ARC CENTRES OF EXCELLENCE

Selection Report
for funding commencing in
2003

ARC Centres of Excellence - Selection Report for funding commencing in 2003

Background

The ARC's Centres of Excellence program will maintain and develop Australia's international standing in the Commonwealth Government's designated Priority Areas of Research:

- Nano-Materials and Bio-Materials (hereinafter NBM),
- Genome/Phenome Research (GPR),
- Complex/Intelligent Systems (CSI), and
- Photon Science and Technology (PST).

The objectives of the ARC Centres of Excellence program are to:

a) undertake highly innovative research at the forefront of developments within the designated Priority Areas, with a scale and a focus leading to outstanding international and national recognition;
b) promote research that will enhance Australia's future economic, social and cultural wellbeing;
c) link existing Australian research strengths and build new capacity for interdisciplinary, collaborative approaches to address the most challenging and significant research problems;
d) build Australia's human capacity in the Priority Areas by attracting, from within Australia and abroad, researchers of high international standing as well as the most promising research students;
e) provide high-quality postgraduate and postdoctoral training environments for the next generation of researchers in the Priority Areas;
f) offer Australian researchers access to world-class infrastructure and equipment, and to key research technologies;
g) develop relationships and build new networks with major international centres and research programs that help achieve global competitiveness and recognition for Australian research;
h) establish Centres of such repute in the wider community that they will serve as points of interaction among higher education institutions, Governments, industry and the private sector generally; and
i) raise awareness of the designated Priority Areas in Australia, particularly their importance in innovation and international competitiveness.

Selection processes

Applications

In March 2002, the ARC held a series of public forums to discuss the program with the research community and invite feedback on the program's proposed funding rules. Advice received during these consultations was incorporated into the Centres of Excellence Funding Rules, which were approved by the Minister on 6 June 2002 and released on the ARC's website on 10 June 2002.

The ARC encouraged potential applicants to explore opportunities for collaboration and cooperation prior to the competitive selection process. To facilitate discussion and negotiation,

the ARC required potential applicants to provide an expression of their intention (EOI) to submit a full application. The ARC required prospective applicants to submit EOIs by 15 July 2002. A total of 88 EOIs were submitted by 23 administering universities, involving more than 1,000 researchers as potential participants. The numbers of EOIs nominating in each priority area as either their principal area or as covering some research in the area were:

Table 1: Distribution of Expressions of Interest by Priority Area

Area	Principal Area	Coverage
NBM	14	28
GPR	27	35
CSI	30	43
PST	17	31

Full applications closed on 16 September. The ARC received 56 applications from 21 administering universities, involving more than 750 researchers as potential participants. While the ARC did not ask applicants about the merging of EOIs, it believes that at least 10 of the full applications resulted from merging at least two EOIs.

Table 2: Distribution of Applications by Priority Area

Area	Principal Area	Coverage
NBM	10	16
GPR	20	22
CSI	13	18
PST	13	19

Selection committee

The ARC Board appointed an ARC Centres of Excellence Selection Committee with the approval of the Minister for Education, Science and Training. The Selection Committee was chaired by Professor Mary O'Kane. The membership of the Committee is listed at Appendix 1.

Assessment

Applicants were asked to nominate five international expert assessors in the relevant priority areas at the time of submitting Expressions of Intent to Apply. Applicants had been asked to confirm that each assessor was willing to assess up to four applications, and would be available to do so during a specified interval defined by the ARC's application processing timeline. Applications were assigned to approximately 12 of these nominated international assessors, whose reviews of applications were provided to Committee members, along with applicants' rejoinders to these reviews.

The Committee met on 14 November to shortlist applicants for interview, using a videolink to allow all members to participate without the requirement for long-distance travel. The Committee shortlisted a total of 22 applications. The Committee met again on 25-28 November to interview the shortlisted applicants, and on 29 November to finalise ranks and to formulate funding recommendations. At both meetings ARC rules for managing institutional and personal conflicts of interest were strictly observed.

Selection criteria

The Committee's assessment of applications was based on the program's selection criteria:

A. Research program
   i) The creative and innovative nature of the proposed research program, and its capacity to lead to a significant advancement of knowledge in the designated Priority Areas;
   ii) The degree to which the application enhances the concentration and coordination of research in the particular field(s) of research; and
   iii) The adequacy of the conceptual framework, design, methods and analyses and their integration into the aims of the research programs.

B. Investigators
   i) The applicants' track records, relative to opportunity, in the designated Priority Areas, as indicators of their potential to contribute to the Centre's research program;
   ii) The Director's capacity for leadership, vision, management and strategic planning; and
   iii) The commitment of Chief and Partner Investigators to the research program.

C. Research training and professional education
   i) The potential contribution of the Centre to research training at the Honours, Postgraduate and Postdoctoral level; and
   ii) The potential value of the education and outreach programs in professional and technical training.

D. National benefit
   i) The extent to which the Centre would expand Australia's knowledge base and research capability in the designated Priority Areas;
   ii) The number and spread of applications within and across the designated Priority Areas;
   iii) The capacity for the research program to enhance innovation in Australia; and
   iv) The potential of the research project to result in economic, cultural, environmental or social benefits for Australia from the expected results and outcomes of the project.

E. International, national and regional links and networks
   i) The potential standing of the proposed Centre relative to major international centres in the general field(s) of research;
   ii) The potential for enhancement of effective international interactions and linkages;
   iii) The planned links with Australian researchers in universities and other research organisations working in the proposed fields of research;
   iv) The commitment and mechanisms proposed to provide a national and regional intellectual focus for the planned field(s) of research; and
   v) The potential contribution of proposed links with scholars in the Humanities and Social Sciences to the Centre's activities.

F. End-user links
   i) The participation of end-users in research planning and Centre governance;

ii) Where applicable, the adequacy of plans and strategies for facilitation of technology transfer including fostering a culture of innovation; and
iii) The adequacy of organisational arrangements and plans relating to ownership of intellectual property and/or utilisation or commercialisation of research.

G. Organisational support
i) The commitment of the Collaborating Organisations to provide basic infrastructure, including provision of space, equipment, administrative and technical staff support, telecommunications and computing facilities, library and other key resources, over the funding period;
ii) The fit or complementarity of the proposed Centre with the Collaborating Organisations' overall research strengths and directions; and
iii) The provision of funding to support the Director and key investigators to execute their research leadership roles.

H. Governance
i) The adequacy of the proposed management arrangements and responsibilities, including the organisational structure of the proposed Centre, its reporting arrangements both internally and externally, its financial systems, and its business and strategic plans which should include milestones for achievement of objectives; and
ii) The relevance of the performance measures listed in the application to the Centre's objectives and their pertinence for assessing the Centre's performance.

Funding for Centres of Excellence 2003-2007

As determined at the 7th Board meeting (27 February 2002), funding available for allocation under the ARC Centres of Excellence program over the 2003-2007 period was $80,000,000. Several of the applications under consideration involved existing ARC Key Centres of Teaching and Research and/or ARC Special Research Centres, which the applicants proposed to "roll up" in any new Centre of Excellence that might be awarded. The ARC advised the Selection Committee that any funding rolled up in this way would be applied towards the proposed funding assistance for the new Centres of Excellence, through administrative processes. In the event, two former Special Research Centres and two former Key Centres are to be rolled up if the recommendations for new Centres of Excellence are accepted, releasing a further $10,422,660 in the ARC's Research Centres program.

Recommended applications

The Committee considered 56 applications that sought a total of $622,664,974 in ARC funds. Table 3 lists the 8 applications (14.3% of applications) recommended for funding. The Selection Committee found that each of these applications met the Selection Criteria. The Committee noted that several of the research teams recommended for funding already rank as outstanding relative to top research teams overseas, and that all have the potential to rank among the very best in the world. The recommended funding for these applications totals $89,004,323. Several of the recommended Centres of Excellence build on existing ARC Special Research Centres (Quantum Computer Technology and Third-Generation Photovoltaics) and ARC Key Centres (Photovoltaics Engineering and Field Robotics). Summary descriptions of the recommended Centres are provided at Appendix 2.

Table 3: ARC Centres of Excellence recommended for funding

ARC Centre of Excellence	Administering university	Interim Director	Total Funding 2003-2007
Quantum Computer Technology	The University of New South Wales	Prof RG Clark	$14,000,000.00
Advanced Silicon Photovoltaics and Photonics	The University of New South Wales	Prof SR Wenham	$12,175,000.00
Biotechnology and Development	The University of Newcastle	Prof RJ Aitken	$9,458,900.00
Autonomous Systems	The University of Sydney	Prof HF Durrant-Whyte	$10,000,000.00
Ultrahigh-bandwidth Devices for Optical Systems	The University of Sydney	Dr CM de Sterke	$11,513,848.00
Mathematical and Statistical Modelling of Complex Systems	The University of Melbourne	Prof AJ Guttmann	$10,906,575.00
Integrative Legume Research	The University of Queensland	Prof PM Gresshoff	$10,000,000.00
Quantum-Atom Optics	The Australian National University	Prof HA Bachor	$10,950,000.00

Uncompetitive applications

A total of 39 applications (69.6%) were considered uncompetitive and have not been recommended for funding.

Reserve List

The Committee identified a reserve list of 9 applications from the shortlist. The Selection Committee found that each of these applications met the Selection Criteria. These proposals are recommended for funding should any of the recommended Centres ultimately not be funded. The Committee was impressed by the potential of the Reserve applications to form valuable concentrations of research excellence in Australia, building scale and focus in the Priority Areas. It encouraged the ARC to seek other ways to fund the Centres proposed in these applications if they cannot be funded from the current allocation to the Centres of Excellence program, possibly at a lower level of funding than requested in the Centres of Excellence application.

Statistical characteristics of recommendations

Overall outcomes

Table 4 shows all applications and applications recommended for funding, with details of requested and recommended funds and partner cash contributions offered in the application.

Table 4: Requested funding and partner contributions

Institution	ARC Centre of Excellence	Requested ARC $	Partner matching $	Recommended ARC $
UNSW	Quantum Computer Technology	$14,000,000	$20,740,000	$14,000,000
UNSW	Advanced Silicon Photovoltaics & Photonics	$12,175,000	$2,950,000	$12,175,000
UNewcastle	Biotechnology and Development	$9,458,900	$2,250,000	$9,458,900
USydney	Ultrahigh-bandwidth Devices	$11,513,848	$6,879,212	$11,513,848
USydney	Autonomous Systems	$10,000,000	$2,500,000	$10,000,000
UMelbourne	Mathematical & Statistical Modelling of Complex Systems	$10,906,575	$2,125,000	$10,906,575
UQueensland	Integrative Legume Research	$10,000,000	$5,330,000	$10,000,000
ANU	Centre for Quantum-Atom Optics	$10,950,000	$3,784,000	$10,950,000
TOTAL		$89,004,323	$46,558,212	$89,004,323

Outcomes by priority area

Table 5 provides information on funded applications classified according to priority areas of research. Each application nominated the percentage overlap between its proposed research program and the designated priority areas. It is important to note that a large part of the research in the Centres for Advanced Silicon Photovoltaics and Photonics, Ultra-high Bandwidth Devices, and Quantum-Atom Optics relies on nano-fabrication technologies, and will produce elaborately constructed nano-devices and novel nano-materials. While the Nano-materials & Bio-materials priority area at first sight appears to be under-represented, the Centres in practice cover the four Priority Areas in approximately equal proportions.

Table 5: Percentage of research in Priority Areas

ARC Centre of Excellence	NBM	GPR	CIS	PST
Advanced Silicon Photovoltaics and Photonics				100%
Quantum Computer Technology	75%			25%
Biotechnology and Development		100%		
Autonomous Systems			100%	
Ultrahigh-bandwidth Devices for Optical Systems				100%
Mathematical and Statistical Modelling of Complex Systems			100%	
Integrative Legume Research		100%		
Quantum-Atom Optics				100%

Institutional outcomes

Table 6 shows, by administering university, the funding requests and partner contributions for those applications recommended for funding.

Table 6: Funding requests & partner contributions by administering institution (HEFA order)

	All applications		Funded applications			
Administering Institution	**Nr. sub.**	**ARC request $**	**Nr. rec.**	**ARC request $**	**Participant**	**ARC funded $**
The University of New South Wales	6	$67,111,400	2	$26,175,000	$23,690,000	$26,175,000
The University of Newcastle	2	$24,458,900	1	$9,458,900	$2,250,000	$9,458,900
The University of Sydney	5	$53,715,888	2	$21,513,848	$9,379,212	$21,513,848
The University of Melbourne	8	$101,576,383	1	$10,906,575	$2,125,000	$10,906,575
The University of Queensland	7	$76,450,000	1	$10,000,000	$5,330,000	$10,000,000
The Australian National University	9	$95,549,584	1	$10,950,000	$3,784,000	$10,950,000
TOTAL		$622,664,974		$89,004,323	$46,558,212	$89,004,323

Incidence of collaboration

The ARC's Centres of Excellence program involved an exceptionally high degree of collaboration between Australian universities, Commonwealth and State Government research organisations, State and Commonwealth Government funding bodies, and international partners. A total of 31 Australian universities were involved in at least one full application, and 6 were involved in more than 10 applications each. A total of 180 other organisations were involved in full applications, including approximately 30 non-university Australian research organisations, over 25 Commonwealth and State agencies, over 30 Australian companies, and more than 60 overseas organisations, mainly universities. A total of 12 Australian universities are committed to the 8 recommended proposals, along with 9 other partner organisations.

Appendix 1

ARC Centres of Excellence Expert Advisory Committee

Chair

Professor Mary O'Kane FTSE, former Vice-Chancellor, University of Adelaide

Members

Dr Vijoleta Braach-Maksvytis, Senior Principal Research Scientist CSIRO, Leader Nanoscience & Systems, Chair CSIRO Science Forum

Professor Richard Brent FAA, Professor of Computing Science, Oxford University

Professor Tony Burgess AC FAA, Director, Ludwig Institute for Cancer Research

Dr Ian Corbett, Deputy Director General, European Southern Observatory and former Director of Science, PPARC, UK

Professor Peter Day, Professor Emeritus, Genetics, and founding Director of the Biotechnology Center for Agriculture and the Environment**,** Rutgers University

Professor Chris Fell FTSE, President of FASTs, former Deputy Vice-Chancellor, UNSW

Dr Robert Frater AO FAA FTSE, VicePresident for Innovation, ResMed

Professor David McClelland, Head, Department of Physics, ANU

ARC Centres of Excellence Program

ARC Centre of Excellence for Quantum Computer Technology

Interim Director: Professor R G Clark

Collaborating Institutions:
The University of New South Wales
The University of Queensland
The University of Melbourne
Macquarie University
Griffith University
The University of Sydney
Australian Defence Force Academy
Defence Science and Technology Organisation
Los Alamos National Laboratory
Ohio State University
LPS University of Maryland
Hewlett-Packard Laboratories

Development of a quantum computer is one of the century's major challenges in science and engineering. The international race to construct such a computer is of the highest technological calibre. Australia is currently placed amongst the front-runners through its groundbreaking research in quantum computing theory and in world-leading capacity to manipulate the atomic building blocks of a quantum computer. The existing ARC Special Research Centre for Quantum Computer Technology has played a pivotal role in positioning Australian research in the highly competitive field. The new Centre of Excellence will build on this success to enhance Australia's momentum in this race, by building stronger research teams of theoreticians and experimentalists working on coordinated projects towards the common goal.

The Centre's main technological thrust is a form of quantum computer based on the quantum control of individual atoms precisely situated in a silicon crystal. Key milestones already reached in this program include the ability to register the implanted atoms one by one, the capacity to fabricate atomic-scale arrays, and the demonstration of architectures for reading and controlling the quantum states. The roadmap past these milestones towards the goal of a quantum computer has been drawn up in detail by the Centre's key researchers, often with alternative paths if one is found to be blocked. The Centre will also undertake theoretical and experimental research on a complementary form of quantum computing, based on optical methods.

The potential economic and social benefits of quantum computing are of strategic importance. The Centre maintains a close relationship with government and industry, regarding in particular the commercialisation opportunities. The Centre plays a leading role in training gifted Australian researchers, engineers and technologists in the methods and innovation cultures of the modern photonics, electronics and nanotechnology industries. It also acts as a magnet to expatriate researchers, and to attract some of the world's best scientists to Australia.

ARC Centres of Excellence Program

ARC Centre of Excellence for Advanced Silicon Photovoltaics and Photonics

Interim Director: **Professor S R Wenham**

Collaborating Institutions: The University of New South Wales
Max-Planck-Institut fur Mikrostrukturphysik
FOM Institute for Atomic and Molecular Physics
Pacific Solar Pty Ltd

Photovoltaics is the science and technology of converting light (generally sunlight) to electricity. Many studies have identified photovoltaics as the most promising of presently known energy conversion options for a globally sustainable energy future. Australia has been a large player in photovoltaics as a manufacturer, end-user, and source of new technology and, with appropriate nurturing, it is not impossible that Australia could reach a world-dominant commercial position in photovoltaics comparable to Denmark's 50% presence in the world wind generator market.

The Centre will undertake a large-scale, coordinated and cross-fertilizing program including top overseas researchers to capitalise on Australia's position in photovoltaic research. Projects will aim at improving 'first generation' technologies by developing low-cost buried contacts, 'second generation' technologies through the use of laser-induced doping interconnects that reduce cost and complexity, and 'third generation' technologies through the experimental investigation of novel materials and structures. Another exciting and innovative research strand will explore high-efficiency silicon light emitters and microelectronic light modulators, exploiting the deep understanding of silicon's photonic properties that has been built up by the Centre's researchers.

The Centre will also play a central role in training researchers, technologists and entrepreneurs for the booming photovoltaics industry, through higher degree programs and new undergraduate programs in photovoltaics and solar energy. The Centre will develop a range of exciting educational materials for school teachers and students, work with industry associations to provide training resources for solar energy system installers and maintainers, and contribute to discussions about Australia's and the world's sustainable energy future.

This new Centre of Excellence will incorporate two existing ARC research centres, the Special Research Centre for Third-Generation Photovoltaics and the Key Centre of Teaching and Research for Photovoltaics Engineering. Using the critical mass provided by this new funding and leveraging off these existing centres, the new Centre so formed will create a truly world-class facility with personnel who will place Australia at the forefront of a modern industry which will be critical to the advancement of society in the 21st century.

ARC Centres of Excellence Program

ARC Centre of Excellence in Biotechnology and Development

Interim Director: **Professor R J Aitken**

Collaborating Institutions: The University of Newcastle
Monash University
The University of Queensland
The University of Melbourne
The Australian National University

The Centre will bring together a unique group of experts to study the differentiation and maturation of male germ cells. There are few areas where intensive study of the complex processes that control cell behaviour and fate could have such immediate, practical applications in the development of Australian biotechnology industries, the management of animals in the Australian environment, and the health and well-being of the Australian people.

The Centre will undertake integrated and coordinated research across a spectrum of problems associated with male fertility. One program will explore the mechanisms leading to the formation of spermatogonial stem cells, a transition believed to be central to testicular cancer. The research may identify the environmental factors that are inducing a rising tide in the incidence of this distressing disease in young Australian men. Another program will explore new ways to enhance, diminish and control male fertility, for application to human fertility issues and also to control male fertility in animal populations for commercial and environmental applications. Centre research will aim to explain a number of genetic diseases that result from exposure of the male parent to environmental toxicants and are expressed as increased risk of disease (e.g. cancer or dwarfism) in the offspring. Biotechnology benefits from the Centre's research may include non-surgical methods to sterilize male domestic animals, and new methods for the production of transgenetic animals using the male germ line, which would then express commercially valuable genetic products. The Centre recognises the opportunities in these areas, and has already established links with manufacturers of veterinary products.

The Centre has a strong commitment to building national and international networks for research, research training and commercialisation. Such networks are of particular importance to a regional university such as the University of Newcastle.

ARC Centres of Excellence Program

ARC Centre of Excellence Centre for Autonomous Systems

Interim Director: Professor H F Durrant-Whyte

Collaborating Institutions: The University of Sydney
The University of New South Wales
University of Technology, Sydney

Autonomous systems represent the next great step in the fusion of machines, computers, sensors and software to create robots capable of rich, cooperative interactions with the real world.

The Centre brings together the existing ARC Key Centre for Field Robotics at the University of Sydney, the Department of Artificial Intelligence at the University of New South Wales, and the Mechatronics and Intelligent Systems Group at the University of Technology, Sydney. Working together, the teams will undertake innovative fundamental research and persuasive experimental demonstrations of complete autonomous systems, involving many agents interacting, cooperating and working towards a common goal. The themes interact and are brought together in two demonstrations, one focussed on the built environment and the other the natural outdoor environment.

Australia already enjoys a leading international position in autonomous systems, addressing strong national needs in mining, waterfront cargo handling and agriculture. Other opportunities include field applications in construction, forestry and transport; potentially hazardous applications in bush fire fighting, warfare, search-and-rescue and air, land and maritime defence; and social applications such as robotic wheelchairs, walkers and carers; domestic and automotive devices; and entertainment.

The Centre will broaden and deepen its already extensive industry links with the strategic aim of establishing a vibrant new autonomous system industry in Australia. To support this, the Centre will provide a large and vigorous program of education and training in schools and universities and will provide specialist courses for researchers and industry.

ARC Centres of Excellence Program

ARC Centre of Excellence for Ultrahigh-bandwidth Devices for Optical Systems

Interim Director: Dr C M de Sterke

Collaborating Institutions: The University of Sydney
The Australian National University
University of Technology, Sydney
Macquarie University
Swinburne University of Technology
Osaka University
University of Central Florida
Lucent Technologies
Institut Fresnel
NSW Department of Information Technology and Management

The photonic chip will be the basic building block of the next generation of ultra-high bandwidth optical telecommunications systems, and will appear as a core component of defence systems and sensor technologies. The Centre's research will address fundamental physics and technology problems, leading to devices that integrate several all-optical photonic processors on a single chip. The research will create new material with unique properties designed to allow the guiding and control of light, microstructures, optical fibres and artificial photonic crystals that will enable a range of high-speed operations on signals encoded in light beams, and develop microphotonics capability to encapsulate the Centre's optical processors onto devices that can be installed in photonic networks.

Australia is now amongst the world leaders in the science of optics and photonics, and has successfully translated this science into devices that have been commercialised on the international market. Australia also has special demands for low-cost, increased bandwidth linking remote and regional communities in critical services such as education and health. This know-how and need comes together in the Centre's vision to be a foundation for a vibrant Australian photonics and communications industry serving national needs and exporting Australian technologies to the world. The Centre is committed to forming the networks and linkages, including critically important strategic links with international partners required to achieve this aim.

In addition to its undergraduate and postgraduate education programs training the next generation of photonics researchers, technologists and innovators, the Centre will sponsor a large community outreach program through secondary schools and the media. The program will convey the excitement, significance and implications of the latest photonic technology, and of the social transformations it will enable.

ARC Centres of Excellence Program

ARC Centre of Excellence for Mathematical and Statistical Modelling of Complex Systems

Interim Director: Professor A J Guttmann

Collaborating Institutions: The University of Melbourne
The Australian National University
The University of New South Wales
La Trobe University
The University of Queensland

Complex systems play an integral role in providing society with amenities such as the internet, air traffic control, irrigation systems, robotics, electrical power and telecommunications grids, defence and security systems, and manufacturing services and financial infrastructure. They also provide models for biological and economic systems of all types. Complex systems are characterised by the property of 'emergence', where the system considered as a whole displays properties that are not displayed by the component parts – 'the whole is greater that the sum of the parts'.

It is of pivotal interest to society to have a greater understanding of complex systems, and ability to model and predict their behaviour. The Centre will assemble a very strong team to investigate mathematical and statistical models of complex systems, and to cross-fertilize these investigations with systems analysis and control theory.

The Centre will conduct research on criticality and phase change (e.g. in control of traffic queuing, and understanding catastrophic failure), Monte Carlo methods (e.g. in modelling financial systems), statistical modelling (e.g. in understanding telephone and internet traffic), dynamic systems (e.g. in meteorology, oceanography, and the behaviour of polymers and composite materials), risk modelling (e.g. in insurance, national security and health interventions), and advanced computation (e.g. to speed industrial design and to predict large-scale, long-term environmental impacts).

Mathematic and statistics lie at the centre of thought and reasoning in science, social science, engineering and technology. The Centre will lead research not only in complex systems, but will reinforce the importance of mathematics and statistics across the spectrum of Australia's scientific and technological development. To achieve this, the Centre will maintain an extensive and vigorous outreach program, encompassing schools, commerce and industry, and the broader research community in Australia.

ARC Centres of Excellence Program

ARC Centre of Excellence for Integrative Legume Research

Interim Director: **Professor P M Gresshoff**

Collaborating Institutions:
The University of Queensland
The Australian National University
The University of Melbourne
The University of Newcastle

Legumes, such as peas, chickpeas, lupins and soybeans, are very special plants. Their nitrogen fixing qualities assist sustainable pasture production and cereal crop rotation capability. Legume crops yield high quality vegetable oils, vegetable protein, and nutriceuticals such as anti-oxidants, phytoestrogens and folate.

Australia has a long record of outstanding legume research and its application to sustainable food production. The Centre will bring together an internationally competitive research team from the Universities of Queensland, Melbourne and Newcastle and the Australian National University to build on this research base through understanding the primary action of individual genes and the complex interaction of genes controlling plant development. The Centre has the opportunity to make a major breakthrough by the discovery of long-distance signalling molecules, including peptides.

The new knowledge will lead to new legume breeding and screening strategies, capable of side-stepping genetically engineered food products through smart breeding technology in which specific gene combinations, demonstrated to be beneficial, are selected from natural or mutated plant material through advanced molecular diagnostics.

Through fundamental research on processes affecting legume flowering, shoot branching, lateral rooting, stem elongation and nodulation, the Centre will improve understanding of ways to modify legume growth and architecture. For example, breeding pasture legumes with more extensive and deeper roots can help mine soil moisture and nutrients in areas where the water table is rising. This can provide competitive advantage in legume cropping, and also reverse environmental degradation through the use of legume rescue crops.

The Centre will implement a science and education program attractive to the community, farmers and scientists. There will be an emphasis on assisting secondary school teachers in the theme ‘plants for health and the environment’.

ARC Centres of Excellence Program

ARC Centre of Excellence for Quantum-Atom Optics

Interim Director: **Professor H A Bachor**

Collaborating Institutions:
The Australian National University
The University of Queensland
Swinburne University of Technology
Universitat Hannover
Université Pierre et Marie Curie
Vrije Universiteit
University of Otago
University of Auckland
Imperial College

Using delicately controlled laser light beams to nudge individual atoms together, scientists have recently learned how to make a new state of matter called the Bose-Einstein Condensate (BEC). In a BEC, the matter-waves of individual atoms overlap, producing unusual and unexpected properties and behaviours. The Centre brings together an extremely strong, balanced, international team that aims to develop a quantum toolbox for atoms and photons, and to apply this to conduct fundamental research on the quantum nature of multi-particle states comprising atoms, photons or both.

Australia is particularly well placed to build a world-class Centre in this emerging field, which has already seen the award of two Nobel prizes in the past five years. The Centre research team will combine pre-eminent quantum theorists with experimenters who have a powerful armoury of techniques for producing squeezed states of light and BECs.

The five-year research program of the Centre aims to develop a pumped, continuous-wave atom laser as a direct analogy to an optical laser, to study atom-light entanglement which is a potential storage process for quantum computing, to explore BECs in optical lattices as a way of controlling matter waves, to investigate 'superchemistry' using molecular BECs, and to produce a BEC on an electro-magnetic microtrap on a chip. Each one of these aims has the potential to lead to a range of novel and innovative applications over the next few decades, in a manner analogous to the way that the optical laser has become the basis for many commercial and social applications since its invention approximately 50 years ago.

Research conducted by the Centre's team has already captivated the attention of the Australian community (the optical teleportation experiment) and it will continue to excite and inspire young Australians' interests in scientific frontiers. The education programs of the Centre will train a generation of R & D staff and technology experts who will be key personnel in the industries that emerge from atom-optics, advanced photonics, and quantum computing.