# HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON SCIENCE AND INNOVATION
# INQUIRY INTO PATHWAYS TO TECHNOLOGICAL INNOVATION
# AUSTRALIAN RESEARCH COUNCIL (ARC) SUBMISSION

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## BACKGROUND

### This submission

On 18 March 2005, the House of Representatives Standing Committee on Science and Innovation announced a new inquiry into the pathways from innovation to commercialisation. In conducting the inquiry, the Committee is seeking to compile a series of successful case-studies about technological innovation and through these case-studies to examine pathways to commercialisation; strategies to overcome potential barriers to commercialisation; and factors which determine innovation success.

This submission is organised into two sections. The first section describes briefly three key factors underpinning Australia's innovation performance – a base of excellent research; strong collaborative linkages between universities, industry and publicly funded research agencies; and Government support across the life-cycle of innovation activities. In the second section, the role of the ARC in supporting innovation is outlined (see also Attachment A), with particular reference to the contribution of the schemes of the ARC's National Competitive Grants Program (NCGP).

The examples and case-studies provided in this submission are drawn from ARC-funded research. The examples provided throughout the text are drawn primarily from material in final reports submitted by researchers as part of the reporting requirements specified under the schemes of the NCGP[1]. The more detailed case-studies, which are provided in Attachment B, are drawn from material prepared for the following ARC-commissioned studies: *A Wealth of Knowledge: The return on investment from ARC-funded research*[2] and the *National Survey of Research Commercialisation-Year 2000*[3].

### The Australian Research Council

The ARC's mission is to advance Australia's research excellence to be globally competitive and deliver benefits to the community. This entails activities in three broad areas: (i) supporting the best research which is most likely to contribute to innovation; (ii) brokering partnerships among researchers, industry, government, community organisations, and the international community; and (iii) providing policy advice to the Australian Government on investment in the national research effort.

The NCGP is the primary vehicle by which the ARC pursues its mission. Funding for the Program – over $480 million in 2004–05 – accounts for approximately nine per cent of the Commonwealth Budget for science and innovation. Support provided through the NCGP dominates competitive funding for university research and is one of the principal avenues for direct support of pure and strategic basic research in Australia's R&D system as well as fostering university-industry collaboration in research.

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1 Successful applicants for ARC funding are required to provide a final report on completion of their research project (within six months of completing the research).

2 *A Wealth of Knowledge: The return on investment from ARC-funded research*, The Allen Consulting Group, 4 September 2003

3 *National Survey of Research Commercialisation-Year 2000*, ARC, CSIRO and NHMRC, September 2002

The NCGP is composed of a set of interrelated program elements that are deliberately structured in such a way as to provide a pathway of incentives for researchers, as they develop in expertise and experience, to build the scope and scale of their work. The incentives are provided to researchers through a program structure that, broadly, targets funding in two areas: (i) building research capability, and (ii) achieving focus through critical mass.

## SECTION 1: FACTORS UNDERPINNING AUSTRALIA'S INNOVATION PERFORMANCE

A nation's innovation performance is driven or underpinned by capabilities in a range of areas, including the following which are addressed briefly in this section: the conduct of excellent research across a range of disciplines, strong collaboration and linkages between different elements of the national innovation system; and Government support across the 'life-cycle' of innovation activities.

### A base of excellent research

Research is one of the major drivers of Australia's economic growth and competitiveness in the global market. The continuum that ends with significant jobs growth in new industries begins with research activity which, through links between the providers and users of research, enables industry to seize the benefits of new knowledge. Together with the training and provision of highly skilled people able to recognise applications of new knowledge, research and development leads to greater employment opportunities, economic growth and enhanced quality of life for all Australians.

Concentrations of activity involving innovative firms, publicly funded research agencies (PFRAs) and universities can act as magnets for new technology, skilled personnel and investment in research. They emerge in circumstances where the critical mass of activities allows economies of scale and scope, where there is access to a strong science and technology base, and where there exists a culture conducive to collaboration.

*The importance of publicly funded research*

Evidence from studies carried out in the US and Australia by Narin *et al*, which link patents – as indicators of innovative activity in the economy – to publicly funded research, indicates the economic importance of publicly funded basic research.

The results of a study conducted for the ARC and CSIRO in 1999[4] found a strong relationship between patents and high-quality publicly funded research:

- Ninety-seven per cent of citations in Australian-invented US patents were to papers authored at publicly funded institutions – 45.5 per cent to papers authored at universities;
- Of all Australian-authored scientific research papers cited in 1988–97 US patents, the ARC and the NHMRC are the individual organisations most frequently acknowledged in those papers – the ARC in papers across a broad range of discovery research and the NHMRC predominantly in clinical medicine and biomedical research papers; and
- the only countries which had higher science-linked patents than Australia are Israel, the USA and Canada[5].

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4 Narin, F. et al, *Inventing Our Future*: *The link between Australian patenting and basic science*, ARC and CSIRO, Canberra, 2000

5 The countries analysed were Israel, the US, Canada, Australia, the United Kingdom, Sweden, the Netherlands, Finland, Japan and Taiwan.

*The importance of research excellence*

A 2000 study by CHI Research[6] found that the papers that are most highly cited in the research literature are the most likely to be cited in US patents. More specifically, a paper that is amongst the top one per cent of cited research papers is nine times more likely to be cited in a US patent.

A policy conclusion, which with some degree of certainty can be drawn from these data, is that scientific excellence and innovation are closely linked. Assuming that patents (all else being equal) accelerate innovations with commercial potential, the fact that highly cited papers are much more likely to be cited in patents suggests that research excellence and contributions to innovation go hand in hand. Consequently governments and private sector companies that fund the best research are likely to have the best chance of reaping technological benefit.

At a recent forum on the internationalisation of R&D held in Brussels a speaker from Microsoft drew attention to the fact that this year Microsoft would invest some $7 billion – approximately 20 percent of its net revenue – in research and development. In addition, approximately 25,000 of Microsoft's 55,000 employees (45 per cent) would engage in some aspect of research and development, including an estimated 1,000 persons involved in pure research. The level of commitment is a clear indication of the centrality of research to the company's endeavours.

The Chief Executive Officer of CSL Limited, a biopharmaceutical company, is also reported recently as saying "We don't see ourselves in competition with the traditional Australian biotech companies. They tend to make a discovery that has been to some degree worked up. We tend to work with the academics earlier than that where we might have an insight that they may not have. But we recognise that they may have a lot of info that we may not have. So we try to marry our expertise and create the intellectual property together[7]."

A clear message from these studies and observations is the necessity for a broad-based foundation of basic research of the highest quality. While one of Australia's major strengths is its publicly funded excellent research base it is imperative that this competitive advantage be maintained and enhanced. Australia must capitalise on its research strengths if it is to be a successful knowledge-based economy and a foundation of basic research excellence is a vital prerequisite to this pursuit.

**Strong collaborative linkages**

It is acknowledged that in situations where there is a higher degree of collaboration, innovation generally occurs more rapidly and with greater intensity[8]. The collaborative links (and the mobility of people that are encouraged by them) facilitate the free flow of ideas between the different parts of the national innovation system stimulating innovation.

In recent years there has been a plethora of studies on the nature and strength of collaborative links between universities and industry as well as between universities and major publicly funding research agencies. One of the most recent evaluations of these links, conducted in 2003 as part of an exercise of mapping Australia's science and innovation system, concluded that the linkages among the elements of our national innovation system (and the initiatives in place to encourage them) were strong in some areas and weaker in others.

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6 CHI Research, Vol. VIII, No.1 - July 2000

7 *CSL's anti-viral breakthrough set to be blockbuster*, Robert Gottliebsen, The Weekend Australian, 23 April 2005

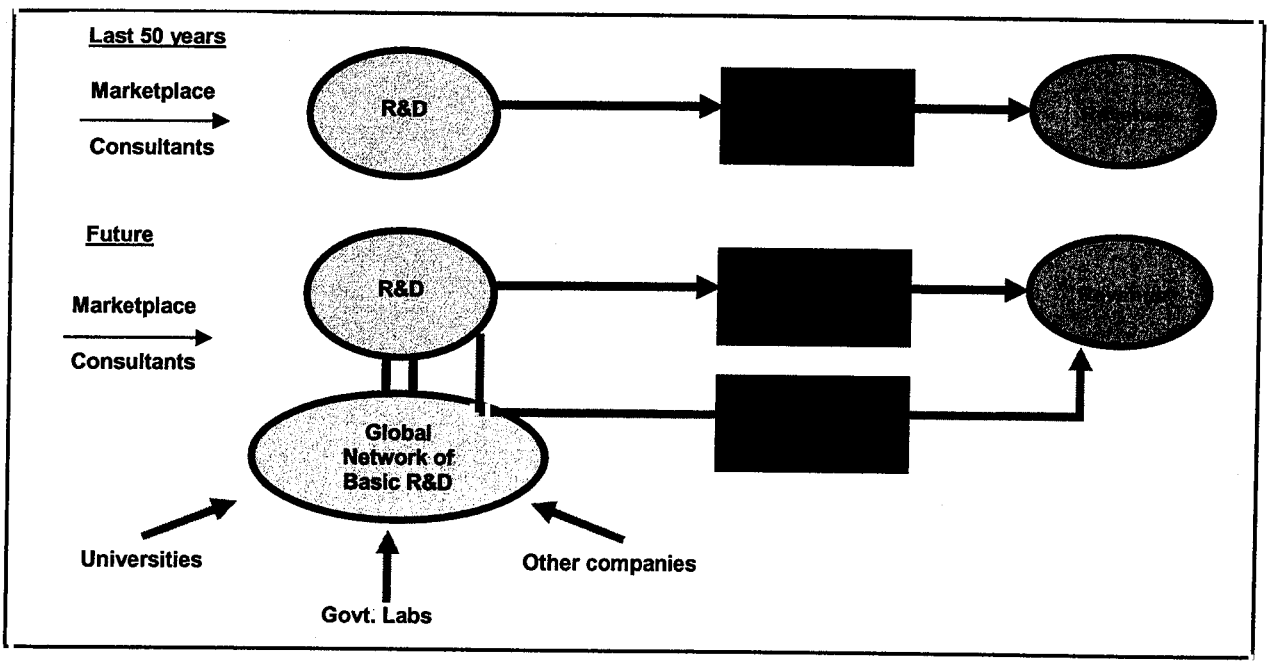
8 See, for example, Nelson, R., *On the uneven evolution of human know-how*, Research Policy, vol.32, no.6., 2003.

A strengthening performance in this area was indicated by[9]:

- a doubling between 1994 and 2000 of payments (in nominal terms) from Australian businesses to universities;
- an increase in joint university/government, university/industry and university/CSIRO research publications;
- increasing contributions to Cooperative Research Centres (CRCs) from states and industry compared to the start of the 1990s; and
- growing numbers of nodes of collaboration in the research system (for example, centres of excellence and networks).

The fact that payments from businesses to universities has increased, supports the notion of a growing emphasis on business-university partnerships which has been fuelled, in part, by changing business behaviours in an increasingly competitive environment. Rather than exclusively conducting most of their research and development in their own laboratories, as was previously the case, businesses are increasingly seeking to outsource these activities and collaborate with others in a new form of innovation[10] (see Figure 1). A survey conducted recently by the Business Council of Australia[11], for example, found that 80 per cent of respondents were undertaking some form of external R&D with roughly half of the expenditure allocated for this purpose going on research conducted with other businesses and half on research with universities and publicly funded research institutions.

**Figure 1: Changing paradigms for large company R&D (Source: Dupont)**




In this environment, the basis for development of successful sustainable partnerships and more natural flows of ideas and skills between the sectors is communication and trust[12]. It has been argued, for example, that links will follow naturally where universities and business are receptive to working together. Government programs, including those administered by the ARC play an important role in creating the relationships that enable that trust to be built.

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9 *Mapping Australian Science & Innovation: Main Report*, Commonwealth of Australia, 2003

10 *Lambert Review of Business-University Collaboration Final Report*, December 2003

11 *Research and Development Investment by Australia's Leading Businesses – A Survey of BCA Member Companies*, Business Council of Australia, 2004

12 [see footnote 10]

Notwithstanding this evidence of more and strengthened linkages, the mapping exercise[13] also concluded that there were weaknesses in 'linkages and collaboration' as demonstrated by the impediments to collaboration between the higher education and business sectors. Key impediments identified included the disincentives for people to cross the boundary between industry and university and different understandings of suitable intellectual (IP) arrangements for the commercialisation of IP.

Lack of mobility is a significant barrier to collaboration, due in most instances, to inflexible and widely different conditions of employment and remuneration across different sectors. One of the best ways to transfer knowledge or technology from the performers to the users of research is to transfer people. Without this capability it becomes very inefficient to transfer knowledge from one organisation to another. The ARC's Linkage Projects scheme is aimed, in part, at trying to 'break-down' this barrier and it has been successful particularly at the postgraduate level. In the last funding round under the scheme, 426 Australian Postgraduate Awards (Industry) were awarded.

An additional strength of the Linkage Projects scheme is that the ARC requires – as an element of its funding agreements with institutions – that institutions not allow a research project to commence, nor funding to be expended, until the project's partner organisation and the institution have entered into a written agreement. The written agreement must, among other things, include arrangements for managing IP.

**Life-cycle support**

A 1998 report[14] highlighted the importance of life-cycle support for innovation to ensure an efficient flow from the generation of new ideas to their utilisation. It noted that the complex and dynamic inter-relationships between research and commercialisation, and between universities, other public research organisations and firms, need to be mirrored by a coordinated, whole-of-government approach to funding to assist collaborative interactions to grow in scale and complexity.

The report identified a specific barrier to life-cycle support in the form of what it termed the "innovation progression gap", between the generation of ideas from discovery research and the stage at which proposals for commercialisation of these ideas become investment-ready. Efforts have been devoted to closing this gap – notably under the *Backing Australia's Ability* packages. Nonetheless, there is a gap still evident, as indicated by the results of a survey[15] commissioned by the Department of Industry, Tourism and Resources. Over 85 per cent of respondents (both investor and client groups) verified the existence of a gap in funding at the very early stage (between $100,000 and $2 million).

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13 [see footnote 9]

14 *Interactions between universities and industry: A report to the Coordination Committee on Science and Technology,* CCST University-Industry Working Group, Commonwealth of Australia, 1998

15 *Investigating the existence of anecdotally reported innovation funding gap, Survey commissioned by the Commonwealth Department of Industry, Tourism and Resources,* Australian Institute for Commercialisation

## SECTION 2: ARC SUPPORT FOR INNOVATION

### Overview

The ARC supports innovation across the range of its responsibilities – by supporting excellent discovery research; providing incentives for the formation of linkages within the national innovation system; benchmarking Australia's research performance against international best practice; acting as a broker between researchers and users of research; and contributing to policy debate and development. A more detailed description of the ARC's activities in each of these areas is provided in Attachment A.

### National Competitive Grants Program

*Discovery Projects*

A key aim of Discovery Projects, the largest of the ARC's schemes at approximately $260 million in 2004–05, is to 'support excellent fundamental research by individuals and teams'. Although the grants are not allocated in order to promote links with industry, they do provide a platform of basic research on which more applied work in a range of areas can build (see Examples 1 and 2 below).

ARC-funded research has led to many outstanding breakthroughs that have served as a basis for the development of new products or processes – examples include the 'bionic ear' medical technology developed by Cochlear Ltd and the solar energy production technology of Pacific Solar that was on show at the Sydney Olympic Games. Further examples are provided in the case-studies at Attachment B of this submission.

> ***Example 1: Intelligent monitoring and control of resistance spot welding [ARC Large Research Grant[16]]***
>
> *In 2000, Associate Professor Stephen Simpson from The University of Sydney was awarded a research grant to research and develop a new spot welding monitor for use in the automotive industry.*
>
> *The outcomes of the project – a novel signal processing technology (signature image monitoring) – were licensed to an Australian start-up company Welding Technology Innovation (WTi). The company won the $100,000 inaugural Peter Doherty Prize for Australasian Innovation in 2003, and has recently accepted venture capital funding to assist with commercialisation of the product.*
>
> *The technology uses cutting-edge mathematics and chaos theory to analyse the quality of arc and spot welds in motor vehicles and other metal products – and pick out flaws in the blink of an eye. It has the unique ability to identify and categorise welding faults non-invasively, in real time.*
>
> *When commercialisation is complete, the new technology is expected to lead to improved quality, reliability and safety of welded products as well as improved efficiency in manufacturing. The technology is already in use in several major automotive plants in Australia and Europe. In response to industry demand, the technology has been*

[16] The Large Research Grants scheme preceded the current Discovery Projects scheme.

*successfully trialled for training of manual welders, and the first commercial system will be in operation later this year.*

*The adaptability of the signature image technology investigated in the grant has led to further lines of research. In collaboration with staff at Royal Prince Alfred Hospital, detection of pre-seizure in patients with epilepsy is currently under investigation. Results are very promising with signature image analysis of EEG (electroencephalogram) data from one patient predicting seizures twenty minutes in advance. If this technology can be commercialised, it will be possible to improve the quality of life of epilepsy sufferers, by giving them warning of impending seizures and allowing them to take medication only when necessary.*

***Example 2: Australia goes to Mach 10 on the way to the future***[17]
***[ARC Discovery Projects grant]***

*Australia's hypersonic scramjet engine will be flight tested at speeds above 10,000 kilometres per hour in 2005, in a major advance for the nation's aerospace program. The speeds, if applied to aircraft, could radically cut the time of long distance air travel. Sydney to London, for example, would take only a couple of hours.*

*With ARC funding of almost two million dollars, Professor Allan Paull and his team at the Centre for Hypersonics at The University of Queensland are pushing research boundaries in the area of high-speed travel.*

*The team will test new concepts expected to lead to greater flexibility in operational engines and work speeds in excess of 3,000 metres a second. Flight testing negotiations with several international agencies are in progress.*

*Hypersonics is a growing area of research in Australia, attracting investment from international agencies and companies. Australia is a world leader in scramjets, launching the first-ever successful test flight in 2002. NASA has an edge in flight control and scramjet development at the lower Mach numbers (the ratio between the airspeed of an object and the speed of sound), but Australia has the edge at higher Mach speeds.*

*The HyShot flight program's aim is to develop a correlation between pressure measurements made from supersonic combustion in the University of Queensland's T4 shock tunnel, simulating those observed in flight. The scramjet configuration is being used to develop this correlation, with huge implications for the development of a fully-functioning and efficient scramjet engine.*

*Federation Fellowships*

In addition to the Fellowships offered under the Discovery Projects scheme, the ARC also administers the Federation Fellowships scheme. By providing an internationally competitive salary, these awards are designed to encourage outstanding researchers to establish and build their programs of research here in Australia. To date, 69 Federation Fellowships have been awarded, including 21 to returning Australians and seven to foreign nationals.

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[17] As reported in *The Australian Government's Innovation Report 2004-05: Research Results, Real Jobs*, Commonwealth of Australia, 2005 (page 48)

Federation Fellows are expected to forge strong links among researchers, industry and the international research community, and many bring with them to their appointment experience in the commercialisation environment. Research undertaken by Professor Keith Nugent, for example, a 2002 Federation Fellow, underpinned the development of a new form of microscopy which is currently being marketed worldwide through the start-up company IATIA Ltd (see case-study in Attachment B).

*Linkage Projects*

In 2004–05, approximately 20 per cent of funding under the NCGP will be allocated through the Linkage Projects scheme. As a key element within the NCGP, Linkage Projects encourages the formation of long-term alliances between university researchers and industry, government and community organisations (otherwise known as partner organisations). These alliances facilitate the transfer of skills and ideas as a basis for securing commercial and other benefits from research.

The scheme, which comprises several elements including project grants, postgraduate awards, postdoctoral fellowships and industry-exchange fellowships, has been in operation in one form or another since 1990. In that time the size of the program and the level of partner organisation commitment to it has grown significantly and today demand continues to outstrip supply. In the most recent year of funding under the scheme[18], for example, 1,047 applications were received of which 51 per cent were successful. Table 1 indicates the performance of the scheme in leveraging cash or in-kind contributions from the partner organisations.

Table 1: New Linkage Projects grants 2004

| | Applications | Funded |
|---|---|---|
| Number | 1,047 | 532 |
| Partner organisation contribution (cash) | $77.3m | $49.6m |
| Partner organisation contribution (in-kind) | $193.3m | $114.4m |
| Partner organisation contribution (total) | $270.5m | $164.0m |
| ARC funding | Not applicable | $119.9m |

Approximately 59 per cent of the total partner contributions listed in Table 1 was provided by private companies or industry partners. This is important given the relatively low level (compared to the OECD average) of Business Expenditure on Research and Development as indicated in figures provided by the Australian Bureau of Statistics. The industry partners include a range of well-known firms such as Telstra, Optus, BHP-Billiton, Comalco, Wesfarmers CSBP, Microsoft, Westpac, Orica Australia, DuPont Australia, Herron Pharmaceuticals, Visy Industries and the Ford Motor Company, as well as a host of small- to medium-sized enterprises.

To some extent, the Linkage Projects scheme is unique among the suite of programs offered by the Australian Government to encourage universities to work with industry, government and community organisations. While it doesn't provide funding directly for commercialisation activities, it enables the parties involved to take a first step towards working together. It is this first step that, in many cases, leads to the development of longer-term relationships (see Examples 3, 4, 5 and 6 below).

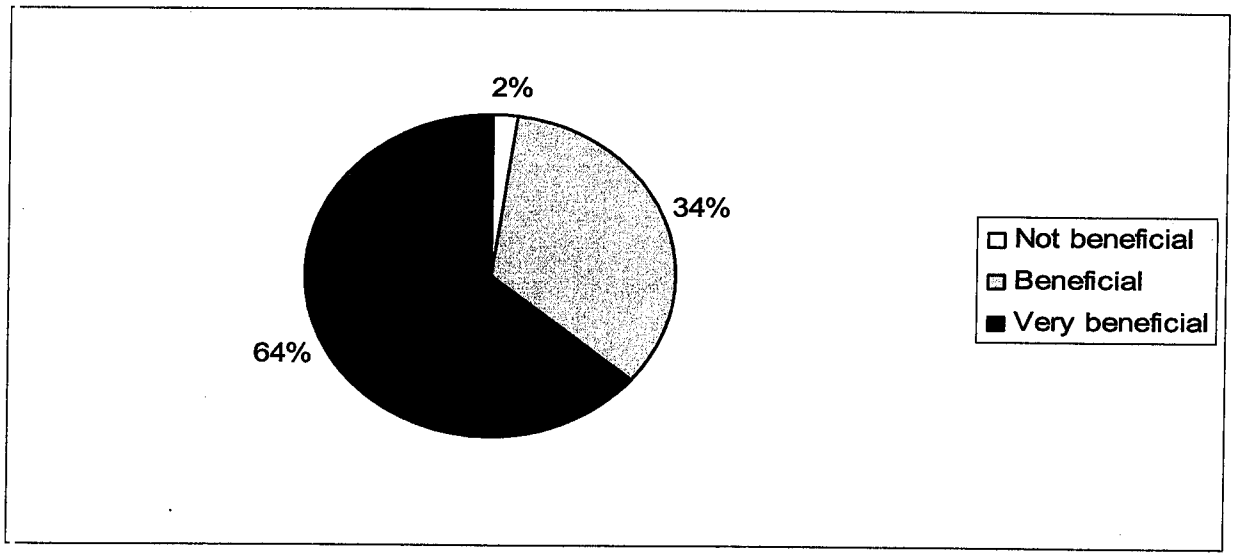
[18] The Linkage Projects scheme comprises two rounds of applications each year. The last year for which data for both rounds are available is 2004, that is, funding commencing in 2004.

In a 1999 evaluation of the ARC's linkage schemes[19], partner organisations indicated that they became involved in these schemes to capture scientific expertise not available in-house – usually to solve a particular problem or for the training and employment of research staff; to access core research in the field and capture potential flow-ons from basic research; and to complement in-house industry research, which tends to be more applied and conducted in a shorter time frame.

The evaluation also found that while large companies were the dominant participants, the scheme had been instrumental in bringing small- to medium-sized enterprises (SMEs) into research and research training partnerships with universities, particularly through the postgraduate element – the Australian Postgraduate Awards Industry. The evaluation concluded that the SPIRT scheme[20] was highly valued and utilised by Australian industry and community groups and contributing significantly to the integration of effort and efficient use of resources between the sectors.

A preliminary analysis[21] carried out during the first half of 2005 has reaffirmed these findings with ninety-eight per cent of partner organisations (who completed final report forms) indicating that the collaborative research project had been 'beneficial' to their organisation. Of this total, 64 per cent indicated that the project had been 'very beneficial' (see Figure 2).

**Figure 2: Partner organisation responses – 'how beneficial has this collaborative research project been to your organisation' (n=341)**




Partner organisations referred to the collaborative arrangements 'helping them maintain a competitive edge over rivals', allowing 'participation in long-term research that is necessary to solve a major industry problem', and being 'a cost-effective method of conducting more speculative research and development'.

19 *University and Industry Research Partnerships in Australia: An evaluation of ARC/DETYA industry-linked schemes*; A/Professor Tim Turpin, et al, 1999

20 The Strategic Partnerships with Industry-Research and Training (SPIRT) scheme is the predecessor of the current Linkage Projects scheme.

21 The preliminary analysis was conducted on 260 Linkage Projects and SPIRT grants for which final reports were received electronically during the year 2003–04.

***Example 3: Development of a roof integrated heating cooling and ventilation system [SPIRT grant]***

*In 2003 researchers at The University of South Australia (UniSA) announced that they had developed a revolutionary heating system that was 'effective, cheap to run, environmentally friendly, and designed to be tucked away inside the roof of the home or office' (UniSA Media research, University beats the heat, 1 July 2003).*

*Development of the new system, which uses existing corrugated iron roof sheets as a solar collector for heating air, was assisted by an ARC SPIRT grant awarded to the researchers in 2000 and enabled by a close collaboration between the partner organisations involved – BlueScope Steel (formerly BHP Steel), the South Australian Housing Trust and TEAP Pty Ltd. A prototype system was installed in a new house in Adelaide in 2003 and a number of other applications are under consideration for both domestic and commercial buildings. In commenting on the final outcomes, BlueScope indicated its intention to facilitate the commercialisation process for the new system.*

*In 2004, the UniSA researchers and BlueScope again collaborated on an application under the Linkage Projects scheme to investigate the development of novel roofing panels integrating solar heat collection and phase change storage. Collaborative work is continuing in refining the detailed design of the system to make it easier to manufacture and install.*

***Example 4: Novel aerodynamic techniques for a cost-effective and efficient roof top ventilator [SPIRT grant]***

*Under a SPIRT grant awarded in 2000 researchers at The University of New South Wales (UNSW), working in close collaboration with industry partner Edmonds Products Pty Ltd, developed a simple new conceptual model for ventilator design. Using the model, the researchers modified the ventilator blade design resulting in enhanced ventilator performance (in this case higher air extraction at low speed). Incorporation of the new blade design in the industrial partner's products has led to an increased share of the domestic market as well as an increase in export sales.*

*In this instance, Edmonds Products approached UNSW for joint collaboration in an effort to optimise the use of their resources by combining the company's mechanical design and manufacturing expertise with the aerodynamic expertise of the UNSW. The success of the grant has led to additional collaborative activities in the area of 'next-generation wind-driven rotating ventilators'.*

***Example 5: Sorption-reaction trench technology for the remediation of groundwater pollution originating from aluminium smelter wastes [SPIRT grant]***

*In 2000, the ARC funded a collaborative research project between Hydro Aluminium (formerly VAW Aluminium) and the University of Newcastle's Geotechnical Research Group which aimed to identify a method for remediating groundwater contaminated with fluoride and cyanide. The method is based on the use of interception-sorption-reaction trenches (or reactive barriers), and addresses a common and serious problem associated with contaminated industrial sites.*

*The research found that fluoride can be removed from contaminated groundwater using a calcite reactive barrier. In May 2004, approval was granted by Newcastle City Council and the NSW EPA to build the world's first pilot-scale testing facility at the University of Newcastle to enable research on reactive barrier technology for remediating groundwater contaminated with aluminium smelter waste. This facility was funded at a level above the original linkage proposal by Hydro Aluminium, and is due to be commissioned in May 2005. Pilot scale testing will begin in July 2005.*

**Example 6: Pelletisation of seawater-neutralised bauxite refinery residues for construction of permeable reactive barriers to treat flowing acid mine waters [Linkage Projects]**

*A collaborative research project between researchers at Southern Cross University and industry partner, Virotec International, resulted in successful patenting of a method for pelletising Bausxol™ and commercialisation of a new product for treating flowing acid rock drainage and a wide range of industrial effluents. The porous pellets are in use in a growing number of applications and a production facility has been established in Australia; other production facilities are currently being established in Europe and North America.*

*The research also led to the development of high strength Bauxsol™-based concretes that are resistant to salt and sulphuric acid attack, and to strong collaborative links with several industry and research organisations, including the European Concrete Research Institute, Belfast, Northern Ireland. The industry partner reported that collaboration and cooperation between the company and the research team has been excellent and that it intends to continue to support the work of the geochemical engineering group.*

*Centres*

Important models of collaboration funded under the NCGP today are centres of excellence and research networks. Such initiatives are being established in many countries around the world to provide a focus for collaborative cross-cutting activities. Cross-cutting activities that are characterised by multi-disciplinary, team-based approaches to research and innovation are becoming increasingly important in drawing together expertise to address problems in areas of national importance.

In 2005, the ARC is funding 36 research centres including three co-funded centres of excellence, eight ARC Centres of Excellence, nine ARC Centres and 16 Special Research Centres. The three co-funded centres – the Australian Centre for Plant Functional Genomics (with the Grains Research and Development Corporation), the Australian Stem Cell Centre (with the Department of Industry, Tourism and Resources), and National ICT Australia (with the Department of Communications, Information Technology and the Arts) – are building critical mass through co-investment across government agencies. Partner organisations are drawn from across Australia including universities, state government agencies, industry organisations, medical research institutions and Commonwealth research institutes such as the Defence Science and Technology Organisation.

The ARC Centres of Excellence and ARC Centres, which were first established in 2003, involve 108 collaborating organisations. A second round of applications under the scheme is currently being conducted and the ARC expects that approximately ten additional ARC Centres of Excellence will be established in 2005 with funding of $1 million to $3 million per year each over

five years. Applicants were strongly encouraged to maximise the impact of ARC funding by obtaining commitments for additional financial contributions from other sources, including venture capital firms and business investors.

On 25 August 2004, funding of $42 million over five years was announced to support the establishment of 24 new Research Networks, including five networks which will be co-funded by the ARC and National Health and Medical Research Council (NHMRC). The Research Networks scheme was established to provide stronger support for building interconnections between individual researchers and between research teams across disciplinary, organisational, institutional and geographical boundaries. It is estimated, for example, that the 24 new networks will bring together more than 3,400 participants from Australia and overseas.

The ARC/NHMRC Research Network for Fluorescence Applications in Biotechnology and Life Sciences, for example, lists over ten companies as network members. The Network is aimed at researching new applications of fluorescence to biological systems (to solve significant problems in health diagnostics, biotechnology and the environment) and the involvement of the industry partners is expected to facilitate the transfer of basic scientific discoveries into commercial outcomes.

***Example 7: ARC Centre of Excellence in Advanced Silicon Photovoltaics and Photonics***

*The ARC Centre of Excellence in Advanced Silicon Photovoltaics and Photonics, which was established in 2003, will 'coordinate previously independent world-leading programs conducted under the Key Centre for Photovoltaic Engineering, the PV Special Research Centre, and the Special Research Centre for Third Generation Photovoltaics. The reorganisation is expected to increase the coordination, cross-fertilisation and concentration of effort of the previously separate Centres, as well as launching new initiatives in the commercial application of recent applications to silicon photonics.*

*Research at the Centre focuses on the key challenges facing the field of photovoltaics over the next 20 years as well as "spin-off" applications in microelectronics and optoelectronics. It covers areas including silicon wafer-based ('first generation') photovoltaic approaches, silicon thin-film ('second generation') approaches, 'third generation' photovoltaic approaches, thin film gallium arsenide solar cells, research on photovoltaic systems and applications, and industry issues*[22].

***Example 8: ARC Centre of Excellence for Autonomous Systems***[23]

*The Centre of Excellence for Autonomous System was established in 2003 as a partnership between the Australian Centre for Field Robotics (ACFR), the Artificial Intelligence Corporation (at The University of New South Wales), and the Mechatronics and Intelligent Systems Group (University of Technology, Sydney). Prior to being incorporated in the Centre of Excellence, the ACFR was an ARC Key Centre (first established in 1999).*

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22 ARC Centre of Excellence in Advanced Silicon Photovoltaics and Photonics website [http://www.pv.unsw.edu.au/]

23 *ARC Centre of Excellence for Autonomous Systems Annual Report 2004*

*For nearly a decade the Centre partners have worked closely with Patrick Corporation to improve the efficiency of Australia's waterfront through the application of autonomous systems technology. Patrick Technology, a Patrick joint venture with Kalmar, is currently commercialising an automated straddle carrier developed by the partners and a new automated terminal is currently being brought into production. This system was one of the first fully free-ranging field robotic vehicles to be developed anywhere.*

***Example 9: ARC Centre of Excellence for Quantum Computing***[24]

*Computers that are more powerful than anything even conceivable using conventional binary processing could usher in a technological revolution unprecedented in human history in the next 10 or 20 years—and Australian researchers are at the leading edge.*

*The concept of 'quantum computing' using single atoms as the basic transistor switches has been capturing the imagination of computer researchers for some years. Around the world there are numerous research programs trying to find ways to control and use atoms in this way. Success would mean super-computers the size of a pin-head, or as one researcher described: NASA's football field of computers reduced to a single desktop unit.*

*In Australia the research effort has been pulled together into a multi-university collaboration through the Centre of Excellence. Originally established as Special Research Centre in January 2000 through funds from the Australian Research Council and participating institutions, the Centre has eight nodes at The University of NSW (UNSW), The University of Queensland, The University of Melbourne, the Australian Defence Force Academy (UNSW), Department of Defence, Griffith University, Macquarie University and The University of Sydney.*

*The international standing of the Centre is reflected in the significant funding support (over $2 million) which has been received from a number of United States government agencies. A commercial entity, Qucom Pty Ltd has been set up to manage spin-off business ventures.*

**Impact/outcomes of ARC-funded research**

NCGP-funded research underpins the development of new technologies and new company formation in many areas – including medicine, telecommunications, transport, financial services, energy, food production, microelectronics and pharmaceuticals.

Due to the long-term nature of research, tracking of these outcomes is often difficult for the ARC. Successful applicants are required to submit a final report on completion of their research project, but for those conducting discovery research there may be no immediate or tangible benefits identifiable at this stage apart from additions to the knowledge base. For those conducting more applied research, the commercialisation potential of the research outcomes is often only just starting to be assessed.

[24] ARC Centre of Excellence for Quantum Computer Technology website (www.qcaustralia.org/home.htm) and Annual Report 2004

The ARC periodically conducts studies aimed at benchmarking Australia's research performance against international best practice. As part of a study on the return on investment on ARC-funded research[25], The Allen Consulting Group analysed the benefits of ARC-funded research through identification of a range of case-studies. Detailed stories were also prepared as part of the ARC's contribution to the *National Survey of Research Commercialisation–Year 2000* (published in 2002).

The case-studies prepared for those reports are reproduced in their entirety in Attachment B of this submission. They comprise the following: Advanced Nanotechnology Ltd, Australasian Legal Information Institute (AustLII), BioSignal Pty Ltd, Boger Fluids, Chirogen Pty Ltd, Cochlear Limited, Hortical, Impedimed Pty Ltd, the Jameson Cell, OBEL and Xcell Diagnostics Ltd, Proteome Systems, Quantitative Phase Microscopy, Radiata Communications Pty Ltd, ResMed, Seeing Machines, the Securities Industry Research Centre of Asia-Pacific (SIRCA), VentrAssist™ and Xenome Ltd.

The case-studies serve to reinforce the fact that the process of taking new ideas to new processes, products or services is complex, often involving complicated interactions between research providers, the companies wishing to exploit the outcomes from research and in many cases, the investment sector.

[25] *A Wealth of Knowledge: The return on investment from ARC-funded research,* The Allen Consulting Group, September 2003

**ATTACHMENT A**

## THE ROLE OF THE ARC IN SUPPORTING INNOVATION

*Supporting excellent discovery research*

The ARC, along with the National Health and Medical Research Council (NHMRC), is the primary national source of support for excellent discovery research by researchers in the higher education sector. Funding provided under the Discovery element of the NCGP ensures a continuing supply of new ideas and the identification of new areas of inquiry which are essential to innovation. It also provides continuing opportunities and incentives for Australia's leading researchers to build their careers in Australia.

*Providing incentives for the formation of linkages*

As one of its key objectives, the ARC seeks to encourage and extend cooperative approaches to research by strengthening links within Australia's innovation system and with innovation systems internationally. This objective is pursued through both the Discovery and Linkage elements of the ARC's NCGP. Both the Discovery and Linkage Projects schemes, for example, are designed to facilitate collaboration within investigator-initiated research, providing support for researchers to establish partnerships with partner investigators (in both Discovery and Linkage) and partner organisations (in the case of Linkage). Similarly the research networks and centres schemes are aimed at building strong collaborative links into wider innovation networks.

*Benchmarking Australian research performance*

In its 1999 policy statement on research and research training, *Knowledge and Innovation*, the Government identified a role for the ARC in providing regular reports on the performance of Australia in relation to that of other research active countries. Since then, the ARC has commissioned a series of studies aimed at benchmarking Australia's research performance against international best practice:

- A study of the links between patenting and basic science found that 'Australian patenting is highly science-linked, a signal that Australia is well positioned to develop new technologies in leading edge areas of high-market value' (*Inventing Our Future, The link between Australian patenting and basic science*, ARC and CSIRO, 2000).
- A survey undertaken in 2002 of the commercialisation activities of Australian universities, publicly funded medical research institutes and CSIRO found that overall, and in an international context, Australia's performance in this area was mixed (*National Survey of Research Commercialisation: Year 2000*, ARC, CSIRO and NHMRC, 2002).
- An evaluation conducted during 2003 of journal publications arising from ARC-supported research found that the impact of publications generated by ARC-funded research across all fields was significantly higher than the world average (*ARC-supported research: the impact of journal publication output 1996–2000*, ARC, 2004).

In 2003, the ARC commissioned a study to try and provide an estimate of the return on investment from ARC-funded research. In its final report, The Allen Consulting Group identified a social rate of return on investment from NCGP-funded research that is twice that of the average rate of return from all publicly funded R&D in Australia (*A Wealth of Knowledge: the return on investment from ARC-funded research*, The Allen Consulting Group, September 2003).

*By acting as a broker between researchers and users of research*

Another important aspect of the ARC's role and responsibilities is the brokerage of partnerships between researchers and the users of research at both the national and international levels. The ARC involves end-users in its decision-making processes through the inclusion, on both the ARC Board and its committees (for example, the College of Experts), of members whose expertise and experience is drawn from all sectors within the national innovation system. This ensures that the activities of the ARC take into account the imperatives of each stage of the innovation cycle.

The ARC is also committed to developing strategic alliances with other Government agencies to support fundamental research through to commercialisation. In recent years the ARC has forged strong collaborative relationships with a number of agencies including CSIRO, the Department of Communications, Information Technology and the Arts (DCITA), the Department of Industry, Tourism and Resources (DITR), and the Grains Research and Development Corporation. The ARC has sought to play a role in brokering partnerships with these organisations, encompassing co-investment, in order to build the quality, scale and focus of research in areas of importance to the country.

*By contributing to policy*

A report prepared by the ARC in 2000 (*Research in the National Interest: Commercialising University Research in Australia,* ARC, July 2000) identified some of the barriers to efficient and effective research commercialisation and provided a number of suggestions to improve the level of commercialisation of university research in Australia.

In 2003 the ARC provided input to a number of reviews conducted by the Government as a means of informing its consideration of future policy and funding for science and innovation. As part of its submission to the *Review of Closer Collaboration Between Universities and Major Publicly Funded Research Agencies* the ARC argued that collaborative links stimulate innovation by facilitating cross-cutting interactions and a free flow of ideas and knowledge.

The ARC was one of a number of agencies involved in the preparation of the *National Principles of Intellectual Property Management for Publicly Funded Agencies.* The existence of various different intellectual property (IP) regimes across institutions and research agencies is recognised as potential impediment to the commercialisation process. The National Principles assist researchers, research managers and their research institutions to ensure that they have access to best practices for the identification, protection and management of IP, so that they are able to maximise the national benefits and returns from public investment in research.

**ATTACHMENT B**

## CASE-STUDIES

### Case-study 1: Advanced Nanotechnology Ltd
### [Extract from: *National Survey of Research Commercialisation–Year 2000* (page 48)]

Advanced Nano Technologies is producing industrial powders that are almost unimaginably small for commercial applications that are potentially vast.

To grasp the dimensions of the ANT NanoPowders is to split hairs – its NanoPowders can be 2 nanometers, equivalent to about 1/15,000$^{th}$ of a human hair.

Produced using its patented Mechanochemical Processing (MCP) technology, the properties of such microscopically-fine powders make them invaluable for products as diverse as coatings for computer components, paint pigments and cosmetics.

Depending on the application, NanoPowders can reduce weight, increase strength, lower costs and revolutionise everyday products.

In 2000, ANT was created as a $A12 million joint venture between the University of Western Australia's spin-off, Advanced Powder Technology, and Korea's electronic materials giant, Samsung Corning. Advanced Powder Technology develops the products while ANT commercially produces the NanoPowders.

ARC contributed about $250,000 to the research behind Advanced Powder Technology from 1990-1999 through its support of the Special Research Centre for Advanced Mineral and Materials Processing (SRCAMMP). More recently, ANT was awarded an Australian Government R&D grant of $2.8 million.

Samsung Corning's investment was used to construct a pilot plant as a crucial step in the commercialisation of MCP NanoPowders. The pilot plant revealed that MCP technology was even cheaper and more efficient than anticipated and, within months of start-up in May 2002, the plant was operating commercially.

Samsung Corning's interest in the technology is growing: in September 2001 ANT signed a $US1 million licence agreement with the Korean company to produce cerium oxide in Korea. ANT will also receive production royalties.

ANT's CEO, and a co-inventor of MCP, Dr Paul McCormack, says cerium oxide NanoPowder slurries are expected to be extensively used for the manufacture of the next generation of silicone chips, of which Asia is expected to be the major supplier.

Samsung Corning plans to begin commercial production of these NanoPowders in 2003 and is aiming for sales of cerium oxide worth US$23 million in 2005.

ANT's target is to win more than 15 per cent of the estimated $1 billion world market for NanoPowders, building on the low-cost, high-quality advantages of its MCP technology. ANT says MCP uses lower temperatures and shorter milling times than competing technologies, and produces highly uniform powders that can be tailored from a range of raw materials to a client's required size and shape.

APT continues to develop new products from ANT's NanoPowders, achieving early success with zinc oxide in applications that require UV protection and transparency. Its ZinClear, a transparent zinc oxide base for use as a UV absorber in sunscreens and cosmetics, is being marketed internationally and is expected to generate annual revenue of $20 million within about five years. Also in the pipeline for 2002 is a transparent, UV-resistant paint, also based on zinc oxide, for protecting fabrics and wood from fading caused by ultra-violet radiation.

**Case-study 2: Australasian Legal Information Institute (AustLII)**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.84)]**

AustLII, the Australasian Legal Information Institute, provides free on-line access to Australian and international legal material—in effect, a public law library on the Internet. AustLII publishes public legal information—that is, primary legal materials (legislation, treaties and decisions of courts and tribunals) and secondary legal materials created by public bodies for purposes of public access (law reform and royal commission reports for example).

The scale and impact of AustLII is impressive. AustLII covers over 100 Australian and international jurisdictions and holds over 80 full-text databases of Australian primary legal materials including legislation of all 9 Australian jurisdictions, decisions of the States' Supreme Courts, the Federal Courts and the High Court, and special collections (the Australian Treaties Library, Industrial Law Project, Reconciliation and Social Justice Library and the reports of the Australian Law Reform Commission). International databases include laws from South Pacific nations and the British and Irish Legal Information Institute. In partnership with the Asian Development Bank, AustLII is providing training in Internet legal research to government lawyers and law reform personnel in 7 Asian nations (China, Mongolia, Pakistan, India, Indonesia the Philippines and Vietnam).

AustLII receives up to 620,000 'hits' per week day from over 30,000 'sessions'. Users include law professionals, researchers and general public. AustLII users include educational institutions (30%), the legal profession & business (25%) community organisations (15%), government (10%), and overseas users (20%). It provides a major database for research in Law and Justice Studies. With over 1.5 million searchable documents, AustLII is one of the largest sources of legal materials on the net.

The argument for free access to AustLII runs parallel to the arguments for publicly funded research. For AustLII, 'maximising access to the law supports the rule of law and a transparent legal system enhances the nation's economic and global competitiveness'. It is, partly, because AustLII gives free access that the databases have been made available for on-line access.

AustLII is built on partnerships. ARC funding is supplemented by funding from the Asian Development Bank, Australian Business Ltd., DFAT and IP Australia. It represents a major investment, totalling $820,000, from the ARC since 1994 and the ARC is the major funding source.

ARC funding for AustLII is cross-disciplinary and cross-programme. In addition to the infrastructure grants, the ARC has supported both the computing development and the databases, including:

- 1997-9 $170,000 ARC Large Research Grant – research on new methods of delivering legal services on the internet through inferencing technologies (on AustLII)
- 1997-9 $200,000 ARC SPIRT Grant for research on new methods of integrating primary and secondary legal materials on the internet, and presenting them to diverse audiences, as part of using the internet to further the process of reconciliation (on AustLII)
- 1996-8 $180,000 ARC Major Grant for research on new methods of legal text retrieval

- 1994 $160,000 ARC funding for the establishment of the Australian Legal Information Institute (includes $50,000 UTS/UNSW contributions).

The research team that developed AustLII is now leading the development of WorldLII, an unparalleled online global legal research facility. AustLII software, infrastructure, expertise and development support have supported the development of other 'LIIs' - British and Irish, Canadian, Pacific Islands and Hong Kong Legal Information Institutes. Launched in 2002, WorldLII already provides access to 300 databases from 51 jurisdictions in 26 countries and acts as an incubator for new national and regional LIIs.

By maximising access to the law, Australasian Legal Information Institute (AustLII) and World Legal Information Institute (WorldLII) support the rule of law and transparent legal systems that enhances Australia's economic and global competitiveness.

**Case-study 3: BioSignal Pty Ltd**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.79)]**

BioSignal Pty Ltd is the privately owned company established to develop and commercialise technology developed at the University of New South Wales' Centre for Marine Biofouling and Bioinnovation (CMBB). Through research funded by the ARC, Dr Peter Steinberg and Professor Staffan Kjellberg from the Centre discovered a naturally occurring compound on seaweed that is resistant to 'biofouling'. Biofouling is the layer of slime that builds up on many surfaces. The furanone compound resists biofouling by emitting chemical signals.

The practical applications of these compounds are considerable. The growth of marine organisms, such as barnacles, on the hulls of ships is a major problem. It costs shipping and other marine industries over $6.5 billion per year globally to control this problem with paints which are highly toxic to the marine environment. The team from CMBB is investigating methods for treating surfaces, such as ship hulls, with furanone compounds by incorporating the compounds into paints and polymers. There are considerable environmental benefits of this treatment, as furanone compounds are biodegradable and likely to have low-level toxicity to humans.

There are also many potential health benefits from application of this technology to the medical and pharmaceutical industries, particularly with respect to combating bacterial infection. Instead of killing bacteria, as do antibiotics, furanone compounds could resist bacteria and persuade them to settle elsewhere. Other applications include more effective deodorants and domestic cleaning products, toothpaste that keeps plaque away and contact lenses that do not cloud over.

The ARC has provided $1.1 million funding over nine years for the development of this technology. Biosignal Pty Ltd is currently in collaboration with a number of international companies developing numerous applications of this technology. These products are in the development phase, with product-related revenues anticipated by 2005. The projected revenue from commercialisation in 2005 is $2.5 million, rising to $63.8 million by 2008.

**Case-study 4: Boger Fluids**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.82)]**

Boger fluids derive their name from the discoverer, Professor David Boger. Professor Bogor is an internationally renowned rheologist – someone who studies the flow and deformation of materials. Professor Boger and his colleagues discovered a new class of material behaviour and developed revolutionary experimental techniques over the last 25 years, with the ARC providing funding of $1.4 million between 1979 and 2000. Professor Boger's research has led to collaboration with research groups in Australia, Europe, Canada, Japan and the USA.

Boger fluids are viscoelastic fluids. Understanding the mechanics of viscoelastic fluids allows various industries to make products like ink, paint, tomato sauce, toothpaste and ointments that flow perform in a predictable way.

The extent of Professor's Boger work in viscoelastic fluids over the last 25 years is considerable. The best-known application of Professor Boger's research has been to the problem of toxic 'red mud' residues during the processing of alumina. The implication of this technology for Australia, as the world's largest producer of alumina, are significant. Alumina production generates vast quantities of potentially hazardous waste. The standard disposal practice of pumping the highly caustic red mud into settling pools created considerable environmental risks such as groundwater contamination. In the early 1980s, Prof Boger, jointly funded by the ARC's predecessor organisation and Alcoa Australia, developed a more effective red mud waste disposal system. The research yielded a revolutionary 'dry disposal' scheme. By identifying the properties of the red mud, Prof Boger made the sticky residue into a fluid by draining and stirring the residue until it became liquid enough to be pumped down a pipe to a disposal area where it would dry and resolidify. Much of the caustic waste was recovered, the dry solid stacked until it formed a stable surface, overlaid with soil and planted with grass and trees.

The major benefits of this new technology were decreased land use and much reduced long-term environmental liabilities for the industry, as well as significantly reduced environmental costs to the community. For the aluminium industry, the cost savings over old techniques are estimated to be over $10 million per year, and will continue for the next century, given current resources. The technology has also been adopted in the nickel and gold sectors.

Prof Boger also applied the technology developed for the aluminium industry to waxy crude oil transportation. Prof Boger and his laboratory worked with Delhi Petroleum in Queensland to convert a specific form of crude oil from a solid to a liquid (at room temperature) so that the $180 million Jackson-to-Moonie pipeline could operate efficiently. The pipeline was constructed to transport crude oil from Jackson in the southwest corner of Queensland to Brisbane. The particular crude oil is high in wax content and behaves like a solid at room temperature. Boger's laboratory at the University of Melbourne tested the flow properties of crude oil and modified these properties, creating a liquid that could flow at room temperature. This technology was been used to examine similar problems for BHP and Petrocorp. Orica has provided funding to further develop the work.

**Case-study 5: Chirogen Pty Ltd**
**[Extract from: *National Survey of Research Commercialisation–Year 2000* (page 51)]**

The quest for cheaper and safer pharmaceuticals has been given a fillip through the invention of a process that can control the formation of chiral molecules – and if necessary eliminate unwanted isomers – when chemical compounds are synthesised for drug manufacturing.

The process, dubbed "Chirotechnology", has become the basis for a new Melbourne-based company, Chirogen, which is in the final stages of scaling up its technology to be of use commercially.

Chiral molecules can exist as mirror images, similar to a person's left and right hands, but while they have identical physical and chemical properties, chiral molecules can behave very differently when interacting with biological organisms or with other chiral molecules.

This was the cause of the Thalidomide tragedy in the 1960s when the potentially-life-saving drug caused deformities in unborn children.

Since then, regulators have required drug manufacturers to market single chiral molecules – a process involving separation techniques or the use of bio-organisms and enzymes during synthesis. Often these routes are not cost effective.

However, in the 1990s researchers at the University of Melbourne and Deakin University invented a new method to control chirality during some free-radical reactions and have applied this to the preparation of a wide cross-section of molecules of interest. In effect, the new technology prevents the formation of the unwanted molecules in the first place.

The work resulted from collaboration between Deakin's Professor Dainis Dakternieks, a "main group" chemist and Melbourne University's Professor Carl Schiesser, a "free radical" chemist.

The pair received an ARC grant of $60,000 a year for three years and set out to try and control chirality in the synthesis of molecular compounds.

Although they made significant progress, their second application for ARC funding was knocked back, which slowed the work until a later application secured a three-year $270,000 grant, which finishes in 2003.

As a result of this research, Schiesser and Dakternieks established a company, Chirogen, which in July 2000 became the first spin-off company under the University of Melbourne's new policy of assigning intellectual property rights to inventors rather than just the university.

Chirogen's prime investors are Uniseed (part-owned by Melbourne University Private), Deakin University, and a private investor.

Its prime commercial targets are the chemical intermediate supply companies that provide pharmaceutical manufacturers with their base 'ingredients'.

Professor Schiesser said the next stage of research was to bring some newer technology up to the same level as the original core technology, and to transfer the proof-of-concept to molecules of commercial relevance.

The original work was concentrated on proving the concept worked, but now the company's emphasis is on demonstrating the technology's use for molecules used in pharmaceutical products.

**Case-study 6: Cochlear Limited**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.76)]**

With support from both the University of Melbourne and a number of Commonwealth research grants, during the late 1970s Professor Clark at the University of Melbourne developed the prototype for the Cochlear implant. Professor Clark began research into the feasibility of cochlear implants in 1967, and trailed the implant in 1978. Cochlear Limited was formed in the early 1980s to commercialise this technology. The company is now the world leader in hearing implant products, providing cochlear implants for children who are deaf and adults who have become deaf. Today, Cochlear Limited is one of Australia's top 50 companies with a market capitalisation of over $1.9 billion.26

Cochlear employs over 700 people, 400 of them in Australia, with head office, manufacturing, and the majority of R&D remaining in Australia. They have regional offices in the USA, the UK, Belgium, Switzerland, Germany, Japan and Hong Kong.27

Cochlear's nucleus product range is available in more than 70 countries, with over 95 per cent of sales generated outside Australia. Since the first commercial implant 20 years ago, Cochlear's award-winning nuclear range has been implanted in nearly 40,000 people worldwide. Cochlear is the only publicly listed company in this industry and seeks to achieve strong ongoing growth of at least 20 per cent.28

Cochlear was formerly a business segment of Nucleus Limited, with Nucleus Limited itself being a wholly-owned subsidiary of Pacific Dunlop Limited. It was decided by Pacific Dunlop Limited in 1995 to establish the hearing implant division as a separate listed company in order to facilitate the future growth and expansion of the company's activities and markets. This was achieved through a public float of the 50 million ordinary shares of Cochlear Limited on the Australian Stock Exchange at $2.50 per share. Priority access to the shares in Cochlear was given, under the public issue, to Pacific Dunlop shareholders, various research centres and technological institutes involved in hearing-impairment and implant research.29

Cochlear has been one of the major success stories on the Australian sharemarket over the last five years, experiencing enormous growth in revenue and operating profits and providing substantial share returns for investors over this period. The company's share price has increased from an initial issue price of $2.50 in December 1995 to a price of $33.30 in August 2003 (with a peak of $48 in December 2001).

Sales revenue for the year ending June 2002 for the company was A$255 million, an increase of 16 per cent over the previous year, and an increase of 56 per cent since 2000. This result was driven by strong system sales, which grew by 21 per cent in 2002. Cochlear is a significant investor in R&D, with $37.7 million spent on R&D in 2002. R&D expenditure has increased significantly over recent years, increasing by 30 per cent between 1998 and 2002.30 Profit after income tax in 2002 was $40.1 million, an increase of 29 per cent from 2001. The first half of 2002-03 has provided record half year profits, with system sales 22 per cent higher in

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[26] http://www.asx.com.au

[27] Cochlear Annual Report 2002, accessed from http://www.cochlear.com.au

[28] Cochlear Annual Report 2002, accessed from http://www.cochlear.com.au

[29] Online case studies, accessed from http://www.mcgraw-hill.com.au/mhhe/fin/peirson8e/stu/casestudy04.doc

[30] Cochlear Limited, *Annual Report 2002*, accessed from http://www.cochlear.com.au

December 2002 from December 2001. This resulted in $27 million profit after tax, an increase of 57 per cent from the previous year. Cochlear now hold global market share of 65-70 per cent.31

**Case-study 7: Hortical**
**[Extract from: *National Survey of Research Commercialisation–Year 2000* (page 54)]**

The last time you bought melons, nectarines, peaches or plums, you probably examined them, perhaps felt them for firmness, and dropped them in the plastic bag hoping the taste would live up to the appearance. It's hit and miss.

Now there is a way for producers to measure the sugar content of fruit without taking a chunk out of it, and to be able to guarantee sweetness. This is the result of a test developed by a company called Hortical, a joint effort between Central Queensland University and Victorian company Color Vision Systems.

Their non-invasive sugar measurement system is based on near-infrared spectroscopy, and it enables fruit to be graded on sweetness at the packing shed stage. It means that now, consumers have science to back up eye and feel.

Project leader Kerry Walsh, Associate Professor of Plant Sciences at Central Queensland University, said that previously, technology had always gone into grading on external appearance. ``For farmers, all their effort has gone into growing good-looking fruit, but there was no index of what's inside."

Previously a French-based company had marketed a system that removed a small core of fruit, squashed the flesh to measure sugar content, and replaced the skin before marketing the fruit. It was clearly ``not a goer", said Dr Walsh.

``We run the fruit under the light, it penetrates, and we look at how it is absorbed by the fruit, and that relates to sugar," he said. ``In many fruits, the higher the sugar content the better the taste."
It had to be developed to a point where it could be used under harsh packing shed conditions, where speed and capacity would be important factors.

The Australian Research Council awarded the university an initial Large grant of $50,000 in 1997, then continued its support under its collaborative system, whereby research bodies working with commercial units qualify for funding. Over three years this amounted to just over $200,000.

Dr Walsh said that although the ARC's contribution was small in the overall development cost of roughly $3 million, it was critical in getting the research up and running. By the turn of the millennium, the system was ready for the marketplace.

``The year 2000 was the break point between straight R&D and commercialisation," he said. Fruit sorted by Hortical's system is already used by Australian fruit packhouses through The Harvest Company, with fruit marketed through Woolworths and Coles, and Dr Walsh is in the process of examining the viability of exporting the technology.

[31] ASX Announcement/Media Release, accessed from http://www.asx.com.au

**Case-study 8: Impedimed Pty Ltd**
**[Extract from: *National Survey of Research Commercialisation–Year 2000* (page 55)]**

A Brisbane-based company, Impedimed Pty Ltd, has developed a non-invasive diagnostic and monitoring instrument for lymphoedema which is four times more sensitive than any previous test for the condition.

Lymphoedema, which involves a build-up of lymphatic fluid in the body, can be unsightly and incapacitating. It affects about 30 per cent of women – 1.5 million worldwide -- who undergo breast cancer surgery: in all, about 400-thousand Australians suffer from some form of lymphoedema.

Impedimed, formed in 1999 as a spin-off from Queensland University, received a Queensland Government innovation grant in 2000, and, with the university and Royal Women's Hospital, has applied for an NHMRC grant for continuing research. In 1992-3, the ARC provided funding for the original research which led to Impediment's 'Lymphometer', the most accurate instrument in existence for measuring lymphoedema.

So far, sales of the Lymphometer, released in 2002, have earned $32,000, and the company's sales of bioimpedance instruments have already reached just under $1 million.

The company has received Government grants in excess of $120,000. Its founder and Managing Director, Lucille Bridges, says: "ARC funding was a great help in the early stages, and obtaining the Innovation Start-Up Scheme (ISUS) grant enabled us to move from low-tech to high-tech research and development in one giant leap!

"Lymphoedema has been widely ignored and is not well understood. It hasn't been taken as seriously as it should. There is still no cure for Lymphoedema, but early and accurate diagnosis makes for far better management and much improved quality of life."

Before the Lymphometer, she says, "one of the more common ways to determine the degree of fluid build-up was by using a tape measure, or imprecise procedures such as prodding, pinching the skin, or water displacement, which involves placing the affected part of the body into a bath and noting how much water was displaced. Too often, the lymphoedema had to be quite severe before it could even be detected".

Although Impedimed is small, it is about to increase the number of people it employs in line with its goal of becoming the world leader in medical applications for bioelectrical impedance.

"This exciting, emerging technology lends itself to the monitoring and management of such procedures as drug dosing and renal dialysis, and a wide range of medical conditions, including oedema (fluid build-up), cardiac disease, obesity, diabetes and wasting disorders such as AIDS and anorexia," says Mrs Bridges.

"Impedimed is implementing plans to launch its range of three bioimpedance devices worldwide, and, as part of this, we're in the process of obtaining approval to sell them in the US through the Federal Drug Administration."

**Case-study 9: Jameson Cell**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.87)]**

The Jameson Cell is the invention of Professor Graeme Jameson from the University of Newcastle. Professor Jameson began research in 1965 into multi-phase processes. In 1986, after 21 years of research, this work resulted in the invention of a radical new device for the separation of minerals known as the Jameson Cell, which is making a major impact on the Australian mining industry.

The Jameson Cell induced air flotation (IAF) device was invented for the recovery of valuable minerals in mineral processing plants. The Jameson Cell has all the advantages of previous processes used, and not only occupies far less space but is a distinct leap in technology with substantial improvements over existing methods. Costs can usually be recovered in a very short time and the grade of product emanating from the ore concentrators has been improved substantially.

The licensing rights for the Cell were acquired by MIM Holdings Limited, Brisbane. Since that time the Jameson Cell has been installed in numerous major minerals and coal projects on the worldwide market. It is estimated that the commercial value of this technology is in excess of $500 million in export coal each year.

While MIM enjoyed significant success in the mineral industry, Professor Jameson and colleagues pursued alternative applications for the technology. Initially, such applications were in the area of industrial effluent treatment, particularly for dairy and industrial manufacturing applications. It was soon apparent that the Jameson Cell IAF process was excellent for the removal of suspended solids, oil and grease from effluent streams. A couple of demonstration sites were installed during 1993-4 and, following their success, Jetflote was granted the licence for the Jameson Cell for non-metallurgical applications and commenced trading in July 1994.

Environmental Group Limited (EGL) acquired the business of Jetflote Pty Ltd in September 1999, including the exclusive worldwide licence of the Jameson Cell technology for water applications. EGL is an Australian-owned public environmental technology company listed on the Australian Stock Exchange.

The Jameson Cell IAF technology provides a cost-effective alternative to upgrading inland wastewater treatment works since it addresses the problem of algae growth in ponds, thereby allowing water authorities and councils to continue to utilise the benefits of wastewater pond systems. The aim of providing an effective means of simultaneous phosphorus removal is also addressed. The first municipal unit to remove algae and phosphorus from treated sewage (maturation pond) effluent was installed for Wagga Wagga City Council at its Narrung Street Sewage Treatment Plant. The plant, was commissioned in June 1999, and has met or exceeded all performance expectations, producing water suitable for discharge to sensitive receiving waters. Process plants have since been installed for Wagga Wagga City Council and the North East Region Water Authority.

Jameson Cells are installed in Korea and Malaysia for effluent treatment from compressed timber products manufacture and terminal tank washing facilities. In UK the technology is represented by Brightwater Engineering.

There remain numerous application areas for which the Jameson Cell is likely to be a leading-edge technology solution. The process is very compact and cost-efficient compared to traditional technologies. The process is well suited to stormwater and combined sewer overflow

(CSO) treatment due to the features of low start-up time, high process rate, and ease of augmentation to an existing site.

Professor Jameson has received a total of $2.1 million in ARC funding from 1979 to 1998. He currently receives ARC funding through the Special Research Centre for Multiphase Processes.

**Case-study 10: OBEL and Xcell Diagnostics Ltd**
**[Extract from: *National Survey of Research Commercialisation–Year 2000* (page 60)]**

In a few short years, GPs could be diagnosing skin cancer on the spot using a pen light probe that employs Diffuse Reflectance Spectroscopy (DSR).

The seemingly simple "point and click" procedure – using a fibre-optic probe that both beams light and collects it for analysis – promises certainty in an area still fraught with inaccurate diagnoses.

The probe's inventor, Professor David Sampson, says that for every melanoma detected, 30 harmless moles are removed at an overall cost of about $75 million per year. This is in addition to the impact on patients who have undergone unnecessary surgery that can sometimes be disfiguring.

With deadly melanomas, early, accurate diagnosis can mean the difference between life and death – more than 1000 Australians die every year from melanomas but early detection gives melanoma patients a 100 per cent five-year survival rate.

Professor Sampson is project director at OBEL, the Optical and Biomedical Engineering Laboratory at the University of Western Australia. The DSR skin cancer probe is being developed in a joint venture between the university and Xcell Diagnostics.

ARC funding of $220,000 over three years helped to develop a related technology that contributed to this project, which also received $40,000 from the Cancer Foundation of Western Australia.

Professor Sampson says the DSR probe measures the absorption of light by certain types of tissue. A melanoma with its dark pigmentation will absorb more light. More important, however, is the characteristic "signature" it reveals in scattering the white light, produced by the larger nucleus size of the cancer cells. In a GP's surgery, the scattered light is fed into a spectrometer that will feed an LCD reading to the GP immediately.

The whole device is expected to be no larger than a lunchbox and affordable for all GPs. The potential market is vast, encompassing North America, Western Europe and the United Kingdom. Its commercialisation could take between three and five years.

Unlike competing technologies, no imaging is required.

Initially the probe will be a diagnostic aid but ultimately it could become a screening tool, he says. Patients could be spared the present delays and possible surgery and "you will get a diagnosis and have confidence in that diagnosis".

**Case-study 11: Proteome Systems Limited**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.83)]**

Proteome Systems Limited (PSL) is the privately owned company founded in 1999 to commercialise technology developed with the support of ARC funding by Professor Keith Williams and his team at Macquarie University.

PSL is recognised as a world innovator in the development of proteomic technologies. In just three years of existence PSL has established itself as a player in the emerging 'post-genomic' phase of biotechnology, where companies are moving beyond genetic manipulation to engage directly with the core building blocks of life: proteins and their biochemical linkages. PSL's four main areas of activity are drug discovery for human disease, agricultural biotechnology, scientific instruments and consumables for proteomics technology, and protein databases and tools.

Proteomics, the science of proteins, is the global study of the interaction and modification of proteins in the body. This study promises to be the pathway to a detailed understanding of health and disease in humans, and an extension of understanding in animal husbandry and agriculture. Proteomics offers medical research groups and drug companies the possibility of faster, safer and more effective drug design and a better way to diagnose disease.

Dr Williams began working in the field of protein analysis in 1984, as the chair of biological sciences at Macquarie University. Williams established the Macquarie University Centre for Analytical Biochemistry in 1992, and began working with corporations in Australia and overseas on scientific instrumentation. In 1995 Williams founded the Australian Protein Analysis Facility, the first major national facility for the analysis and characterisation of proteins. The facility developed instruments for protein sequencing, including automation.

PSL was founded by six academics, led by Dr Williams, all former Macquarie University research scientists. Since is inception PSL has built powerful partnerships with several overseas companies, including:

- Dow Agrosciences (USA), leading to research into plant proteins;
- Shimadzu Corporation, a manufacturer of scientific instruments, which has led to the development of a patented product for protein identification;
- Sigma-Aldrich, a life science and high-technology company, which recently released, in conjunction with PSL, a line of preparation kits for use in scientific and genomic research.

A large number of computer-driven tools have also been developed at PSL that facilitate the identification of proteins from gene sequences.

PSL employs 100 staff in Sydney and Boston. Turnover in the 2002-03 financial year is forecast to reach $15 million, up from $7.7 million in 2001-02, with the unlisted company valued at $400 million. The global market for the proteomics sector in 2000 was estimated at $US1 billion, growing to nearly US$6 billion in 2005.

**Case-study 12: Quantitative Phase Technology**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.80)]**

Quantitative Phase Microscopy (QPm) technology was developed by University of Melbourne physicist and ARC Federation Fellow, Professor Keith Nugent and his team. The technology enables a standard optical microscope to perform like a specialised phase microscope. It also,

when used in conjunction with its accompanying software, allows, for the first time, quantitative measurements with a standard microscope. For example, a researcher studying cells in the normal, two-dimensional view can now measure the volume of cells, by gaining access to three-dimensional information.[32]

Conventional phase microscopy was developed in the late 1940s and allows the viewing of unstained specimens by using the light phase amplitude differences within microscopic objects. When an unstained biological specimen is observed in a normal microscope, it is often difficult to see because most biological material is uncoloured and transparent. A phase microscope picks up the differences in refractive index between the object and the background; created when light passing through an object is deviated. QPm was developed by Professor Nugent, with ARC funding of approximately $765,000. The technology adds a new dimension to scientific research by allowing users to make quantitative measurements. QPm has given researchers a new tool, providing increased capacity for new scientific discovery.

In 2000, a new company, IATIA, was floated to commercialise QPm technology. Using an ARC linkage grant, researchers are now studying new ways in which the QPm can be applied. Since publicly listing, IATIA has launched two new products, QPe and QPt. In 2002 the company had a market capitalisation of $30 million and 30 employees.

**Case-study 13: Radiata Communications Pty Ltd**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.80)]**

Radiata Communications developed groundbreaking chip technology for enabling very high-speed communications over wireless local area computer networks, or LANs. Radiata built a 'wireless engine' capable of sending data through the air at 54 megabits per second, during a time when the industry was just getting used to wireless networks that could carry bits and bytes at 11 megabits per second (almost 200 times faster than a standard 56K modem).

This new technology would make it possible to run multiple channels of full motion video and other multimedia items between PCs and other electronic devices such as phones and television sets. The business market alone for this technology is estimated to reach $US1 billion by 2005.

Radiata was founded in 1997 by Dr David Skellern and Dr Neil Weste to commercialise development work (funded in part by the ARC) by Skellern and Weste in conjunction with the CSIRO. Dr Skellern had spent most of his career as an academic at Macquarie University where he founded the institution's new microelectronics department. Both Skellern and Weste had experience working in the US for technology companies, including Hewlett-Packard, Bell and Phillips. The network of engineering and commercial companies that the pair developed during their time in the US served them well when it came to pitching Radiata's technology.

Cisco Systems purchased Radiata Communications in November 2000 for $US295 million. Cisco already owned an 11 per cent stake in the company after providing early stage funding in 1999.

[32] National Survey of Commercialisation 2000.

**Case-study 14: ResMed**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.77)]**

Dr Peter Farrell formed the ResMed group of companies to commercialise technology developed by Dr Sullivan at the University of Sydney in the 1980s. This research was supported by both the University and through Commonwealth research grants. Dr Sullivan and his colleagues invented a method of treatment of one a major forms of sleep disorder, Obstructive Sleep Apnoea (OSA). Left untreated, OSA can severely affect quality of life, health and mortality, and is strongly associated with hypertension, heart disease and stroke. The disease affects approximately 10 per cent of adult males in Australia.[33] Based on technology developed by Dr Sullivan, ResMed developed a range of masks that provide continuous positive airway pressure, thus treating the main cause of OSA.

ResMed has grown into an international success story, after starting in 1989 as ResCare Ltd, a company formed by Dr Farrell. ResCare raised $1.2 million from staff and private investors to begin production of devices for the treatment of OSA. Sales began in Australia in 1989, the USA later that same year and in Europe in 1990. Research and development undertaken by ResCare was supported by an IR&D Board grant of $150,000 in 1989 and an Austrade International Business Development Grant of $110,000 in 1990.[34] During these early years the company faced difficulties with attracting interest from potential financiers, primarily due to perceptions about its one product focus and a lack of understanding about OSA.

In June 1995 the company registered on the Nasdaq exchange as ResMed Inc, raising US$24 million.[35] In late 1999 the company transferred to the New York Stock Exchange and later co-listed on the Australian Stock Exchange. Subsequently, wholly owned subsidiaries have been formed (such as in the UK) or successful distributors have been acquired.

ResMed currently employs approximately 1,300 staff (over 400 of which are located in Australia). ResMed revenues exceeded $400 million in 2002-03. It has a current market capitalisation of A$1.9 billion on the Australian Stock Exchange and US$1.3 billion on the New York Stock Exchange.[36] As of June 2002, the company's compound annual growth rate was 36 per cent for revenue and 44 per cent for net income (using 1995 as a base).[37] The total size of the 'sleep industry', of which ResMed is the market leader, was valued at $1 billion in 2001 worldwide, and growing at 20 per cent per year. ResMed operates through direct offices in the United States, Australia, Germany, France, Sweden, the United Kingdom, New Zealand, Singapore, Malaysia, Japan, and through a network of distributors in more than 60 other countries. More than 95 per cent of ResMed products are exported.

Critical factors which influenced the success of ResMed include:
- *the research base* — Professor Sullivan's group has always led this field of research;
- *attracting the best overseas researchers through strong research credentials* — which enabled ResMed to access international markets;

[33] ResMed Corporate Fact Sheet, accessed from http://www.resmed.com.au
[34] http://www.atse.org.au/publications/focus/focus-barnes.htm.
[35] http://www.atse.org.au/publications/focus/focus-barnes.htm
[36] http://www.nyse.com/cgi-bin/ny_quote?sym=RMD
[37] ResMed Corporate Fact Sheet, accessed from http://www.resmed.com

- *establishing intellectual property* — the original patents enabled ResMed to keep potential competitors out of Australia for approximately five years. This was enough time to enable ResMed to start selling and establish an important base in the US.[38]

**Case-study 15: Securities Industry Research Centre of Asia-Pacific (SIRCA) [Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.81)]**

By pooling several ARC grants in 1992, University of Sydney Professors Michael Aitken and Peter Swan created the Securities Industry Research Centre of the Asia Pacific (SIRCA) as their own research centre.

SIRCA was established as a joint venture between four universities. The purpose of the centre was to work with industry to undertake research into Australia's capital markets, with the aim of improving market efficiency. SIRCA now has 25 member universities across Australia and New Zealand.

SIRCA is a not-for-profit company limited by guarantee and governed by a board comprising senior representatives from member universities, commercial organisations, government representatives and industry associations. Aided by almost $5 million of ARC funding since 1994, the centre's research has involved every sector of the Australian Securities Market, leading to various technological innovations, and has directly improved Australia's market efficiency.

The work undertaken at the centre has led to considerable benefits to the efficiency of Australia's Securities Industry. The direct impact of the research on market efficiency is best illustrated by the work of Professors Aitken and Swan on transaction taxes. Their modelling of the relationship between trading activity and transaction costs on behalf of the ASX helped convince State Governments in Australia to halve stamp duty. The net effect was a $4 billion increase in the value of securities and a 20 per cent reduction in the costs of trading — potentially millions of dollars.

Another major innovation arising from the research program has been the creation of an independent company, Asia-Pacific Capital Market Limited (ACM). The central purpose of the ACM is to co-ordinate resources of universities, industry and governments to enhance the international competitiveness of regional capital markets. ACM builds, maintains and shares research infrastructure resources to support research into the financial services industry. These resources include super-computing power (MEMlab), software, data and programming services. MEMLab was funded by a $700,000 ARC Research Infrastructure Equipment and Facilities Grant and a subsequent $1.2 million contribution by the Australian Stock Exchange.

The development of expertise in research infrastructure resources has lead to the creation of leading-edge software which to date has been sold to a number of international clients, including the Russian Central Bank, the Moscow Inter-bank Currency Exchange, the Jakarta Stock Exchange, the Hong Kong Stock Exchange, the Oslo Stock Exchange and the Hong Kong Securities and Futures Commission. The sale of software attracts some $3 million to $5 million in export income per annum. The software, known as SMARTS (Securities Markets Automated Research, Training and Surveillance), was designed by Professor Aitken and funded by Computershare Limited, an Australian public company.

The software is the first off-the-shelf product of its kind in the world. An educational version of the software, UNI-SMART has also been developed and distributed to a number of universities around the Asia-Pacific region for students to recreate the trading floor of the stock exchange.

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[38] Australian Academy of Technological Sciences and Engineering (NSW Division), *Commercialising Innovation "The Second Step"* Workshop Proceedings Sydney – 10 May 2001, p. 26.

In summary, the outcomes of the research have been:

- the design of world-class software (SMARTS) now being used commercially by regulators and exchanges around the world for market surveillance/integrity;
- the creation of research commitments from the industry partners, amounting to at least $1 million per annum to 2004;
- significant research collaboration between six major universities;
- international collaboration with researchers from NZ, US, Hong Kong and many others; and
- the design of unique research-based training materials currently being used in post-graduate and under-graduate teaching programs.

**Case-study 16: Seeing Machines**
**[Extract from: *National Survey of Research Commercialisation–Year 2000* (page 65)]**

Your car will soon be able to warn you if you've dozed off at the wheel, not only saving you and your passengers, but also the thousands of other people killed or injured by sleeping or inattentive drivers around the world each year. Not to mention saving some of the $3 billion each year in costs directly attributable to fatigue-related road accidents in Australia alone.

The installation of fatigue warning systems in cars is now only three to five years away thanks to an eye-tracking system called 'faceLAB', which was developed by a commercial spin-off from the Australian National University, Seeing Machines Pty Ltd. The Canberra-based company has only been operating since 2000, yet the automotive and electronics giants that have already bought 'faceLAB' include Bosch, DaimlerChrysler, Mitsubishi, Motorola, Nissan, Toyota and Volvo. Some have bought several, even though each unit costs up to $80,000.

The original research at the ANU which produced 'faceLAB' was supported by an ARC grant in 1995 and 1996. Indeed, "ARC funding was vital to the early development of this technology at the ANU – 'faceLAB' would not exist without it", says the company's International Market Developer, Gavin Longhurst.

Seeing Machines, which was recently awarded the 2002 Eureka Prize for Information and Communications Technology Innovation, was founded by its CEO, Alex Zelinsky, a former Professor of Robotics in the ANU's Faculty of Engineering, and now employs 20 people. "Our two main investors are the ANU and Volvo, which collaborated on the original research," says Mr Longhurst.

In the past, observation of driver behaviour was subjective, laborious and frequently imprecise, with analysis prone to error. By contrast, 'faceLAB' is a computer vision research tool that allows driver behaviour to be objectively observed, measured and recorded. It is capable of registering even the tiniest of eye movements that betray driver fatigue or distraction. It is not only being used to develop driver warning systems, but also to intercept car design problems before they reach the road, and to supply evidence for legislative decision processes.

In addition to this, and generating revenue for Seeing Machines and its investors, 'faceLAB' has another important use – stopping the brain drain. As Mr Longhurst says: "We've shown that it's not just places like MIT or Stanford that can spin off commercially successful enterprises – Australian universities can too."

**Case-study 17: VentrAssist™**
**[Extract from: *A Wealth of Knowledge – The return on investment of ARC-funded research* (p.78)]**

The VentrAssist™, currently being developed by publicly listed company Ventracor, is a rotary blood pump designed to take over the pumping function of the heart's left ventricle. This new technology provides a much longer period of pumping support than current blood pumps. It does not require the removal of the heart itself, but rather assists the blood pumping function of a failing heart, providing a long term alternative to transplantation.

The VentrAssist™ was initially developed by a group of researchers at the University of Technology in Sydney (UTS) and the University of New South Wales. In 1995, Dr John Wood approached Professor Vic Ramsden to develop a prototype rotary blood pump. They established the company Micrometrical Industries, which, in conjunction with UTS, later applied for and received an ARC Collaborative Grant of $80,000 per annum for 3 years, commencing in 1997, to get the research going. Micrometrical Industries provided matching funds. In 1999 the team received further ARC support through a $150,000 SPIRT grant.

The rotary blood pump is one of several styles of blood pumps being developed and researched around the world in an international effort to develop the world's first implantable blood pump. At present, congestive heart failure can be cured only by organ transplantation.

Blood pumps currently used are pulsatile pumps. They are implanted as a temporary 'bridging' measure to keep a patient alive long enough to receive a heart transplant. Unfortunately traditional blood pumps have an effective lifespan of two years only and there are problems with infection, blood damage, blood clotting and maintenance of the equipment. The surgery itself is high-risk: one in seven patients does not survive the surgery. Patients also need to recharge the battery for the device every few hours.

The VentrAssist™ rotary blood pump is a significant departure from current artificial heart technology because it has removed the seals, shafts and bearings which have caused serious side effects for patients in the past, including blood damage and blood clotting. The rotary pump is operated by a small and efficient motor drive and is designed to support the work of the human left ventricle for five years or longer.

The market for this product is estimated to be between US$7.5 billion and US$12 billion annually. It is estimated that, in the United States alone, there are 81 million people suffering from various forms of cardiac disease. This number is growing by 6.8 million per year. There are obvious public health benefits from development of this new product. Around 44 per cent of all deaths in Australia are directly related to heart disease and about 750 Australians die from congestive heart failure every year. Many of these patients die while they are awaiting transplantation of a scarce donor heart. A major advantage of the new technology is that it can be produced at a lower cost than other pumps on the market.

Ventracor is currently has a market capitalisation of $200 million. A pilot trial of the VentrAssist™ is currently being undertaken at the Alfred Hospital in Melbourne, consisting of about 10 patients. A global trial is timed to begin in the second half of 2003.

**Case-study 18: Xenome Ltd**
**[Extract from: *National Survey of Research Commercialisation–Year 2000* (page 66)]**

The same chemical compounds that enable some animals to stun and capture prey may provide human medicine with a new source of pain-killing drugs.

Researchers at Xenome Ltd have completed successful animal trials of a new pain killing compound derived from the venom of cone shells, common to many reef environments. The animals, members of the Conidae family, prey on other marine organisms, immobilising them with unique venoms.

In January 2000, the promising results of seven years' research conducted at the University of Queensland, led to the formation of Xenome Ltd to begin commercialising new pain-killers and sedatives for humans.

The research has concentrated on the components of the venom conotoxins which act by preventing neuronal communication.

The cone shell research was initiated by a Venoms Research Group at the University of Queensland in 1993, lead by Dr Richard Lewis and Professor Paul Alewood. The team found that while the venom as a whole was potentially fatal, it was found that individual molecules within the venom had unique and potentially beneficial effects.

It was found that these molecules were able to bind with receptors in the nervous system in a similar manner to drugs like morphine, but without the same side-effects such as nausea and addiction. This became the basis for further investigating the potential use of these natural compounds as new therapeutics.

Initial funding was supplied by the ARC and NHMRC to the Venoms Research Group at the University and subsequently via a core START Grant to Xenome Ltd of $1.75 million.

The ongoing commercialisation of the science at Xenome has also been supported by Medical Holdings Limited, a pool development fund which has invested $3 million into the venture, plus $3.5 million from and another specialist investment fund, BioTech Capital.

The compound that has been developed has been tipped to be the leader in a new class of pain-killing drugs for the treatment of chronic pain conditions.

Xenome's Operations Manager, Joanne Schrauwen, also said that while cone shells had been the initial focus of the research, work was now progressing to investigating the venom of other animals such as spiders.