pioneering work in lupin biochemistry and physiology). In both cases the interaction is facilitated through the Centre’s support of a postgraduate student in a research topic related to the ‘meristem communication’ theme. In the case of Western Australia the CILR’s support for the research contributed to a successful ARC discovery grant to Professor Atkins.
Research momentum was maintained in the Centre as evidenced by publication of our work in leading journals. (see page 8) The ANU node published work on bacterial quorum sensing compounds and their influence on plant gene expression in *PNAS*; the Newcastle node produced a fundamentally important paper on *Medicago truncatula* SERK (specific embryo receptor kinase) in *Plant Physiology*; and the UQ node published two seminal papers on legume gene discovery in *Science* (for the nodulation receptor kinase NARK of soybean) and *Genes & Development* (for the pea RMS1 branching gene). New students, research staff and visitors joined the Centre further enriching our already international mix. As director I welcome this internationalism, as it provides us with different perspectives as well as new challenges, and truly represents the nature of our science.

The Centre also formally established itself as a structure following completion of the contract with the ARC in June. Core additional laboratory and research facilities were approved for UQ and Newcastle and renovation is currently in process. We appointed key administrative and support staff, especially Mr Ian Harris as Chief Operating Officer, and Ms Melisa Lewins as Personal Assistant to the Director. Financial, reporting and IT infrastructure systems were established. Together with the soon to be appointed Education and Outreach Manager these positions form a common resource for the entire Centre and our interacting community.

While recognising that quantity does not necessarily equate to quality, a recent count of CILR staff members and graduate students was about 80. However, the Centre’s staff is of the highest quality as demonstrated by the academic standing of our students, graduation rates, employment opportunities, the experience of postdoctoral staff, and the quality of publications. I am proud to be associated with such a talented group of scientists and support staff who have a common goal and mission, together with a commitment and excitement that comes from researching a frontier of biological science.

We have a vision and a quest; that is to understand how a multicellular organism manages to develop the complexity of functions given only one genome of perhaps 30,000 genes. How do cells differentiate? How do they control their cell proliferation, and how do they communicate? We continue to assert that the analysis of plant developmental processes in an integrative fashion incorporating a balance of reductionist science and Systems Biology, allows us to contribute to paradigm shifts that will be relevant not only to plant biology but to all living organisms on this planet.

I trust that you the readers of this report, will gain additional insight into the Centre’s activities, perspectives, and goals and we welcome contact for further enquiry.

Peter M. Gresshoff
Director, CILR
March 2004
3. Centre Advisory Board & Scientific Expert Advisory Committee

The Centre is privileged to have so many highly respected government, industry, scientific and university leaders who have made a significant commitment to the development of the Centre by agreeing to serve on the Centre Advisory Board and the Scientific Expert Advisory Committee. We look forward to their valuable contribution and guidance as the Centre works to achieve its research goals.

The Centre Advisory Board will provide advice on the development of strategies and vision for the future of the Centre, and its direction in finance and scientific management, commercialisation and IP management.

The members of the Centre Advisory Board are:

**Professor David Siddle**
Deputy Vice Chancellor (Research)
University of Queensland
BRISBANE

**Professor Ron McDonald**
Deputy Vice Chancellor (Research)
University of Newcastle
NEWCASTLE

**Professor Frank Larkins**
Deputy Vice Chancellor (Research)
University of Melbourne
MELBOURNE

**Professor Lawrence Cram**
Deputy Vice Chancellor (Research)
Australian National University
CANBERRA

**Dr Jaydeep Biswas**
School of Engineering
University of Queensland
BRISBANE

**Dr Bruce Wicking**
Consultant
MELBOURNE

**Dr John Manners**
Program Leader
CSIRO Plant Industry
BRISBANE

**Professor Dick Wettenhall**
Director, BIO21
University of Melbourne
MELBOURNE

**Ms Paula Fitzgerald**
Executive Manager
Agrifood Awareness Australia
CANBERRA

**Professor Peter Langridge**
Director
Australian Centre for Plant Functional Genomics
University of Adelaide
ADELAIDE

**Dr Bill Silvey**
Director,
Competitive R&D Investment Programs
Dept of State Development and Innovation
BRISBANE

The Scientific Expert Advisory Committee will advise the Centre Director on the direction of research, educational programs undertaken within the Centre and provide leadership in the Centre’s annual research conference.

The members of the Scientific Expert Advisory Committee are:

**Professor Doug Cook**
Department of Plant Pathology
University of California at Davis
USA

**Dr Noel Ellis**
Department of Crop Genetics
John Innes Centre
UK

**Professor Ueli Grossnikolaus**
Institute of Plant Biology
University of Zurich
SWITZERLAND

**Professor Erwin Herble-Bors**
Institute of Microbiology & Genetics
University of Vienna
AUSTRIA

**Professor John Irwin**
CRC for Tropical Plant Protection
University of Queensland
AUSTRALIA

**Professor Minorou Kanehisa**
Bioninformatics Centre
Institute for Chemical Research
Kyoto University
JAPAN

**Professor Adam Kondorosi**
Institute des Sciences Du Vegetal
Gif-Sur-Yvette
FRANCE

**Professor John Mattick**
Institute of Molecular Biosciences
University of Queensland
AUSTRALIA

**Dr Satoshi Tabata**
Kazusa DNA Research Centre
JAPAN

**Professor Carroll Vance**
Plant Science Research Centre
University of Minnesota
USA

**Professor Carroll Vance**
Plant Science Research Centre
University of Minnesota
USA
4. Research Highlights

Despite the fact that the Centre only formally came into being with the signing of the contract between the University of Queensland (as the lead institution) and the ARC in June 2003, we are proud to report on a number of significant research outcomes from the laboratories of the Centre’s Chief Investigators.

**Professor Peter Gresshoff and Dr Bernie Carroll** set the tone for the year with the publication in *Science* of their paper on ‘Long-distance signaling in nodulation directed by a CLAVATA1-like receptor kinase’. This paper was cited in the Faculty of 1000 Biology Reports, which highlight the world’s most interesting papers in biology, (http://www.facultyof1000.com/start.asp). The evaluators said the paper provided ‘…the first intriguing molecular insight into the autoregulatory signal transduction pathway’.

**Associate Professor Ray Rose** and his group in Newcastle cloned a *Somatic Embryogenesis Receptor Kinase (SERK)* gene from *Medicago truncatula* (*MtSERK1*) and examined its expression in culture using real time PCR. Although the analyses suggest that *MtSERK1* is comparable to *AtSERK1*, (which in Arabidopsis is involved in somatic embryogenesis), in legumes *MtSERK1* may have a broader role in morphogenesis in cultured tissue, rather than being limited to somatic embryogenesis. The group had their paper ‘MtSERK1 cloning and expression analysis in embryogenesis’ published in September in *Plant Physiology*.

From the ANU node, **Dr Uli Mathesius** and **Professor Barry Rolfe** had their work on ‘Extensive and specific responses of a eukaryote to bacterial quorum-sensing signals’ published in the *Proceedings of the National Academy of Sciences USA (PNAS)*. Results indicated that eukaryotes have an extensive range of functional responses to AHLs (signals) that may play important roles in the beneficial or pathogenic outcomes of eukaryote–prokaryote interactions.

**Dr Christine Beveridge** has had a longstanding and active collaboration with colleagues in the Institut National de la Recherche Agronomique-France (INRA) and at the University of York (UK) and an important outcome of this collaboration was the publication of their paper ‘MAX4 and RMS1 are orthologous dioxygenase-like genes that regulate shoot branching in Arabidopsis and pea’ in *Genes and Development*. The research reported in this paper may provide the opportunity for discovery of a novel plant hormone that regulates shoot branching.

**Dr Michael Djordjevic** and **Dr Georg Weiller** also published an extensive proteome of a *Rhizobium* bacterium, *Sinorhizobium meliloti* in the *Journal of Molecular Plant-Microbe Interactions*. This is the first time that such an extensive proteome analysis had been done on *Rhizobium* and has shown a number of novel proteins not predicted in the DNA sequence. In addition, they identified many genes expressed in the symbiotic bacteria isolated from root nodules that were not present in bacterial cells grown in laboratory media.
The Centre’s focus is on scientific discovery and as such we aim to publish regularly in high impact journals, as appropriate to the research that is being reported. In this way we can maximise our communication of the work of the Centre to the international scientific community.


The staff and students at each of the nodes of the Centre as at 31 December 2003 are listed below. The total was 58 and this is anticipated to grow to 95 when the Centre is fully operational by mid 2004.

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7. Collaborations and Outreach

The Centre recognises that with the rapid rise of the genomics and phenomics revolution, and dramatically improved communication systems, good science depends on effective collaboration. As a newly established Centre with a primary objective to keep at the forefront of discovery in plant development, we have applied resources from day one to growing tangible collaborations with other top quality organisations and research groups both in Australia and overseas. In 2003 these collaborations included:

- **School of Plant Science, University of Tasmania**
  Prof Jim Reid, Dr Jim Weller, Dr John Ross
  The legume group at this institution has had continuous ARC funding for research on plant development for over 30 years. A PhD student at UTAS is now jointly funded and supervised by CILR. Future CILR projects will benefit from the screening of novel developmental mutants by this group.

- **Institute of Molecular Biosciences UQ**
  Comparative and Computational Genomics Group
  Investigations of sequence motifs responsible for DNA deletion with Dr Georg Weiller.

- **Carleton College Northfield, MN USA**
  Prof Susan R. Singer
  Joint supervision of CILR PhD student and is providing data for incorporation into garden pea flowering model.

- **Bureau of Sugar Experiments Stations Indooroopilly Queensland**
  Dr Prakash Lakshmanan
  Assisting with the comparative genetics of RMS1.

- **CRC for Tropical Plant Protection.**
  Dr Christine Beveridge is facilitating joint work on a research grant for a mutational approach to the discovery of recognition and signalling genes that control compatibility between soybean and Phytophthora. Dr Bernie Carroll is also collaborating with Dr David Jones (ANU) on the map-based cloning of a Fusarium wilt resistance gene.

- **Centre National de la Recherche Scientifique, Gif-sur-Yvette France**
  Dr Martin Crespi
  Detailed transcriptome analysis of *Medicago truncatula* plants that overexpress ENOD40, a major regulator of meristem activity in plants.

- **Institute National de la Recherche Agronomique, Versailles France**
  Dr Catherine Rameau
  Major contributor to the vegetative axillary meristem project. Co-supervision and student and researcher exchanges, sharing genetic resources, intellectual property and ideas. An important link to the EU Legume Project and to several important resources provided therein.

- **Department of Plant Biology, University of Minnesota, USA**
  Prof Kathryn VandenBosch
  Three month sabbatical visit by Assoc Prof Ray Rose; joint funding with Prof Carroll Vance of a protoplast transformation project which could serve the basis for a high throughput transformation system with the capability of producing large numbers of T-DNA insertional mutants; Dr Michael Djordjevic submitted a joint grant proposal with Prof VandenBosch to the NSF of the USA.
• **CRC for Sugarcane Industry Innovation Through Biotechnology.**
Dr Christine Beveridge and Dr Bernie Carroll are also Chief Investigators for this CRC, and accordingly CILR is contributing significant genetic and other in-kind resources in a program to meet industry objectives of improving sugarcane yield.

• **School of Biochemistry & Molecular Biology (BaMBi), Australian National University**
Dr Barry Pogson
Joint ARC Discovery grant with Dr Christine Beveridge. CILR is providing genetic and other in-kind resources. Research funded through this grant may yield information that CILR can use to meet its objective of discovery of novel long-distance signals.

• **School of Molecular and Microbial Biosciences, University of Sydney**
Prof Jenny Brand-Miller
Strategies to promote the utilisation of legumes in low glycaemic index (GI) diets, promoting better health and improved quality of life in ageing.

• **Sanitarium Health Foods, Avondale NSW**
Strategies to promote the utilisation of legumes in food for better health and improved quality of life in ageing.

• **Plant Biology (Botany), University of Western Australia**
Prof Craig Atkins. A PhD student at UWA is funded and jointly supervised by CILR. The project will focus on using techniques developed within CILR for the screening of regulatory genes in lupin mutants.

• **Faculty of Arts, University of Queensland**
The CILR and the Faculty are jointly funding research into public perceptions and ethical issues surrounding the development of genetically modified organisms (GMOs). This includes the enrolment of two PhD students who are jointly supervised by Prof Peter Gresshoff, and Assoc Prof William Grey, the Centre’s bio-ethics advisor.

Dr Uli Mathesius was a finalist in the Fresh Science competition, which involved presenting to the public during National Science Week in Melbourne in August 2003. Following the competition an article was published in the Sydney Morning Herald on 28th August, 2003.
8. Visitors to the Centre & Visits to overseas Institutions

Visitors to the Centre

To the ANU Node:

Prof Eric Triplet
University of Florida, FL USA
(January - July)

Prof W. D. Bower
Ohio State University, Ohio USA
(May)

Prof Prudence Hall
Hiram College, Ohio USA
(July - December)

Prof Xu Zhihong
President
Peking University
(December)

To the UQ Node:

Prof Joe Cowles
Department of Biochemistry
Virginia Tech Blacksburg, VA USA
(April – June)

Mr Pat Bell
Program Director, Science Research and Innovation
and Dr Bill Silvey
Director, Competitive R&D Innovation Programs
Department of Innovation and the Information Economy
Queensland Government
(December)

Dr Catherine Rameau
Program Leader
INRA Station de Genetique et d’Amelioration des Plantes, France
(December)

Prof Susan R. Singer
Carleton College Northfield, MN USA
(December)

To the Melbourne Node:

Prof Kinya Tokiyama
Tohoku University
(August – December)

Prof Scott Russell
University of Oklahoma USA
(November – December)
Visits to overseas institutions

**Assoc Prof Prem Bhalla**
- Station de Genetique et d’Amelioration des Plants
  INRA France
  Seminar presented: Regulatory mechanisms controlling male gamete specific gene expression in flowering plants.
- Dept of Pathophysiology University of Vienna, Austria
  Seminar presented: Biotechnological approaches for reduction of grass pollen allergenicity.

**Dr Bernie Carroll**
- Institute of Plant Biology, University of Zurich Switzerland
  Seminar presented: Short and long-distance signalling in plant development.
- Chinese and Shanghai Academy of Sciences, Shanghai, Peoples Republic of China
  Seminars presented: Short and long-distance signalling in plant development and Application of molecular biotechnology to genetic improvement of crops.

**Prof Peter Gresshoff**
- Biomaterials Science & Engineering, and Department of Biology, Massachusetts Institute of Technology, USA
  Seminar presented: Functional genomics of systemic regulation of cell division.
- Department of Plant and Soil Sciences, University of Delaware USA
  Seminar presented: Molecular genetics of nodule formation.
- Crop Genetics Research & Development Division – DuPont, Delaware USA

**Assoc Prof Ray Rose**
- Department of Plant Biology, University of Minnesota, USA
  Three month sabbatical.

**Assoc Prof Mohan Singh**
- Station de Genetique et d’Amelioration des Plants
  INRA France
  Seminar presented: Molecular biology and immunology of grass pollen allergens.
- Institute of Plant Biology, University of Zurich Switzerland
  Seminar presented: Male gamete specific gene expression in flowering plants.
- Biological Research Centre, HAS EU Centre of Excellence Hungary
  Seminar presented: Molecular biology of male gametogenesis and fertilization in flowering plants.
- Botany Department, University of British Columbia Canada
  Seminar presented: Male gamete specific gene expression in flowering plants.
The Centre has given priority to best practice management of intellectual property that will be generated by research undertaken within the Centre. To this end, all staff and students have been required to sign confidentiality and assignment of IP agreements.

Work has already been done to develop the infrastructure, strategies and policies for commercialisation of IP, laying the groundwork to maximise our capacity to respond to opportunities arising out of significant discoveries and new technologies. Working with UniQuest, the commercialisation arm of UQ, we have registered the business name of MERISTOMICS, and an appropriate entity will be established by the partner universities as a vehicle for commercialising IP in the future.

An international patent application was lodged in October for the regulation of cell division and plant nodulation, based on the legume gene discovery reported in *Science*.

Research planning has centred on setting up projects in line with the six research programs outlined in our initial application to the ARC.
10. Future Directions and Priorities

Going into 2004, the foundations are well set for a rapid increase in the momentum of the Centre on all fronts – research, education and outreach, industry collaboration and national and international linkages.

By the end of 2003 recruitment processes were well advanced for the appointment of additional highly qualified and talented post doctoral fellows at all nodes, and for the Education and Outreach Manager position. Allowing for the normal lead time for individuals to relocate, including several from overseas, the Centre is anticipated to have its full complement of staff in place by June 2004.

Research planning has centred on setting up projects in line with the six research programs outlined in our initial application to the ARC. A particular focus will be to ensure optimal interaction between the laboratories at each of the nodes, through joint responsibility for specific projects, the exchange of experimental material and extended personal visits by staff and students.

Our research momentum is expected to continue with fascinating discoveries relating to pollen and meristem specific gene expression. We will also conduct an integrative analysis of autoregulation zones on developing soybean roots using transcriptomes, proteome and targeted metabolome analysis. We expect to confirm further recognition of signal substances transported in xylem and phloem. Our pea branching work will be extended with the new definition of functional genes for mutated loci. We hope to develop functional assays for some of the key genes controlling morphogenic processes in legumes, allowing the recognition of biochemical mechanisms. In embryogenesis, the coupling of molecular tools to cell biology will develop an ’atlas’ of molecular markers for key transition points between the globular and heart shaped embryo. Integral to this will be our focus on micro-analysis of gene expression in meristems of different origins. Again, as in all biological research, one wonders whether the differences or the similarities will be the most intriguing.

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. To this end the ANU node appointed a science/law graduate, Mr Greg Bodulovic, who has initiated an evaluation of these issues, together with the intellectual property and legal issues, and their implications for the development of GMOs. In addition, the University of Queensland node has appointed Associate Professor William Grey as the Centre’s bio-ethics adviser and two PhD students supported through a collaboration with the Faculty of Arts at UQ will undertake studies to assess public perceptions and ethical issues with respect to GMOs.

With the appointment of the Education and Outreach Manager, we will be in a strong position to rapidly extend the Centre’s development of educational resources. We will also be formalising links with industry partners who stand to benefit from the Centre’s research.
# Financial Statement

Statement of operating income and expenditure year ended 31 December 2003

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<th><strong>INCOME</strong></th>
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<td>ARC Centre Grant</td>
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<td>State Government Funds</td>
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<td>NSW (TBC)</td>
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<td>Scholarships</td>
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<th><strong>Funds carried forward to 2004</strong></th>
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<td>1,541,675</td>
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Acknowledgements

The Chief Investigators wish to express their appreciation for the cash and in-kind support provided to the Centre by the following groups:

The Australian Research Council
The Vice-Chancellors and Deputy Vice-Chancellors (Research) of the four partner universities.
Faculty of Biological and Chemical Sciences, University of Queensland
School of Molecular and Microbial Sciences, University of Queensland
School of Life Sciences, University of Queensland
School of Land and Food Sciences, University of Queensland
Research School of Biological Sciences, Australian National University
School of Biochemistry and Molecular Biology, Australian National University
John Curtin School of Medical Research, Australian National University
School of Agriculture and Food Systems, University of Melbourne
School of Environmental and Life Sciences, University of Newcastle

The University of Queensland and the University of Newcastle are also working with the state governments of Queensland and New South Wales respectively, to finalise agreements for support of the Centre.

Photographs and Images
Diana Lilley, University of Queensland
Chris Stacey, University of Queensland
Dr Jiri Stiller, University of Queensland
Qunyi Jiang, University of Queensland
Jeff Wilson, Australian National University
Kim Nolan, University of Newcastle
Assoc Prof Prem Bhalla, University of Melbourne
Gary Cranitch, Queensland Museum
Bruce Cowell, Queensland Museum