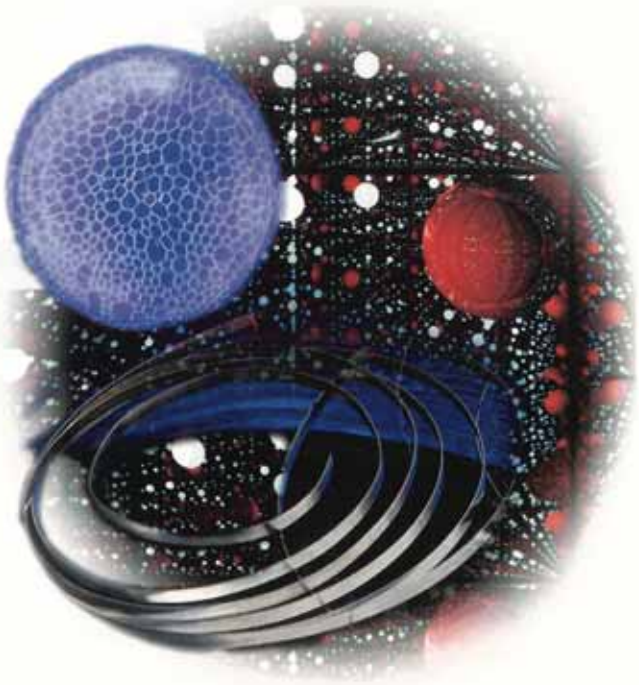
Science and Technology
Budget Statement
2000–01



Senator the Honourable Nick Minchin
Minister for Industry, Science and Resources

COMPETITIVE AUSTRALIA

SCIENCE AND TECHNOLOGY BUDGET STATEMENT 2000-01

CIRCULATED BY
SENATOR THE HONOURABLE NICK MINCHIN
MINISTER FOR INDUSTRY, SCIENCE AND RESOURCES

DEPARTMENT OF INDUSTRY, SCIENCE AND RESOURCES
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HIGHLIGHTS

Commonwealth support for major science and innovation programs is expected to be $4538 million in 2000-01, an increase of $167 million over the 1999-00 amount. Maintaining the funding level is a significant achievement in a Budget where it has been necessary to exercise unusually tight fiscal restraint. Aparticular highlight is the eleven percent funding increase for the National Health and Medical Research Council - a second instalment of the $600 million boost to medical research funding promised in the 1999-2000 Budget.

The 2000-01 Budget also falls during a major review of science and innovation policies - through the Science Capability Review and the Innovation Summit process (see pages 2.4-6). The Government is committed to developing a coherent and effective strategy that integrates our science, technology and innovation capabilities, and that maximises the benefits that flow from the investment of tax-payers' money. Major funding decisions that would pre-empt the outcomes of these review processes have been avoided.

Impressive outcomes from Australia's publicly funded research continue:

- The Australian Geological Survey Organisation and the University of Sydney have uncovered evidence that life was present on earth a billion years earlier than previously believed. This discovery was hailed as one of the top ten scientific breakthroughs for 1999.
- CSIRO research developed by the Australian company capXX Pty Ltd is positioning Australia to capture a large part of the market for supercapacitors — the components that store energy in mobile phones, lap-tops and wireless modems.
- The University of Queensland has developed a software translation tool in collaboration with the University of Virginia. The program is a step closer to the goal of being able to run software across a variety of computer systems.
- Science fiction becomes science fact: the Plasma Research Laboratory at the ANU has developed a plasma antenna that disappears when transmission ceases, making it invisible to enemy radar detection!
- Researchers at the John Curtin School of Medical Research, in collaboration with the Brisbane company Progen Industries, have identified a drug that can prevent the spread of cancer to other organs (metastasis) — the usual cause of cancer deaths.
- The revolutionary Stuart Piano, designed at the the University of Newcastle, represents the first major step in the evolution of the piano since the nineteenth century. Following a recently released set or Beethoven sonata recordings of performances on the piano, its superb qualities have drawn wide international acclaim.

SUMMARY NOTES

SUPPORT FOR SCIENCE AND INNOVATION IN 2000-01

- In 2000-01, Commonwealth support for major science and innovation programs is expected to be $4538 million in accrual terms, a one per cent real increase over 1999-2000.
- Total support for industrial R&D and innovation in the business sector, including both direct support through appropriations and the estimated effects of tax revenue forgone, is expected to be $851 million in 2000-01. This is a real increase of 2 per cent overall.
- Support for general science and technology programs will rise to $642 million, a real increase of five per cent. These programs include the Cooperative Research Centres, rural science, energy research, environment R&D, transport studies — and health and medical research, where funding increases substantially.
- Medical science — following the announcement in the 1999-2000 Budget of a $600 million boost over a six year period — sees a rise to $321 million in 2000-01. This represents an overall real increase of 11 per cent over the 1999-2000 estimate.
- Targeted research in universities (mostly funded on the advice of the Australian Research Council) will receive $455 million.
- In accrual terms, a total of $1257 million will be provided to the major research agencies in 2000-01, including $264 million for defence R&D. CSIRO will receive $616 million, but external earnings will raise this to about $890 million. ANSTO receives a substantialboost in capital funding, initiating the lead up to construction for the new research reactor.
- In common with trends in many countries with high levels of government R&D, Australian policy over a long period has sought to encourage greater reliance on external earnings, particularly those resulting from productive interactions with industry. In this context, international comparisons have consistently shown that combined R&D expenditure within Australian public sector agencies and universities — when considered relative to GDP — ranks very highly in world terms.
- Budget support is provided in the expectation of useful outcomes and outputs, including the development of the national skills base. The *Science and Technology Budget Statement* provides many impressive examples of the discoveries, advances in understanding and steps in commercialisation resulting from Government support for science and technology.

SUMMARY TABLE

COMMONWEALTH SUPPORT FOR MAJOR PROGRAMS OF SCIENCE AND INNOVATION

	1999-00 est accr $m	2000-01 est accr $m	real change
TARGETED HIGHER EDUCATION R&D[1]	446.5	455.3	-0.7%
OTHER HIGHER EDUCATION R&D	1304.2	1332.3	-0.5%
COOPERATIVE RESEARCH CENTRES	142.9	134.4	-8.4%
R&DStart etc	155.5	154.5	-3.3%
OTHER INNOVATION SUPPORT	110.3	96.7	-14.6%
IR&D TAX CONCESSION	553.0	600.0	+ 5.6%
RURALR&D	159.7	170.3	+ 3.8%
NHMRC	281.5	320.7	+10.9%
OTHER R&D GRANTS[2]	12.0	16.2	+ 31.7%
CSIRO[3]	623.2	615.8	-3.8%
DSTO[4]	268.9	263.5	-4.6%
OTHER R&D AGENCIES	313.0	377.9	+ 17.6%
TOTAL	**4371**	**4538**	**+ 1.1%**

1 Represents the total of Budget and HEF Act funding and incorporates funds allocated on the advice of the Australian Research Council (ARC).

2 Australian Biological Resources Study, Greenhouse research grants, Energy R&D and Australian Road Research Board.

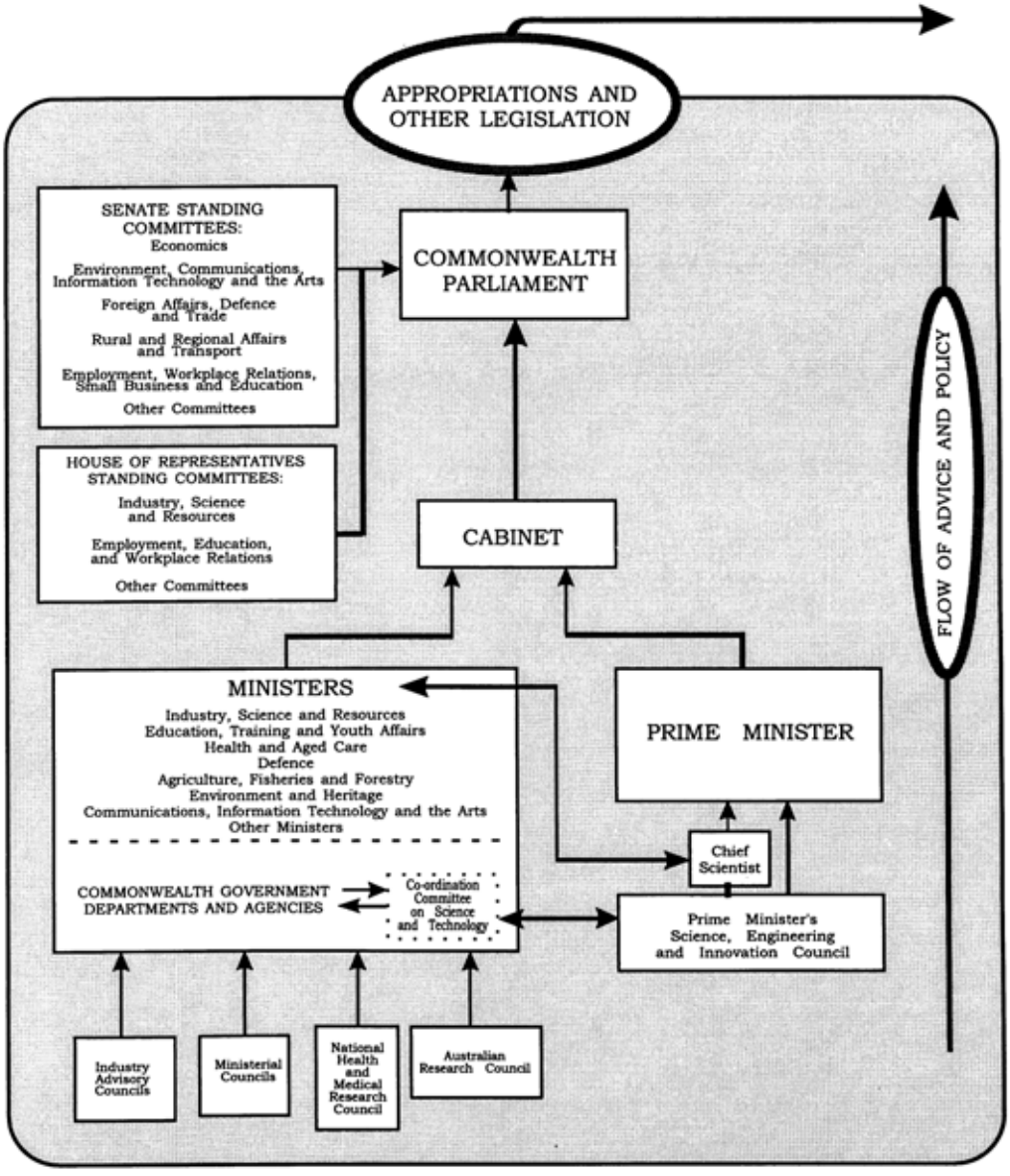
3 Includes funding through AFFA for the Australian Animal Health Laboratories. In addition to the budget funding shown, CSIRO expects to earn about $270 million from external sources in 2000-01.

4 These figures include components funded through appropriations to other parts of the Defence portfolio. (See note 1 to Table 4.)

For more detailed information see Tables 2 to 6

Figure 1

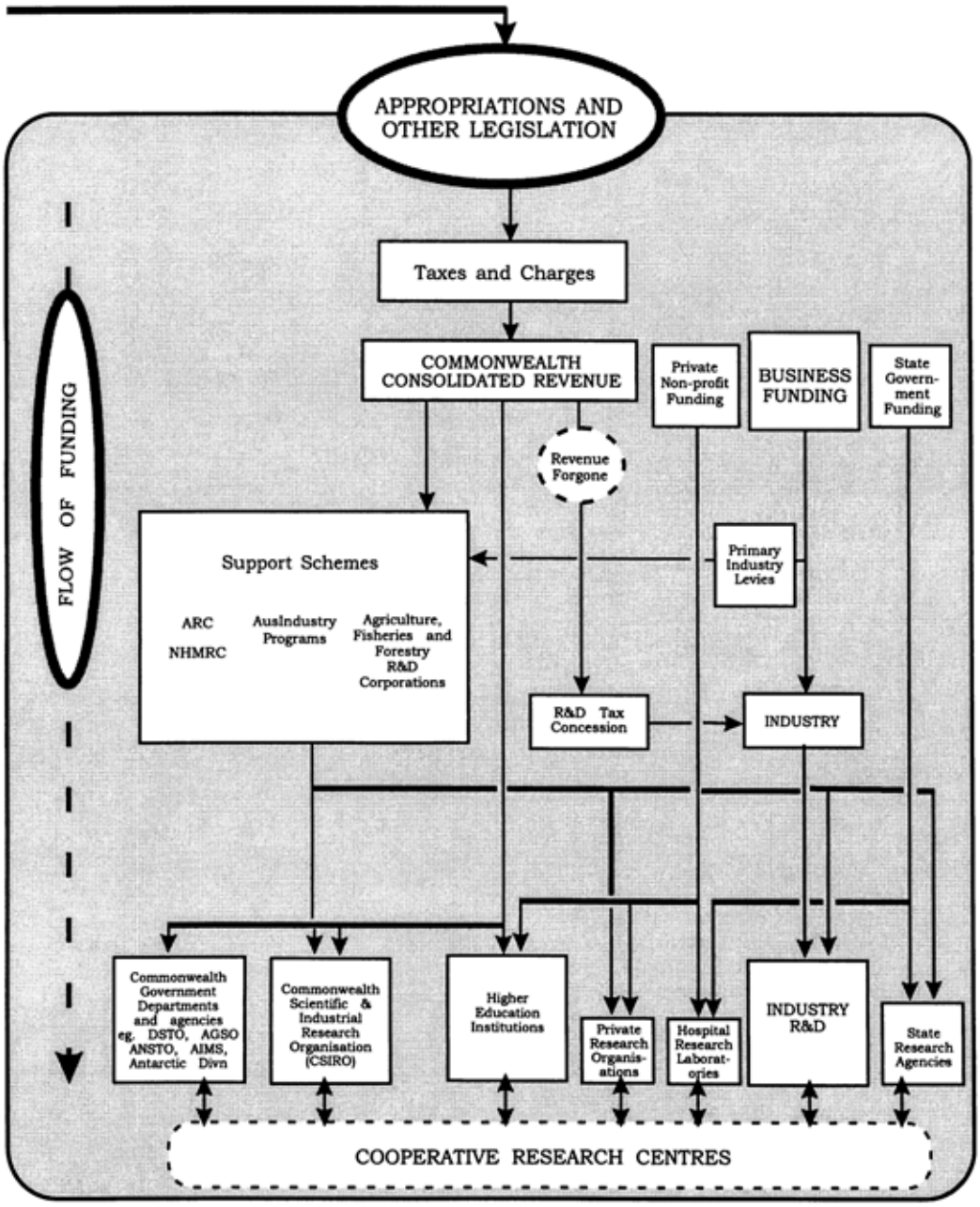
MAIN CHANNELS OF ADVICE
FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY



The figure is indicative of major bodies and principal channels for the flow of policy advice leading to Parliamentary and Cabinet decisions on science and technology issues. It does not purport to be other than illustrative.
Of course, there are a host of influential forces, including professional organisations and other non-government groups, and there are many cross-links and productive interactions between them.

Figure 2

FLOW OF FUNDING SUPPORT FOR R&D



The figure illustrates the main channels of funding to R&D performers. Funds originate primarily with the taxpayer and private business. The Commonwealth Government is the major funding source. For simplicity, minor funding flows are omitted.

Renewing the Science and Innovation System for the 21st Century

Introduction

Science and technology were the major transforming force in the 20th Century. By current trends they will continue to be a very important influence on life in the 21st Century.

Recognising this, and building in part on last year's Higher Education White Paper, the Government has put in train two complementary processes to assist it in setting appropriate policy directions. Following the deliberations of February's National Innovation Summit, a high-level Implementation Group is to make a report on recommended actions in August. In parallel with this process, the Chief Scientist is undertaking a Science Capability Review and will also report later this year.

The character of science and technology policy has changed significantly over the past fifty years. For much of the 20th century Australian science and technology policy was pre-occupied with government funding of public sector research. Over the past two or three decades, we have seen a fundamental shift in the emphasis of science and technology policy. A range of policy actions have sought both to increase the level of innovation in industry and to transfer greater benefits from public research and development to the commercial sector.

The scene is now set for a further shift in policy thinking. More than ever before, it is now widely accepted that the generation *and application* of knowledge is the key to future prosperity. In recent decades it was widely taken for granted that knowledge developed in universities and research laboratories would be applied in industry as a matter of course. It is now clear that this is not always the case. Application depends on a complex array of interactions between the generators and translators of intellectual capital. It requires a whole host of factors to be present, including for example, understanding industry needs, access to finance, the ability to negotiate intellectual property rights, effective business management, marketing skills, and, perhaps most importantly, vision, leadership and drive. Bringing the necessary elements together requires effective cooperation and high levels of communication. This cooperation may occur within a firm, but it is just as likely to involve outside elements, perhaps other firms in complementary, or even like industries, universities, research organisations, and government granting and regulatory bodies.

Participants in the recent Innovation Summit concluded that 'coordination of the National Innovation System and the linkages within it are more about people, partnerships, behaviours, incentives and culture and less about the institutional structures themselves.'

Similarly, submissions to the Chief Scientist's Science Capability Review have stressed that the development of a knowledge-based economy depends not only on the maintenance of a robust science base, but also effective linkages between the research sector and industry, a world class education system and a well informed community. The Chief Scientist himself has highlighted the issues of linkages, awareness and culture in his preliminary

discussion paper *Investing in Knowledge Generation for the 21st Century*. There is an increasing need for a science, engineering and technology base that emphasises excellence and quality; connection and relevance; and collaboration and efficiency.

The science base

Australian businesses, governments and individuals invest approximately $9 billion per annum in research and development. This has resulted in an Australian research performance that is very good by world standards. Australia produces 2.7 per cent of the world's scientific publications, with 967 papers per million population published per year. This is higher than the USA and France. The Government is committed to providing world class infrastructure and retaining our best scientists.

The Commonwealth Government has embarked on the process of matching Australia's science infrastructure to emerging needs. For example, in the 2000-01 Budget there is an eleven per cent real increase in funding for the National Health and Medical Research Council (NHMRC), an installment in the doubling of funding over five years for health and medical research, in response to recommendations made in the report of the Strategic Review of Health and Medical Research (Wills Report).

Equally important is the change in the emphasis of government science and technology policy towards building better links between the generators and translators of new knowledge. Education and cultural change are seen as an important key to a sustainable and prosperous future.

Awareness and cultural change

Cultural change — the need for changes in behaviour and attitudes — was a dominant theme of February's Innovation Summit. Nearly a third of the recommendations from Summit participants related to the need for schools and universities, research institutions and businesses to nurture attitudes and behaviour conducive to innovation, in particular those which pave the way for researchers and business people to work together. A number of further recommendations focused on the need for linkages. In consolidating more than 120 recommendations from the Summit, the Innovation Summit Implementation Group (ISIG) has included the need to develop innovation awareness across all sectors of the community through a variety of mechanisms. For example, by nurturing entrepreneurialism through the education system and marketing innovation success stories.

Schools and universities

In the future, Australia will need a work force equipped with the diverse range of skills needed for successful innovation. A pool of highly skilled scientists and technologists needs to be matched with entrepreneurs and business managers who have a deep appreciation of the value of science and technology, and can convert ideas into tradeable products and services. Scientists, technologists and research students need to become active players in global innovation networks.

The Higher Education White Paper, *Knowledge and Innovation: a policy statement on research and research training*, released in December 1999 announced measures to improve:

- excellence and diversity;
- collaboration between universities and industry, especially the links between universities and the users of research;
- levels of commercialisation and spin-offs from research activity;
- the quality of the research training environment and the skills possessed by research graduates; and
- concentration of research in areas of strength.

These measures will more closely match Australia's education and research capabilities to the demands of the new knowledge-based economy.

The education system overall needs to develop a culture which rewards both excellence and innovation and encourages entrepreneur ship.

At primary and secondary levels, schools need to capture the curiosity of young students and inspire them to take up further studies in scientific and technological fields. Schools may also encourage entrepreneurialism by building confidence and promoting a can-do attitude, and by highlighting the positive role that risk taking and 'failure' play on the road to success.

In universities, students can be offered a strong foundation in the enabling sciences, with added options to pursue a variety of multi-disciplinary studies, including, for example, studies in management, business, communication or law.

Steps of the kind above will provide abroad range of well-educated graduates, some of whom will go on to perform further research in our world class research institutions and private companies. Others will take up positions in other parts of the innovation system, facilitating technological innovation focused on business imperatives — perhaps engaging in technology search or managing company intellectual property strategies, acting as science communicators, or marketing high-tech products.

Businesses

The level of interaction between the publicly funded science base and industry in Australia has traditionally been low. A significant cultural change is needed both in research institutions and in the business community, and opportunities and incentives for interaction introduced for all players in the innovation system. The Cooperative Research Centres are one government initiative that has successfully begun to change attitudes to public-private research collaboration.

Increased communication between the business and research communities will build a deeper understanding and respect for each other's role. This will enable scientists and business people, with their different motivations, to work together as equal partners for their mutual benefit. Respect for different motivations and goals can be matched with a willingness to explore 'hybrid' activities. For example, contractual arrangements that allow public sector researchers to work with industry outside their core functions, the inclusion of industry interaction considerations among promotion criteria, and flexible intellectual property regimes within industry that allow a degree of knowledge sharing in the academic tradition.

Business needs to recognise the benefits that a close relationship with the science base can offer. Appropriate networks and linkages allow businesses to access skills and knowledge needed for the establishment of new products and processes. Industry leaders can gain immeasurable benefit from being in the communication loop with scientists and engineers engaged in basic research, and from using the instruments of knowledge translation — such as venture capital — to invest strategically. This depends too on a finance sector that is able to respond effectively to innovation-based investment proposals.

Science awareness of business needs

Strong relationships between research bodies and the business sector are needed to generate academic interest in and understanding of industry needs, influencing the directions of research. The development of such relationships will pave the way for Australia to become internationally regarded as a prime location for value adding to products and for rapid development in the innovation cycle. One pathway to improving relationships is for regional centres to host large industry clusters, incorporating arrangements that will encourage university collaboration.

The Government already has a number of programs in place that provide incentives for interaction between industry and researchers. For example, funding for Cooperative Research Centres, about $134 million, aims to encourage partnerships between universities, government research agencies, and industry. The Commonwealth also encourages collaborative projects by funding the Strategic Partnerships with Industry – Research and Training (SPIRT), the Special Research Centres and the Key Centres of Teaching and Research. External earning targets for organisations such as CSIRO encourage government research agencies to work with industry.

Communicating the benefits of research

Increased interaction between disparate players highlights the need for transparency and accountability, particularly for publicly funded researchers. Both the Higher Education White Paper and the Strategic Review of Health and Medical Research Report proposed increased accountability for research funding.

An understanding of the role and benefits of research generates appreciation and acceptance by the broader community, business and government. Researchers can adopt increased responsibility for participating in public forums on issues which rely on science and technology for community understanding and acceptance. The research community can have closer interactions with the school system, ensuring students at a younger age are more familiar with the role of science in society and those who perform it. We need to build a widespread awareness and appreciation in which research or innovative achievement will capture the 21st century community's imagination in the same way that sporting heroes do today.

Coordination of the innovation system

Coordination involves 'the harmonious or effective working together of different parts'. It is not the same as direction or control. Under normal circumstances, attempts to control or direct the detail of an innovation system are likely to be as self-defeating as attempts to control or direct the detail of artistic expression. It is more effective to set an appropriate and widely understood legal and regulatory framework for the system's operation, and then to encourage and facilitate appropriate patterns of behaviour within it. The aim should be for the system to become 'self-organising' in ways that will benefit the community overall — in ways that enhance us socially, environmentally and in health, as well as commercially.

Coordination of the innovation system is best effected when all players know what others are doing, so that they can tailor their own actions accordingly. Self-organisation is assisted by dense networks of linkages which facilitate communication and feedback — for example, industry associations, partnerships, clusters and arrangements that encourage informal relationships. These connections enable the transmission of information about what others in the system are doing, and they help build shared visions and alignment with common goals. So, while linkages are the key to generating innovation and novelty they are also the key to coordination.

Government's role

There is a clear role for government in facilitating self-organisation.

The government can help in two main ways:

- by creating opportunities for interaction and communication (such as the Innovation Summit and the development of action agendas); and
- by performing overall monitoring activities (collecting data and making it widely available and user friendly).

Actions of this kind are particularly important during periods of rapid change — when it becomes more difficult to find out what others are doing.

There is also a need for government to keep an overview of the innovation system, to address gaps — ensuring, for example, that public good research continues to be performed, and that the science and technology infrastructure is adequate. Infrastructure here includes the 'knowledge' infrastructure as well as the buildings and equipment of research facilities. The maintenance of a diverse range of skills and knowledge bases is necessary to ensure adaptability in a rapidly changing world. Without this diversity there is a danger of becoming stuck in particular tracks, trapped by a limited range of expertise, so that we cannot easily move into new and productive areas of scientific and technological activity.

There may also be a role for government in helping bridge unanticipated skills gaps to ensure a smooth transition into new technological paradigms.

Another kind of gap that the government has already gone to some lengths to address is the limited availability of venture capital and seed funding, especially at the early stages of commercialisation. The Innovation Investment Fund (IIF) and changes in the taxation system are stimulating the venture capital industry, and encouraging early stage investment. The new COMET (Commercialising Emerging Technologies) program is working with start-up companies commercialising new technology by helping them become 'investment ready' and attractive to financiers. And as part of another new initiative, the BITS (Building Information Technology Strengths) program will establish incubator centres to provide seed funding and business development services to start-up firms in the information technology and communications industries.

It is clear that 'science policy' and 'non-science' policy are becoming increasingly interconnected. The science and technology policy management system of the future will need to incorporate a sophisticated whole of government approach, monitoring the innovation implications of policies in a wide range of areas, not just in those traditionally associated with science and technology. The new concept of the 'knowledge-based economy' will assist in this process.

Renewing our science and innovation capacities

The forthcoming report of the Innovation Summit's Implementation Group, together with the complementary review of Australia's Science Capability being undertaken by the Chief Scientist, provide the opportunity to create a blueprint for action on innovation as Australia enters the third millennium.

At the threshold of the 21st century Australia faces many unique challenges and opportunities that raise questions about the kind of innovation system we should have. Our physical size and length of coastline, the arid nature of our country, its dry but highly variable climate, its vast biological diversity, its extensive mineral resources and geographical location, together raise a great number of scientific problems and opportunities, most of which are not duplicated in other parts of the world. Our biodiversity and our vast marine zone are just two factors whose potential have yet to be fully realised.

R&D has played a very significant but poorly recognised role in our economic success over the 20th century. Our past success in agriculture, particularly wool production, depended heavily on a sustained and first-class research effort that was able to keep us competitive for far longer than would otherwise have been the case. Our current success in minerals exporting is to a large degree due to our research base in that field, including significant science and technology investment by the mining industry.

In an uncertain world we need to be adaptable as well as efficient. This implies that we need to maintain a diverse range of industrial activities, which in turn implies the need for a strong and highly diverse science and technology base. This is the testing context in which the Innovation Summit's Implementation Group and the Chief Scientist must report.

Recent Major Developments

This section outlines the major developments of the past year and initiatives to be taken in science and technology across all Government portfolios

Note that the financial information in this *Statement* has been provided and confirmed by the agencies and departments with responsibility for the programs, and/or by the Department of Finance and Administration.
Further information is available from the *Portfolio Budget Statements* of each department. These can be accessed through the Federal Government entry point on the World Wide Web (*www.fed.gov.au*).

Science and Technology Advice

Prime Minister's Science, Engineering and Innovation Council (PMSEIC)

The Prime Minister's Science, Engineering and Innovation Council (PMSEIC) is the Government's principal independent source of advice on science, engineering and innovation.

The Council is chaired by the Prime Minister, and its members include ministers, representatives of the business and scientific communities, and personal members. The Minister for Industry, Science and Resources, Senator the Hon Nick Minchin, is Deputy Chair and the Chief Scientist is its Executive Officer.

The most recent meetings of PMSEIC, the third held in June 1999 and the fourth in November 1999, discussed the following topics:

- roles for science and innovation in natural resource management;
- Australia's response to the greenhouse effect;
- opportunities evolving from innovation in medical biotechnology;
- the nexus between science and its applications, with particular emphasis on innovation;
- advantages to be gained through innovation in established businesses;
- science and technology teaching and learning in primary and secondary education;
- themes to be considered at the National Innovation Summit in February 2000;
- the factors behind the success of the wine industry in Australia;
- the state of science and technology awareness in Australia; and
- the potential for the development of nanotechnology in Australia.

Further information on the Council and its agenda papers, prepared by independent working groups, can be accessed on the Internet at *www.isr.gov.au/science/pmseic/pmseic.html.*

Coordination Committee on Science and Technology (CCST)

The Coordination Committee on Science and Technology (CCST) acts as a forum for information exchange among those federal departments and agencies that have interests or responsibilities in science and technology.

CCST is chaired by the Deputy Chief Exective Officer, responsible for science and technology, in the Department of Industry, Science and Resources (ISR). Other members include senior officials from departments with responsibilities in science and technology, the Chief Scientist, the heads of major Commonwealth research providers and the chairs of major research funders.

During 1999-2000, CCST met five times. Matters discussed included:

- publication of a CCST report on interactions between industry and universities;
- access to major research facilities for Australia;
- mitigating the risks to natural hazards in Australian communities;
- commercialisation — maximising national returns for public investment in research and development;
- sustainable development;
- science awareness;
- greenhouse research; and
- access to research information.

Further information on CCST is available on the Internet at *www.science.gov.au/ccst/index.html*.

Chief Scientist

The Chief Scientist advises the Government on the contributions of science, technology and innovation to national goals, and assists in ensuring that public investment in science and technology is properly focused on issues of national importance.

Dr Robin Batterham was appointed Chief Scientist in May 1999 on a part-time basis for a three-year term.

The Chief Scientist's web page is at *www.isr.gov.au/science/cs/cs.html*.

Australian Science Capability Review

In September 1999, the Minister for Industry, Science and Resources announced that the Chief Scientist would conduct a major review of Australia's science, engineering and technology base. This review, the Australian Science Capability Review, is being undertaken as a demonstration of the government's commitment to the science base and recognition that research, whether it is basic, applied or strategic, is fundamental to the wealth of Australia. The terms of reference for the review include:

- examining the current state of Australia's science base;

- investigating mechanisms for funding and other support for the science base;
- identifying the required characteristics of the science base to support the development of leading-edge industry; and
- identifying the contribution the science base should make to economic development.

The Australian Science Capability Review will draw upon existing work, including:

- the Wills report into Health and Medical Research, *The Virtuous Cycle – Working Together for Health and Medical Research*;
- *Knowledge and Innovation: a policy statement on research and research training*, released by the Minister for Education, Training and Youth Affairs; and
- relevant outcomes from the National Innovation Summit.

The Chief Scientist has assembled a fifteen-member group of strategic advisers who are high profile representatives of the research and business communities and government to assist with the review, which involves wide consultation. As part of the consultation process in 1999, invitations to make submissions to the review were advertised. Over 100 submissions were received from interested parties including the higher education sector, government research organisations, professional associations, the business sector and individuals. A discussion paper, *Investing in Knowledge Generation for the Twenty First Century*, drawing on issues identified by the submissions and advice by a strategic group was released by the Chief Scientist for the National Innovation Summit in February 2000. The Chief Scientist intends to present an interim report at the June 2000 PMSEIC meeting. The final report will be completed by the end of October 2000.

Further information can be accessed at *www. isr.gov.au/science/review/*.

Innovation in Industry

Innovation Strategy Development

National Innovation Summit

As part of the Government's commitment to innovation, the Government and the Business Council of Australia jointly convened the National Innovation Summit in Melbourne on 9-11 February 2000.

With direction from a national steering committee, six expert working groups explored innovation in Australia and reported on the gaps and opportunities in the innovation system. The six working groups focused on: Industrial Innovation; Managing Intellectual Property; the Human Dimension; Institutional Structures and Interfaces; Innovation and

Incentives; and Resource and Infrastructure Consolidation and Cooperation. Debate was also inf ormedby over 70 general submissions and a number of sectoral submissions.

ISR prepared a number of papers as background material for the Summit, including the key background paper, *Shaping Australia's Future: Innovation -Framework Paper*. This paper provides a summary overview of Australia's national innovation system and includes contributions from five academics prominent in the field of innovation research. It is available at *www.isr.gov.au/industry/summit/Framework/Shaping.pdf*.

The Summit Communique, containing the broad range of findings from the Summit, is at *www.isr.gov.au/industry/summit*. A high-level Innovation Summit Implementation Group (ISIG), chaired by Mr David Miles, Senior Partner, Corrs Chambers Westgarth, was established in March 2000. This is to advise on a prioritised approach to the specific actions of the Summit by the end of August 2000.

The Commonwealth, State and Territory Advisory Council on Innovation

Following the Australian Industry Ministers Meeting of February 2000, the Minister for Industry, Science and Resources announced the establishment of the Commonwealth, State and Territory Advisory Council on Innovation to enhance the effectiveness, integration and coordination of Australia's innovation system. It is intended that the Council will play a significant role in addressing issues raised at the National Innovation Summit. The new Council replaces the existing Joint Advisory Group on Science and Technology (JAG).

The Council's membership will comprise senior representatives of all State and Territory governments, chairs of State and Territory Innovation Councils and/or senior representatives of State and Territory-based firms. Its first meeting is being convenedby the New South Wales Government in May 2000.

Case studies and workshops on the innovation strategies of successful Australian firms

In 1999, ISR commenced a project to develop case studies of 150 innovative Australian firms to determine their strategies for growth and commercialisation of new technologies. Its findings are expected to contribute to the design of government programs aimed at stimulating business innovation. The information will also be used to produce promotional material that will raise Australia's technology and business profile, both locally and internationally. Ten case studies were incorporated into a background paper for the National Innovation Summit under the title *Case Studies on Innovative Australian Firms (Some Examples)* (available at *www.isr.gov.au/industry/summit/Framework/casestudies.pdf*). Subsequently, an interactive CD-ROM entitled *Business Improvement 2000 - Innovation Case Studies* has been prepared. This incorporates sixty case studies, along with thirty others from Australian Business Ltd.

A series of Innovation Workshops entitled 'Business Improvement through Innovation' have been conducted for small and medium-sized businesses in all State capitals and major regional centres, using the CD-ROM Case Studies to raise awareness of innovation and the benefits that have accrued in real cases.

New national benefit principles for *R&D Start*

The reality of the global economy means that Australian companies and research organisations must forge links with international companies and markets to realise their full potential. In 1999, the Industry Research and Development (IR&D) Board endorsed a new decision framework for assessing national benefit in relation to *R&D Start* grants to reflect this need.

The new framework has been developed to ensure that Australia receives the maximum benefit from its public investment in R&D. It acknowledges that Government R&D programs should reflect global realities, and that offshore commercialisation might often be required and will not necessarily be contrary to Australia's national benefit. For example, national benefit could include: retention of the home base in Australia; commercialisation of the products, processes or services arising from R&D activities leading to an increase in the number of employees in Australia-based operations; and as a result of the commercialisation, Australian residents receiving commercial benefits through royalties, licence fees, equity, dividends or outright sale.

Review of *R&D Start* Ministerial Directions

As part of the ongoing management process of the Government's programs supporting innovation, the *R&D Start* program's Ministerial Directions have been amended. The amendments reflect an approach to national benefits which recognises the global economy, incorporate changes necessitated by the introduction of the GST, streamline the administrative functioning of the program to reflect current practices followed by Auslndustry and the IR&D Board; and provide the Board with the power to make guidelines for the new Commercialising Emerging Technologies (COMET) program.

Commercialising Emerging Technologies (COMET) Program

The COMET Program was launched in November 1999. Under this program, the Government has allocated $30 million over three years to provide individuals, early-stage growth firms and spin-off companies with support to improve their potential for successful commercialisation of innovative products, processes or services and/or to better manage for future innovation. Assistance is provided on a competitive basis and successful applicants receive support for activities such as market research and development of management expertise. Outcomes from the commercialisation strategies can include attracting capital, entering into joint ventures or other partnerships, or licensing intellectual property. Within six months of the launch, Auslndustry had approved ninety-four applications under the program.

Venture Awareness Program

The Venture Awareness Program commenced in February 2000, with funding of $1 million over three years. It aims to facilitate the growth of Australian firms, including early-stage, technology-based firms, by improving their access to venture capital. This will be achieved by establishing a set of investment benchmarks for Australian venture capital and by assisting institutional and other investors to improve their evaluation of venture capital investments.

Innovation Investment Fund (IIF) Program

The IIF Program is having a strong impact on the early-stage, technology-based venture capital market in Australia. Applications for a licence under Round Two of the IIF Program closed in March 2000. It is expected that the $91 million available under Round Two will license three or four additional IIF fund managers in addition to the five licensed under Round One in 1998. The successful fund managers are expected to be announced in the second half of 2000.

The 'Raising Finance for Innovation' breakout group at the National Innovation Summit reinforced the need for the IIF Program to address the gap in funds available for start-up investment. Several independent commentators credited the growth in the number of seed, start-up and early expansion deals in Australia during 1999 to the IIF Program, with Australia seeing record levels of investment activity as a result.

In response to the message received at the National Innovation Summit, the Minister for Industry, Science and Resources announced in March 2000 the establishment of a Revolving Fund for the IIF Program. Under this scheme, the capital and interest returned from the Commonwealth's investment in fund managers licensed in Rounds One and Two of the IIF Program will be reinvested. In April 2000, there was $31 million in the Revolving Fund from the successful investment by one of the IIF fund managers, AMWIN, in the company LookSmart.

Renewable Energy Commercialisation Program (RECP)

RECP is a 5-year competitive grants program designed to support and promote renewable energy initiatives which have strong commercialisation potential. RECP is designed to:

- support and/or promote the demonstration and commercialisation of innovative renewable energy equipment, technologies, systems or processes that:
  - have strong potential for widespread commercial application in Australia and internationally, including the potential to compete effectively with other energy sources;
  - offer the prospect of significant abatement of greenhouse gas emissions over the longer term, including through the wider commercial application of the equipment, technologies systems or processes; and

- support industry development activities that will facilitate the wider application of renewable energy technologies, and encourage the development of a sustainable and internationally competitive Australian renewable energy industry.

Applicants must be incorporated bodies located in Australia, be financially viable, and able to demonstrate their ability to provide at least 50 per cent of the project costs from their own or commercial sources. Competitive selection rounds will be conducted twice a year, with grants usually between $50,000 and $1 million.

Emerging Industries and Technologies Forum

An Emerging Industries and Technologies Forum was held in August 1999 to identify key issues affecting the development of emerging industries and technologies. Emerging industries are seen as encompassing not only the newly formed 'smart, high-tech' industries, but also reformed industries or spin-offs from existing mature industries, including services sectors. Work in this area has also included a pilot study to explore the value of identifying key enabling technologies Australian industry will demand over the next five years and a study of Government R&D expenditure by sector and technology. The proceedings from the Forum and the outcomes of the two studies have been published. The papers and further information are available at *www.isr.gov.au/industry/emerging*.

Intellectual Property

Review of intellectual property (IP) legislation

As part of the Commonwealth and State Governments' Competition Principles Agreement, an independent committee has been established to review the impact of Australia's intellectual property legislation on competition. After extensive public consultation, the committee issued an interim report in April 2000 and expects to finalise its reportby the end of June 2000.

Cooperation with the World Intellectual Property Organization

On 6 March 2000, the World Intellectual Property Organization (WIPO) and Australia signed a joint statement on cooperation for the provision of legal and technical assistance in the area of intellectual property to countries in the Asia-Pacific region. A joint Working Group of officials from the International Bureau of WIPO and the Government of Australia has been formed to progress cooperation activities under this statement.

IP in biotechnology

An Intellectual Property Strategy Discussion Paper has been developed by Biotechnology Australia. It outlines a number of initiatives to assist biotechnology stakeholders in developing capabilities for the effective and strategic management of their IP assets. In addition, a CD-ROM on managing IP for biotechnology stakeholders is being produced by Biotechnology

Australia, in conjunction with IP Australia. This information resource will provide biotechnologists with information about IP and commercial strategies.

A seminar series focusing on developing management skills associated with biotechnology IP is being presented in May 2000. It is aimed at executives in biotechnology companies andbiotechnology researchers. Emphases include IP issues for Australian biotechnology companies seeking international investment and partners (particularly in the United States).

Higher Education Research

Measures announced in the 2000-01 Budget

Strategic Partnerships with Industry - Research and Training (SPIRT) Scheme

The Government will maintain current funding levels for the Strategic Partnerships with Industry - Research and Training (SPIRT) Scheme on an ongoing basis, providing $13.0 million in 2001-02, $24.7 million in 2002-03 and $25.1 million in 2003-04. Provision for this funding has already been included in the forward estimates. This measure extends the Government's 1998 election commitment to provide additional funding for SPIRT for a three year period, and provides ongoingbase funding of $56.8 millionper calendar year. The SPIRT Scheme aims to improve links between universities and industry by supporting collaborative research projects undertaken to acquire new knowledge and by providing awards and fellowships for training and research in industrial settings. The Scheme leverages substantial financial contributions from industry partners that, at a minimum, match Commonwealth funding. The 2000-01 Budget provides for additional SPIRT funding of $62.8 million over three years, commencing in 2002, to ensure that the total number and value of new SPIRT projects are maintained at 1998 levels on an ongoing basis.

Research Infrastructure Equipment and Facilities (RIEF) Scheme

The Government will provide additional on-going funding to the Research Infrastructure Equipment and Facilities (RIEF) Scheme to boost base funding to $24.6 million per annum from 2001. The RIEF Scheme funds large items of research infrastructure for collaborative use by universities, research organisations and industry and supports access by Australian researchers to major national and international research facilities. These additional funds will further promote private investment in Australia's research infrastructure, while universities, research organisations and industry partners contribute at least 25 per cent of the cost of equipment and facilities acquired under the Scheme.

Knowledge and Innovation: a policy statement on research and research training

A new policy and funding framework for research and research training

In June 1999, the Government released a discussion paper on university research and research training, *New Knowledge, New Opportunities*. The paper identified a number of deficiencies in the current framework which limit institutions' capacity to realise the economic and social benefits of the knowledge they create and use: funding incentives that do not sufficiently encourage excellence and diversity; poor connections between university research and the national innovation system; too little concentration by institutions on areas of relative strength; inadequate preparation of research graduates for employment; and unacceptable wastage of resources associated with low completion rates and long completion times of research graduates.

In a related development for the higher education research sector during the year, *The Virtuous Cycle: the Final Report of the Strategic Review of Health and Medical Research* (the Wills Review), was released in May 1999. This report made major recommendations about the level and manner of funding available to universities, hospitals and other research organisations for medical and medical biotechnology research. Both *New Knowledge, New Opportunities* and *The Virtuous Cycle* agreed on the need to strengthen Australia's research effortby building on our strengths and taking advantage of new opportunities to improve linkages between researchers, industry and other social and economic institutions, and to improve the commercialisation of research. In addition, both focused on deficiencies in the area of research training.

Following a period of extensive discussion, the Government released its policy statement on research and research training, *Knowledge and Innovation*, in December 1999. The new policy and funding framework for research and research training, based on principles of excellence, autonomy, student choice, collaboration and accountability as the focus for the allocation of resources, will provide the tools to ensure that our university research and research training system is appropriate to our social, economic and cultural goals as we move into the 21st century. The statement announced:

- a strengthened Australian Research Council and an invigorated national competitive grants system;
- performance-based funding for research student places and research activity in universities, with allocative formulae and transitional arrangements designed to ensure that all universities are able to compete effectively under the new arrangements;
- the establishment of a broad quality verification framework supported by Research and Research Training Management Plans; and
- a collaborative research program to address the needs of rural and regional communities.

Independent Australian Research Council (ARC)

The key features of the reforms to the ARC, announced in *Knowledge and Innovation*, are:

- the establishment of the ARC as an independent body within the Education, Training and Youth Affairs portfolio, under its own authorising legislation and with new organisational and governance arrangements; and
- the establishment of a new National Competitive Grants Program, comprising two elements, Discovery and Linkage, to replace the current program elements.

Knowledge and Innovation announced that the new ARC will have a prominent member of the Australian community as its Chair, and that membership of the Council will reflect the breadth of academic, industry and government interests in research. The ARC's new Chief Executive Officer will be responsible for the day-to-day management of the ARC. Program Managers will be appointed with responsibility for overseeing the peer review process, liaising and communicating with the research community and users of research, and identifying emerging and innovative approaches to research.

The *Discovery* element of the National Competitive Grants Program will recognise the importance of Australian universities as major sources of fundamental research. The *Linkage* element of the National Competitive Grants Program will support national and international collaboration necessary for Australian research to contribute to a strong and vibrant knowledge economy. It is anticipated that grants will be made under the new program from 2002.

The changes to the ARC and the Commonwealth programs it manages are expected to be fully implemented in 2001. The year 2000 will be a transition year as the ARC assumes responsibility for management and administration of some existing programs (from January 2000) and prepares for the introduction of a new administrative and program structure. Important activities during 2000 will be consultations with the higher education sector about proposed changes to the program arrangements, and the appointment of the Program Managers.

Performance-based funding

Universities' research and research training activities will be assisted under the new framework through two new performance-based block funding schemes. This approach will best recognise and reward those institutions that provide high-quality research training environments and support excellent and diverse research activities.

From 2001, the Institutional Grants Scheme (IGS) will support the general fabric of institutions' research and research training activities, and assist institutions in responding flexibly to their environment in accordance with their own strategic judgements. The IGS absorbs the funding previously allocated for the Research Quantum and the Small Research Grants Scheme.

Funding under the IGS will be allocated on the basis of a formula that reflects success in attracting research income from a diversity of sources (60 per cent), attracting research students (30 per cent), and the quality and quantum of its research publications, assessed through a revised publications measure (10 per cent). The Government considers that institutions are likely to be more outwardly focused in their research when research income from all sources is equally weighted, unlike current arrangements which give lesser weight to income received from industry.

Funding for research training will also be allocated according to a performance-based formula. The Government has decided that institutions will attract a number of scholarship places based on their performance through a formula comprising three elements: numbers of all research students completing their degree (50 per cent), research income (40 per cent) and a revised publications measure noted above (10 per cent). The values for each element will be the average of the latest two years' data. Students will be eligible for a Commonwealth-funded place for up to four years for PhD study and up to two years for Masters study, on a full-time equivalent basis.

Under the new framework all commencing Commonwealth-funded research places from 2001 will be HECS-exempt. At the outset, the Government will maintain the current level of funding for total student places for each institution and, within that level, negotiate the number of research places with each institution.

The Research Infrastructure Block Grants Scheme will be retained as a separate scheme for allocating research infrastructure funding.

The Institute of Advanced Studies (IAS) of the Australian National University (ANU) does not currently have access to all research funding programs. The Government and the ANU have agreed that the IAS should have access to both the new competitive and formula-driven research and research training schemes, in exchange for making up to 20 per cent of the current IAS block grant contestable. Further consultation will take place to determine the basis on which the new arrangements will be phased in over the next four years.

Quality assurance

The introduction of an external quality verification framework and the publication of institutions' Research and Research Training Management Plans will enable institutions to demonstrate that the research and research training they provide is of a high international standard. The first of the Plans will be the subject of discussion during the Profiles reviews in 2000. Core areas that institutions are expected to report on through the Plans include past research and research training performance; future directions for research and research training; collaborative arrangements and arrangements for managing commercialisation and intellectual property.

One of the functions of a new Australian University Quality Agency will be to review claims made by universities concerning their teaching and research performance. Where an institution's claims are not able to be substantiated, a

more in-depth assessment of its research and research training activity will be conducted by broadly based independent expert panels. The results of the verification process will be published to aid transparency and accountability.

Regional needs

Regional institutions' contributions to their local communities will continue to be supported by the Government through the introduction of a regional package. Under the package, $10 million of the existing Strategic Partnerships with Industry - Research and Training Scheme, will be earmarked on an ongoing, competitive basis, to support research on issues of benefit to rural and regional communities. Research projects funded under this element will be consistent with the Government's regional priorities.

Regional institutions will be further supported by a $6 million fund to enable them to adapt to the new arrangements. The fund will ensure that no regional institution suffers a deterioration in its research funding, from its starting position, in the first three years of the new arrangements. An evaluation of the impact of the reforms on regional institutions and communities will be conducted before the end of this transitional period, and consideration will be given to extending the availability of assistance if regional universities were to face difficulties if funding were to be discontinued.

Science Lectureships

The Government is providing $25 million over three years for innovative approaches to the development of science education and training ($5 million in 1999-2000, $10 million in 2000-01 and $10 million in 2001-02).

The initiative has a number of objectives, including:

- encouraging industry to invest in education and training;
- developing courses to meet the needs of emerging industries and thus indirectly addressing areas of skill shortages, such as in information technology; and
- attracting more school leavers into science courses through development of innovative approaches to course design and delivery.

Following consultation with key stakeholders in industry and the science and academic communities, proposals were invited nationally for projects which involve lectureships and course development in science education. Twenty eight projects were funded under this initiative. The projects cover a wide range of fields of science-related education, including information technology, biotechnology, engineering, health sciences, science education and physical sciences. Projects involve a total of twenty-nine universities and a wide range of industry partners who will contribute in cash and in kind to the various projects.

Program reviews of higher education targeted research

The Department of Education, Training and Youth Affairs (DETYA) and the ARC have continued to implement a monitoring and evaluation strategy for the higher education targeted research program through the Research Evaluation Program. The following reviews concluded during 1999-2000:

University and industry research partnerships in Australia - an evaluation of ARC/DETYA industry-linked research schemes

The purpose of the study was to assess the extent to which industry-linked research schemes have met the Government's objective of supporting university and industry interaction, evaluate the administrative processes of the schemes, and assess the program's impact on other programs.

The study found that both university and industry respondents appear positive about their experiences with the schemes. Fromboth university and industry perspectives, the schemes have served to build closer alliances between the sectors, in the context of both first-time and existing collaborative activities. The study also suggested that ARC/DETYA industry-linked schemes are initiating and promoting research activities that would not otherwise occur. Responses to the study clearly indicate that the industry-linked schemes are more effective than any other mechanisms for promoting collaboration in research.

Biological sciences

Two studies of biological sciences were undertaken:

- An evaluation of biological science research was carried out to assess the effectiveness of ARC/DETYA targeted research support in the field of biological sciences for the period 1990 to 1997 and, in particular, the extent to which this support has enabled the discipline to meet the Government's objectives in relation to research and research training. The review found that ARC/DETYA funding has led to important discoveries and produced a steady stream of outputs that have been successful in meeting the objective of advancing knowledge; assisted researchers to build strong links with local and international industry and other researchers; and succeeded in meeting research training objectives.
- A bibliometric analysis of biological sciences research in Australia was carried out for the period 1991 to 1993. The study presents a comprehensive set of data on publication and citation rates from the field and sub-fields of the biological sciences, specifically those publications attributable to ARC/DETYA targeted research funding. One main finding of the study was the positive effect of collaboration between researchers on publication and citation rates, with citation rates increasing as the level of collaboration increases; and internationally co-authored publications achieving significantly higher citation rates than average. Other findings pointed to the fact that researchers appointed to full-time research positions in the biological sciences, irrespective of the source of funding support, achieved higher visibility for their research than did researchers with significant other duties. The study also identified a systematic difference between work funded through Large Grants and that

undertaken in Special Research Centres and Key Centres of Teaching and Research, with Centre-based researchers publishing in journals of higher impact and visibility.

Australian Research Council key developments

ARC Strategic Plan 2000-2002

Under the changes announced in the Government's policy statement on research and research training, the ARC will be required to bring forward each year, for Ministerial approval, a three-year rolling strategic plan that outlines the objectives to be achieved over the triennium. The *ARC Strategic Plan for 2000-2002* was released on 3 May 2000.

Special Research Centres selection round

The Special Research Centres (SRCs) funding supports special units of concentration of research workers and resources in Australian higher education institutions, aimed at encouraging the pursuit of excellence in research. The Centres act as major linkages to international centres and programs and high-quality research environments for postgraduate research education and postdoctoral training. Eleven new centres are being funded from the beginning of 2000, for up to nine years. The new Centres are:

- Applied Philosophy and Public Ethics;
- Cognitive Science and Cognitive Neuropsychology;
- Quantum Computer Technology;
- Third-Generation Photovoltaics;
- Environmental Stress and Adaptation Research;
- Green Chemistry;
- Particulate Fluids Processing;
- Ultra-Broadband Information Networks;
- Functional and Applied Genomics;
- Molecular Genetics of Development; and
- Particle and Material Interfaces.

Studies and reports

- Commercialisation of research and technology transfer. In 1999, the ARC released a commissioned report, *University Research: Technology Transfer and Commercialisation Practices*, that presents a discussion of issues and approaches for the technology transfer and commercialisation of research conducted in universities. The Council expects the report will assist universities in improving their relationships with industry. The findings recognise the diversity of universities and the unique research focus of each. The report focuses on the importance of individual researchers developing good relations with prospective industry partners early in the research process and maintaining them. It also identifies and addresses a

number of barriers to successful technology transfer and commercialisation of research.

- **Cross-disciplinary research.** The ARC released a commissioned report, *Cross-Disciplinary Research - a Discussion Paper,* in December 1999. The paper presents options for allowing cross-disciplinary research proposals to receive the appropriate level of attention in the ARC assessment process, and discusses broader policy options for supporting and promoting cross-disciplinary research. The paper was circulated to the higher education sector and interested organisations for comment. The Council will give careful consideration to all comments prior to implementing any recommendations in ARC Grant Guidelines and assessment procedures for the 2001 applications.
- **Australian science and technology linkages.** The ARC and CSIRO have commissioned a study to investigate the linkages between science (as represented by published papers) and technology (as represented by patents), to assist the ARC and CSIRO to understand the nature and extent of linkages between science and technology within the Australian national innovation system and between the national and international innovation systems. The final report of the study is expected to be published in mid-2000.
- **National Strategic Workshop on Genomics and Gene Technology.** The ARC and Rural R&D Corporations (RDCs) agreed to sponsor a series of workshops for leading researchers and representatives of industry with expertise in genomics and gene technologies. The aim was to develop strategies to maintain and increase Australia's competitiveness in this area of biological science and its application to the development and prosperity of rural industries. A final report of the Workshops that were held in April and July 1999 identifies the key emerging science and technologies in genomics and gene technologies and the strategic issues that need to be addressed, and is to be published shortly. It identifies potential synergies between industry and research conducted within universities and public research institutes and considers future strategies to support innovation networks in this area. A Working Party comprising representatives of the ARC and RDCs is currently investigating options for on-going collaborative activity in this area.
- **Long-term impact of research supported by the ARC.** One objective of the ARC is to increase community awareness of the role and importance of research in Australian society and the outcomes (in terms of benefits to the community) of research activities supported by the ARC's programs. The Council has recently commissioned a project to develop a number of case studies to highlight the long-term impact of research supported by ARC grants or awards.

South Australian research infrastructure audit

The ARC is currently funding an audit of research infrastructure in South Australia in conjunction with the University of Adelaide, the University of South Australia and Flinders University of South Australia. The audit will provide details of existing physical infrastructure, including items located at universities and State and Commonwealth Government agencies co-located with universities in South Australia, as well as identify gaps in the

infrastructure available to university researchers. The project is expected to be of benefit to the universities involved in assisting their planning for infrastructure development and to provide a model that can be applied in other states.

Information Technology

Building Information Technology Strengths (BITS)

BITS is funded at $158 million through the Telstra Social Bonus. It is designed to address current market failures and promote the growth of new and developing innovative Australian businesses in the information technology and telecommunications industries. BITS has three core elements:

- the **Incubator Centres Program** will provide funding of $76 million to establish a total of ten incubator centres in the following locations: two centres in New South Wales and one each in Victoria, South Australia, Western Australia, Queensland, Australian Capital Territory and the Northern Territory, as well as one national centre and another centre servicing both New South Wales and Victoria. The successful applicants under the program were announced in April 2000. The centres will open in the latter half of 2000 and will provide seed funding and business development services to start-up firms in the information technology and communications industries. Services will be delivered through a range of strategic linkages, including universities, R&D organisations, private sector firms and venture capitalists.
- the **Australian Advanced Communications Infrastructure Development (AACID) Program**, will provide a stimulus to the development and implementation of leading edge network infrastructure and applications ('test-beds') in Australia. An implementation strategy is being developed following the completion of a consultancy report which examined key issues associated with advanced networks and possible program directions for AACID. $40 million is being provided for the program.
- **Intelligent Island Program**, funded at $40 million, will support a range of new projects and build on existing Tasmanian Government initiatives to further develop an internationally competitive information technology and telecommunications sector. A Board comprising representatives of the Commonwealth and Tasmanian Governments, Tasmanian industry and the Tasmanian tertiary education sector will oversee the Program.

Information Technology Online Program

The Information Technology Online (ITOL) Program is a competitive grant program administered by the Department of Communications, Information Technology and the Arts - National Office for the Information Economy (NOIE). ITOL has provided funding to some thirty collaborative projects in three funding rounds. Applications for grants under the fourth round closed in November 1999 with 78 applications received. Approximately $2 million is available for funding fourth round projects.

ITOL is designed to accelerate the national adoption of electronic commerce business solutions, especially by communities of small and medium enterprises. ITOL provides catalytic grant support to consortia of firms, business/industry associations and universities for collaborative projects. Projects are assessed on a competitive basis against published selection criteria. An outline of the ITOL program is available on the ITOL web site, *www.noie.gov.au/ITOL*.

Year 2000

The Government's assessment that Australia was amongst the nations best prepared for Year 2000 proved to be correct. Australia's passage into 2000 was free of any major Year 2000 computer-related disruptions. Since 1996, the Commonwealth had supported a range of initiatives aimed at ensuring this outcome. The Commonwealth provided national leadership through strategies that included:

- legislative and taxation support for business efforts;
- raising awareness of the need for business preparedness;
- ensuring the preparedness of Government's own systems; and
- informing the wider community of the state of preparedness.

This program entailed extensive cooperation with industry and State and Territory governments.

Trials In Innovative Government Electronic Regional Services (TIGERS) Project

The TIGERS Project is part of the Government's *Accessing the Future* initiatives, funded from the Telstra Social Bonus announced in June 1999. It is a Commonwealth project to be delivered in collaboration with the Tasmanian State Government. The project was announced with abudget of $10 million to trial a range of innovative means of delivering government services to Tasmanians over the Internet, phone and over the counter (supported electronically) with an emphasis on regional and remote areas.

TIGERS has been set up for a period of three years to December 2002, to trial the integration of services across the various tiers of government, building on the success of Service Tasmania. It will assist consumers and businesses to transact and obtain information, irrespective of the level of government that has responsibility for the service.

Development of assessment methods for compliance with EMR standards

The Australian Communications Authority (ACA) has introduced regulatory arrangements to limit exposure of the general public to electromagnetic radiation (EMR) from radiocommunications and telecommunications transmitters. A mandatory standard has been introduced for mobile phones and their base stations in recognition of public concern about possible adverse health effects associated with their use and siting, respectively. It is the ACA's intention to progressively broaden the scope of the standard to apply to all transmitters.

The development of standards and a compliance framework for human exposure to EMR is a relatively new science. With this work Australia is at the forefront of international progress in this area.

Biotechnology

Biotechnology Australia

Biotechnology Australia (BA) was established in May 1999 to provide a coordinated approach to the Commonwealth's biotechnology activities. Funding, as announced last year, is $10 million over two years ($6 million in 1999-2000 and $4 million in 2000-01.)

National Biotechnology Strategy

Following the release of a Biotechnology Discussion Paper and wide consultation, BA is developing a National Biotechnology Strategy. The Strategy will address the following key issues:

- biotechnology in the community;
- ensuring effective regulation;
- biotechnology in the economy;
- Australian biotechnology in the global market;
- resources for biotechnology; and
- maintaining the momentum and coordination.

Public awareness program

A major element of the BA program is the public awareness program which has been developed in consultation with stakeholders. Following a national survey of public awareness of biotechnology issues, BA established an information program with the following elements:

- the Gene Technology Information Service - a 'hot line' telephone information service to answer public queries;
- wide distribution, through major supermarkets, of an information brochure on genetically modified food through major supermarkets; and
- community and media briefings.

Access to biological resources

BA is developing a strategy to improve the policy and regulatory framework for enhanced access to biological resources. A key element of this is the Inquiry to examine Access to Biological Resources. The Commonwealth is aiming to lead by facilitating the development of a nationally consistent access system and also to maximise the community benefits from biotechnology.

Draft gene technology legislation

The Interim Office of the Gene Technology Regulator has worked closely with State and Territory Governments, other Commonwealth agencies, and interested parties to produce a draft Gene Technology Bill 2000, which was released for public comment in December 1999. Public forums on the Bill were held in all State and Territory capitals and some major regional centres in February-March 2000, and written submissions were requested by 10 March 2000. The Bill was subsequently amended to address major concerns. The objective of the legislation is to protect the health and safety of people, and to protect the environment, by identifying risks posed as a result of gene technology, and by managing those risks through the regulation of certain dealings with genetically modified organisms. It is intended to operate in close collaboration with existing systems for the regulation of food, agricultural and veterinary chemicals, industrial chemicals and therapeutic goods.

Marine Science and Technology

Marine Science and Technology Plan

Australia's Marine Science and Technology Plan and its summary *Overview* were released by the Minister at the PMSEIC meeting in June 1999.

The Plan nominates a series of priorities and strategies to further our understanding and sustainable use of the Australian marine environment. These assist the effective implementation of Australia's Oceans Policy.

The Plan's top priorities are to:

- define the boundary of Australia's Marine Jurisdiction (AMJ);
- map the form and nature of the seabed;
- develop an integrated southern temperate research program;
- develop an integrated northern tropical research program;
- improve the skills base;
- implement an Australian Ocean Observing System (AOOS);
- better coordinate the management of marine data;
- upgrade the Research Vessels *Franklin* and *Southern Surveyor*;
- upgrade other marine facilities;
  - acquire deep water swath mapping equipment;
  - refurbish existing, and establish new, coastal and island research stations in southern temperate and northern and northeast tropical waters; and

– acquire new ocean engineering facilities to strengthen the nation's marine engineering capabilities in the design of offshore oil platforms and high speed vessels.

In 1999-2000, the Government provided funds to complete the definition of Australia's Marine Jurisdictional (AMJ) Boundary south of Macquarie Island and authorised AGSO to define the AMJ Boundary off the coast of the Australian Antarctic Territory. AGSO will undertake this work over the next two Antarctic summers.

A further key priority was to establish a Marine Science Advisory Group to:

- oversight the implementation of the Marine Science and Technology Plan, and to ensure its continuing relevance and responsiveness to change;
- facilitate coordination between all parties undertaking activities consistent with the Plan;
- report to the Minister for Industry, Science and Resources concerning progress in implementing the Plan, and on other matters as required;
- facilitate research input to the development of Regional Marine Plans called for by the Oceans Policy; and
- assist in identifying means to define and manage large marine ecosystems or regional domains, in the context of implementing elements of both the Plan and the Oceans Policy.

The Minister for Industry, Science and Resources approved the formation of the Marine Science Advisory Group in October 1999. Its membership comprises senior representation from AIMS, CSIRO, AGSO and AUSLIG; the Group is chaired by the Head of ISR's Innovation and Science Division. The Group has met twice to date.

Review of Tropical Marine Research

In August 1999, the Minister for Industry, Science and Resources requested that the Chief Scientist conduct a Review of Tropical Marine Research. The review was to focus particularly on research off the coast of Queensland, and to address two main issues:

- what role should tropical marine science research, with a particular focus on the marine environment off the coast of Queensland, play as part of the national marine research and development effort; and
- how should that contribution be delivered, recognising the continuing role of the Australian Institute of Marine Science (AIMS) and other organisations in this field.

A first Report of the Review, presenting findings and conclusions concerning infrastructure for marine research in the Townsville region, was completed in March 2000, and formed the basis of the Minister's decision to proceed with the refurbishment of AIMS at its Cape Ferguson site. The final report of the Review is expected later this year.

New research vessel

A Western Australian shipbuilding company (Tenix Shipbuilding WA) has been contracted to construct a new research vessel for AIMS, based in Townsville. The new vessel will be named *RV Cape Ferguson* after the site of AIMS' Marine Operations headquarters. The vessel will cost $3.45 million.

RV Cape Ferguson will provide a boost for Australia's marine science effort. Its work will be primarily in the tropical waters of northern Australia, providing a platform for improved understanding of the valuable marine resources of the region.

Nuclear Science and Technology

Replacement research reactor

The 2000-01 Budget provides ANSTO with a total budget of $159 million, of which $53 million represents capital funding. This capital injection will initiate a new phase in the development of the replacement reactor. In August 1999, ANSTO requested tenders for the replacement reactor project from four pre-qualified tenderers: INVAP, Argentina; AECL, Canada; Siemens, Germany; and Technicatome, France. The tenders closed in January, and have now been assessed. The announcement of the successful tenderer is expected in July and the construction and instrument development phase can then commence.

Field emission electron microscope

ANSTO has commissioned an advanced field emission electron microscope equipped with full analytical facilities. This facility provides atomic resolution and crystal chemical information essential for the study of actinide elements in radioactive wastef orms. It is expected to assist greatly in the formulation and development of synroc for specific wastes and in the study of alteration processes of wasteforms immersed in aqueous media, required as part of the wasteform qualification process. Synroc is the Australian developed technology for long-term immobilisation of radioactive waste.

Asian Workshop on Waste Management Action

During the coming year, ANSTO will host a major Asian workshop on waste management organised under the umbrella of the Forum for Nuclear Cooperation in Asia. This builds on the experience developed from ANSTO's Waste Management Action Plan, initiated in 1996. ANSTO's plan involves upgrading waste management facilities, minimising the quantities of radioactive waste generated, and converting stored waste from past operations into stable solids for disposal or long-term storage.

Health and Medical Research

Health and Medical Research Strategic Review

The *Health and Medical Research Strategic Review (Wills Report)* was presented to the Government in April 1999. The Government responded in the May 1999 Budgetby doubling the funding for health and medical research over the next five years. It also endorsed a majority of the recommendations of the *Strategic Review* and established a Ministerial Committee with responsibility for overseeing implementation of the Government's response. In addition, an Implementation Committee was appointed to support the Ministerial Committee. The Implementation Committee comprises representatives of industry, government and the research community. The Implementation Committee presented an interim report to the Ministerial Committee in March 2000 (specifically on performance measures) and will present a final report in August 2000. The National Health and Medical Research Council (NHMRC) willbe reporting on those aspects of the Government's response to the *Review*, which have been referred to the Council.

National Health and Medical Research Committee (NHMRC)

Key features of the 1999 NHMRC funding round of applications included:

- a total of 367 new project grants, representing a success rate of approximately 25 per cent of applicants for project grant funding;
- a 16.5 per cent increase in funding for training awards;
- 14 new appointments to NHMRC Research Fellowships;
- $4.2 million in funding has been allocated for projects to be carried out in conjunction with the Australian Genome Research Facility; and
- a 6 per cent increase in the average level of project grants (10 per cent increase in average project grant funding for Fellows).
- The new project grant category, Clinical Trials/Large Patient recruitment studies resulted in eight such studies being funded in 2000.

Other initiatives of NHMRC, through its Committees, included:

- Strategic Research and Development Committee (SRDC)

  A number of major initiatives and reforms were initiated by the SRDC of the NHMRC during 1999.

  – In March 1999, the SRDC, in conjunction with the Department of Health and Aged Care, hosted a workshop to discuss the applicability of economic analysis in health, and to consider the implications for health research priorities. Following this workshop, the SRDC approved $500,000 for economic research in health. To oversee the Health and Economics Research Program, the SRDC established a Working Committee.

  – In August 1999, the SRDC called for expressions of interest in research that would focus on the larger systemic issues of the Australian health system. Following assessment of these initial

proposals, the Working Committee has shortlisted eight applications and has invited the Chief Investigators of these proposals to submit full applications.

- SRDC's Evidence Based Clinical Practice Research Program has funded fourteen research projects which cover areas as diverse as innovations in routine clinical practice to reduce youth suicide rates; to prevent infections at the time of birth; to minimise separations of mothers and babies immediately after birth; to implement interventions that aim to reduce the number of costly and inappropriate diagnostic tests on women; to implement evidence based guidelines to tackle diabetes in Aboriginal communities; to reduce falls and strokes in residential care; and to investigate the uptake of evidence based practice in the management of breast cancer, heart disease, asthma and chronic obstructive pulmonary disease.
- The SRDC's Priority Setting Program invited over forty organisations, inside and outside the health sector, to make written submissions and attend one of three discussion groups. During the consultations, stakeholders acknowledged that it was important for the SRDC to retain its strategic focus in order to respond to emerging health issues that need research, and viewed this as an important SRDC function. However, stakeholders believed that the SRDC should respond to requests for such research on the basis of evidence and not on the basis of advocacy.

- Research Committee of the NHMRC

  A number of major initiatives were undertaken by the Research Committee of the NHMRC during 1999 including:

  - **The quality of Australian health research.** During this triennium, the RC sponsored a ground breaking bibliometric study of the publication output of Australia's health sector, particularly papers supported by the NHMRC. The Research Evaluation and Policy Project group from the ANU conducted the research. One of the significant findings was, that while NHMRC-funded research was associated with only 25 per cent of all publications examined, NHMRC funding was acknowledged in 47 per cent of publications in the top 1 per cent most highly cited band. The results of this study point to a healthy, internationally-competitive research sector in Australia with NHMRC funding being highly effective. A second phase of this study has been initiated and is expected to be completed in the second half of 2000.
  - **Strong Partnerships in Research** The RC, in conjunction with the SRDC, has developed the concept of Partnership Grants, with the first expressions of interest called for in the second half of 1999. These grants will support research (on the basis of excellence) which seeks to bring NHMRC, government and private sector funding together to investigate issues of major health significance.
  - **Medical Genomics.** The Commonwealth Government announced enhanced funding for medical genomics in the 1999 Budget to ensure that Australian medical genomic research projects can be

better supported to help build the biotechnology base, which is essential, if Australia is to capitalise on the genomics revolution. To this end the NHMRC has called for expressions of interest for funding in 2000 through the Program in Medical Genomics. $4.2 million has been allocated to this.

Environment

Greenhouse science strategy

The Greenhouse Science Advisory Committee submitted a strategic plan for greenhouse science, the Australian Greenhouse Science Initiative - Strategy and Business Plan 2000 to 2005, to the Minister for the Environment and Heritage in December 1999. The Plan outlines strategies, priorities for research, lead agencies for coordinating activities, outcomes and performance measures. The priority areas are greenhouse and the climate system, climate variability and trends, impacts and adaptation, mitigation, and tracking emissions and sinks.

Establishment of the National Oceans Office

In December 1999, the Government announced the formation of the National Oceans Office as an Executive agency under the *Public Service Act 1999*. The National Oceans Office, located in Hobart, is responsible to the National Oceans Ministerial Board for implementation of Australia's Oceans Policy, with its commitment to ecosystem-based management of Australian marine jurisdictions. The Office reports to the Ministerial Board as a 'whole-of-government' agency. Consistent with the Government's commitment to establish an improved scientific basis for oceans planning and management, the roles established for the National Oceans Office include:

- providing secretariat and technical support to the National Oceans Ministerial Board, the National Oceans Advisory Group and Regional Marine Plan Steering Committees, once established;
- coordinating development of Regional Marine Plans based on large marine ecosystems, which will integrate environmental, economic, social and cultural objectives for the Region; and
- providing advice to the National Oceans Ministerial Board on marine research priorities related to *Australia's Oceans Policy*.

Carbon Accounting

The Government announced in 1999, the establishment of the Cooperative Research Centre for Terrestrial Carbon Accounting, which will receive $56 million over seven years, with $17.7 million contributed by the CRC Program. The centre will ensure that Australia is in a strong position to argue internationally for a comprehensive system of accounting for carbon emissions and sinks, through improvements of the fundamental science that underpins the National Carbon Accounting System.

The National Pollutant Inventory

The first report from the National Pollutant Inventory (NPI), for the year 1998-99, was released on the Internet in January 2000. The database provides nearly 1200 facility emission estimation reports on NPI listed substances from more than 23 industry sectors. Reports were received on a total of 67 substances. In addition to the facility (or point source) reports, information was provided on specific air pollutant sources in capital city airsheds and nutrient emissions to major water catchments in each State.

The database will be updated annually and next year's report will cover approximately 78 industry sectors. It is intended that airshed and water catchment information willbe added on an ongoingbasis. The Inventory will be a major tool for environmental assessment of pollutant emissions and trends in emissions, and hence for environmental management, as well as being a strong impetus for cleaner production practices by industry. It will also provide the community with the first publicly accessible comprehensive database on priority pollutants on a nationwide basis; it is accessible at *www.npi.ea.gov.au*.

Convention on Biological Diversity

Australia continues to take an active part in the implementation of the Convention on Biological Diversity. Delegations have attended various meetings to advance initiatives such as:

- the Global Taxonomy Initiative, a program to address the taxonomic impediment to managing biodiversity globally. It aims to build taxonomic capacity, provide appropriate taxonomic tools and facilitate access to taxonomic information;
- active participation in the development of the Cartagena Biosafety Protocol on transboundary movements of living (genetically modified) organisms which was adopted at the resumed Extraordinary Conference of the Parties to the Convention on Biological Diversity in Montreal on 28 January 2000;
- assessment of the status and trends and options for conservation and sustainable use of terrestrial biological diversity;
- development of guiding principles for the prevention of impacts of alien species;
- consideration of the consequences of the use of new technology for the control of plant gene expression;
- incorporation of biological diversity considerations into environmental impact assessments; and
- development of the ecosystem approach to managing biodiversity.

Establishment of Antarctic Marine Living Resources Program

The Australian Antarctic Division has created a research program devoted solely to understanding the inter-relationships in the Southern Ocean ecosystem; this program feeds directly into Australia's negotiating position in the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). With the objective of developing management strategies that

allow for the rational development of the economic potential of the Southern Ocean, the program is equally concerned with the fishing industry as it is with the wide range of species inhabiting these waters.

Australian State of the Environment Reporting Process

The Commonwealth State of the Environment Reporting system is an ongoing process to enhance the quality, accessibility and relevance of data relating to ecologically sustainable development. The first major product of the system was Australia: State of the Environment 1996 - an independent, nation-wide assessment of the status of Australia's environment. The recent *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* now makes preparation of state of the environment reports, and their tabling in Parliament, a legislative requirement. Arrangements are well under way for production of the 2001 Australian State of the Environment (SoE) Report. This will concentrate on changes since the last report, cover new and emerging issues and pioneer the use of environmental indicators on a continental scale.

Assessment of the Jabiluka Project

Following representation from the World Heritage Committee, the Supervising Scientist provided a thorough review of all the issues raised by the Committee and provided a detailed assessment of the risks to wetlands of Kakadu National Park arising from the storage of uranium ore at the surface at Jabiluka, the management of water and the storage of tailings. Based on this review the Supervising Scientist concluded that the natural values of Kakadu National Park are not threatened by the development of the Jabiluka uranium mine and the degree of scientific certainty that applies to this assessment is very high.

Regional Program Office of the Intergovernmental Oceanographic Commission

A Southern Hemisphere focus for the Global Ocean Observing System (GOOS) has been provided through the establishment in Australia of a Regional Program Office of the Intergovernmental Oceanographic Commission (IOC) of UNESCO. The Office was established in Perth during 1999 under a tripartite agreement between the IOC, the Bureau of Meteorology and the Western Australian Government. The role of the Perth Office is to facilitate the development and implementation of GOOS activities in the Indian Ocean, SW Pacific and South-East Asia, and to build the capacity of countries in the region to participate. This initiative is part of a wider Australian response to the International Year of the Ocean and reflects an increasing national and international interest in the role of the oceans, especially in relation to climate and climate change.

Atmospheric Science and Related Technologies

Air Pollution in Major Cities Program

The $16 million Air Pollution in Major Cities Program, funded from the Natural Heritage Trust and administered through Environment Australia's Environment Protection Group, is developing national strategies to minimise the impact of air pollution. Under the Program, air quality is addressed in five major areas: national standards; strategies; monitoring; research and community education. Key projects have been focused on three areas: research and development; monitoring; and transport emissions.

Research

Two key research projects under the Air Pollution in Major Cities Program target particles and nitrogen oxides:

- Secondary Particle Formation by Photochemical Reactions project

  This project involves monitoring and modelling particles to result in an understanding of photochemical particulate formation in order to develop control strategies ($240,000 over three years).

- The Nitrogen Oxides (NOx) Catalyst for Diesel Engines Project

  This project is aimed at progressing significant work on de-NOx catalyst materials to reduce NOx emissions from diesel engines and to develop a product to the point of full scale field trials ($170,000 over three years).

Monitoring air pollution

Two key monitoring projects under the Program are the:

- Air Pollution Forecasting System for Major Cities project

  This project aims to develop a full air quality forecasting model, integrating new high-resolution weather and photochemical smog forecasting using real-time emissions inventory techniques. The system provides detailed 3-D high-resolution objective forecasts of major weather and air quality constituents on a daily basis to suburb levels ($855,000 over 3 years).

- Fine Particle Measurement Calibration study

  This study is exploring the relationship between two currently used methods of monitoring and reporting air quality. Comparison of data using the two different methodologies is important to understanding changes in air quality over time ($114,000).

Transport

- Diesel National Environment Protection Measure (NEPM)

  In 1999-2000 Environment Australia contributed $880,000 to development of a diesel NEPM by the National Environment Protection Council. Preparation for development of the NEPM involves a number of research projects designed to determine a suitable in-service emissions test for diesel vehicles and a reliable

method of measuring particulate emissions during the selected test. Results will be published in March 2000.

- Intelligent Transport Systems project

  This project, undertaken in collaboration with Department of Transport and Regional Services (DoTRS), examines the air quality benefits that could be gained from integrating high-technology equipment and software into transport systems ($40,000).

- National Fuel Quality Standards development

  Environment Australia, in consultation with ISR, DoTRS and the Australian Greenhouse Office is developing National Fuel Quality Standards as part of the government's program of actions addressing the emissions performance of new and in-service vehicles. The standards will set levels for both petrol and diesel fuel composition for those parameters that influence exhaust emissions and impact on new emission control technology. The total budget for 1999-2000 is $100,000.

Living Cities - Air Toxics Program

In 1999, a new Living Cities - Air Toxics Program was established within the Environment Protection Group of Environment Australia. With funding of $4.85 million over 3 years, this program will address air toxics in the urban environment including consideration of indoor air quality. This program will fund a series of studies to identify the sources and impacts of air toxics including emission from motor vehicles, indoor sources and combustion sources. Benefiting from the recently established dioxins testing capacity at the Australian Government Analytical Laboratories (AGAL), the Living Cities - Air Toxics Program is preparing to implement a dioxins sampling program to clarifying the extent of environmental exposure to dioxins.

Federal Sector Science Programs

Cooperative Research Centres (CRC) Program 2000 selection round

The 2000 CRC selection round was formally launched in January 2000, with applications closing in July. The guidelines for this selection round have been revised to ensure that they fully reflect the Government's objectives and the recommendations of the Mercer-Stocker report, Review of Greater Commercialisation and Self Funding in the CRC Program. New and emerging industries are encouraged to participate through the new guidelines which reinforce the importance of cooperation between CRC partners, including Federal and State Governments, industry, universities, and the CSIRO.

Anew CRC Committee will manage the selection process and take an active role in monitoring the performance of CRCs and advising on their progress.

Antarctic continental shelf survey

In December 1999, the Australian Government announced it will take action to define the limits of the continental shelf off the Australian Antarctic Territory (AAT). To implement this decision the Government will provide $31 million over 5 years to carry out the survey, required to establish the baselines, determine the foot of the continental slope and delineate the outer limit of the shelf. The surveys will comprise use of satellite imagery and ice radar to establish baseline, an inner bathymetric survey and two outer seismic surveys along the full extent of the 5,000km coastline of the AAT. In addition to providing data to define the offshore jurisdiction, the surveys will significantly enhance understanding of the geology of offshore Antarctica. Undertaking the survey work will enable the Government to lodge the necessary data with the Commission on the Limits of the Continental Shelf before November 2004, the deadline established under the United Nations Convention on the Law of the Sea (UNCLOS).

Agricultural IP Centre

The Australian Centre for Intellectual Property in Agriculture is being established at the Australian National University's Faculty of Law. It is anticipated that the Centre will operate from mid-2000. It will provide education and training, and engage in research and policy development, focusing on intellectual property issues as they apply to agriculture and agricultural biotechnology. The Grains Research and Development Corporation (GRDC) has allocated investment of $3 million over five years to establish the Centre, with additional support of $0.4 million from the Commonwealth.

Graingene

To keep step with the changing, global approach to the management of proprietary intellectual property, three major players in Australian agriculture have come together to form the Graingene joint venture:

- the Australian Wheat Board Ltd;
- CSIRO's Division of Plant Industry; and
- the GRDC.

Graingene aims to identify, develop and bring to the market, grains technology, and generate intellectual property to position Australia in the global grains business of the 21st century. Graingene will pursue alliances with rural R&D corporations to pave the way for Australian access to essential intellectual property. The Graingene joint venture is an innovative approach for both the grains industry and the GRDC, to which the GRDC has committed $10.5 million over six years.

New Cooperative Research Centre for Viticulture

Anew CRC for Viticulture has been set up to provide knowledge, technology and skills needed to ensure that Australian viticulture remains internationally competitive and profitable. Specifically the Centre's four programs are designed to deliver: improved wine quality and security of supply; enhanced sustainability of vineyard production systems; new and

beneficial grapevine varieties via genetic engineering; and training and development of industry and professional staff. The Grape and Wine Research and Development Corporation (GWRDC) will invest around $2.5 million per annum in the new CRC over the Centre's seven-year lifespan, providing the major share of the wine industry's contribution to the Centre.

Managing dryland salinity

The National Dryland Salinity Program (NDSP) has released an information package for use by local governments that draws attention to the major impact that salinity has on urban and rural infrastructure, amenities and environment. Work undertaken through the National Land and Water Resources Audit as part of NDSP has established a national technical framework, based on the hydrogeological characteristics of catchments across the continent, which will form the basis for a nationwide strategic approach to the management of dryland salinity.

Cheaper and better access to improved remote sensing imagery

AUSLIG, through its Australian Centre for Remote Sensing (ACRES), commenced the acquisition, processing and distribution of Enhanced Thematic Mapper Plus (ETM+) data from the Landsat 7 satellite in August 1999. The new data improves the interpretation of satellite imagery in agriculture, mining and exploration, environmental monitoring, land use, mapping, hydrology and coastal resources. ACRES has reduced prices by up to 75 per cent. This initiative has greatly assisted in the increased usage of the data by a wide range of commercial and scientific users.

First satellite navigation system in Antarctica

AUSLIG installed the first permanent satellite-based global navigation system receiver in Antarctica to deliver information for navigation applications, together with data from other AUSLIG receivers installed at Mt Stromlo in Canberra and Yaragadee in Western Australia, for potential incorporation in a Global Navigation Satellite System.

International Science and Technology Links

APEC

The Economic Committee of APEC agreed to examine the implications for APEC members of the trend towards knowledge-based economies. Australia is making a major contribution to this project through a research paper which defines a set of characteristics of a fully developed knowledge-based economy (KBE), and identifies which are preconditions for a KBE. The paper focuses on a representative sample of APEC countries and examines characteristics including research and development, linkages and the national innovation system, education and training, thebusiness climate and information and communication technologies. A draft of the research paper

will be reviewed by an APEC symposium in Seoul in June 2000, prior to its presentation to APEC leaders in November.

The Government supports participation by the Australian research community in APEC science and technology activities, through the APEC Industrial Science and Technology Working Group (1ST WG). Australia led the Working Group's consideration of the Agenda for S&T Industry Cooperation into the 21st Century. The paper analysed the various projects under APEC's Economic and Technical Sub-Committee, of which the 1ST WG is a part. Ministers endorsed the paper's various conclusions, including the need to focus on the opportunities and challenges for small and medium sized enterprises in knowledge-based economies. This topic is expected to be taken up in the Working Group's Action Plan for the year 2000.

Information about 1ST WG can be found at *www.apecst.org*. This site contains a directory of links to other science and technology sites throughout APEC, information on science and technology activities, discussion forums and a calendar of APEC science and technology events.

OECD

Over three decades, the OECD has made a substantial contribution to the study and discussion of policy issues in science, technology and innovation through the OECD Committee for Scientific and Technological Policy (CSTP) and its various working groups. This work has greatly facilitated the exchange of policy experience between member countries and has had a major influence on the directions of science and technology policy in all developed countries. The CSTP met at Ministerial level in June 1999.
Outcomes included endorsement of key priorities that included the new OECD Global Science Forum (GSF), the Global Biodiversity Information Facility (GBIF), the Square Kilometre Array (SKA) radio astronomy project, and the development of Biological Resource Centres. Ministers sought closer links between science and technology and stakeholders in society, education and business - both to enhance innovative capacity and to increase public understanding of the knowledged-based economy as a driver of growth and development. Themes common to much of the Ministerial discussion were:

- The need to see knowledge as a source of innovation, and build linkages within and between research, government and industry;
- The recognition that, while rapid changes in science and technology offer great opportunities, there are also challenges that need to be addressed: such as the unequal distribution of benefits; the difficulty of adjusting to rapid change; threats to the environment; and ethical questions relating to biotechnology.

CSTP work focuses on the following areas:

- **The development and analysis of science and technology indicators,** to provide a" consistent international approach to the measurement of science and technology activity so as to provide an empirical base for comparing member countries' performance;

- **Innovation and technology policy,** which includes the exploration of new policy approaches, national innovation systems, technology diffusion, and issues relating innovation to productivity;
- **The science system,** looking at, for example, trends affecting university research and education, public understanding of science and technology, and how results of the science system contribute to economic growth and employment;
- **International cooperation in relation to large facilities and projects** Australia has been particularly active in relation to the development of GBIF, SKA and a possible new major facility for radio astronomy;
- **Biotechnology studies** related to human health, intellectual property, technology transfer and genetic resources, water use and conservation, and food safety.

The Working Party on Technology and Innovation Policy (TIP) is playing a leading role in guiding the OECD's work on innovation and economic growth, as a substantial contribution to a major OECD project on economic growth factors. Australia holds one of the Vice-Chair positions on TIP.

The OECD GSF succeeded the OECD Megascience Forum and met for the first time during 1999-2000. Australia has played a leading role in development and implementation of the GSF's work program, and Professor Vicki Sara (Chair, Australian Research Council) is one of the Vice-Chairs of the Forum.

As indicated above, Australia has also played a leading role in the development of GBIF, which has its genesis in discussion at the Megascience Forum, and now falls under the aegis of GSF. GBIF will improve access to biological information through the establishment of an international network of databases. Australia's participation has been central to development of the implementing agreement and business plan for GBIF and to the development of a sound basis for the establishment of the facility.

Bilateral activities

- China

- Australia and China successfully completed a number of collaborative activities in the 1999-2000 financial year.
  - As a result of the workshop held in the margins of the Fifth International Union of Materials Research Societies International Conference on Advanced Materials in Beijing in June 1999, a number of collaborative projects are progressively being identified and developed during the year;
  - In October-November 1999, an Australian delegation participated in a workshop in Beijing on Science and Technology Indicators and their Policy Application in the People's Republic of China and Australia. The aim of the workshop was to improve opportunities for building commercial, educational and research relationships with China;

- During October/December, six delegations from China were briefed on Australia's S&T and innovation policy. The delegations were from the Ministry of Science and Technology (MOST), the Commission of Science, Technology and Industry for National Defence, the Chinese Academy of Sciences, and several provincial Commissions of Science and Technology and research centres;
- In January 2000, a Memorandum of Understanding between ISR and MOST was signed to establish a Special Fund for Scientific and Technological Cooperation. Under the agreement, each country contributes up to $250,000 in support of scientific and strategic R&D projects of interest to both countries; In April 2000, a working group with delegates from MOST, the National Natural Science Foundation of China, and the Institute of Scientific and Technological Information visited Australia to discuss operation of the Fund and to visit organisations with potential to initiate, develop and support cooperative projects.

- European Union

- On 9 December 1999, the amendment of the Agreement Relating to Scientific and Technological Cooperation between Australia and the European Community entered into force. This amendment broadens the scope for S&T cooperation based on the original 1994 Agreement. Under the amendment Australian researchers can participate in most aspects of the European Union (EU) Framework Programs and EU researchers can participate in all Australian S&T activities. The EU's Fifth Framework Program (1999-2002) aims to solve socio-economic problems through research and development. This program calls for research projects to address specific topics under four broad themes:
  - Quality of Life and Management of Living Resources (health, biotechnology, agriculture, fisheries and forestry);
  - User-friendly Information Society (information and communication technologies);
  - Competitive and Sustainable Growth (transport, manufacturing and new materials); and
  - Energy, Environment and Sustainable Development (including cultural heritage).
- Australian participation in previous framework projects has provided benefits to Australia and Europe in sectors as diverse as the wool industry, small goods manufacturing, strawberry biotechnology, geographic positioning systems applications, e-commerce, vaccine delivery, Creutzfeldt-Jakob disease and climate change modelling.

-France

- The French-Australian Industrial Research (FAIR) program supported a range of collaborative follow-up activities, between Australian and French research organisations and companies. These resulted from the FAIR Workshop on Food Processing Technologies held in 1998 in Paris; and the Workshop on Water and Wastewater Treatment in Adelaide in April 1999.

- The FAIR 2000 workshop, on Health Information Systems was held in Paris. The Australian delegation comprised representatives from 16 companies and research organisations coordinated by the Collaborative Health Informatics Centre (CHIC). An equivalent number of French organisations was present.
- In January 2000 the ARC signed a new Memorandum of Understanding with the French Centre National de la Recherche Scientifique. The agreement renews the collaborative partnership between the ARC and Centre National to promote international research and the exchange of researchers.

- Germany

- Under the Australia-Germany Collaboration on Water and Environment Research and Development, three Australian and two German research organisations formed a Strategic Alliance in 1999 to help solve water contamination problems in Australia and overseas. The Australian partners of the Alliance have received support from the TDP. The three year $600,000 funding will help the Alliance to pro-actively promote its technology solutions to industry. The German partners have received matching funding support from the German Ministry of Education and Research (BMBF).
- In October 1999, Australia participated in a major Bio-partnering and technology showcasing mission to Germany aimed at developing a mutually beneficial relationship between Australian and EU biotechnology industry. 32 Australian biotechnology companies and research bodies participated in show casing their capabilities in biotechnology in Europe. The Bio-partnering initiative was the result of a $800,000 project funded by ISR through its TDP program. The project generated valuable direct business in terms of new licensing agreements, contracts for DNA sequencing and genomics services and sale of key reagents to EU pharmaceutical companies. BMBF will send a German biotechnology fact finding mission to Australia later in 2000.

- India

- Renewed contact with India saw the development of closer working relationships and the discussion of a revised Memorandum of Understanding to improve the basis for S&T cooperation and of a program of S&T cooperation.
- Environment Australia, in cooperation with the Government of India, is investigating opportunities to establish a national halon essential uses panel and also education and training activities to ensure the effective operation and management of India's halon stocks.

- Indonesia

- Australia and Indonesia have agreed to develop a new bilateral Agreement on Science and Technology Cooperation over the next year to replace the current agreement which expires in August 2001.
- Strategic forums in agricultural biotechnology, mining/mine site rehabilitation and clean water are being held in the period April to June 2000. These forums will involve experts from both countries in

focusing research interests within these broad priority areas, leading to a more focused call for project proposals in the latter half of 2000.

- Italy

- A geoscience program was undertaken in 2000 jointly with the Italian Antarctic program. Using the NZ research vessel *Tangaroa*, a significant part of the seabed adjacent to Adélie Land and George V Land was surveyed using seismic and coring techniques. The work will yield information on the age of seabed deposits and enable an assessment to be made of the glacial history or the nearby continent.

- Japan

- Japan hosted the 9th Australia-Japan Science and Technology Cooperative Meeting in Tokyo in June 1999 to review the relationship, to discuss national policy issues which could have an impact on bilateral research activities, and to discuss future directions.

  There was agreement for collaboration to focus on issues relating to: energy, marine science, medical and health science, environment, new materials, and biotechnology.

  Three joint workshops are being held in 2000 on drug design and development (Melbourne, May 2000); better management of Wastes and Contaminated Soils (Adelaide, May 2000); and partnerships for Sustained Observations of Climate in the Indian Ocean (Perth, November 2000).

- During the year Australia funded a workshop on lightweight magnesium alloys for the automobile industry, and sponsored a number of research scientists to attend workshops and visits sites in Japan.

- Korea

- The S&T relationship between Australia and Korea continues to develop, with a Treaty-level Agreement on Scientific and Technological Cooperation signed in September 1999. The Agreement d is expected to enter into force by mid- 2000. One of the most important aspects of the Agreement is the establishment of a joint Committee on Science and Technology. This committee offers a valuable, high-level coordination mechanism between the research communities of Australia and Korea.

- Australia and Korea have established a pilot bilateral Industrial and Technology Co-operation Fund. The Fund comprises of a $250,000 contribution each from Australia and Korea.

- Mexico

- During 1999 a joint Mexico-Australia bilateral workshop on Aquaculture was held in Sydney and a number of potential collaborative projects were identified for consideration. In late 1999 both Australia and Mexico agreed to form a Joint Mexican-Australian Commission for Scientific and Technological Co-operation. The Agreement between the two countries provides for the establishment of such a Commission to identify and facilitate joint projects of

mutual interest and benefit. The first meeting of the Commission is being held in Mexico in May 2000.

- United Kingdom

- A high level Australian technology delegation will travel to the United Kingdom in July 2000, under the auspices of the Australia-UK Partners in Innovation program. The Chief Scientist, Dr Batterham, will lead this delegation. The delegation will comprise experts in telemedicine, advanced manufacturing, opto-electronics, photonics, advanced materials and chemical engineering. Several scientists received grants from ISR to participate in workshops, and undertake short-term study visits at British universities.
- In April 1999 the ARC signed an agreement with the United Kingdom Office of Science and Technology renewing the Anglo-Australian Postdoctoral Fellowship Scheme for a further three years, from 2000 to 2002 inclusive. The Scheme has been operating since 1998 as an initiative of the newIMAGES program endorsed by the Governments of Australia and the United Kingdom to promote and foster links between the two countries. It provides for an exchange of early career researchers between Australia and the United Kingdom in certain discipline areas.

- United States

- During 1999 a number of science and technology projects with the United States were funded. In particular, ISR funded a major Australian biotechnology mission to the United States to attend the Bio 1999 (the world's largest biotechnology fair) held in Seattle. During 2000 ISR will be working with the Australian biotechnology industry and researchers on two major biotechnology partnering events in the United States.

- Vietnam

- Environment Australia oversees a bilateral project in Vietnam, funded by AusAID, on the implementation of a recovery and recycling system to phaseout CFC consumption in domestic and commercial refrigeration and airconditionmg sectors.
- A pilot AusAID project on meteorological support to Vietnam was implemented by the Bureau of Meteorology, following the signing in May 1999 of a Memorandum of Understanding on cooperation in hydrometeorology with Vietnam. The project included the installation at Phu Quy of an automatic weather station, which serves also as a data collection platform for real-time data retrieval from Japan's Geostationary Meteorological Satellite-5. This station will form part of Vietnam's early warning system against typhoons during the tropical cyclone season from 2000-01.

Other initiatives in support of science and technology

- in industry, science, technology and resources

- At the National Innovation Summit, the Minister for Industry, Science and Resources announced that up to $5 million will be provided from the Technology Diffusion Program (TDP) to support proposals from business and research communities to bring the best researchers and innovators to Australia, to pass on their knowledge and experience to Australians. Another change to the TDP saw support provided for a young scientists exchange program with the United States and the European Union (EU).
- In the past year, the TDP has contributed funding to a number of innovative projects through **Technology Transfer grants.** These include:
  - feasibility studies for the development of semiconductor photonics manufacturing capabilities;
  - network opportunities for high leverage technologies;
  - technology diffusion for improved competitiveness in the tooling industry;
  - development of a network for harnessing materials R&D resources to benefit Australian manufacturing;
  - demonstration and awareness programs in environmental management issues for small and medium enterprises in mining and extractive industries;and
  - business improvement through innovation, a workshop program and interactive CD-ROM.
- In February 2000, ISR released the publication, *Commonwealth and State Government Programs Supporting Innovation in Firms - At October 1999*. It **summarises innovation programs** administered by the Commonwealth and State Governments. It is a resource for firms seeking to improve their business through technological, managerial and organisational innovation, as well as for industry policy makers. A summary of this publication is at *www.isr.gov.au/industry/summit/framework/InnSummit.pdf*. This web site will be updated annually.
- House of Representatives Committee Report on *The Effect of Certain Public Policy Changes on Australia's R&D Business* was released in September 1999. It raised a number of important issues concerning the effects of **public policy reform on R&D.** ISR coordinated the Government's response, incorporating the outcomes of the National Innovation Summit, presenting it to Parliament at the end of the first quarter of 2000.
- **Emerging Industries Workshops** have been held with business, government and research agency participants in New South Wales, Victoria, Queensland, South Australia and Western Australia. The Worksships identified key issues affecting the development of new technologies and emerging industries, including opportunities for

regionally based industries. Outcomes from these Workshops point to the importance of cross-sectoral and cross-institutional networks as well as the need for in-depth analyses of potential high growth sectors through pre-feasibility studies.

- The **Future Industries Network (FIN)** is a means of tapping into ideas and views from a wide range of stakeholders including those from industry, government, research, academic and other organisations. It facilitates a national dialogue on emerging industries and technologies and provides relevant information on Government's initiatives and outcomes.
- In November 1999, the new community advisory body **NetAlert** was established as part of the Government's commitment to manage offensive online material. NetAlert is responsible for researching new filtering technologies and running national education and awareness campaigns to promote a safer Internet experience for young people. NetAlert is currently in the process of establishing a telephone advisory service and an informative web site to assist parents and other concerned community members manage their and their children's access to the Internet.
- ***Australian Horticulture in the Global Environment***, a report recently released by ABARE, provides an effective industry resource, profiling a number of industries and their products. It complements the annual *Australian Horticultural Statistics Handbook*, produced by the Australian Horticultural Corporation, by providing in-depth commentary on topics such as major producing areas and production and consumption trends, export trends and competition, state regional export contributions, market access issues and technical barriers to trade.
- Regulations formally ending the **Energy Research and Development Corporation (ERDC)** as a separate Government research and development support agency were gazetted in December 1999, and were tabled in the first session of the Parliament in 2000. There remains substantial funding for energy research, particularly relating to the development and commercialisation of renewable and alternative energy resources and energy efficiency, through targeted programs as well as through the Government's broader research and development support programs. Reports of the outcomes of ERDC-supported research projects are now available at *www.energypublications.com.au*.
- CSIRO researchers in Plant Industry have found a 'suite of promoters', called **pPLEX**, which will improve agricultural production and provide access to vitally important research technology. CSIRO and RhoBio, a joint venture between Rhone Poulenc Agro and Biogemma specialising in biotechnology of field crops, have formed a strategic research alliance to collaborate, centred on this technology. The technology provides great opportunity for improving agronomic traits in crops and has already been successfully tested in potatoes, cotton and pastures. The alliance will see the technology developed for other major crops, especially cereals.
- CSIRO Animal Health Division has licensed Virax Holdings Limited to use a **vaccine delivery technique** for diseases, including

HIV/AIDS. The license allows Virax to use a harmless virus, the fowl pox virus, as a vehicle to carry the active parts of a vaccine or treatment into the body. It also gives Virax exclusive use of the existing Virax Co-X-Gene™ technology for other human health problems.

- A three-year **collaborative construction research agreement** has been established between CSIRO Building Construction & Engineering and Queensland University of Technology (QUT). The alliance is expected to produce $5 million in business for Queensland over the next five years. It follows a successful one-year trial alliance.
- **CSIRO has signed an agreement with the Commonwealth Department of Health and Aged Care** to provide Medicare benefits claims records and Pharmaceutical Benefits claim records, linked at patient level, for all Western Australians and all Queenslanders for the period 1994 to 1998 inclusive. This massive linked, but depersonalised, data set will provide the basis for the development of population level utilisation, disease management and funding models.
- CSIRO has announced a new **'Glass Earth'** research program which has the aim of making the top kilometre of the Australian continent 'as transparent as glass'. The goal is to give the nation's $37 billion mining and resources export industry the tools to locate the next generation of giant orebodies. To find these deposits, researchers aim to develop ways to 'see' through hundreds of metres of rock, sand and rubble, deep into the very bedrock of the continent.
- **New developments in facilities**
  - CSIRO is proceeding with plans to re-locate its **Energy Technology headquarters** to Newcastle, New South Wales. The move, scheduled for 2002, will provide CSIRO with a world-class facility incorporating best practice in energy efficient design and operation. The new centre will provide access to CSIRO's scientific effort in sustainable energy technologies and serve as a national and global showcase for the Australian energy industry and for worldwide technologies with potential application in Australia. Funding for the new building will be provided by CSIRO and the New South Wales government, with the acquisition of land facilitated by BHP Ltd.
  - in October 1999, a new CSIRO **hydrometallurgy and minerals research facility was commissioned** in Perth. The facility combines CSIRO's modern chemical and metallurgical research laboratories with the pilot plant facilities of the former WA Mineral Processing Laboratories. Both have been significantly upgraded, making the new facility the largest of its type in Western Australia. The primary focus is on research for the alumina, gold, base metals, iron ore and titanium minerals industries.
- In February 2000, the Panel for World Data Centers approved the Ionospheric Prediction Service Radio and Space Services' application to become a **World Data Centre for Solar-Terrestrial Science**. IPS became the first World Data Centre in the southern hemisphere. This formally recognises the fact that IPS already has a major role in the

archiving of solar terrestrial data. As a World Data Centre, IPS will gain greater access to data, which is the lifeblood of its space weather services, and will make all these data available in Australia.

- **Amendments to the *National Measurement Act 1960*** have extended its scope to include metrological requirements for utility metering, measuring instruments used for regulatory purposes and certified reference materials. The increased confidence in these measurements will support the national market in electricity and gas and reduce disputation over transactions and regulatory enforcement.
- In support of the Government's Greenhouse Gas Emission Reduction Policy, the National Standards Commission has been funded by the Australian Greenhouse Office (AGO) to develop standards, test procedures and test facilities for the certification of compressed natural gas fuel dispensers.
- AGAL and Australian Federal Police hosted two international forensic drug meetings in Sydney in November 1999. A meeting of the United Nations International Drug Control Program (UNDCP) and the National Illicit Drug Strategy (NIDS) Regional Cooperative Workshop were attended by internationally recognised experts in the field of heroin and cocaine profiling, and representatives from forensic drug testing services in the Asia-Pacific region. Hosting these meetings reinforced Australia's position among **world leaders in drug profiling and general forensic drug testing**, and has increased Australia's profile amongst forensic laboratories in the Asian region.
- In conjunction with the Australian Petroleum Cooperative Research Centre, AGSO is applying computer database and mapping techniques to **identify potential sites** for the geological sequestration of large volumes of carbon dioxide produced as a by product of oil and gas production.

- in science and technology awareness:

- The Department of Communications, Information Technology and the Arts and the National Museum of Australia are involved in the construction of state-of-the-art new facilities on Acton Peninsula, Canberra. The new National Museum will be able to broadcast to remote communities and will be developing a program for schools. Its permanent and temporary exhibitions will deliver information about Australian industry including agriculture, mining, technology, space exploration, gold and many other aspects of Australia's contribution to science and technology.
- In 2000, a **new format for science prizes** has been instituted in response to recommendations of a review of elements of the Science and Technology Awareness Program. The major prize is the Prime Minister's Prize for Science having a value of $300 000. This award is available to Australian nominees from any field of science. In addition there are two young achievers awards of $35 000. The Minister's Prize for Achievement in Science is targeted on life sciences and the Malcolm Mclntosh Prize is for physical sciences. The awards are expected to be made in September 2000.

- National Science Week continues to increase its profile each year. In May 2000, the Commonwealth supported highly successful activities coordinated and arranged by the ABC, the Australian Science Teachers Association (ASTA) and the Australian Science Festival (ASF). **National Science Week 2000** featured up to 1000 events involving schools, businesses, museums, science centres and industry.
- The National Standards Commission's schools program **Measurement in Sports** has now been adopted by over 500 secondary schools in Australia as well as schools in New Zealand, Singapore and Malaysia. The program was developed by the Commission to increase awareness of the principles of good measurement and the importance of measurement in society.
- During 1999-2000, the Government, in partnership with the Committee for Economic Development of Australia (CEDA), organised a series of seminars on ***Building the Knowledge Economy***. The seminars raised awareness around the following themes:
  - using knowledge to improve economic performance;
  - the key drivers of a knowledge economy;
  - Australia's emerging knowledge industries; and
  - policies to support a knowledge-based economy.
- The Australian Antarctic Division has developed and promoted a touring exhibition of scientific posters aimed at informing the people of Australia about the **significant contribution Australian scientists are making** towards Australia's goals in Antarctica. The exhibition, has toured a large part of regional Australia during 1999 and 2000. The Australian Antarctic Division has also developed the most comprehensive Antarctic web site. The site provides detailed information on Antarctica generally, Australian activities there, scientific research, environmental management, tourism and the Antarctic Treaty. It has been substantially re-organised to make its large store of information more accessible. Its value will be greatly increased over the next twelve months with the integration of new interactive educational and client service modules.
- **Reef HQ**, the Reef Education Centre for the Great Barrier Reef Marine Park Authority (GBRMPA), developed educational programs for primary to tertiary level students using state of the art videoconference technology. In conjunction with TAFE Queensland, Education Queensland and Integrated Vision, Reef HQ runs real-time, interactive science education programs on the Great Barrier Reef (GBR) with remote locality students from across Australia and overseas. Reef HQ was the start and end location for **Global Leap 2000**, a non-stop international videoconference event which involved education organisations from over 60 locations across 5 continents between 29 February and 1 March 2000.

- in international science and technology collaboration

- The effective management and delivery of the three out-sourced components of the TDP (International Science and Technology Networks, Access to Major Research Facilities and International

Conference Support Scheme) ensured that they continued to contribute to innovation objectives. New projects supported included:

  - a collaborative arrangement between the University of Sydney and Germany's Technische Universitat Darmstadt to develop technology that joins ceramics, polymers and metals. Funding was provided under International Science and Technology Networks for the development and implementation of a long-term strategy which includes building the team's resource capacity, and a series of reciprocal visits between the two institutions.
  - access by the Ian Wark Research Institute to the Australian National Beamline Facility in Japan through Access to Major Research Facilities. The Institute uses the synchrotron facility to research the structural analysis of minerals and mineral surfaces at a molecular level for the Australian mining industry.
  - funding under the International Conference Support Scheme for the Humic Substances Downunder conference held in Adelaide in late 1998. The conference provided Australia's scientists working in this area with the opportunity to learn about leading-edge research being conducted overseas as well as to demonstrate their capabilities to international scientists.

- Following **commercial success** at the April 1999 Hannover Fair in Germany - where CSIRO and some of Australia's leading high-tech companies showcased top Australian technology - CSIRO organised a further display of innovations at the March 2000 Fair.
- CSIRO Building, Construction and Engineering emerged during 1999 as a **preferred supplier of technical expertise** in the $5 billion megacity development at Chongquing in central China.
- **Better management of the coastal marine environment** is being achieved through the use of isotope and radiation technology in a major regional research project led by Australia through AN5TO as part of an international effort. Participating countries are Australia, Bangladesh, China, India, Indonesia, Korea, Malaysia, Myanmar, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand and Vietnam.
- As a result of ANSTO's work in organising and promoting regional activities in safety culture research, all nine countries within the **Forum for Nuclear Cooperation** in Asia are now reporting annually against a set of safety culture indicators produced by ANSTO. Several of these countries have initiated new activities to research and promote safety culture in their respective organisations.
- The international nuclear safeguard system is being further strengthened by the continued development by ANSTO of ultra-sensitive techniques for measuring environmental samples from around nuclear installations. The value of this technique in identifying previous activities undertaken at a nuclear site has been confirmed.
- In May 2000 Australia will host a meeting in Sydney of the Board of the International Gemini Project. Under the Gemini project, the ARC, representing the Australian astronomical community, has joined with

partner agencies in the United States of America, the United Kingdom, Canada, Chile, Argentina and Brazil to **fund the construction and operation of two new generation optical telescopes** - one in Hawaii and one in Chile.

- in environment

- AIMS is the host organisation for the Global Coral Reef Monitoring Network (GCRMN), which was established as a prime instrument of the International Coral Reef Initiative. To date, operational networks have been created in the Western Indian Ocean, East Africa and South Asia; existing networks have been strengthened in areas like the Caribbean, the Pacific and South-East Asia. Training workshops have been held in Asia and the Pacific based upon the monitoring protocols developed by AIMS for the Great Barrier Reef. The US State Department has affirmed the pivotal role of the GCRMN and provided $A1 million to the United Nations Environment Program to sustain the immediate future of the network.
- Collaborative studies between medical practitioners and researchers of the Australian Antarctic program and colleagues at the newly created National Space Biomedical Research Institute in Houston, Texas, commenced in 1999. The study is examining **human immune system responses** to neo-antigens associated with life in remote places and is being integrated with studies in reactivation of latent viruses to determine whether a new type of secondary immuno-deficiency is developing in ANARE subjects. Increasingly, Antarctica is being seen as providing an analogue to long-term space flight.
- Understanding of Antarctica's role as a **major driving force behind the world's ocean circulation** patterns was significantly advanced in July and August 1999 when a midwinter research voyage determined some fundamental facts about the rates of ice accretion and transport in open 'lakes' in the ice, known as polynyas. Coupled with data on salinity and temperature changes associated with rapid ice formation, the polynya study has advanced our understanding of the influence of Antarctica in the world's climate.
- The **TIGER SuperDARN** radar array, established on Bruny Island off eastern Tasmania, is now operational. It is a high frequency over-the-horizon radar that monitors the location of aurora and other space weather features in the outer atmosphere between Tasmania and Antarctica. The Australian Antarctic Division, together with an international consortium, is using the instrument to conduct studies on the geospace environment far over the Antarctic continent. The SuperDARN radar network is a major international research collaboration linking both polar regions.
- Under the Natural Heritage Trust, the Government has allocated $15.8 million to the **National River Health Program** for the period 1996-97 to 2001-02, There are two major components of the program: Environmental Flows Initiative and Australia-Wide Assessment of River Health. The program operates as a partnership between the Commonwealth, the States and Territories and research organisations to assist in implementation of the Council of Australian Governments (COAG) Water Reform Framework.

- The Centre for Plant Biodiversity Research and the Australian National Herbarium are partners with the Royal Botanic Gardens Kew and the Harvard University Herbaria to produce the ***International Plant Names Index***, a collaborative and distributed application to list all published names of the world's vascular plants. The interim version of this database was demonstrated at the International Botanical Congress in St Louis.
- **Integrated projects** to identify the source, trends, fate and consequences of pollutants entering the Great Barrier Reef (GBR) lagoon including research to identify all coastal development occurring adjacent to the Great Barrier Reef lagoon; modelling of flood plumes to improve the understanding of water quality processes and patterns in the GBR lagoon and continuation of long term monitoring of chlorophyll in the GBR lagoon are being undertaken. Research has classified coastal development and identified that chlorophyll concentrations in the inshore lagoon opposite the Wet Tropics World Heritage Area are 2-3 times higher than those in the inshore region north of Port Douglas.
- The **Effect of Line Fishing Project** has entered its final phase. This project investigated the impacts of line fishing on reef fish species, including life history and population dynamics of key species and the operating dynamics of the fishers. The project provides a range of information that will assist future management of the fishery, including a management strategy evaluation model which will incorporate all available data to evaluate the effectiveness of management options on a range of spatial scales.
- A **reconstruction of vegetation and climate change** over the past 200 000 years along a transect from Indonesia to Antarctica was made using measurements of fossil pollen and carbon-13 in sediment cores. This study, involving the application of nuclear techniques to understanding climate change, has been undertaken by ANSTO in collaboration with the University of Adelaide, Monash University, the University of Tasmania and the University of Wollongong.
- The international study of large-scale air movements benefited from the additional data provided by ANSTO's two new radon measuring stations in the Southern Hemisphere (at Cape Point, South Africa, and on Rottnest Island, Western Australia). ANSTO now has a network of eight such measuring stations.
- Under Australia's Oceans Policy, the Antifouling Program is providing $650,000 over three years to assist research into alternatives to toxic antifoulants containing organotins (such as tributyltin - TBT). Through the Natural Heritage Trust's Coasts and Clean Seas Initiative, the Introduced Marine Pest Program administered by Environment Australia funds projects supporting Australia's commitment to ban the application of TBT antifoulants. Antifouling Solutions Pty Ltd is trialling a non-toxic alternative to TBT, and Unisearch UNSW is studying the effect of novel antifouling chemicals on non-target species. The Queensland Environment Protection Agency is undertaking TBT Analysis Protocol Development and Current Contamination assessments. In addition, the Clean Seas Program is supporting projects to develop marine whole-sediment toxicity tests in Victoria and Western Australia over 1999-2000 and 2000-01.

- in meteorology

- The computing facilities associated with the joint Bureau of Meteorology/CSIRO High Performance Computing and Communications Centre (HPCCC) were upgraded in December 1999 through the acquisition of an NEC SX-5 supercomputer to replace an earlier acquired SX-4 machine. Key applications that benefit from the upgrade include operational weather forecasting, climate research and the modelling of various molecular structures.
- An external review of the Bureau of Meteorology Research Centre (BMRC) was completed by a review panel which included leading experts from Australia and overseas. The review underscored the **very high quality** of the BMRC research program and emphasised its ongoing national and strategic importance.
- The Bureau of Meteorology Research Centre has completed the first phase of a collaborative research program with CSIRO, for the Western Australian Government, to improve the understanding of and capability to predict climate variations in SW Western Australia.
- The Bureau of Meteorology's climate services were enhanced with the introduction of seasonal temperature outlooks. These products are based on the observed statistical relationship between temperature across Australia and the sea-surface temperature patterns in the Pacific and Indian Oceans.
- In cooperation with the South Pacific Regional Environment Program, the Bureau of Meteorology chaired a Team to work on an AusAID-funded analysis of **meteorological needs of developing countries** in the SW Pacific. The results of the analysis will form the basis for Pacific national/regional development plans for the next 10 years, commencing 2000-01.
- To increase the range of climate information available for agriculture planning and management activities, the National Climate Centre of the Bureau of Meteorology, with funding assistance from Agriculture, Fisheries and Forestry Australia, commenced a two-year project to assess the quality of four to six month seasonal predictions produced by coupled ocean-atmosphere climate models.
- The geographic coverage of Probable Maximum Precipitation design rainfall methods was improved with the successful development by the Bureau of Meteorology of a method of storm transposition and maximisation for western Tasmania.
- A three-year, $1.5 million Bureau of Meteorology project, to improve the method of estimating Probable Maximum Precipitation in tropical regions of Australia, achieved two significant milestones in 1999-2000: the identification of 120 tropical rainstorms which will form the database for the project; and the successful testing of the proposed storm transposition methodology on a sample of these storms.
- **Long-standing links and collaboration** between the Bureau of Meteorology and the University of Melbourne were formalised with the signing of an Affiliation Agreement in December 1999. The agreement facilitates research collaboration and the sharing of infrastructure resources.

- in defence

- The Defence Strategic Plan for the Coordination of Modelling and Simulation has been endorsed, and an Australian Defence Simulation Office (ADSO) has been established. ADSO's mission is to promote the most effective and efficient exploitation of computer-based modelling and simulation capabilities for the defence of Australia and its interests.
- The Defence Science and Technology Organisation (DSTO) has established a **Submarine Science and Technology Centre** at *HMAS Stirling*, Western Australia to focus the resources of industry and academia on improving the operational capabilities of submarines. Current initiatives include the establishment of collaborative research programs with the sonar industry, Curtin University and Murdoch University in underwater acoustics, analysis of submarine operations and advanced sonar processing.
- DSTO has undertaken **an internal Review of Research Priorities**, aimed primarily at ensuring that DSTO's research program is optimally focused on clients' needs. The review has identified areas of new and expanding research, which have the potential for increased contribution to defence outcomes. The resulting framework will assist with DSTO's planning and priority setting.
- A **Combat Systems Research Centre has been established** by DSTO to develop a self-reliant capability to improve the operational performance of the Royal Australian Navy's (RAN) submarine and surface ship combat systems. This research centre is shared by DSTO, the RAN, and industry and provides a facility for the rapid prototyping and evaluation of combat system concepts and algorithms in order to minimise technical risk and cost before incorporation into operational systems.

Significant statements, reviews and reports

Over the past year, a number of statements, reviews and reports dealing with major issues relating to innovation, science and technology have been published. These are listed below. Highly specialised scientific reports are not included in the list. These are normally listed in Annual Reports, which are also omitted from the list presented here.

Agriculture, Fisheries and Forestry Portfolio

- Bureau of Rural Sciences
  - *1999 Fisheries Status Reports*
  - *Country Matters: Social Atlas of Rural and Regional Australia*
  - *Hydrogeology of the Great Artesian Basin*
- Grains Research and Development Council:
  - *Annual Operational Plan 2000-01*; May 2000
  - *Australian Grains Industry - Performance by GRDC Agroecological Zones*; ABARE/GRDC; April 2000
  - *Australian Regional Feed Demand and Supply Projections: ABARE Report for the Grains Research and Development Corporation*; April 2000

Education, Training and Youth Affairs Portfolio

- Minister for Education, Training and Youth Affairs
  - *Knowledge and Innovation: A Policy Statement on Research and Research Training*; Commonwealth of Australia, Canberra; December 1999
  - *New Knowledge, New Opportunities: A Discussion Paper on Higher Education Research and Research Training*; Commonwealth of Australia, Canberra; June 1999
- Department of Education, Training and Youth Affairs
  - Bourke P, Butler L and Biglia A; *A Bibliometric Analysis of Biological Sciences Research in Australia*; Higher Education Research Evaluation Program, DETYA, Canberra; June 1999
  - Grigg L; *An Evaluation of Biological Science Research*; Higher Education Research Evaluation Program, DETYA, Canberra; September 1999
  - Higher Education Division; *Australia's Information Future: Innovation and Knowledge Management for the 21st Century*; Evaluation and Investigations Program 99/5, Canberra; December 1999
  - Matthews M and Johnston R; *International Trends in Public Sector Support for Research and Experimental Development: A Preliminary Analysis*; Evaluation and Investigations Program 99/8, Canberra; March 2000
  - Turpin T, Aylward D, Garrett-Jones S, Speak G, Grigg L and Johnston R; *University and Industry Research Partnerships in Australia: An*

Evaluation of ARC/DETYA Industry-linked Research Schemes; Higher Education Research Evaluation Program, DETYA, Canberra; October 1999

- Australian Research Council
  - *Cross-Disciplinary Research - A Discussion Paper*; Commissioned Report No. 61; December 1999
  - *Research of Interest to Aboriginal and Torres Strait Islander Peoples*; Commissioned Report No. 59; June 1999
  - *University Research: Technology Transfer and Commercialisation Practices*; Commissioned Report No. 60; November 1999

Environment and Heritage Portfolio

- Australian Antarctic Division
  - *Australia's Antarctic Science Program Strategic Plan 2000-2005*; Antarctic Science Advisory Committee; October 1999
- Biodiversity Group
  - Cowley KJ and West JG (eds); *Resources of Australian Herbaria*; published on behalf of the Council of Heads of Australian Herbaria; CSIRO Plant Industry; 1999
  - Hewson HJ; *Australia: 300 Years of Botanical Illustration*; CSIRO Publishing, Melbourne; 1999
  - Hyland BPM, Whiffin T, Chrisophel DC, Gray B, Elick RW and Ford AJ; *Australian Tropical Rain Forest Trees and Shrubs: an interactive identification system for trees and shrubs*; CD-ROM; CSIRO Publishing, Melbourne; 1999
  - Makinson RO; *Grevillea*; Flora of Australia Vol 17; CSIRO Publishing, Melbourne; 1999
  - Meney KA and Pate JS; *Australian Rushes: Biology, Identification and Conservation of Restionaceae and Allied Families*; University of Western Australia Press, Nedlands/Australian Biological Resources Study, Canberra; 1999
  - Orchard AE, Thompson HT and McCarthy PM (eds); *Proteaceae 3, Hakea to Dryandra*; Flora of Australia Vol 17B; Australian Biological Resources Study, Canberra/CSIRO Publishing, Melbourne; 1999
  - Steyn EMA and Smith GF; *Welwitschiaceae*; Species Plantarum: Flora of the World, Part 3; Australian Biological Resources Study, Canberra; 1999
  - Steyn EMA, Smith GF and Hill KD; *Stangeriaceae*; Species Plantarum: Flora of the World, Part 2; Australian Biological Resources Study, Canberra; 1999
  - Thiele KR and Adams LG (eds); *The Families of Flowering Plants of Australia: an interactive identification guide*; CD-ROM; CSIRO Publishing, Melbourne; 1999

- Wells A and Houston WWK; *Diptera: Nematocera*; Zoological Catalogue of Australia Vol 30.1; Australian Biological Resources Study, Canberra/CSIRO Publishing, Melbourne; 1999

- Environment Protection Group
  - *National Pollutant Inventory Contextual Information December 1999*; Environment Australia; 1999

- Science Group
  - van Dam RA, Finlayson CM & Watkins D; Supervising Scientist Report (SSR) 150 *Vulnerability assessment of major wetlands in the Asia-Pacific region to climate change and sea level rise*; 1999
  - Corbett MH; SSR149*; Revegetation of mined land in the wet-dry tropics of northern Australia: A review*; 1999
  - Finlayson CM & Spiers AG; SSR148*; A compendium of information for managing and monitoring wetlands in tropical Australia*; 1999
  - Finlayson CM & Spiers AG; SSR147*; Techniques for enhanced wetland inventory and monitoring*; 1999
  - Thurtell L, Finlayson CM, Yibarbuk D & Storrs MJ; SSR 146*; The Blyth/Liverpool wetlands, Arnhem Land, northern Australia: Information for management planning*; l999
  - Finlayson CM & Spiers AG; SSR144*; Global review of wetland resources and priorities for wetland inventory*; 1999
  - Kalf FRP & Dudgeon CR; SSR143*; Analysis of long-term groundwater dispersal of contaminants from proposed Jabiluka Mine tailings repositories*; 1999
  - Chiew FHS & Wang QJ; SSR142*; Hydrological analysis relevant to surface water storage at Jabiluka*; 1999
  - SSR141 Climate change analysis relevant to Jabiluka. 1999 (Jones RN, Abbs DJ & Hennessy KJ)
  - Bureau of Meteorology; SSR140*; Hydrometeorological analyses relevant to Jabiluka*; 1999
  - Johnston A & Needham S; SSR139*; Protection of the environment near the Ranger uranium mine*; 1999
  - Finlayson CM, Yibarbuk, Thurtell L, Storrs MJ & Cooke P; SSR137*; Local community management of the Blyth/Liverpool wetlans, Arnhem Land, Northern Territory, Australia* 1999

- Australian Greenhouse Office
  - Carter JA and Howden SM; *Global Change Impacts on the Terrestrial Carbon Cycle*; Working Paper Series 99/10; CSIRO Wildlife and Ecology, Canberra
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  - Howden SM, Reyenga PJ and Meinke H; *Global Change Impacts on Australian Wheat Cropping: Studies on Hydrology, Fertiliser Management and Mixed Crop Rotations*; Working Paper Series 99/13; CSIRO Wildlife and Ecology, Canberra
  - Howden SM, Reyenga PJ, Meinke H and McKeon GM; *Integrated Global Change Impact Assessment on Australian Terrestrial Ecosystems: Overview Report*; Working Paper Series 99/14; CSIRO Wildlife and Ecology, Canberra
  - Mackey BG, Lindenmayer DB, Gill A, McCarthy MA and Lindesay JA; *The Central Highlands Ecosystem Study: Wildlife Refugia, Fire Regimes and Climate Change*; a report to the Australian Greenhouse Office; February 2000
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  - *From Defence to Attack - Australia's Response to Greenhouse*; Department of Industry, Science and Resources Report to the Prime Minister's Science, Engineering and Innovation Council; Australian Greenhouse Office; June 1999
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  - *BMRC Review: Report of the Review Committee, December 1999*; Bureau of Meteorology, Melbourne; 2000
  - *Climate Activities in Australia 1999 - a report on Australian participation in international scientific climate programs*; compiled by the Bureau of Meteorology; Bureau of Meteorology, Melbourne; 1999
  - *Development of the method of storm transposition and maximisation for the West Coast of Tasmania*; Hydrology Report Series 7; Bureau of Meteorology, Melbourne; 2000
  - *Preliminary report on meteorological aspects of the 1998 Sydney to Hobart Yacht Race*; Bureau of Meteorology, Melbourne; 1999
- Great Barrier Reef Marine Park Authority
  - KPMG Consulting; *Economic and Financial Values of the Great Barrier Reef Marine Park*; GBRMPA Research Publication No. 63; 1999

- Ormsby J and Shafer S; *Visitor experiences, values and images of Whitehaven Bay: An assessment of perceived conditions*; GBRMPA Research Publication No. 62; 1999

Health and Aged Care Portfolio

- Interim Office of the Gene Technology Regulator
  - *Current Regulatory and Administrative Arrangements for Controlling Genetically Modified Organisms in Australia*; Department of Health and Aged Care; 1999
  - *Proposed National Regulatory System for Genetically Modified Organisms - How should it work?*; Department of Health and Aged Care; 1999
  - *Draft Gene Technology Bill 2000*; Department of Health and Aged Care; 1999
  - *Explanatory Guide to the Draft Gene Technology Bill 2000*; Department of Health and Aged Care; 1999

Industry, Science and Resources Portfolio

- Minister for Industry, Science and Resources
  - *Science and Technology Budget Statements 1999-2000* and *2000-01*
- Department of Industry, Science and Resources
  - *Australia's Marine Science and Technology Plan*; ISR; 1999
  - *Australia's Marine Science and Technology Plan: An Overview*; ISR; 1999
  - *Business Improvement 2000 - Innovation Case Studies*; CD-ROM; ABL/ISR; 2000
  - *Case Studies on Innovative Australian Firms (Some Examples)*; ISR; 1999
  - *Commonwealth and State Government Programs Supporting Innovation in Firms: at October 1999*; ISR; 1999
  - *Enabling Technologies for Australian Industry - Pilot Study; Emerging Industries Occasional Paper Series 2*; ISR; 1999
  - *Knowledge-Based Activities: Selected Indicators February 2000*; 2000
  - *ISR/CSIRO Emerging Industries & Technologies Forum - Proceedings; Emerging Industries Occasional Paper Series 1*; ISR; 1999
  - *National Innovation Systems of Selected Nations*; ISR; 1999
  - *Programs Promoting the Knowledge-Based Economy - Selected Programs for OECD Countries*
  - *Measuring the Knowledge-based Economy - How does Australia Compare*; ISR; 1999
  - *Shaping Australia's Future: Innovation - Framework Paper*; ISR; 1999
  - *Study of Government R&D Expenditure by Sector and Technology; Emerging Industries Occasional Paper Series 3*; ISR; 2000

- Chief Scientist
  - *Investing in Knowledge Generation for the Twenty First Century: A Discussion Paper*
- CSIRO
  - *Benefits from CSIRO Research for the Forestry, Wood and Paper Industries Sector: Impact Analysis and Evaluation*
  - *CSIRO Operational Plan 1999-2000*
  - *CSIRO – Solutions for Greenhouse*
  - *Delivering the Goods: Returns on Investment in CSIRO*
- Australian Institute of Marine Science
  - *Australian Institute of Marine Science Research Plan: 2000-2003*
- Australian Nuclear Science and Technology Organisation
  - *ANSTO Operational Plan 1999-2000*
  - *ANSTO Strategic Plan 2000/2001 - 2004/2005*
- Biotechnology Australia
  - *Australian Biotechnology Report 1999*; ISR and Ernst & Young
  - *Developing Australia's Biotechnology Future*; Biotechnology Australia; September 1999
  - *Genetically Modified Foods* brochure; Biotechnology Australia; January 2000

Treasury Portfolio

- Australian Bureau of Statistics (ABS)
  - *Business Use of Information Technology, Australia, 1997-98*; Cat No 8129.0; 5 October 1999
  - *Government Use of Information Technology, Australia, 1997-98*; Cat No 8119.0; 14 December 1999
  - *Household Use of Information Technology, Australia, 1998*; Cat No 8146.0; 27 May 1999
  - *Research and Experimental Development, Businesses, Australia, 1997-98*; Cat No 8104.0; 4 June 1999
  - *Use of the Internet by Householders, Australia, November 1998*; Cat No 8147.0; 1 March 1999
  - *Use of the Internet by Householders, Australia, May 1999*; Cat No 8147.0; 6 September 1999
  - *Use of the Internet by Householders, Australia, August 1999*; Cat No 8147.0; 20 December 1999
  - *Use of the Internet by Householders, Australia, November 1999*; Cat No 8147.0; 1 March 2000

Science and Innovation in the Budget

BOX 3.1

ACCRUAL ACCOUNTING

The 2000-01 Commonwealth Budget and the 1999-00 Budget differ from all previous budgets. They were developed according to accrual, rather than cash accounting.

Accrual appropriations provide agencies with the full financial resources they need to deliver their outcomes and outputs. This includes costs that accrue over time, such as depreciation, superannuation and long service leave. Hence, agencies are no longer seeking cash to fund programs and activities.

Generally, the level of funding provided for research grants under accrual accounting is very similar to that provided under the previous cash regime. However, under accrual accounting, expenses are recognised when they occur rather than when the cash is paid, and this may not always occur at the same time during the financial year.

The other main reason for changes between 1998-99 and 1999-00 in Commonwealth agencies' estimates is the introduction of the Capital Use Charge on the agencies' net assets. Agencies now receive additional revenue equal to the expected charge that will be paid back to Government at the end of each financial year.

Note that the financial information in this *Statement* has been provided and confirmed by the agencies and departments with responsibility for the programs, and/or by the Department of Finance and Administration. Further information is available from the *Portfolio Budget Statements* of each department. These can be accessed through the Federal Government entry point on the World Wide Web (*www.fed.gov.au*).

Australia's national R&D expenditure

Table 1 provides a broad outline of recent data on R&D expenditure in Australia, based on surveys by the Australian Bureau of Statistics (ABS). The most recent data showed that Australia's gross expenditure on R&D (GERD) stood at $8769 million in 1996-97, corresponding to 1.64 per cent of gross domestic product (GDP). Broadly, about 47 per cent of Australia's R&D expenditure, corresponding to 0.79 per cent of GDP, was undertaken within business enterprises in that year.

TABLE 1 Australia's expenditure on R&D, by sector of performance, 1994-95 to 1998-99*

	1994-95			1995-96			1996-97			1997-98			1998-99		
Sector of performance	$m	%GDP	% real annual increase	$m	%GDP	% real annual increase	$m	%GDP	% real annual increase	$m	%GDP	% real annual increase	$m	%GDP	% real annual increase
Business	3508	0.74	11.9	4343	0.86	20.8	4200	0.79	-6.2	4044	0.71	-5.9	na	na	
Government	1983	0.42	3.0	na	na		2090	0.39	0.3	na	na		na	na	
- Cwlth	1197	0.25	0.3	na	na		1266	0.24	0.8	na	na		na	na	
- State	786	0.17	7.6	na	na		825	0.15	-0.4	na	na		na	na	
Higher educ.	1830	0.41	1.8	2039	0.42	8.3	2308	0.45	11.1	na	na		2600	0.44	3.3
Priv non prof.	156	0.03	25.5	na	na		171	0.03	0.9	na	na		na	na	
TOTAL	7476	1.57	5.9	na	na		8769	1.64	5.6	na	na		na	na	

Source: ISR based on ABS data.

* *It is expected that ABS business sector R&D data for 1998-99 will become available in June 2000, followed by the government sector bulletin in August.*

The other principal R&D sectors include higher education, where 27 per cent of R&D expenditure (0.46 per cent of GDP) was undertaken, and Commonwealth agencies, which accounted for 24 per cent of R&D expenditure and 0.25 per cent of GDP.

At 1.64 per cent of GDP, GERD in 1996-97 stood at an all time high and had increased from 1.57 per cent in 1994-95 and 1.32 per cent in 1990-91. The substantial increases in GERD since 1990-91 mainly reflect substantial increases in the level of R&D in the business sector. Business sector R&D expenditure increased sharply from 0.74 per cent of GDP in 1994-95 to 0.86 per cent in 1995-96, but decreased to 0.79% in 1996-97 and 0.71% in 1998-99. (It should be noted that increases in the series of ABS estimates for GDP have changed these percentages over those published in the 1999-2000 *Science and Technology Budget Statement*.)

Further background on Australian science and technology is provided in the box of 'key facts' on page 4.2.

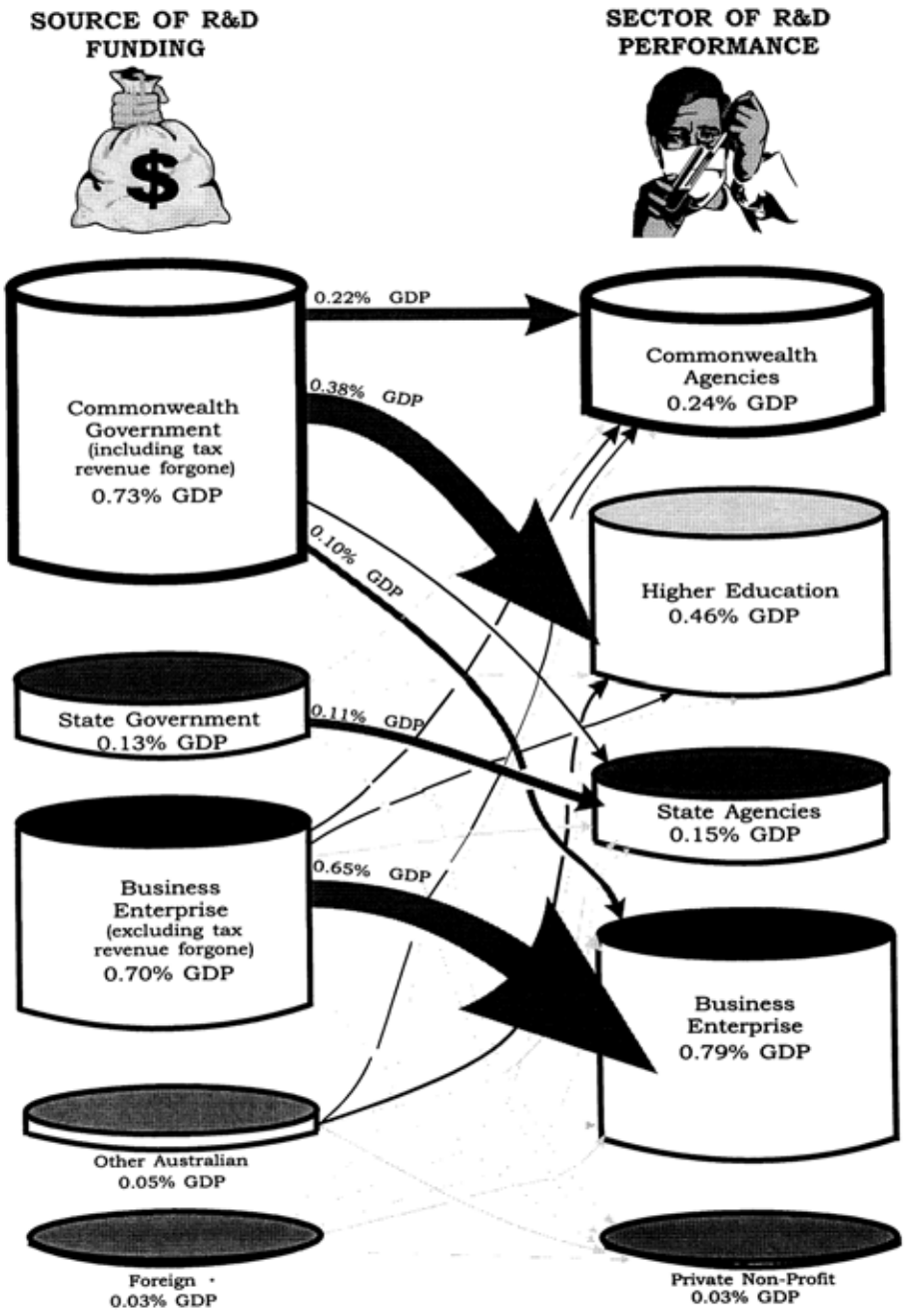
Commonwealth support for R&D in a national perspective

As is seen from Table 1, Commonwealth agencies are significant performers of R&D, but undertake only 15 per cent of total R&D expenditure. As a funding source, however, the Commonwealth Government provides about 40 per cent of R&D funds directly, and has provided an additional 5 per cent through the indirect means of the R&D tax concession. Derived from ABS survey data, Figure 3 provides a schematic picture of the Commonwealth's activity in the national R&D context and its relative size and interactions compared with other elements of the system.

While the ABS surveys provide the definitive data on Australian R&D expenditure, they cannot be directly related to Government programs. However, a data series has been derived which draws on Budget and other information relating to major Commonwealth research agencies and programs supporting research-related activities. These 'science and innovation' data (named so as to distinguish them from ABS R&D data) are described below.

Figure 3

COMMONWEALTH R&D SUPPORT IN A NATIONAL PERSPECTIVE



The figure illustrates major flows of funding support between sectors, based on ABS 1996-97 data. It places Commonwealth funding of R&D in a national perspective.

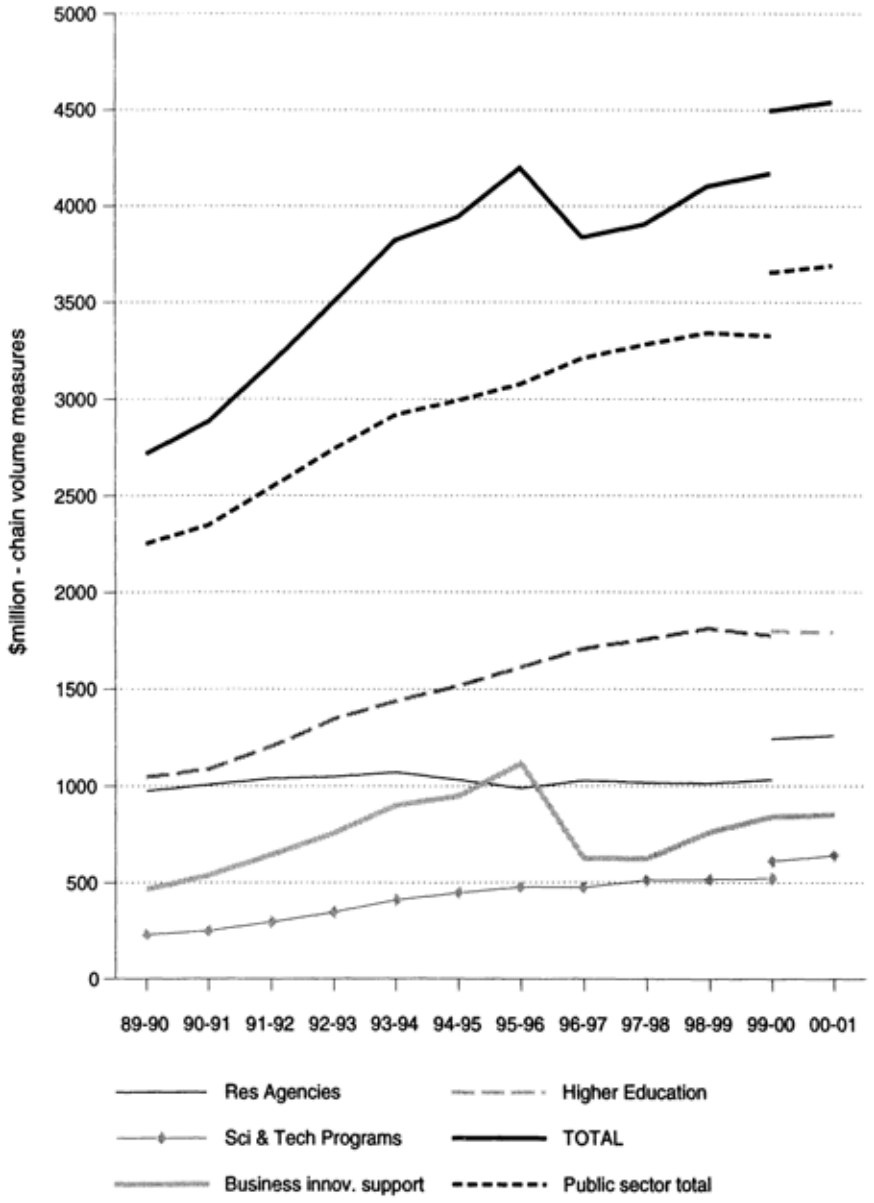
TABLE 2 Summary of Major Commonwealth Support for Science and Innovation, through the Budget and other Measures - chain volume measures

	1990-91	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*est cash** *1999-00*	est accr 1999-00	est accr 2000-01
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	274.8	275.6	270.6	297.4	271.5	286.7	269.8	256.7	259.5	260.5	276.2	263.5
• Civil	733.2	764.5	777.4	773.7	760.1	702.9	759.2	760.1	753.9	771.1	961.5	993.8
SUB-TOTAL	1008.0	1040.1	1047.9	1071.1	1031.6	989.6	1029.0	1016.8	1013.4	1031.7	1237.7	1257.3
SCIENCE AND TECHNOLOGY GRANTS												
• Health and Medical	125.8	143.2	148.7	157.7	166.6	174.7	175.8	181.6	201.7	198.8	289.1	320.7
• Cooperative Research Centres	-	20.7	50.8	100.4	113.8	142.2	151.5	153.6	148.2	146.8	146.8	134. 4
• Rural	95.3	107.4	123.8	129.5	143.2	135.5	133.3	146.9	156.4	164.0	164.0	170.3
• Energy and environment	26.4	22.7	22.3	21.2	20.9	21.0	12.0	26.3	8.4	10.1	10.2	15.2
• Transport	2.5	2.5	2.5	2.4	2.4	2.4	2.1	2.1	2.1	2.1	2.1	1.0
SUB-TOTAL	250.0	296.5	348.0	411.2	446.9	475.9	474.8	510.5	516.8	521.7	612.2	641.6
INNOVATION SUPPORT												
• IR&D tax concession	417.2	491.1	578.1	756.5	796.6	966.4	472.0	459.1	505.1	567.9	567.9	600.0
• R&D Start	-	-	-	-	-	-	59.7	95.4	134.6	159.7	159.7	154.5
• Other innovation support	119.6	153.1	178.4	143.1	152.3	151.4	93.1	67.1	120.0	113.3	113.3	96.7
SUB-TOTAL	536.8	644.2	756.5	899.7	948.9	1117.8	624.8	621.6	759.6	840.9	840.9	851.2
HIGHER EDUCATION RESEARCH												
• ARC and DETYA grant schemes	211.5	277.8	294.8	327.2	339. 9	374.3	422.5	442. 2	472.5	448.0	465.9	467.6
• Specific R&D support	155.3	160.3	162.5	161.7	161.3	160.7	160.9	157.9	157.2	155.1	155.1	151.0
• Est. general research support	720.9	765.1	889.6	950.4	1013.9	1077.9	1124.0	1154.5	1182.0	1169.8	1176.9	1169.0
SUB-TOTAL	1087.7	1203.2	1346.9	1439.3	1515.0	1612.8	1707.4	1754.7	1811.7	1772.8	1798.0	1787.6
TOTAL COMMONWEALTH SUPPORT IN CHAIN VOLUME MEASURES	**2882**	**3184**	**3499**	**3821**	**3942**	**4196**	**3836**	**3904**	**4101**	**4167**	**4489**	**4538**
EST. REAL % INCREASE/DECREASE	6.1	10.5	9.9	9.2	3.2	6.4	-8.6	1.8	5.1	1.6		1.1

* Estimated to approximate cash accounting expenditure of earlier years.

SOURCE: Based on data in Table 3 and using implicit price deflators based on chain volume measures.

Figure 4 MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION



Source: see Table 2. The break in the series follows the introduction of accrual accounting.

Commonwealth support for science and innovation through major programs

In accrual terms, Commonwealth support for major science and innovation programs is expected to stand at an estimated $4538 million in 2000-01 (see Table 3), a one per cent increase in real terms over the level in 1999-00 (see Table 2). The rise in total Commonwealth support results from increased R&D support to the higher education sector coupled with a steady rise in amounts disbursed through the various granting schemes, including the introduction of the Cooperative Research Centres Program.

Figure 4 and Table 2 present a summary of Commonwealth support for science and innovation in chain volume measures. They provide a four-way breakdown of the data as follows :

- R&D in Commonwealth agencies
- science and technology support for specific areas
- support for business innovation.
- higher education research

– *Research in Commonwealth Agencies*

The largest Commonwealth research agencies are CSIRO, DSTO, ANSTO, AGSO, Australian Antarctic Division and AIMS. Support through Budget appropriations to these agencies, and some smaller ones, is expected to be $1257 million in 2000-01, on an accrual basis.

It is important to note that the research agencies receive funds in addition to those appropriated directly and that these sums are not included in the amounts referred to above. Such external funding has increased significantly in recent years. For example, CSIRO receives business funding, funds from earned revenue (from licensing fees, disposal of assets etc.) and additional Commonwealth support won competitively via the special purpose grant schemes. To encourage improved links with industry, the Government has set a target for external earnings (ie, funds from other than its direct Budget appropriations) of 30 per cent of total funding. Direct appropriations to CSIRO for 2000-01 are expected to amount to $616 million (inclusive of $6 million through AFFA, see Table 4), but the total income of the Organisation is expected to be in the region of $890 million.

– *Science and Technology Support for Specific Areas*

The Commonwealth has established a number of research grant schemes and programs which are directed to special areas of interest - health and medical research (NH&MRC), rural research (RIRFs and other rural), energy R&D, and some smaller ones. The Cooperative Research Centres, established for the purpose of promoting linkages, are also included in this category.

Support for R&D through these special purpose research grant schemes and programs is estimated to increase to $642 million in 2000-01, representing a real increase of about 5 per cent.

– *Support for Business Innovation*

Support for R&D and innovation in the business sector through the industrial R&D tax concession is estimated to be $600 million in 2000-01, an increase of 2 per cent in real terms.

R&D Start this year is $155 million. Together with smaller schemes, total direct support for R&D and innovation in the business sector increases to $851 million.

–- *Higher Education Research*

Support for research in the higher education sector (excluding support from special purpose grant schemes) is estimated to be $1788 million in 2000-01.

The higher education sector is supported through general or nondirected research funds (in fact, the research component of funds which are provided for both teaching and research purposes), funds provided specifically for research, and research funds under the control of the Australian Research Council (ARC). Only funds provided specifically for higher education are considered here. (A significant proportion of the funds provided under special purpose grant schemes also flow to higher education).

The natural sciences and engineering represent about 70 per cent of all higher education research activity supported through all the above means, with the balance being research in the social sciences and humanities.

Changes in the balance of funding

Figure 5, expressed as a percentage of GDP, provides an alternative view to Figure 4. In addition, funding of both civil and defence research agencies is shown and higher education funding is split between specific R&D funding and the research and research training component of the general operating grant for universities.

Looking at the broad changes apparent in Figures 4 and 5, Budget funding for the research agencies has remained approximately static in real terms over the period from 1989-90 to 2000-01. (But note that their external earnings — not shown in the figure — have increased over the same period.) Over the same period, the special purpose science and technology support schemes have increased significantly.

Over past years, significant increases in funding in the higher education sector have been accompanied by a substantial change in arrangements so that the proportion of funds allocated on the advice of the ARC is now much higher than in the mid-1980s.

Detailed data

Table 3 is the current price version of Table 2 and summarises Tables 4,5 and 6. It estimates total annual support for science and innovation.

For the most part, the information in Tables 4 and 5 refers to well-defined agencies and programs that can be readily identified from the various *Portfolio Budget Statements* available on Departmental Web sites. However, Table 6 presents a less clear-cut situation for the two largest items. The first of these is the estimated research component of the general Commonwealth funding for universities. This includes support for teaching activities as well as for research and the research component can only be estimated on the basis of the ABS R&D surveys. Since there were no ABS surveys in some earlier years, and survey results are not yet available for the latest years shown, the effect of adding this series to others, as in Table 3, is to blur the assessment of overall totals. See the footnotes to Table 6.

A further blurring results from the inclusion of data relating to the taxation concession scheme for industrial R&D. The amounts shown in Table 6 are *estimates* only (see footnote (7) to Table 6) and relate to the year in which companies undertake the R&D for which they subsequently claim the concession. (Footnote (7) provides the amounts of tax revenue forgone relating to years in which tax claims are lodged.) This year there are significant revisions to recent historical data and further revision may be necessary as new taxation data become available.

Budget-based science and innovation data and ABS R&D

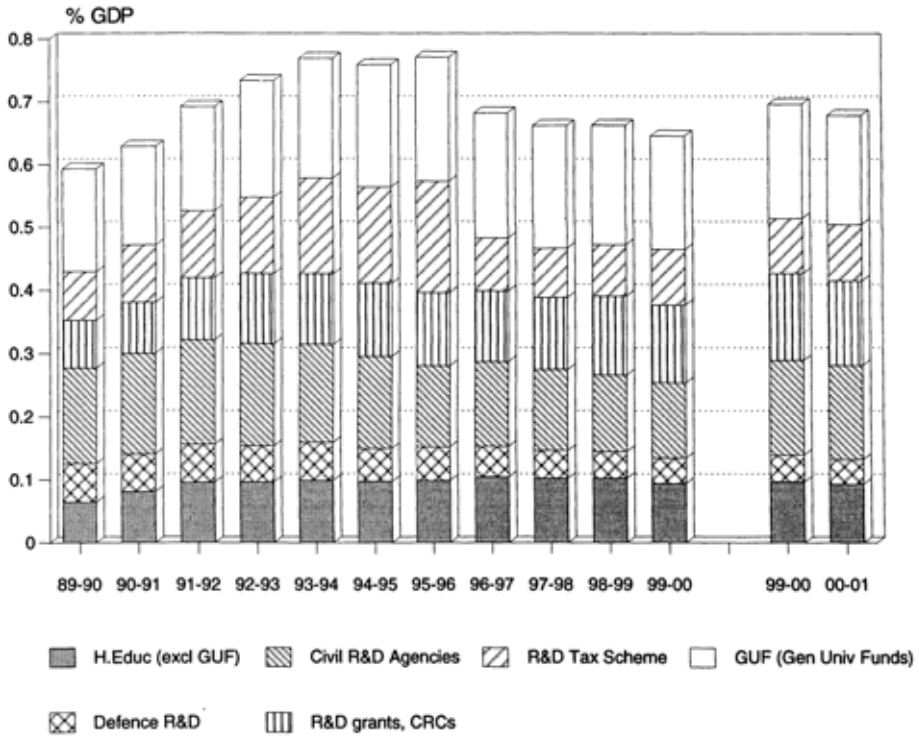
Over the past three decades there has been considerable international effort to reach agreed definitions of R&D. The resulting definitions have been applied with some rigour in periodic surveys conducted within most OECD countries. This so-called "Frascati" methodology has been applied in Australia since 1969 when the national R&D surveys, now conducted regularly by the Australian Bureau of Statistics (ABS), were introduced.

The results from the R&D surveys have been essential in establishing benchmarks and time series in various expenditure and workforce indicators related to the Australian research effort.

At the same time, commentators have frequently sought to use data taken from the Budget papers to formulate views on the adequacy of Commonwealth support for research and the implications of this for science and technology policy. The data series presented in this Section has been developed to meet that need. For this reason, data presented here will not exactly match the R&D aggregates reported in ABS surveys. The practice followed here of listing whole agencies and programs as defined for administrative and financial purposes inevitably leads to the partial inclusion of non-R&D activities. In addition, there is a significant amount of R&D funded through agencies and programs not listed. Nevertheless, there

are broad similarities between trends in what is described here as 'science and innovation' and R&D expenditures as reported by ABS.

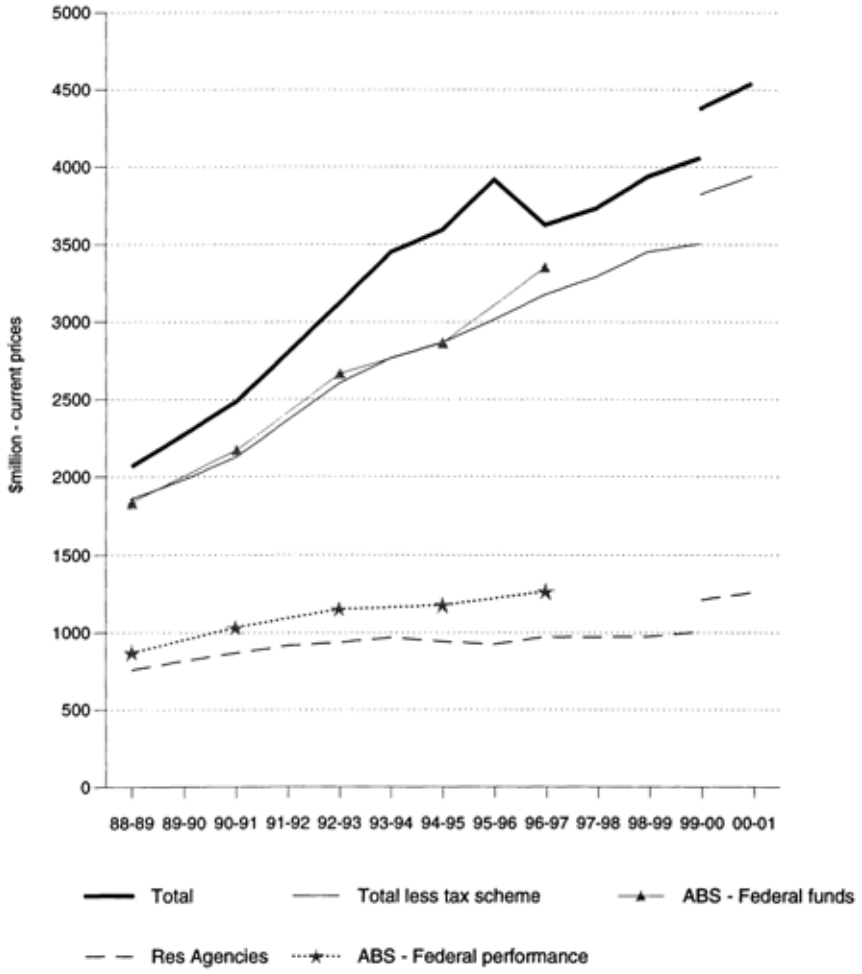
Figure 5 MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION AS A PERCENTAGE OF GDP



Source: See Table 2 and ABS 5206.0. The break in the series follows the introduction of accrual accounting.

Figure 6 shows the comparison between the 'science and innovation' series presented in this Section and ABS (Frascati) R&D. The total appropriation income of the research agencies shows a small but increasing deviation from ABS R&D performance data. The discrepancy which occurs can be explained largely in terms of CSIRO's external income. (ABS R&D performance data for the agencies includes expenditure from all sources of funds. The series based on Table 3 shows only directly appropriated Commonwealth funding.)

Figure 6 BUDGET-BASED DATA AND ABS R&D



Source: ISR and ABS. The break in the series follows the introduction of accrual accounting.

TABLE 3 Summary of Major Commonwealth Support for Science and Innovation, through the Budget and Other Measures - $m actual cost in year incurred

	1990-91	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*est cash** 1999-00	est accr 1999-00	est accr 2000-01
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	237.1	242.4	241.5	268.5	247.4	267.6	254.9	245.5	249.2	253.7	268.9	263.5
• Civil	632.7	672.5	693.8	698.5	692.8	656.1	717.3	726.8	723.9	750.8	936.2	993.8
SUB-TOTAL	869.8	914.8	935.3	967.0	940.2	923.6	972.2	972.3	973.1	1004.5	1205.1	1257.3
SCIENCE AND TECHNOLOGY GRANTS												
• Health and Medical	108.6	125.9	132.7	142.4	151.8	163.0	166.1	173.6	193.7	193.5	281.5	320.7
• Cooperative Research Centres	-	18.2	45.3	90.6	103.7	132.7	143.1	146.9	142.3	142.9	142.9	134.4
• Rural	82.2	94.5	110.5	117.0	130.5	126.5	126.0	140.5	150.2	159.7	159.7	170.3
• Energy and environment	22.8	19.9	19.9	19.1	19.1	19.6	11.4	25.2	8.0	9.9	10.0	15.2
• Transport	2.2	2.2	2.2	2.2	2.2	2.2	2.0	2.0	2.0	2.0	2.0	1.0
SUB-TOTAL	215.7	260.8	310.6	371.3	407.3	444.1	448.6	488.2	496.2	508.0	596.1	641.6
INNOVATION SUPPORT												
• IR&D tax concession	360	432	516	683	726	902	446	439	485	553	553	600
• R&D Start, etc	-	-	-	-	-	-	56.4	91.2	129.2	155.5	155.5	154.5
• Other innovation support	103.2	134.7	159.2	129.2	138.8	141.3	87.9	64.2	115.2	110.3	110.3	96.7
SUB-TOTAL	463.2	566.7	675.2	812.2	864.8	1043.3	590.3	594.4	729.4	818.8	818.8	851.2
HIGHER EDUCATION RESEARCH												
• ARC and DETYA grant schemes	182.5	244.3	263.1	295.4	309.8	349.3	399.2	422.9	453.7	436.2	453.7	467.6
• Specific R&D support	134	141	145	146	147	150	152	151	151	151	151	151
• Est. general research support	622	673	794	858	924	1006	1062	1104	1135	1139	1146	1169
SUB-TOTAL	938.5	1058.3	1202.1	1299.4	1380.8	1505.3	1613.2	1677.9	1739.7	1726.2	1750.7	1787.6
TOTAL COMMONWEALTH SUPPORT	**2487**	**2801**	**3123**	**3450**	**3593**	**3916**	**3624**	**3733**	**3938**	**4058**	**4371**	**4538**
% GDP	0.629	0.692	0.734	0.770	0.759	0.772	0.682	0.662	0.663	0.646	0.696	0.678
TOTAL COMMONWEALTH SUPPORT IN CHAIN VOLUME MEASURES	**2882**	**3184**	**3499**	**3821**	**3942**	**4196**	**3836**	**3904**	**4101**	**4167**	**4489**	**4538**
EST. REAL % INCREASE/DECREASE		10.5	9.9	9.2	3.2	6.4	-8.6	1.8	5.1	1.6		1.1

SOURCE: See Tables 4, 5 and 6. * Estimated to approximate cash accounting expenditure of earlier years.

TABLE 4 Major Commonwealth Research Agencies - Budget Outlays ($m)

	Outlays										est accr	est accr
	1989-90	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	1999-00	2000-01
AGRICULTURE, FISHERIES AND FORESTRY												
Contribution to CSIRO for Aust Animal Health Labs	4.9	5.3	5.5	6.0	5.9	6.2	5.8	6.0	6.1	6.1	6.1	5.8
DEFENCE												
DSTO[1]	235.0	237.1	242.4	241.5	268.5	247.4	267.6	254.9	245.5	249.2	268.9	263.5
EDUCATION, TRAINING & YOUTH AFFAIRS												
Anglo-Aust Telescope	2.7	2.9	3.0	3.1	3.1	3.0	3.2	3.3	3.5	3.6	3.7	3.7
ENVIRONMENT & HERITAGE												
Antarctic Division	57.7	62.8	67.3	65.4	61.0	61.3	63.1	59.4	61.9	62.7	93.9	97.9
Bureau of Meteorology Research Centre (BMRC)	2.4	2.8	3.3	3.3	3.6	3.6	4.0	4.4	4.5	4.4	7.7	7.7
Supervising Scientist –including ERISS	7.6	6.7	7.5	7.6	6.6	6.5	6.0	5.4	4.3	4.2	5.6	5.9
HEALTH & AGED CARE												
Australian Institute of Health & Welfare	4.4	4.2	5.0	6.8	7.2	8.1	7.1	7.6	7.7	7.7	8.1	7.8
CSL[2]	9.4	3.0	1.3	6.9	16.7	-	-	-	-	-	-	-
National Institute of Clinical Studies	-	-	-	-	-	-	-	-	-	-	2.3	7.6
INDUSTRY, SCIENCE & RESOURCES												
Aust Nuclear Science & Technology Organisation	57.5	62.6	64.3	68.2	64.2	66.2	65.6	63.7	72.7	74.5	104.6	158.9
Australian Institute of Marine Science	11.4	13.6	14.2	14.2	16.9	16.5	16.6	16.4	16.4	18.5	25.0	26.1
CSIRO	375.2	414.4	446.3	456.2	460.4	460.8	416.7	433.9	466.8	475.4	617.1	610.0
Kraft Pulp Mill study (CSIRO)	0.5	1.4	1.9	1.9	1.9	-	-	-	-	-	-	-
AGSO *(note capital works in 96-97 & 97-98)*	47.0	52.9	52.9	54.2	50.9	60.5	68.0	117.1	82.9	66.8	62.1	62.4
TOTAL	**815.7**	**869.8**	**914.8**	**935.3**	**967.0**	**940.2**	**923.6**	**972.2**	**972.3**	**973.1**	**1205.1**	**1257.3**

(1) DSTO expenditure shown here includes overhead components funded under other Defence programs, such as salaries for service personnel, FBT, superannuation and some administrative support costs. These have been added to the DSTO figures published in the Budget Papers. For 1996-97,1997-98 and 1998-99, DSTO funding included additional one-off provisions to cover the costs of voluntary redundancies, a redirection of administrative savings and supplementation for a 6% salary increase.

(2) Excludes Budget funding for Reference Centre, which has been mainly for production of antivenom rather than R&D.

TABLE 5 Major Programs Supporting Science and Innovation through the Budget ($m)

	Outlays										est accr	est accr
	1989-90	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	1999-00	2000-01
AGRICULTURE, FISHERIES AND FORESTRY[1]												
Wool Research	20.8	11.7	13.8	13.2	12.0	15.1	11.7	10.4	7.2	9.6	12.0	13.2
Meat Research	13.8	13.6	20.8	22.9	22.1	25.1	22.6	21.1	22.8	21.4	20.5	20.5
Fishing Industry Research	8.1	8.4	6.6	7.5	8.5	9.2	10.4	11.3	11.2	12.1	13.1	14.7
Grains	13.3	14.4	14.8	15.7	21.2	23.3	21.3	29.1	33.8	33.6	32.7	31.8
Horticulture Research	1.2	3.1	4.4	8.3	9.6	10.7	11.4	12.0	11.4	15.3	17.1	17.6
Land & Water research	9.9	13.3	13.3	13.7	11.8	11.3	10.6	9.8	10.8	11.0	21.5	18.6
Rural Industries R&D Corporation	5.0	6.0	8.4	10.5	10.5	10.5	10.5	5.6	10.8	11.0	11.1	15.6
Other rural research	10.1	11.7	12.4	18.8	21.3	25.5	28.0	26.7	32.5	36.2	31.7	38.3
COMMUNICATIONS, INFORMATION TECH & THE ARTS												
Information & Commun. Industries Devel										8.2	10.4	6.7
ENVIRONMENT & HERITAGE												
Aust Biological Resources Study	1.6	1.2	2.0	2.3	2.3	2.0	1.8	1.3	1.0	1.4	1.6	1.8
Greenhouse research (NGRP)	5.7	5.7	6.1	6.0	5.8	6.0	6.0	3.5	3.6	3.1	3.9	4.1
Renewable Energy Equity Fund	-	-	-	-	-	-	-	-	-	-	0.5	3.4
Renewable Energy Comm. Program	-	-	-	-	-	-	-	-	-	2.0	4.0	5.9
Energy research	11.2	15.9	11.8	11.6	11.0	11.1	11.8	6.6	20.6	1.5	-	-
EDUCATION, TRAINING & YOUTH AFFAIRS												
Research evaluation and Academies	-	1.6	2.0	2.0	2.0	2.1	2.1	2.2	2.0	2.5	2.3	2.3
ARGS & ARC grants/fellowships (including marine R&D grants)[2]	35.6	1.2	-	-	-	-	-	-	-	-	-	-
Post-graduate Awards1	11.3	-	-	-	-	-	-	-	-	-	-	-
Targeted Institutional Links Program	0.2	1.0	2.0	1.1	1.4	1.4	0.8	0.5	0.5	-	-	-
HEALTH & AGED CARE												
AIDS Research	5.0	7.1	10.8	10.5	11.6	12.1	12.1	11.7	12.0	12.0	-	-
NH&MRC Research Grants[3]	84.9	96.5	105.1	112.2	120.8	126.7	141.3	152.4	158.9	176.0	281.5	320.7
Capital Works for Medical Institutes	-	5.0	10.0	10.0	10.0	13.0	9.6	2.0	2.7	5.7	-	-
INDUSTRY, SCIENCE & RESOURCES												
Industry Innovation (incl. R&D Start, COMET)	-	-	-	-	-	-	-	56.4	91.2	129.2	155.5	154.5
Industry Innovation Program grants	-	-	-	43.5	40.3	45.6	50.4	-	-	-	-	-
Innovation Investment Fund	-	-	-	-	-	-	-	-	4.0	21.3	48.7	31.5

TABLE 5 Major Programs Supporting Science and Innovation through the Budget ($m) — *continued*

	Outlays										est accr	est accr
	1989-90	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	1999-00	2000-01
Advanced Manufacturing Tech Program	-	-	0.1	-	-	-	-	-	-	-	-	-
Technology Development Program	1.9	3.0	3.2	-	-	-	-	-	-	-	-	-
National Procurement Development Program (NPDP)	5.6	4.2	4.4	-	-	-	-	-	-	-	-	-
IR&D Act 1986 (GIRD)	32.0	29.6	32.2	-	-	-	-	-	-	-	-	-
IR&D Incentives Act 1976												
. Commencement grants	-	-	-	-	-	-	-	-	-	-	-	-
. Project grants	0.3	-	-	-	-	-	-	-	-	-	-	-
. Public interest projects	-	-	0.1	-	-	-	-	-	-	-	-	-
Technology Diffusion Program	-	-	-	-	-	-	-	-	-	14.9	18.6	20.5
Technology Support Centres	-	-	-	-	-	3.9	12.2	7.2	13.7	-	-	-
International S&T Program	4.1	5.0	5.1	5.3	5.4	5.5	5.6	5.6	5.6	-	-	-
Malaria Vaccine Joint Venture	0.8	2.3	9.4	-	-	-	-	-	-	-	-	-
Motor Vehicle R&D	4.7	2.3	-	-	-	-	-	-	-	-	-	-
Australian Technology Group Pty Ltd	-	-	-	30.0	-	-	-	-	-	-	-	-
National Research Facilities	-	-	-	-	-	-	6.4	17.0	20.9	10.7	5.1	4.6
Cooperataive Research Centre Grants	-	-	18.2	45.3	90.6	103.7	132.7	143.1	146.9	142.3	142.9	134.4
Assistance under the Bounty[4] (Computers) Act 1984	45.0	51.3	74.5	75.0	78.0	74.8	64.1	56.5	19.5	58.6	-	-
National Space Program	2.4	5.5	5.7	5.4	5.4	9.0	2.7	1.7	0.5	1.5	-	-
Biotechnology Australia	-	-	-	-	-	-	-	-	-	-	6.0	4.0
Shipbuilding Innovation Scheme	-	-	-	-	-	-	-	-	-	-	9.1	9.5
TRANSPORT & REGIONAL SERVICES												
Payments to Austroads/ ARRB Transport Research Ltd	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.0	2.0	2.0	2.0	1.0
TOTAL	**336.4**	**322.7**	**399.5**	**473.0**	**503.9**	**549.6**	**588.4**	**595.6**	**646.1**	**743.2**	**851.7**	**875.1**

FOOTNOTES TO TABLE 5

(1) For consistency, the expenditure figures for Wool, Meat, Other Rural Research, Fish, Horticulture and Grains exclude that component of Commonwealth outlays funded from industry levies. The component of outlays provided by way of industry levy or contribution is given in the following table.

INDUSTRY CONTRIBUTION
(estimated proportion of levies attributable to research purposes - $m in cash accounting terms))

	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	est 1999-00	est 2000-01
Wool	19.63	17.11	14.05	12.32	12.45	19.50	10.94	12.79	13.09	10.53	11.97	13.16
Meat	13.30	15.17	25.60	25.55	24.65	23.52	22.40	23.13	24.50	12.31	21.33	21.36
Grains												
-Wheat	9.84	8.45	12.92	18.35	19.95	16.28	33.65	35.17	32.02	31.64	29.05	28.06
- Other Grains	3.99	4.27	5.31	9.36	12.61	8.51	17.18	19.48	20.39	17.97	17.75	21.37
Special Rural	0.20	0.30	0.15	0.99	1.03	1.32	1.57	1.39	1.87	1.80	-	-
Fish	-	0.50	1.12	1.01	2.01	2.41	2.46	2.52	2.88	3.30	3.61	4.26
Horticulture	1.62	3.26	4.94	7.24	3.12	3.61	4.28	8.04	9.06	8.86	9.83	9.47
Other Rural												
- Chicken Meat	0.46	0.55	0.78	0.65	0.67	0.71	0.71	0.79	0.82	0.79	0.84	0.86
- Cotton	1.87	2.66	3.87	3.89	2.57	2.13	2.90	4.30	5.48	5.47	5.36	5.47
- Dairying	2.94	4.82	5.21	5.65	6.20	6.13	5.75	8.36	10.94	11.86	14.25	14.15
- Dried Fruit	0.39	0.45	0.78	0.92	0.46	0.49	0.39	0.79	0.41	0.70	0.70	0.71
- Grape & Wine	1.28	1.25	0.96	1.60	1.70	2.08	1.91	2.62	2.37	4.60	5.63	5.25
- Honey	0.12	0.14	0.07	0.12	0.15	0.15	0.15	0.20	0.16	0.18	0.19	0.19
- Pig Industry	1.95	2.58	2.67	2.88	3.61	3.75	3.57	3.42	3.46	3.47	3.65	4.03
- Egg Industry	0.30	0.45	0.57	0.68	0.67	0.63	0.68	0.76	0.77	0.71	0.66	0.68
- Sugar	1.37	1.48	1.28	3.40	4.48	4.89	5.46	5.99	6.17	6.04	5.99	6.21
- Tobacco	0.77	0.59	0.59	0.92	0.64	0.33	0.49	0.57	0.83	0.63	0.76	0.68
- Forestry	-	-	-	-	-	0.38	1.00	1.72	2.53	2.56	3.14	3.19
Total	60.04	64.03	80.87	96.52	96.97	96.84	115.49	132.05	137.77	123.51	134.71	139.10

(2) From 1989-90 most ARC funding has been appropriated through the *Higher Education Funding Act* rather than the Budget. See Table 6.

(3) Includes funding for health and health services research grants, and from 1999-2000 also includes AIDS research and the Medical Institutes.

(4) Provided assistance for local manufacturers of computer hardware, systems software and electronic microcircuits. It covered design and development costs.

TABLE 6 Major Programs and Incentives supporting Science and Innovation outside the Budget ($m)

	1989-90	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	est accr 1999-00	est accr 2000-01
COMMUNICATIONS, INFORMATION TECH & THE ARTS												
Support from the Federation Fund - Commonwealth Technology Park	-	-	-	-	-	-	-	-	-	-	3.0	8.0
EDUCATION, TRAINING & YOUTH AFFAIRS												
Higher Education Funding Act: - special research assistance [1,2]	77.3	178.7	240.3	260.0	292.0	306.3	346.4	396.5	420.4	451.2	446.5	455.3
- Science Lectureships	-	-	-	-	-	-	-	-	-	-	4.9	10.0
Funding for ANU Institute of Advanced Studies3	122	134	141	145	146	147	150	152	151	151	151	151
Estimated research & research training component sourced in the operating grant[4,5,6]	629	622	673	794	858	924	1006	1062	1104	1135	1146	1169
INDUSTRY, SCIENCE & RESOURCES												
Tax Concession[7] for industrial R&D	274	326	432	516	683	726	902	446	439	485	553	600
Tax Deduction for equity subscriptions in Management Investment Companies (MICs)8	19	34	-	-	-	-	-	-	-	-	-	-
Support from the Federation Fund												
- National Marine Science Centre	-	-	-	-	-	-	-	-	-	-	6.0	4.0
- Institute of Molecular Bioscience	-	-	-	-	-	-	-	-	-	-	3.5	8.0
TOTAL	**1121**	**1295**	**1486**	**1715**	**1979**	**2103**	**2404**	**2056**	**2114**	**2222**	**2314**	**2405**

* These data are estimates of funding provided for higher education research through the *Higher Education Funding Act* and predecessor legislation. About 70% of these funds cover research in the natural sciences and engineering, with the balance going to support social sciences and humanities research.

(1) Includes ARC and DETYA funding for research grants, fellowships, centres, postgraduate awards and infrastructure.

(2) Until 1996-97, included funding for Advanced Engineering Centres originally through special research assistance under HEFA, but which was subsequently subsumed in universities' operating grant from 1996 onward. Funding for this element, approximately $1.7 million per annum, ceased after calendar year 1999.

(3) This is an estimate of funds for research and research training provided to the Institute of Advanced Studies (IAS) of the Australian National University (ANU) through the operating grant. Funding for the John Curtin School of Medical Research of the ANU was transferred to the Health Portfolio in 1992, returning to the portfolio in 1997-98, but is here included from 1992-93 to 1996-97 for comparative purposes. For 2000-2001, the IAS block grant is estimated to be $151 million. Within this amount, the University estimates that approximately $40 to $45 million annually can be regarded as being attributable to the IAS in respect of University overheads, major equipment and such campus-wide costs as the library, information technology and central administrative activities.

(4) The sum of the estimates in the previous row and this row of figures is an estimate of the research and research training component of the university operating grant. It does not include funds spent on research by the former advanced education sector institutions prior to the 1989 amalgamations

(5) A new methodology for estimating research and research training is used for 1993-94 onwards, due to changes in ABS data collection introduced in *1994 Research and Experimental Development - Higher Education Organisations* (8111.0). The methodology prior to 1993-94 uses estimates for 1984-85, 1986-88, 1988-89, 1990-91 and 1992-93 based on ABS R&D surveys in the calendar year in which each of these financial years commences. From 1993-94 onwards, the estimate is based on the ABS survey of research expenditure of universities by source of funds. One of the sources identified by the ABS is General University Funds (GUF). Universities' operating grant is the major component of GUF, and can be estimated by using the operating revenue figures from *DETYA Selected Higher Education Finance Statistics*. A research and research training component of the operating grant can then be calculated by applying the same proportion of GUF attributable to the operating grant, to the R&D funds sourced from GUF (this latter is obtainable from ABS Higher Education R&D surveys for 1994, 1995, 1996 and 1998). For example, the estimate for 1993-94 is based on 1994 data; with adjustment for 1993. Estimates for 1998-99 and beyond are based on the 1998 ABS data, using forward projections of the non-capital unified system operating grant for subsequent years.

(6) Under the new framework for higher education research and research training to be introduced in 2001, funding for the proposed Research Training Scheme and most of the proposed Institutional Grants Scheme will be provided from this source.

(7) A 150% company tax deduction for eligible industrial R&D expenditure applied from 1 July 1985 to 20 August 1996, when the rate was reduced to 125%. The data series in Table 6 comprise estimates by the Department of Industry Science and Resources based both on information provided in registrations for the concession and from the Treasury. They do not account for any recoupments arising from the dividend imputation system. Since the policy rationale for the tax concession scheme is to increase business expenditure on R&D, the data in the table are estimates relating to the year when companies undertake the R&D for which they subsequently claim the concession—that is, they are the estimated cost to revenue that would have occurred if companies had claimed the tax concession in the same financial year in which the R&D expenditure was incurred. In fact, some claims are not made until subsequent years (not necessarily in the next financial year). The estimated revenue forgone for the years when claims for the concession are lodged with the Australian Taxation Office is, from 1989-90 to 2000-01, as follows: $195m, $200m, $275m, $305m, $400m, $465m, $685m, $675m $800m, $430m, $490m, $510m and $540m. (See *Tax Expenditures Statement 1997-98*.) Figures published here are revised over those published previously. While these data represent best estimates at the time of publication, they may require further revision as more information becomes available.

(8) Licensed Management and Investment Companies invested in approved high technology/growth activities. The equity subscription in these companies attracted a 100% in ome tax deduction in the year that subscriptions were made. The scheme concluded in June 1991.

TABLE 7 Thematic priorities of Commonwealth Support for Science and Innovation - Budget and other measures

THEMATIC PRIORITIES	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*est cash* 1999-00*	est accr *1999-00*	est accr *2000-01*	*%Total*	*%GDP*
Primary products	232.1	254.3	277.7	287.5	281.0	278.4	299.7	312.3	330.0	359.9	368.8	8.1	0.055
Industrial development	653.9	756.2	882.2	918.7	1060.1	701.7	715.9	850.4	938.6	984.3	1003.5	22.1	0.150
Energy	77.7	87.3	109.0	110.6	127.7	86.2	104.0	90.6	98.4	111.3	131.8	2.9	0.020
Transport & telecommunications	42.1	39.0	34.8	35.9	51.6	34.5	36.0	37.5	40.1	46.3	46.0	1.0	0.007
Urban and rural planning	0.8	0.5	0.5	0.9	1.5	0.3	0.3	0.3	0.4	0.4	0.4	0.0	0.000
Prevention of pollution	59.6	60.5	61.8	68.9	56.8	52.5	57.3	58.7	62.2	72.8	75.1	1.7	0.011
Identification & treatment of pollution	28.5	27.6	32.7	37.0	38.7	32.3	33.1	34.6	37.6	45.1	53.6	1.2	0.008
Health	159.9	181.2	212.6	210.6	232.2	220.5	232.7	256.4	259.0	353.7	405.5	8.9	0.061
Social development & services	13.3	13.1	12.1	14.5	12.3	10.4	11.0	11.4	12.0	14.4	14.4	0.3	0.002
Mining, earth & atmosphere	100.1	117.9	118.9	130.3	129.3	188.9	159.1	141.3	138.4	159.3	160.2	3.5	0.024
Advancement of Knowledge													
- targeted research funding	502.6	524.8	556.6	574.7	624.7	678.7	711.4	735.8	719.9	779.4	814.7	18.0	0.122
- general university funding	673.0	794.0	858.0	924.0	1006.0	1062.0	1104.0	1135.0	1139.0	1146.0	1169.0	25.8	0.175
Defence	257.2	267.1	293.1	279.6	294.5	277.9	268.3	274.2	282.0	297.8	294.6	6.5	0.044
TOTAL	**2801**	**3123**	**3450**	**3593**	**3916**	**3624**	**3733**	**3938**	**4058**	**4371**	**4538**	**100**	**0.678**

Note: Table 7 represents the aggregate data from Table 3 re-arranged by broad socio-economic objective (SEO) categories in accordance with general OECD practice for "overnment budget appropriations on R&D" (GBAORD). The categories are consistent with aggregated groups of the Australian Standard Research Classification (1993 edition). It should be noted that Budget items cannot be allocated to SEO categories with precision corresponding to that achieved through the R&D surveys of the Australian Bureau of Statistics. In general, single Budget lines are allocated to a single broad category in the derivation of the Table. The outlays of CSIRO and those for the CRC Program are, however, split between a number of categories according to available information.

* Estimated to approximate cash accounting expenditure of earlier years.

Thematic Priorities

Table 7 presents a re-arrangement of aggregate outlays from Table 3 according to 'thematic priorities' following a recommendation by the Chief Scientist.

The table shows that support for 'advancement of knowledge' is the dominant category, representing almost 44 per cent of the total - mostly via general university funding. 'Targeted research funding' within this category is also mostly in support of university research, though small componnents are expended through Government programs.

Industrial development, for which the tax concession and the R&D Start Program are the major components, accounts for 22 per cent of total support. Support for activities relating to primary products (mostly agriculture) account for over 8 per cent, while health research and defence R&D are the other substantial categories, respectively at around 9 and 6 per cent of the aggregate.

SECTION

4

Australia in an International Context

AUSTRALIAN SCIENCE AND TECHNOLOGY
- KEY FACTS -

In 1996-97, Australia's total R&D expenditure stood at Aus$8.8 billion*. This corresponds to 1.64% of GDP, the highest recorded level.

In 1996-97, the annual investment of Australian business in R&D fell as a percentage of GDP from a high in 1995-96 of 0.86% to 0.79%, in 1997-98 it fell further to 0.71%. Though still significantly lower than most other developed countries, it has increased markedly since the early 1980s.

Comparing Australian business R&D expenditure and external patenting applications, each as a share of total activity within the OECD, shows a strong correlation between R&D and Australian patent applications to other countries. This indicates an international orientation in Australia's industrial R&D and confirms the reliability of Australian Bureau of Statistics data on R&D expenditure in the business sector.

In 1996-97, R&D expenditure in Australian public sectors (government agencies and universities) was 0.85% of GDP, the fourth highest in the OECD. In fact, data for nonOECD countries (but not published here) indicate that Australia currently ranks fourth in the world on this indicator.

Australia has about 91,000 people in its R&D workforce. These include 42,700 in universities (including 23,800 postgraduate research students), 26,500 in the business sector and 19,500 working in Federal and State Government laboratories.

In 1997, Australian universities graduated some 16,500 students with bachelor degrees in science, and 6,300 with bachelor degrees in engineering. In the same year, 1054 science and 467 engineering PhDs graduated.

Australia's net gain in scientists, engineers and academics through migration has been considerable - over a twelve year period totalling about 55,000, of whom 27,000 were engineers and 16,000 were computer professionals. On average, the annual gain in scientists and engineers is equivalent to the graduate output in these fields from 5 or 6 Australian universities. The high volume of this 'brain gain' should dispel concerns of any overall loss in high level skills.

Professor Peter Doherty shared the Nobel Prize for medicine in 1996. Over the years, seven Australian scientists have received this prestigious international prize in science.

Australia ranks tenth in international scientific effort normalised by population - by publishing some 970 scientific papers per million population per year.

As measured b use of the Internet, Australia has a high capability and readiness to take up new technology. In July 1999, Australia had the seventh highest number of host computer connections to the Internet and, normalised by population, also ranked seventh.

* 1996-97 is the most recent year for which comprehensive data are available. 1998-99 data are being released over this year. See Table 1 (p. 3.3), Figure 3 (p. 3.5) and the associated text.

Broad international comparison of R&D levels

R&D levels in different economies are most commonly compared by considering the ratio of gross domestic expenditure on R&D (GERD) to gross domestic product (GDP). This ratio of GERD/GDP is the most often quoted R&D indicator and provides a standardised method of international comparison. The major advantage of this ratio is that it removes any need for consideration of exchange rates or inflation.

Table 8 shows the latest available GERD/GDP data for twenty OECD and five other economies. Since it is also useful to know the relative scales of R&D effort, the list is ranked by the total R&D expenditure level (in US dollars at

TABLE 8 Gross expenditure on R&D (GERD), GERD as a proportion of GDP, and change and growth rates - international comparisons

			Period 1981 to 1991			Period 1991 to 1998		
	GERD (est. 1996 US$m)	GERD/GDP	Change	Average annual real increase in GERD	Average annual real increase in GDP	Change	Average annual real increase in GERD	Average annual real increase in GDP
United States (1998)	227934	2.77	0.09	2.4	2.5	-0.04	3.5	3.6
Japan (1997)	89452	2.89	0.38	6.9	4.6	-0.09	2.2	1.4
Germany (1998)	43175	2.32	0.10	4.5	3.9	-0.29	-0.1	1.4
China (1998)	-40000	0.69	0.05	9.8	7.5	-0.01	8.2	10.8
France (1998)	28710	2.20	0.20	4.1	2.8	-0.20	0.2	1.6
United Kingdom (1997)	22618	1.87	-0.12	1.8	3.0	-0.24	0.4	2.6
Korea (1997)	19281	2.89	0.79	17.6	9.6	0.97	11.4	-0.3
Italy (1998)	12976	1.03	0.22	5.8	2.8	-0.20	-1.7	1.3
Canada (1998)	11977	1.61	0.12	3.3	2.8	0.09	3.3	2.5
Russia (1997)	10547	0.94	na	na	na	-0.49	-11.2	-8.3
India (1992)	7928	0.74	-0.03	5.0	5.7	na	na	na
Netherlands (1997)	7319	2.12	0.11	3.6	3.0	0.07	3.4	2.7
Sweden (1997)	6965	3.85	0.33	1.7	2.0	0.97	6.1	1.6
AUSTRALIA (1996)	**6487**	**1.64**	**0.24**	**7.3**	**3.1**	**0.33**	**5.4**	**4.3**
Chinese Taipei (1998)	5904	1.98	0.74	18.8	8.7	0.28	8.4	6.5
Spain (1998)	5764	0.88	0.38	13.1	4.2	0.00	1.6	2.1
Switzerland (1996)	4873	2.74	0.44	2.8	2.5	0.08	0.9	0.6
Belgium (1995)	3392	1.59	0.02	2.8	2.8	-0.05	0.3	1.7
Finland (1998)	3258	2.92	0.58	7.0	2.7	0.85	8.4	3.2
Austria (1998)	3158	1.63	0.24	5.6	3.1	0.14	3.4	1.9
Denmark (1998)	2679	1.91	0.45	6.4	1.5	0.26	5.4	3.1
Norway (1997)	1977	1.68	0.26	3.0	0.4	0.03	3.8	3.5
Singapore (1998)	1662	1.80	0.50	15.2	7.0	0.79	16.2	8.0
Ireland (1997)	1080	1.43	0.23	7.1	4.4	0.47	15.6	8.3
New Zealand (1997)	758	1.13	0.11	5.1	0.3	0.14	5.5	3.3
Average (25 economies)		**1.89**	**0.26**	**6.7**	**3.8**	**0.15**	**4.2**	**2.8**
Average (20 OECD only)		**2.05**	**0.26**	**5.6**	**3.1**	**0.16**	**3.9**	**2.5**

Source: ISR based on ABS, OECD and national sources for latest available years.

1996 prices converted at purchasing parities). The Table also shows the change in the GERD/GDP ratiobetween 1984 and 1991, andbetween 1991 and 1998 (or nearest years), and the average annual real growth rates over each period both for GERD and GDP.

In terms of the relative share of national wealth devoted to R&D (GERD/GDP), Australia lies in the middle range. In almost all economies, real growth rates in GERD over the second period were substantially lower than in the first - with Ireland being the striking exception. In the period 1981 to 1998, many economies snowed slower growth in GERD than in GDP, particularly compared to theperiod 1981 to 1988. Australia was one of the exceptions in this case.

GERD is, however, made up of R&D expenditure undertaken in quite different sectors (principally, the business sector, government agencies and universities). There are wide international differences in the relative contribution of these sectors to GERD and policy issues may differ substantially between research sectors. Figure 7 indicates the relative sizes of the research sectors for the economies listed in Table 8, but re-orders the list according to level of GERD/GDP.

There is much advantage in comparing the sectors separately. A complication, however, is that there is great variation internationally in the scope of R&D activities and institutional structures in the government and academic sectors. The type of research or function typically undertaken in government agencies in one economy may be undertaken in universities in another. The reverse also applies. Thus, international comparisons are best based, not on GERD alone, but on its components relating to:

(i) in government agencies and universities combined; and

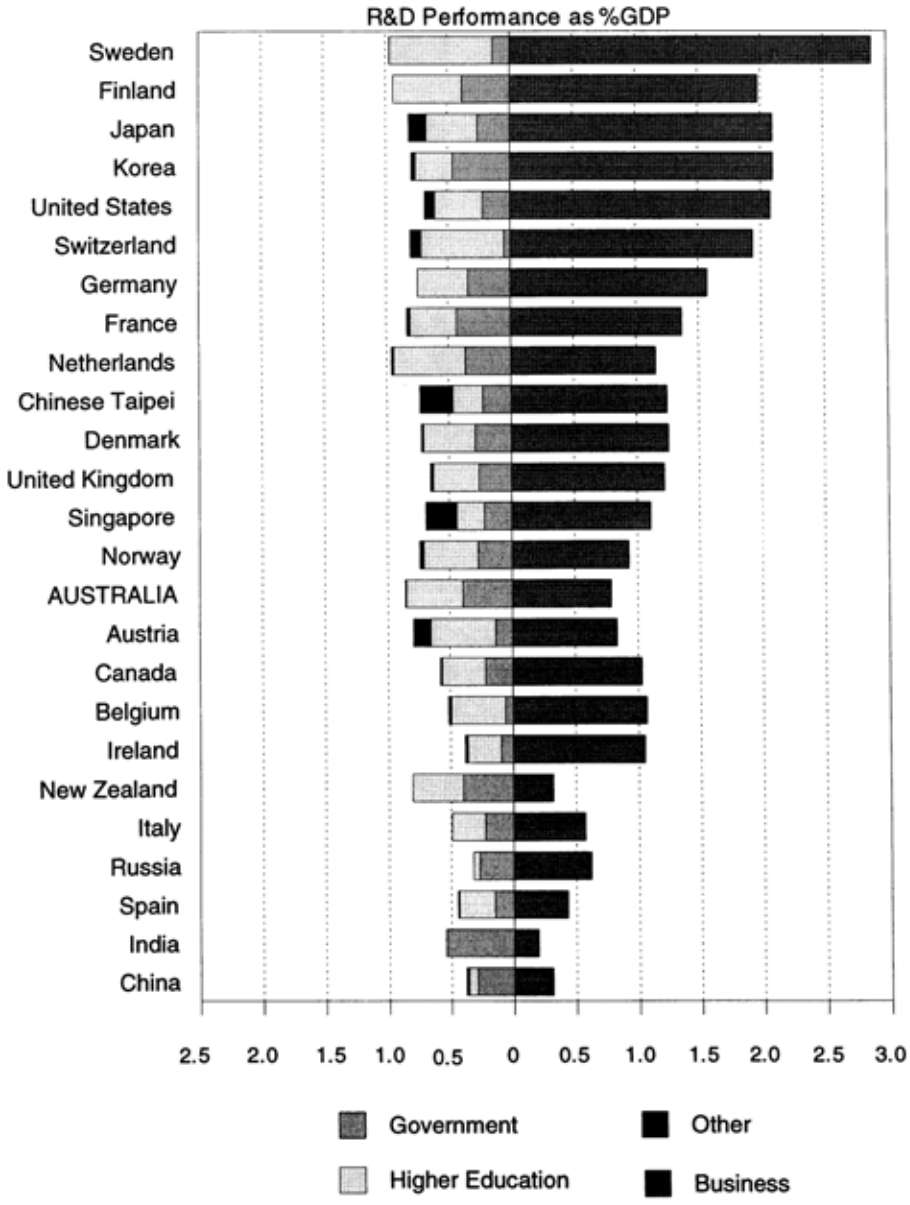
(ii)R&D in the business sector.

R&D expenditure in government agencies and universities

Table 9 shows comparative international data for combined R&D expenditure within government agencies and universities. Although there are exceptions, in most countries university funding is dominated by government. Thus, for convenience in the discussion below, the aggregate in the first column of table 9 is described as 'public R&D'

In Table 9, the arrangement is in order of R&D expenditure as a percentage of GDP. The Table also shows changes in this ratio for the periods 1984 to 1991 and 1991 to 1998, as well as the average annual real growth rates. Added to these indicators is the growth rate in government Budget appropriations in support of science and technology activities.

Figure 7 R&D EXPENDITURE AS A PERCENTAGE OF GDP - INTERNATIONAL COMPARISONS



Source: ISR based on ABS, OECD and national sources for latest available years.

In terms of the share of national wealth expended on R&D within government agencies and universities (R&D expenditure as a per cent of GDP), Australia has a high ranking of 0.85% compared with an average of 0.64% for all twenty five economies listed. The change in this ratio for Australia was small between 1984 and 1991, but over the period since 1991 was larger than the OECD average increase. Among all countries, there was some convergence towards the mean over the whole period since 1984.

Australia's level of effort inbasic researchhas been a matter of some interest. In fact, comparative data are available for only fifteen economies. These are shown in Table 9. (The data also include small amounts of basic research conducted in the business and private non-profit sectors.) Australia has increased its level of effort in basic research from 0.33% of GDP in 1978-79, to

TABLE 9 International comparisons of selected indicators relating to R&D in government laboratories and universities, and basic R&D as %GDP

		Period 1984 to 1991			Period 1991 to 1998			
	R&D expend. in govt and universities as % GDP	Change	Average annual % real increase in R&D	Average annual % real increase in Budget	Change	Average annual % real increase in R&D	Average annual % real increase in Budget	Basic R&D as (most recent year)
Sweden (1997)	0.96	0.01	1.8	1.5	0.06	1.8	-3.6	na
Netherlands (1997)	0.94	0.13	4.9	2.6	-0.04	2.1	2.3	na
Finland (1998)	0.94	0.26	6.4	7.9	0.06	3.7	4.3	na
AUSTRALIA (1996)	**0.85**	**0.02**	**4.6**	**1.3**	**0.07**	**3.5**	**2.7**	**0.42**
New Zealand (1997)	0.81	0.13	9.2	1.6	0.09	5.3	3.2	na
France (1998)	0.81	-0.01	2.8	2.2	-0.10	0.2	-2.8	0.51
Korea (1997)	0.76	0.06	10.3	2.9	0.08	23.3	15.0	0.38
Germany (1998)	0.75	0.09	5.7	2.4	-0.04	0.7	-1.5	na
Switzerland (1996)	0.73	-0.03	11.2	16.0	-0.03	-0.8	-1.9	0.75
Norway (1997)	0.72	0.19	5.6	5.8	-0.03	2.6	0.6	0.25
Denmark (1998)	0.70	0.13	5.3	7.5	0.03	3.7	4.0	na
Austria (1993)	0.65	0.11	3.0	4.4	na	na	1.6	0.32
Japan (1997)	0.65	-0.05	3.2	3.1	0.08	4.0	6.5	0.35
United Kingdom (1997)	0.63	-0.08	1.1	-2.8	-0.03	2.0	-0.1	na
United States (1998)	0.61	0.00	2.7	1.8	-0.07	1.8	-0.5	0.44
Canada (1998)	0.56	-0.02	2.2	0.9	-0.13	-0.8	-6.4	na
India (1992)	0.54	-0.04	4.4	na	na	5.3	na	na
Belgium (1995)	0.49	0.13	7.5	3.2	-0.04	-0.8	3.1	na
Italy (1998)	0.47	0.10	5.6	5.1	-0.07	-1.0	-3.0	0.25
Chinese Taipei (1998)	0.46	0.10	8.3	15.7	0.05	6.8	8.3	0.20
Singapore (1998)	0.44	0.07	7.9	n.a.	0.11	11.5	n.a.	0.22
Spain (1998)	0.44	0.14	11.6	15.5	0.06	2.8	2.8	0.16
Ireland (1997)	0.37	-0.03	2.2	1.7	0.02	9.9	7.5	0.12
China (1998)	0.37	na	10.3	3.5	-0.05	5.5	7.4	0.04
Russia (1997)	0.32	na	9.3	na	na	na	na	0.14
Average (25 economies)	**0.64**	**0.06**	**5.9**	**4.7**	**0.00**	**4.0**	**2.3**	**0.30**
Average (20 OECD only)	**0.69**	**0.06**	**5.3**	**4.2**	**0.00**	**3.4**	**1.7**	**0.36**

Source: ISR based on ABS, OECD and national sources for latest available years.

0.35% in 1984-85 to the most recent level (1996-97) of 0.42%. This compares well on the limited comparisons that are available.

Table 9 shows Australia in the top group of economies when these are ranked by public R&D levels. It should be noted here (and in other tables) that the precise ranking will fluctuate as new data come to hand. (And sometimes this occurs not through new R&D data, but through revised estimates for GDP.)

In Australia, questioning of public R&D data sometimes arises from a widespread misunderstanding of the R&D survey procedures adopted by the Australian Bureau of Statistics (ABS) — which are widely thought to rely on a fixed assumption that 30 per cent of academic time is spent on R&D activity. In fact, ABS makes no such assumption. Overall, their survey involves three categories of university personnel:

– those who undertake no research (teaching-only academic staff, for example);

– those who are engaged solely in research (research-only academic staff and full-time research students are the main categories); and

– those who undertake some teaching and some research (teaching-and-research academic staff are the main component).

For the first category, no salary component is included within R&D expenditure. In relation to the second, one hundred per cent of salaries and stipends is included.

For the last category, ABS actively encourages universities to supply realistic estimates of the proportion of time that is devoted to research and warns that this may vary substantially between faculties and departments—that is, there is no fixed fraction that is applied to all salaries, though an average fraction can be computed from the survey results after the event. For the 1996 survey, this computed average was 17 per cent—but across universities it ranged from a minimum of less than 10 per cent to a maximum of 40.

As a further exploration of international comparisons, Figure 8 adjusts public R&D by subtracting general university funding (GUF — the amount of R&D expenditure that is funded by governments, but for general purposes that are not solely confined to R&D). Only those countries for which relevant information is readily available are included in the comparison.

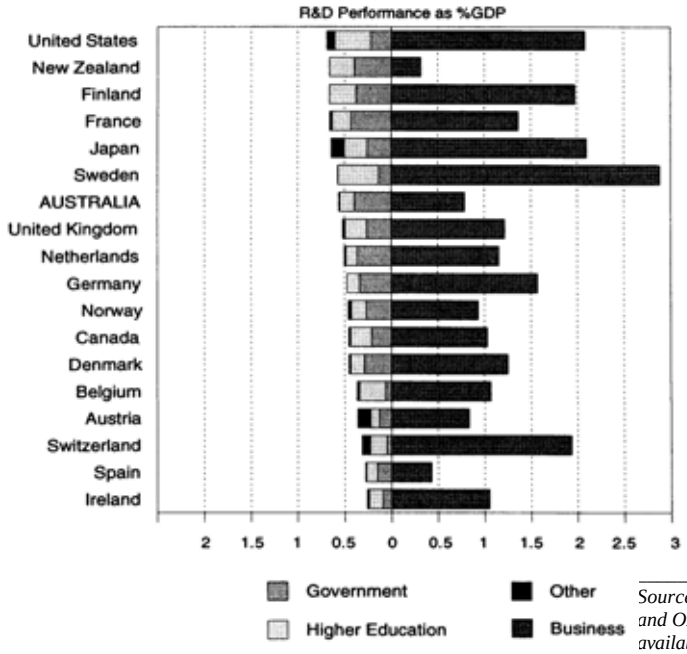
Figure 9, in a further comparative analysis, explores the occasional contention that Australia's data are relatively inflated by the inclusion of research in the social sciences and humanities (SSH). In fact, this inclusion follows standard OECD guidelines and most other countries now do so. However, these data are not always readily available — Figure 9 includes only those countries where they are. Australia's relative ranking in public R&D remains high.

One alternative to making international comparisons as a fraction of GDP is to compare national levels as a proportion of aggregate OECD levels. International trends on this basis are shown in Figure 10 for 'nonBERD' (all R&D expenditure other than in the business sector). An advantage of comparing national performance in this way is that comparisons can also be made on the same basis with national outputs of scientific research papers (the principal measurable output of the non-business sector), and with the impacts of those papers. Figure 10 shows levels and trends on this basis for twelve OECD countries. As well as shares in total nonBERD, Figure 10 also shows trends in shares of its dominant components—higher education expenditure on R&D (HERD) and expenditure on R&D in government agencies (GOVERD).

For a number of reasons (caveats on publication data, particularly, have been well discussed in many reports) these comparisons should be treated with some caution. Nevertheless, there are a number of interesting features. For Australia, a recovery in share of expenditure on nonBERD from about 1990 appears to have improved shares in the output of scientific papers and, more markedly, the relative impact of those papers. Among other countries, the improvement in Spanish shares in all quantities is very striking.

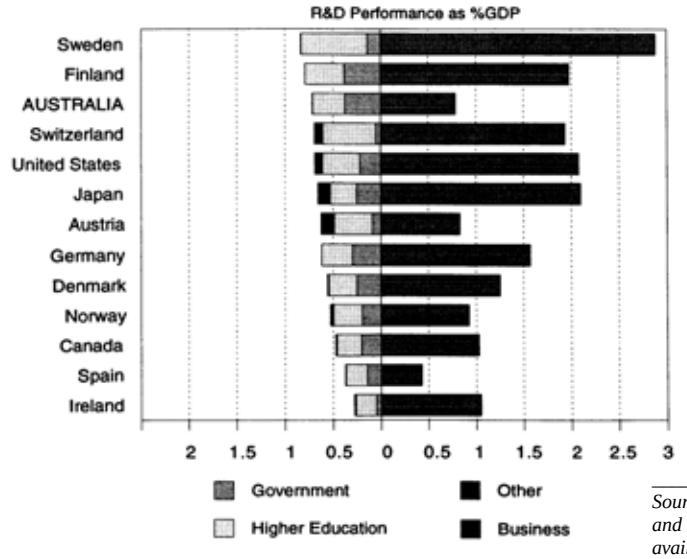
For most countries, universities produce a greater share of scientific papers than government agencies. However, the Figure shows that trends in share of total nonBERD correlate better with trends in shares of scientific papers or citations than shares in HERD alone. This confirms the usefulness of considering indicators that aggregate data for research in universities and government agencies.

Figure 8 R&D EXPENDITURE AS A PERCENTAGE OF GDP - INTERNATIONAL COMPARISONS, ADJUSTED FOR 'GUF'



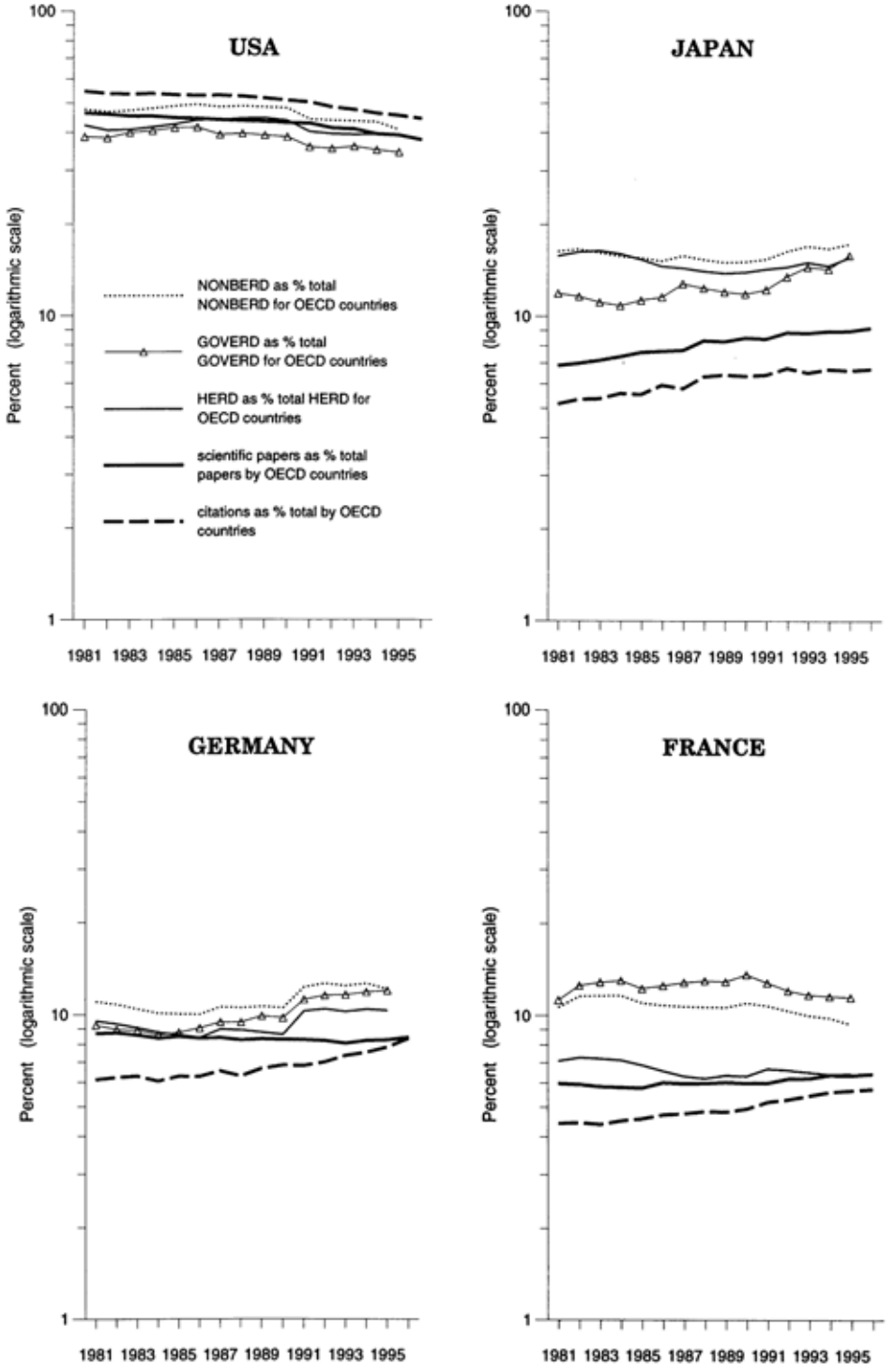
Source: ISR based on ABS and OECD sources for latest available years.

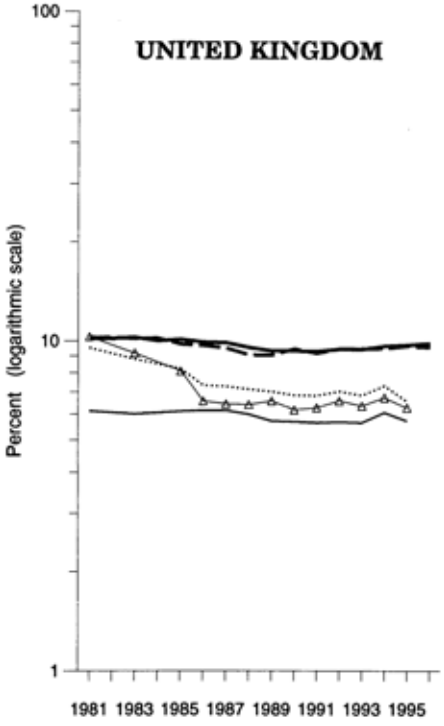
Figure 9 R&D EXPENDITURE AS A PERCENTAGE OF GDP - INTERNATIONAL COMPARISONS, ADJUSTED FOR 'SSH'

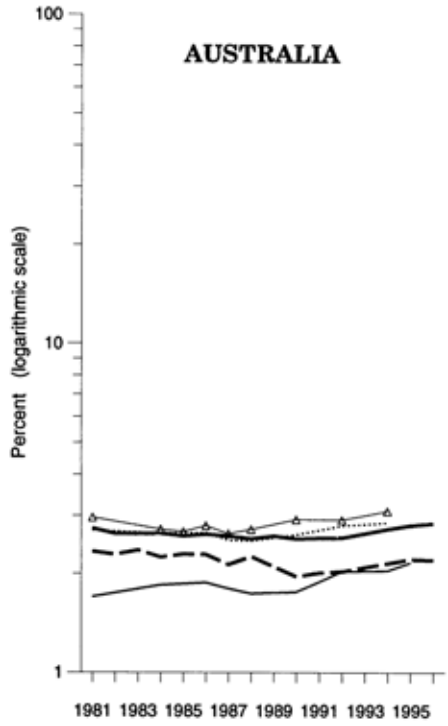


Source: ISR based on ABS and OECD sources for latest available years.

Figure 10 TRENDS IN NONBERD AND SCIENTIFIC PAPERS




UNITED KINGDOM
100
10
1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


AUSTRALIA
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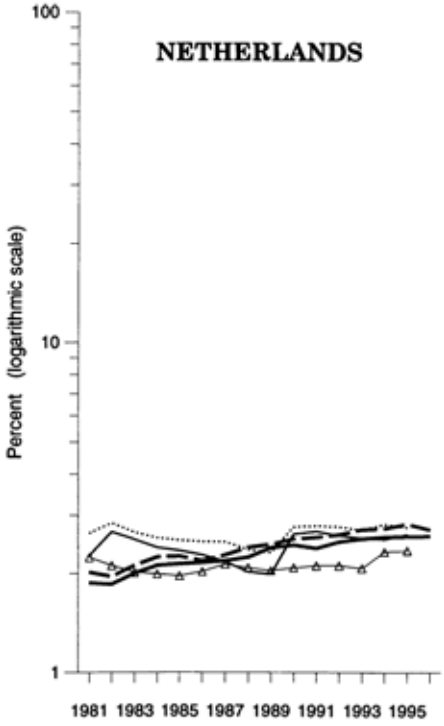
1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


NETHERLANDS
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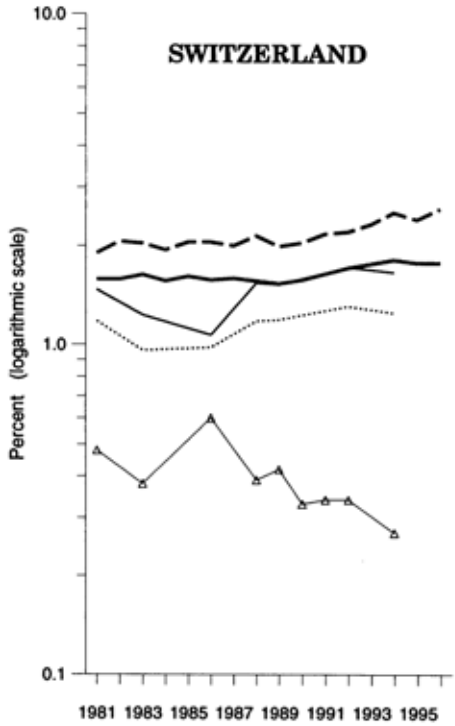
10
1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


SWITZERLAND
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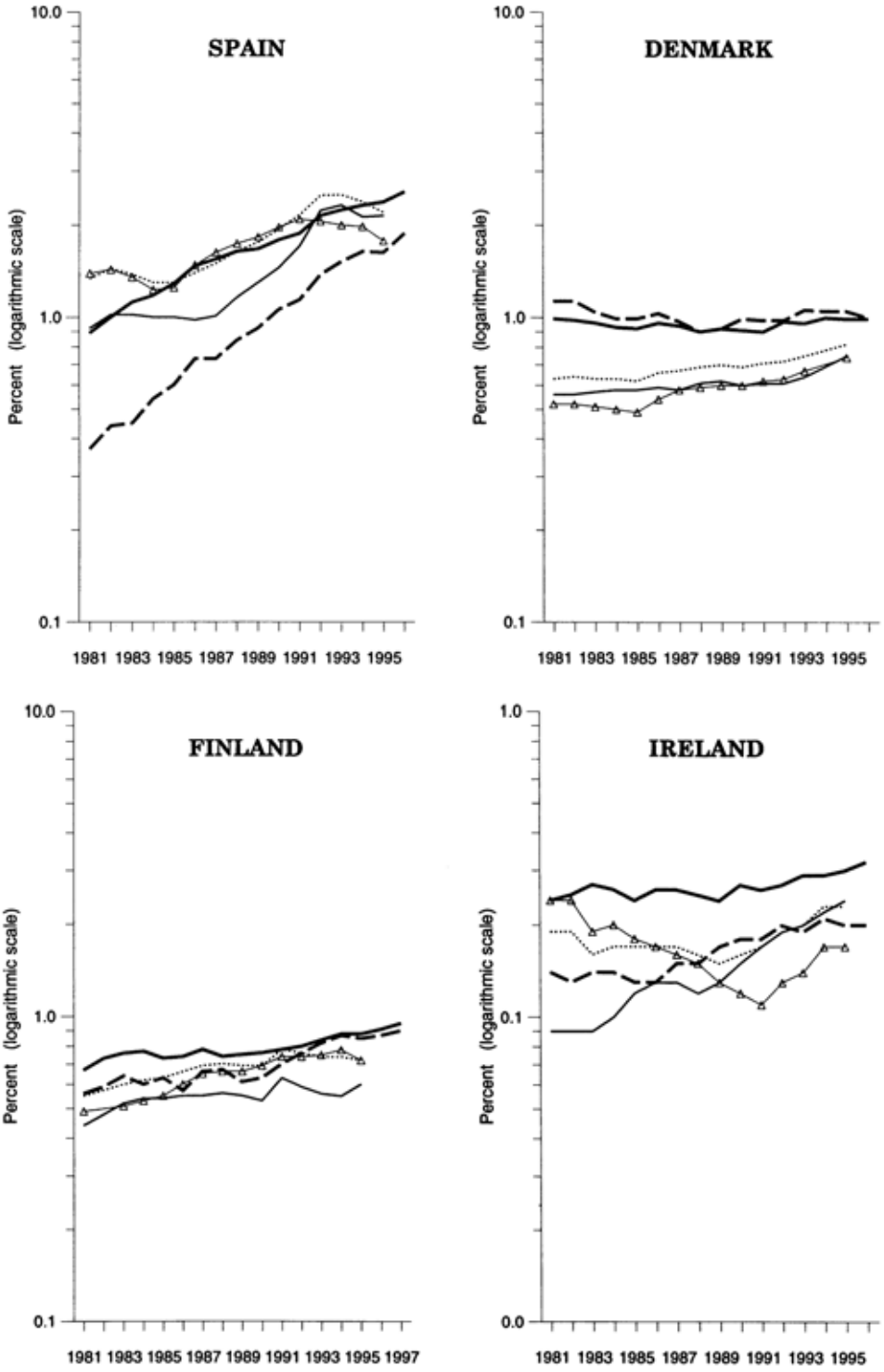
1.0
0.1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


SPAIN
DENMARK
FINLAND
IRELAND
Percent (logarithmic scale)
10.0
1.0
0.1
0.0
1981 1983 1985 1987 1989 1991 1993 1995
1981 1983 1985 1987 1989 1991 1993 1995 1997

Business expenditure on R&D

Table 10 shows comparative international data for business expenditure on R&D (BERD) arranged in order of BERD as a percentage of GDP. The Table also shows changes in this ratio in parallel with those of Table 9. For convenience, the same growth rates in Budget appropriations for science and technology are added to this Table as well as being shown in Table 9.

TABLE 10 International comparisons of selected indicators relating to R&D in the business sector

			Period 1984 to 1991		Period 1991 to 1998		
	%BERD/GDP (latest)	Change	Average annual real increase in BERD	Average annual real increase in Budget	Change	Average annual real increase in BERD	Average annual real increase in Budget
Sweden (1997)	2.88	0.33	1.7	1.5	0.91	7.9	-3.6
Korea (1997)	2.10	0.64	19.7	2.9	0.73	9.6	na
Japan (1997)	2.10	0.42	8.0	3.1	-0.03	1.5	6.5
United States (1998)	2.08	0.07	2.3	1.8	0.03	4.1	-0.5
Finland (1998)	1.98	0.32	7.5	7.9	0.80	11.5	4.3
Switzerland (1996)	1.94	0.22	1.5	16.0	0.07	1.1	-1.9
Germany (1998)	1.57	0.00	4.1	2.4	-0.24	-0.5	-1.5
France (1998)	1.37	0.22	5.1	2.2	-0.11	0.1	-2.8
Chinese Taipei (1998)	1.25	0.44	20.7	15.7	0.03	10.9	8.3
United Kingdom (1997)	1.22	0.05	2.3	-2.8	-0.20	-0.2	-0.1
Denmark (1998)	1.19	0.31	7.2	7.5	0.23	6.6	4.0
Netherlands (1997)	1.15	-0.02	2.6	2.6	0.14	5.2	2.3
Singapore (1998)	1.11	0.37	17.0	na	0.52	17.0	na
Belgium (1995)	1.07	-0.06	1.7	3.2	-0.02	0.8	3.1
Ireland (1997)	1.05	0.25	10.9	1.7	0.44	18.4	7.5
Canada (1998)	1.03	0.13	4.2	0.9	0.22	6.1	-6.4
Norway (1997)	0.95	0.08	1.3	5.8	0.05	4.8	0.6
Austria (1993)	0.83	0.15	6.6	4.4	na	na	1.6
AUSTRALIA (1996)	**0.79**	**0.26**	**10.9**	**1.3**	**0.13**	**10.2**	**2.7**
Russia (1997)	0.62	na	na	na	na	na	na
Italy (1998)	0.56	0.12	5.9	5.1	-0.13	-2.3	-3.0
Spain (1998)	0.43	0.23	14.3	15.5	-0.06	0.3	2.8
New Zealand (1997)	0.32	0.06	-4.0	1.6	0.05	5.9	3.2
China (1998)	0.31	0.19	6.2	3.5	0.12	16.6	7.4
India (1992)	0.19	0.01	6.9	na	na	na	na
Average 25 countries	**1.20**	**0.19**	**6.9**	**4.7**	**0.15**	**6.2**	**1.6**
Average (20 OECD only)	**1.33**	**0.19**	**5.7**	**4.2**	**0.16**	**4.8**	**1.0**

Source: ISR based on ABS, OECD and national sources for latest available years.

There were substantial increases in levels of BERD in most countries over the 1980s and much higher growth rates than for the composite category of R&D expenditure in government agencies and universities. However, changes in BERD and in growth rates were much lower for the period 1991 to 1998 than for 1984 to 1991. As in most other economies beginning with relatively low levels of BERD, Australia achieved increases in BERD/GDP and growth rates were

well above OECD averages—the second highest OECD rate of growth for the period up to 1991, and the third highest for the period since then (Korea having joined the OECD in the period 1991-98). Nevertheless, rowth rates in OECD nations were all much lower than for the three dynamic Asian ecoomies in the Table—Singapore, with a real annual growth rateof about 17 per cent, Chinese Taipei on 10 per cent, and Korea on 10 per cent. But Ireland, with the leading OECD growth rate (19 per cent), is now ahead of all these, and Finland on 11 per cent is ahead of all but Singapore.

Figure 11 provides OECD comparisons for the business sectors in 12 OECD economies on a parallel basis to Figure 10. However, output here should be assessed on the basis of the share in external patent applications (domestic patent applications in most cases have less relevance). For smaller countries in particular, changing patterns in the share of R&D expenditures are reflected (with a small lag) in similar patterns in the share of external patenting. The similarities are particularly striking for Australia - and verify the reality of increased R&D expenditures reported since the early 1980s.

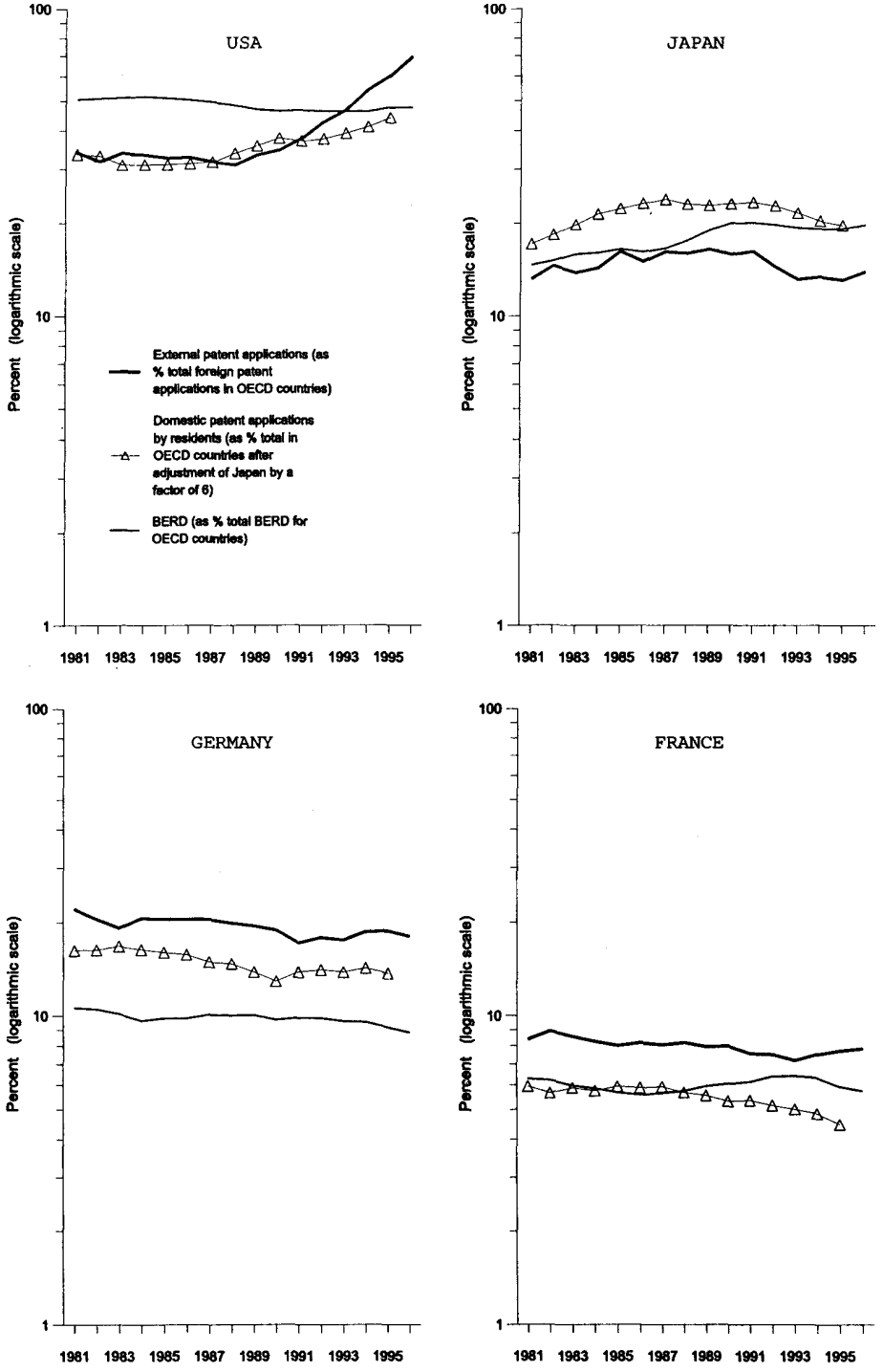
However, improvements for Spain, Finland, Denmark and Ireland should be noted. These might be regarded as indicating the 'dynamic European economies'—to a degree, counterparts to those in Asia.

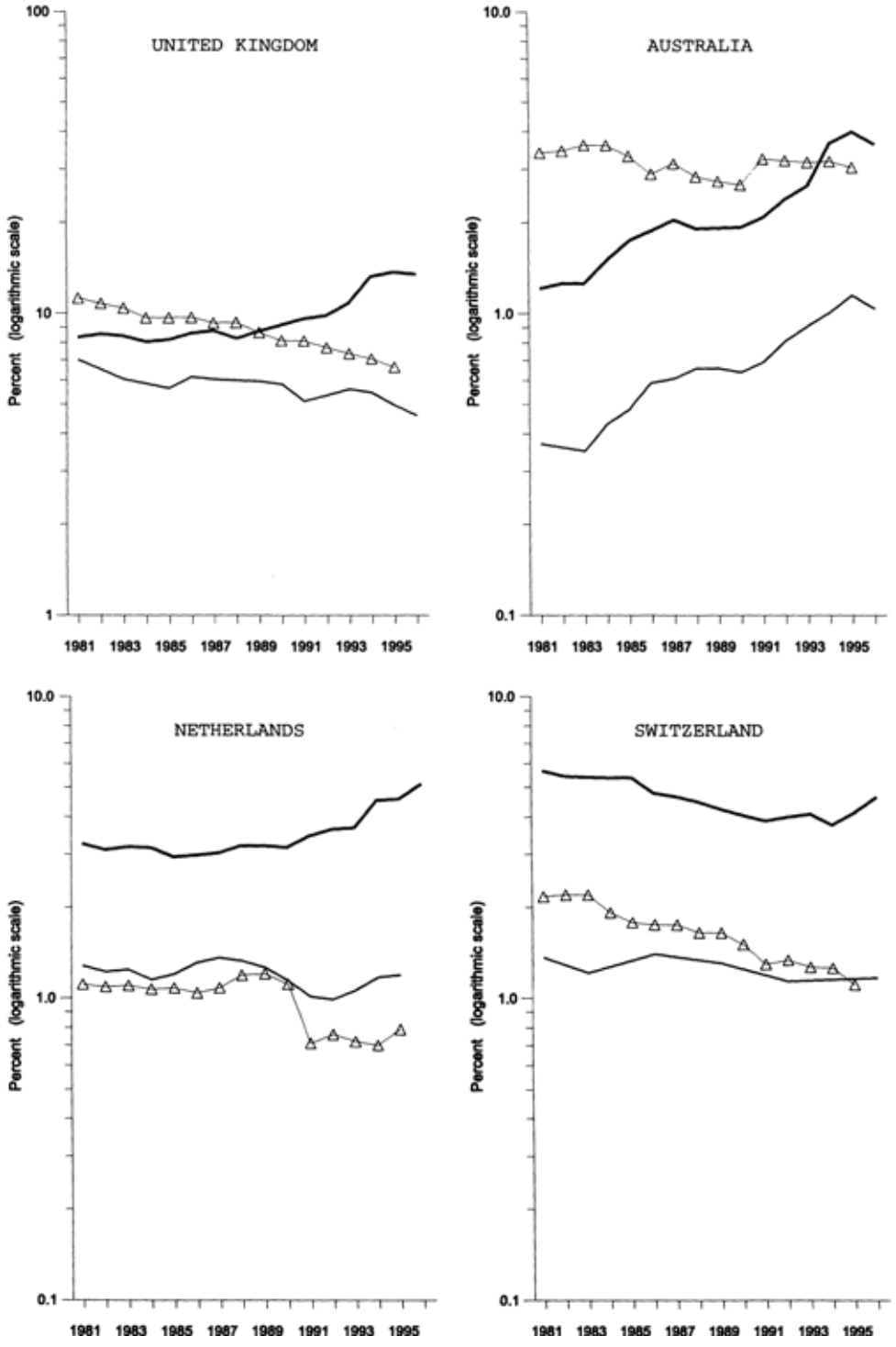
Government science and technology budgets

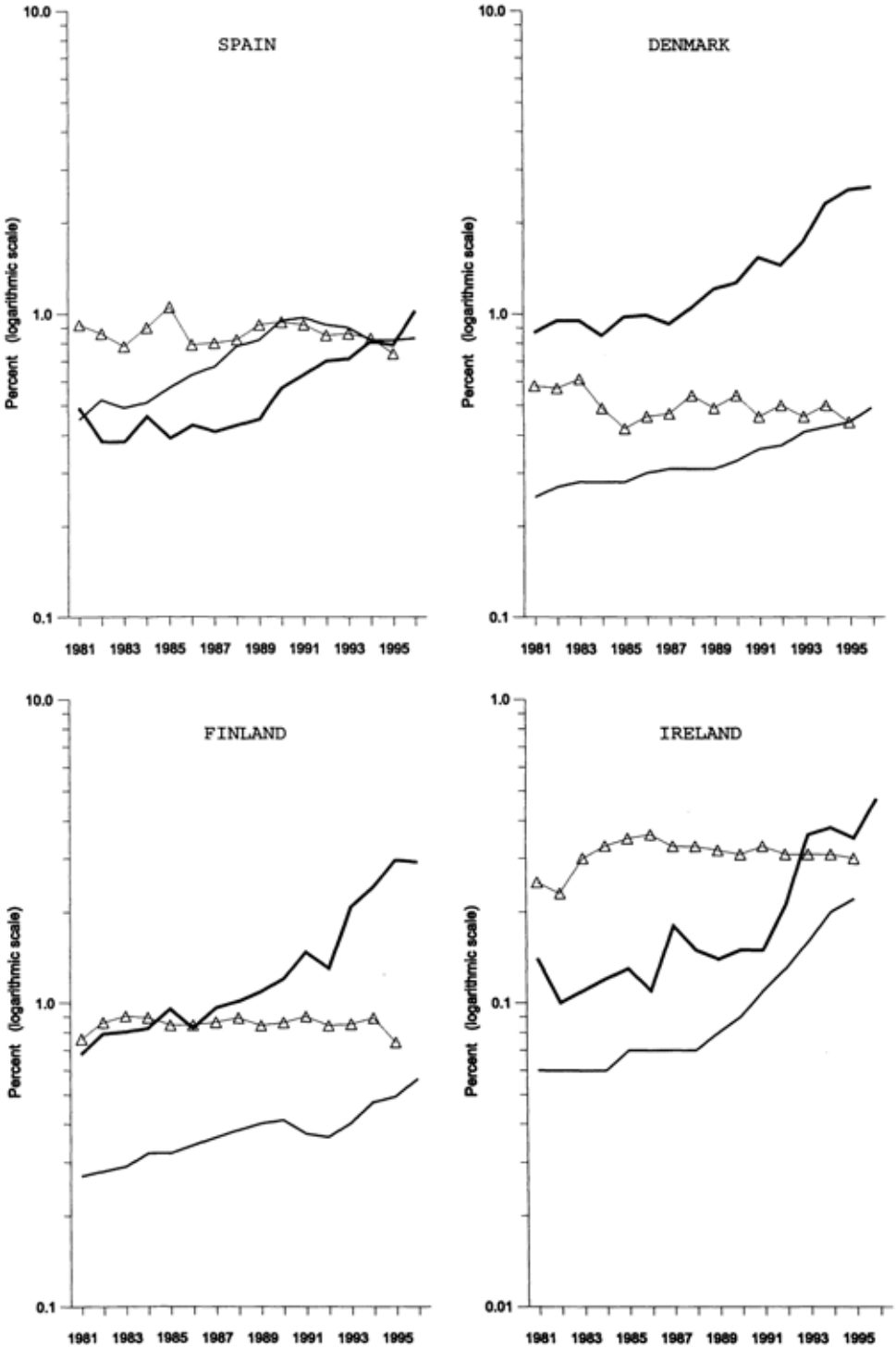
As is the case with a range of other science and technology indicators, the OECD regularly publishes data on national budget appropriations for scientific and technological purposes. However, though there are guidelines that broadly define the items that should be included in such data sets, for a variety of reasons it is not possible for countries to collect those data in as rigorous a manner as R&D data collected via central statistical agencies. For this and other reasons, it is unwise to attempt comparative analysis of indicators based on appropriations as a proportion of total budget outlays or GDP. Comparative studies of growth rates, however, may have more validity and have been added to the other indicators set out in Tables 9 and 10.

These growth rate comparisons are relevant to a particular kind of argument sometimes put by interest groups seeking higher public funding for R&D. In essence, this argument relies on comparative analysis of foreign government announcements of more support for science and technology. There can be a risk in such an approach that the repackaging or revamping of old programs - legitimately included in such announcements together with descriptions concerning new funding - will lead analysts and commentators to draw mistaken conclusions. In particular, amounts of 'new money' being provided are easily over-estimated. For this reason, it can be hard to sustain convincing arguments through an approach of this kind.

Figure 11 TRENDS IN BERD AND PATENT PERFORMANCE




UNITED KINGDOM
AUSTRALIA
NETHERLANDS
SWITZERLAND
Percent (logarithmic scale)
100
10
1
10.0
1.0
0.1
1981 1983 1985 1987 1989 1991 1993 1995


SPAIN
DENMARK
FINLAND
IRELAND
Percent (logarithmic scale)
10.0
1.0
0.1
0.01
1981 1983 1985 1987 1989 1991 1993 1995

In the above context, recent months have seen arguments put that announcements of new science and technology funding and programs in Canada, Japan, the UK, and the USA, mean that Australia is being left behind in some sense. In fact, the much harder data in Table 9 shows a very different situation. All those countries have much lower levels of public sector research than Australia. In the case of three of those countries — Canada, the UK and USA—in relatively recent years there were large cuts in Government funding for public sector research which are very apparent in detailed historical data published by the OECD. The picture is summarised in the negative real growth rates shown in science and technology budget appropriations for those three countries over the period 1991 to 1998. It does not appear that recent announcements of funding increases by those countries fully restore funding levels that were previously cut. By contrast, Figure 4 in Section 3 of this Statement shows a very consistent pattern of Government funding support for Australian public sector research — this is embedded in the relatively high growth rate in column six of Table 9, while the first column of Table 9 shows that this growth occurred in a context of very high levels of R&D.

For the period 1991 to 1998, the comparisons show that Australia achieved a real growth rate in science and technology appropriations that is well above international averages. More remarkably still, given that the major part of Australia's Government support for science and technology goes towards research in government laboratories and universities, Australia's high budget growth rate corresponds to a comparatively high level of R&D carried out in those sectors (see the first column of Table 9).

The imperative for Australia must be to address the weakness in business sector R&D apparent in the first column of Table 10. A wide range of information presented in this Statement indicates that the Government is seeking to do just that. This issue is addressed not only by a set of programs that are directly aimed at strengthening R&D in the business sector, but also through measures that build linkages between industry and our strengths in public sector science.

A regional perspective

Internationally, while there has been increasing attention paid to national 'systems of innovation', this work has also pointed to the importance of regional systems. This is particularly pertinent to the situation of Australia's States and Territories, where the geographical dispersion of centres of economic activity point to the value of considering indicators relating to individual regions as well as those of the nation as a whole. Taken as a whole, Australia shares some features in common with the five Nordic countries —another set of geographically dispersed centres of activity with a degree of economic integration and having, in total, similar levels of GDP and population. This approach can be carried one step further by considering combined indicators for both signatories to the Closer Economic Relationship (CER) Agreement. Table 11 then presents a range of indicators along these lines — with a range of developed countries included that are comparable to

Australia's States and Territories in terms of GDP and population. The various economies listed are ranked by scale of total R&D activity.

TABLE 11 R&D in Australia's regions - an international perspective

	GERD (US$m 1998)	% GERD/GDP	change since 1981	BBRD (US$m 1998)	% BERD/GDP	change since 1981	GDP (US$m 1998)	Population (thousands)
Nordic Countries	14987	2.89	5.91	10257	1.97	4.42	519412	23946
CER (Aust. & NZ)	7556	1.65	0.60	3349	0.73	0.47	459249	22070
AUSTRALIA (1996)	**6798**	**1.70**	**0.70**	**3135**	**0.74**	**0.49**	**395790**	**18309**
Sweden (1997)	6972	3.85	1.56	5219	2.88	1.43	173500	8846
Switzerland (1996)	4778	2.74	0.56	3377	1.94	0.32	174461	7111
Austria (1998)	3158	1.63	0.49	1238	0.83	0.20	176242	8072
Finland (1998)	3258	2.92	1.72	2209	1.98	1.32	99940	5140
Denmark (1998)	2679	1.91	0.91	1676	1.19	0.66	128837	5284
Norway (1997)	1932	1.68	0.50	1100	0.95	0.33	110496	4405
New South Wales (1996)	**2034**	**1.51**	**0.67**	**1125**	**0.83**	**0.61**	**134777**	**6204**
Victoria (1996)	**1925**	**1.86**	**0.78**	**1100**	**1.06**	**0.66**	**103498**	**4561**
Ireland (1997)	1111	1.43	0.73	815	1.05	0.74	68971	3656
Singapore (1998)	2165	1.80	1.52	1334	1.11	0.96	120316	3531
New Zealand (1997)	758	1.13	0.09	214	0.32	0.10	63459	3761
Queensland (1996)	**884**	**1.35**	**0.63**	**336**	**0.51**	**0.45**	**65433**	**3339**
Western Australia (1996	**689**	**1.53**	**0.85**	**381**	**0.85**	**0.73**	**44915**	**1766**
South Australia (1996	493	1.80	0.55	154	0.56	0.36	27414	1474
Australian Capital Territory (1996)	**474**	**6.25**	**-0.13**	**21**	**0.28**	**0.26**	**7589**	**308**
Iceland (1998)	146	2.03	1.22	53	0.74	0.68	6640	271
Tasmania (1996)	**156**	**2.00**	**1.05**	**45**	**0.58**	**0.32**	**7776**	**475**
Northern Territory (1997)	**56**	**1.27**	**0.87**	**13**	**0.30**	**0.30**	**4389**	**182**

Source: ISR based on ABS, OECD and national sources for latest available years.

Since the end of the 1970s, measures to stimulate R&D activity in the business sector have been taken in a wide range of countries, and have proved successful. The results canbe seen in the table, with most economies exhibiting substantial increases. In Australia's case, measures taken at a Federal level have had substantial effects in increasing business R&D expenditures in the States and Territories.

Table 11 provides a different comparative view than that usually seen at a purely national level. For example, Victoria's levels of business R&D activity are seen to be equivalent to those of Denmark, and clearly exceeding those of Ireland, Norway, Austria and Singapore. While the R&D levels for the ACT seem remarkably high, these are essentially for the city of Canberra. Even higher levels would be seen if it were possible to obtain comparable indicators for cities such as Austin, Berkeley, Cambridge, Oxford, etc. where there are also high concentrations of academic and other research within relatively small areas.

Portfolio Budgets and Priorities

Introduction

This Section presents summaries of 2000-01 budget allocations and priority goals relevant to science and innovation. This information is arranged by Ministerial portfolio, with a particular focus on agencies engaged in R&D and on programs funding R&D.

For each portfolio, there is a brief summary of pertinent allocations for the 2000-01 Budget. Where possible this is compared with the expenditure outcome for 1999-2000. Discussion of financial aspects is deliberately brief.

The summary of portfolio funding for major Commonwealth science and innovation programs is followed by an outline of priorities for 2000-01.

The priorities are drawn from Section 2 of relevant Agency Budget Statements contained in Part C of the *Portfolio Budget Statements*. These statements provide detailed information on agencies' outcomes and outputs, including the purpose and nature of agencies' budget measures. They also show how the science and innovation programs are expected to contribute to the achievement of agencies' planned outcomes and outputs. This information is contained in two tables that show the relationship between agencies' old program and appropriation structures and their new outcome structures and resourcing levels.

Please note that the financial information in this *Statement* has been provided and confirmed by the agencies and departments with responsibility for the programs, and/or by the Department of Finance and Administration. Further information is available from the *Portfolio Budget Statements* of each Department. These can be accessed through the Federal Government entry point on the World Wide Web (*www.fed.gov.au*).

AGRICULTURE, FISHERIES AND FORESTRY

Science and Innovation in the Portfolio Budget

The objective of the research and assessment programs operating within the Agriculture, Fisheries and Forestry portfolio is to contribute accurate information and high-quality scientific and economic research, analysis and advice to assist informed and objective decision-making processes for resources management, ecologically sustainable development and industry competitiveness.

Portfolio R&D structure and arrangements are designed to take into account Government and industry needs and objectives in the development of research programs, and to facilitate the rapid integration of outcomes from new technologies into industry so that it benefits directly from R&D.

Two key institutional arrangements exist within the Portfolio which influence the strategic and operational aspects of Portfolio research objectives and priorities:

- two independent research bureaus; and
- thirteen Research and Development Corporations and one Research and Development Council.

These institutional arrangements allow the key stakeholders in the Portfolio's research effort, including producers, scientists and Commonwealth and State Government policy and program managers to have an input into research priority setting.

Research Bureaus

The research bureaus are the:

- Australian Bureau of Agricultural and Resource Economics (ABARE); and
- Bureau of Rural Sciences (BRS).

The research bureaus play a vital role in the conduct of public sector research and provide scientific and economic analysis to assist the process of government. Research undertaken by these bureaus will be funded to a total of $41.5 million in 2000-01.

R&D Corporations and Council

The R&D Corporation model is an alliance between industry and Government that seeks to increase the economic, environmental and social benefits to industry and the general community with innovation through R&D.

R&D Corporations (and one Council) were established to:

- attract a higher level of industry expenditure on R&D by providing funding incentives for statutory levies;
- achieve effective transfer of technology and a high rate of adoption and commercialisation of research by placing an emphasis on the total innovation process;
- cause the research undertaken to be demand-driven by involving industry in the setting of R&D priorities; and
- allow R&D Corporations to operate in a commercial environment relatively free from Government control of their R&D investment, while making research managers fully accountable to both industry and Government.

Most R&D Corporations (and the Council) receive matched appropriation funding against industry levies:

- Australian Wool Research and Promotion Organisation;
- Cotton R&D Corporation;
- Dairy R&D Corporation;
- Fisheries R&D Corporation;
- Forest and Wood Products R&D Corporation;
- Grains R&D Corporation;
- Grape and Wine R&D Corporation;
- Horticultural R&D Corporation;
- Pig R&D Corporation;
- Sugar R&D Corporation;
- Tobacco R&D Corporation; and
- Dried Fruits R&D Council.

In addition, the successor to the Meat Research Corporation, Meat and Livestock Australia (MLA), also conducts research and development relevant to portfolio industries.

The R&D Corporations, the R&D Council and the research and development activities of MLA are jointly funded by industry and the Commonwealth, with Commonwealth contributions generally matching on a dollar-for-dollar basis levies (or export charges) up to a maximum of 0.5 per cent of the industry's gross value of production (G VP). Exceptions to these arrangements are the Fisheries R&D Corporation which, in addition to appropriation funding of 0.5 per cent G VP, has dollar-for-dollar matching up

to 0.25 per cent of GVP, and the Forest and Wood Products R&D Corporation, which receives one Commonwealth dollar for every two industry dollars matching up to 0.25 per cent of GVP.

Two other R&D Corporations in the Portfolio receive the majority of their funding through appropriation:

- Land and Water Resources R&D Corporation; and
- Rural Industries R&D Corporation.

In addition to direct funding of R&Dby the Government, the corporations are able to generate income from royalties and licenses for successful R&D they have sponsored, actively solicit funds to finance worthwhile research proposals, and accept voluntary contributions from industry.

In addition to its appropriation, the Rural Industries R&D Corporation also receives funding from industry levies from smaller industries which are matched by the Commonwealth in a similar manner to the industry specific R&D Corporations. The Corporations and the Council report, and are accountable to, both their respective industry and the Minister for Agriculture, Fisheries and Forestry.

Research objectives of some of the R&D Corporations are listed below:

Cotton Research and Development Corporation (CRDC)
The Australian cotton industry produces about 3 million 227kg bales of fibre each year, and exports are worth more than $1 billion annually to the national economy. With a budget of around $11 million, the Corporation's research program is divided into four key areas:

- efficient, sustainable field production systems;
- viable and healthy regional communities;
- commercially sustainable industry sectors; and
- efficient and responsive management and delivery of R&D.

Grains Research and Development Corporation (GRDC)
The GRDC's research portfolio covers 25 leviable cropping industries spanning temperate and tropical cereals, oilseed and pulses, worth over $7 billion a year in farm production alone. To improve the profitability of grain producers, the GRDC has set out in its Five Year Plan, *Partners for Profit*, four investment objectives for the period 1997 to 2002:

- meeting quality requirements;
- increasing productivity;
- protecting and enhancing the environment; and
- delivering outcomes.

Rural Industries Research and Development Corporation (RIRDC)
The Corporation's budget in 1999-2000 was $23.1 million. RIRDC has three core businesses. They are:

- fostering the development of new industries, both prospective and emerging (such as new animal and plant industries, agroforestry, Asian foods and rare natural animal fibres);
- managing research and development investments for established industries (chicken meat, eggs, honey bee, rice, fodder crops and pasture seeds); and
- addressing strategic cross-sectoral issues facing the rural sector (global competitiveness, resilient agricultural systems and human capital).

The Corporation also provides services for the semi-independent Dried Fruits Research and Development Council.

Sugar Research and Development Corporation (SRDC)
The SRDC pursues the following objectives:

- to improve the competitive position and cost efficiency of the Australian sugar industry;
- to achieve sustainable use and sustainable management of the natural resource base of the sugar industry;
- to apply industry, scientific and community resources more effectively to R&D in the sugar industry; and
- to manage its resources efficiently and to improve the accountability for expenditure on R&D for the sugar industry.

2000-01 Science and Innovation Priorities

Australian Bureau of Agricultural and Resource Economics (ABARE)

In 2000-01 ABARE will:

- further develop the next generation of its global trade general equilibrium model (GTEM) to inform policy development in the lead-up to the Sixth Conference of the Parties to the UN Framework Convention on Climate Change in The Hague in November 2000;
- apply Australian trade and equilibrium model (AUSTEM) to examine issues concerning Australia's compliance with the Kyoto Protocol;
- study the economic effects of the use of agricultural and forest sinks to help countries meet their Kyoto Protocol commitments;
- continue to develop integrated resource management tools for policy evaluation; this work will generally focus on geographic information system (GIS) based catchment modelling to enable assessment of

various land use change options in the mitigation of land degradation;

- continue to develop the 'ANSWER' Windows software, providing additional convenience and flexibility for 'MARKAL' model users; and in addition, under contract to the International Energy Agency's Energy Technology Systems Analysis Program (ETSAP), it will enhance 'ANSWER' so that it can be used as an interface to the ETSAP group's recently developed 'TIMES' energy model which is the more powerful successor of 'MARKAL'.

Bureau of Rural Sciences (BRS)

Major scientific advice outputs for 2000-01 will relate to:

- key issues for agricultural industries including vertebrate pests, agricultural sustainability, food production and gene technologies, carbon accounting of sources and sinks for agriculture and forestry sector greenhouse gases, regional social science parameters and climate and agricultural risk, (e.g. drought exceptional circumstances);
- scientific issues affecting the sustainable development of commercial and recreational fishing, aquaculture, forestry and allied industries, to support the management of Australian forest resources and Commonwealth fisheries;
- groundwater resources, sustainable land use, aquifer risk assessment and water resources relating to public health parameters, to support profitable and sustainable resource management and the National Land and Water Resources Audit;
- the management and enhancement of national databases on forests, fisheries, land and water resources; this also includes management of metadata on Australian land resources, water resources, fisheries and forestry data;
- the development and application of tools and decision support systems for integrated spatial and dynamic modelling and data analysis capacity, to facilitate policy decisions on rural resource management issues; and
- the participation in various research and management national committees including those reporting to the Standing Committee on Agriculture and Resource Management (SCARM) and its committees, the Australian and New Zealand Environment and Conservation Council (ANZECC) committees and international fisheries/forestry committees.

COMMUNICATIONS, INFORMATION TECHNOLOGY AND THE ARTS

Science and Innovation in the Portfolio Budget

Through the Department of Communications, Information Technology and the Arts, the Government has sought to fully develop the synergies between communications and information technology and the creative industries sector. Two key science and technology initiatives undertaken by the Department are outlined below.

Australian Business Number Digital Signature Certificate

The Government is commited to ensuring that all appropriate government services are delivered online by 2001. Digital signature certificates and the underlying public key infrastructure are the basis for ensuring confidentiality, message integrity and non-repudiation for online information. The Government is seeking to establish by mid-2000, a digital signature process, the Australian Business Number Digital Signature Certificate (ABN-DSC), for use by Australian businesses in dealing and transacting with Commonwealth agencies. This initiative builds on the current rollout of the Australian Business Number (ABN), the unique identifier of all businesses.

Government Electronic Resources Network (GOVERNET)

The GOVERNET project is a key initiative designed to support the provision of equitable and seamless access to federal, state and local government information and services in convenient locations and manner. GOVERNET, in the light of improved navigation of the government information space, will not necessitate its users to have prior knowledge of the location of the information within the government jurisdiction or agency.

2000-01 Science and Innovation Priorities

Questacon - The National Science and Technology Centre

In 2000-01, Questacon will continue to provide a national focus for popularising science and technology through touring interactive exhibitions and providing a range of educational programs aimed at increasing awareness and creating positive attitudes to science and technology.

Questacon is working with:

- Shell, its major corporate partner for almost 15 years, to bring an interactive science flavour to the Sydney 2000 Olympics;
- the Australian Technology Park and the New South Wales Department of Education to develop programs to help build a 'culture of innovation';
- the National Capital Authority in Canberra to explore the establishment of a national aerospace centre; and
- Scitech Discovery Centre, Perth to develop a new interactive exhibition, *Natural Disasters*. This exhibition will explore the major natural forces that shape our world, and the human impact of these forces. It will open in Perth in December 2000 before coming to Questacon in mid-2001.

Questacon is developing an interactive exhibition for the new Australian Cotton Exhibition Centre in Narrabri, NSW which is due to open in 2001.

These projects are in addition to Questacon's own exhibition program, with:

- a greater emphasis on the biological sciences reflected in *Predators*, a biology/robotics exhibition currently under development that will open in late 2001;
- current developments in Australian research and development being featured in a new Questacon program combining interactive exhibits at the Centre in Canberra and material on Questacon's web site (*www.questacon.edu.au*).

DEFENCE

Science and Innovation in the Portfolio Budget

The Budget allocation for the Defence Science and Technology Organisation (DSTO) will be $263.5 million in 2000-01 (with an expected outcome of $268.9 million in 1999-2000).

DSTO's strategic direction and priorities lead to recurring themes and key areas for research including support for intelligence, surveillance, electronic warfare, communications, information technology, and exploitation of environmental information. They also include signature management, operational research, combat modelling and simulation, overall systems including the human dimension, and knowledge of advanced materials. Another recurring theme is the need to understand the strengths and weaknesses of our own key weapons and sensors, and those that might be used against us.

2000-01 Science and Innovation Priorities

The information revolution, in the military context often referred to as the 'Revolution in Military Affairs', is a key priority for DSTO. A significant emphasis in this area will be to help the Australian Defence Force (ADF) to exploit information superiority, and to enhance command support and intelligence. A specific priority is to support future imagery handling.

For the Royal Australian Navy (RAN), DSTO's key priorities include research to improve the operational performance of the Collins Class submarines through improvements to the combat and propulsion systems, signature management, and the development of enduring technologies for through-life management. Initiatives for development of maritime capability include modelling of the air-sea warfare environment, including threats posed by advanced anti-ship missiles.

DSTO will continue to support the 'Army Modernisation' process, and will develop modelling and simulation tools for operational-level logistic support to deployed military forces.

Key initiatives in support of the Royal Australian Air Force (RAAF) are life-assessment, and support to the life-extension of P-3C Orion maritime patrol aircraft and C-130 Hercules transport aircraft airframes. DSTO will also conduct research to enhance the capabilities, and to prolong the operational life of the F/A48 fighter and the F-111 strike/reconnaissance aircraft. Studies will be initiated to help decision-making on new aerospace combat capabilities.

Specific research activities in support of the five Defence Outputs: Defenc(Operations, Navy Capabilities, Army Capabilities, Air Force Capabilities and Policy Advice, are listed below.

Defence Operations

Key activities include:

- undertaking an assessment of the Defence Force's ability to process information during warfare to help develop priorities for integration of command, control, computing, communications, intelligence, surveillance and reconnaissance capabilities over the next five years;
- analysing the output of strategic wargaming to support development of improved military experiments to validate future warfare concepts
- developing an advanced version of a prototype portable toolkit capable of rapid on-site deployment to assist in detection and management of intrusion on computer networks;
- implementing 'theatre broadcast technology' for transmitting high-bandwidth video, voice and data signals to deployed troops as a demonstration system and interim operational capability, following the successful deployment in East Timor of a developmental system;
- providing analytical and systems support to increase the preparedness of ADF rotation units prior to deployment with UNTAET, and to improve the capability of ADF units in East Timor to conduct operations;
- completing development of a software component for the combined display of imagery and geospatial information that can be used as a foundation to display other command, control, computing, communications, intelligence, surveillance and reconnaissance information;
- signing a revised Memorandum of Understanding governing *The Technical Cooperation Program* between the United Kingdom, United States, Canada, New Zealand and Australia;
- investigating establishment of a formal relationship with the NATO Research and Technology Organisation; and
- continuing to provide specialist technical advice to the Government on the further development of the Biological Weapons Convention.

Navy Capabilities

Key activities include:

- assisting the RAN to develop an electronic warfare policy to provide a strategic focus and direction for the enhancement of the Navy's electronic warfare capability;
- assisting with the acceptance testing, evaluation and introduction into service of electronic warfare systems acquired for the ANZAC and Adelaide class frigates, and the NULKA active missile decoy;
- analysing options for upgrading the anti-ship missile defence capability of the ANZAC class frigates, and the capability of

electronic warfare systems for the proposed new Navy Air Warfare Destroyer;

- conducting a sea trial of an experimental active control system for reducing the propulsion machinery vibration component of the underwater acoustic signature of surface ships;
- supporting the introduction into service of the Penguin anti-surface missile by assisting Australian industry on insensitive warhead fills and by modelling and simulation to aid in tactics development;
- assisting with the acceptance testing, evaluation and introduction into service of electronic warfare systems acquired for the Seahawk and Super Seasprite helicopters, including work on associated techniques and tactics;
- completing development of a model to assess through-life costs associated with upgrading the Seahawk helicopter;
- advising on new technology options for replacement patrol boats;
- supporting the Collins class submarine program in the areas of managing the acoustic and magnetic signatures of the vessel, improving diesel engine reliability, implementing electronic warfare systems, and improving the combat system;
- providing technical expertise, instrumentation and post-trial analysis for the shock trial of the second Collins class submarine, *HMAS Farncomb*;
- developing collaborative research programs with industry and tertiary institutions to improve the operational capabilities of submarines;
- assessing the technical risk associated with non-hull penetrating periscopes and determining their effect on the combat performance of the Collins class submarines;
- studying the combat system of the Mine Hunter Coastal to identify aspects of the human-machine interface that can be improved; and
- producing analytical modelling tools for operational planning of littoral and amphibious military operations.

Army Capabilities

Key activities include:

- providing experimental tools and methods to support the development of future warfighting concepts and capabilities to conduct mechanised/motorised operations;
- contributing to the evaluation of tenders and potential solutions for Project WUNDURRA - Soldier of the Future;
- pursuing further development of a prototype device which uses Australian technology to detect biological warfare agents;
- undertaking heat acclimation studies with emphasis on the effectiveness of short, intense acclimation periods;

- assessing the complementary use of electro-optical sensors with imaging radar for airborne surveillance for land operations;
- commencing, in conjunction with Australian industry, the development of a capability and technology demonstrator for a rapid route and area land mine neutralisation system to reduce the land mine threat;
- participating in the technical evaluation of tender responses for the systems and sub-systems for an armed reconnaissance helicopter;
- supporting the evolution of the armed reconnaissance helicopter capability, its introduction into service and the development of doctrine, through a series of synthetic environment and modelling experiments;
- progressing the development of a new modelling capability to predict the infrared signature of helicopters to assess their susceptibility to infrared-guided missile attack; and
- completing development of a distribution and maintenance computer modelling tool and beginning validation experiments.

Air Force Capabilities

Key activities include:

- providing extensive scientific support to the introduction into service of the AGM 142 stand-off missile capability;
- assisting with the acceptance testing, evaluation and introduction into service of electronic warfare systems acquired for the F-lll and F/A-18 aircraft;
- evaluating new techniques for non-destructive evaluation of bond degradation and corrosion in F-lll and F/A-18 aircraft honeycomb components;
- simulating the loads acting on a turbine disc in an F-111 TF30 engine to assess the in-service life of the disc to reduce the operating costs of the engine;
- undertaking flight trials to demonstrate remote autonomous monitoring of the structural health of a composite reinforcement for an F/A-18 aircraft aileron hinge; this 'smart' materials technology, if successful, will greatly reduce certification concerns for bonded composite aircraft repairs;
- undertaking operational research to help define requirements for future combat aircraft;
- providing scientific support to help bring the ASRAAM and AMRAAM air-to-air missiles into service and contributing to the future development of ASRAAM;
- continuing to support the Airborne Early Warning and Control Project by providing advice in a wide range of technology areas to assist in monitoring the progress of the contractor, and to prepare for the test and evaluation phase and for introduction into service;

- completing construction of a single-site, surface-wave radar capability and technology demonstrator and conducting a limited trial to test the functionality of the system;
- continuing to support the Jindalee Operational Radar Network Project Office and the prime contractor, with emphasis moving to test and evaluation; and continuing the evolutionary development of the software;
- completing modifications to add a littoral and maritime surveillance capability to the Global Hawk high altitude endurance uninhabited aerial vehicle system prior to the operational demonstration and evaluation of the system in Australia during 2001;
- commencing, under a collaborative program with the US Navy to establish how to extend the structural life of the P-3C aircraft to 2015, the testing of the aircraft's empennage, and supporting the wing and fuselage test to be conducted by Lockheed Military Aircraft Systems;
- investigating new concepts of operation for the P-3C aircraft to help optimise its surveillance effectiveness and assisting with the development and testing of the electronic warfare systems acquired for the P-3C fleet;
- supporting the C-130J aircraft acquisition by assisting with the establishment of through-life management plans and by undertaking airworthiness compliance verification; and
- continuing collaborative research, development and engineering with the United States in aircraft electronic warfare self-protection technologies.

Policy Advice

Key activities include:

- developing a systems engineering approach to help Defence Headquarters staff develop and evaluate future Defence force structure options; and
- conducting research into image analysis and exploitation tools, and the assessment of future imagery systems to support surveillance.

Other Priority Areas

DSTO organisational priorities include:

- establishing a military systems branch to conduct research into key experimental processes necessary to exploit the information revolution;
- undertaking a review of DSTO's priority setting processes and framework to improve the allocation of resources to meet customers' needs; and
- consolidating, and further developing, DSTO's integrated approach to staff development, encompassing induction, research management, the Graduate Certificate in Scientific Leadership program and the Executive Leadership Development Program.

EDUCATION, TRAINING AND YOUTH AFFAIRS

Science and Technology in the Portfolio Budget

Through the Education, Training and Youth Affairs portfolio, the Government will provide an estimated $1.7 billion in 2000-2001 to support research and research training in Australian universities. This estimate comprises targeted funding provided as special research assistance under the *Higher Education Funding Act (HEFA) 1988* ($455 million), approximately $1,300 million estimated to be the research and research training component of universities' operating grant funding, and other *HEFA* and Budget appropriations ($16 million).

Funding allocations at the scheme level are provided on a calendar year basis for the year 2000.

Support through targeted research funding

For 2000, approximately $205.8 million will be available to universities, researchers and other bodies through a number of targeted research schemes administered by DETYA under the *HEFA*: the Small Research Grants Scheme ($28.4 million); Research Infrastructure Block Grants Scheme ($80.3 million); Australian Postgraduate Awards Scheme ($80.9 million); and the International Postgraduate Research Scholarships Scheme ($16.2 million).

Approximately $240.7 million will be provided in 2000 through competitive research schemes administered by the Australian Research Council (ARC) including: the Large Research Grants Scheme ($103.8 million); Research Fellowships Scheme ($27.4 million); International Researcher Exchange Scheme ($2.6 million); Research Centres ($25.1 million); Research Infrastructure Equipment and Facilities Scheme ($22.1 million); Strategic Partnerships with Industry - Research and Training (SPIRT) Scheme ($56.8 million); Learned Academies Special Projects ($0.4 million), the Indigenous Researchers' Development Scheme ($0.2 million), the Special Research Initiatives Scheme ($0.3 million) and unallocated funds ($1.9 million).

Targeted research funding administered by DETYA and the ARC will total $455.3 million in the financial year 2000-2001.

A new funding structure will operate from 2001, with the implementation of the new arrangements announced by the Government in *Knowledge and Innovation: A policy statement on research and research training.*

Support through university operating grants

The Commonwealth is the major source of research income for universities and, given that universities perform the bulk of Australia's basic research, the major source of funding for basic research in general. Support for research is channelled through universities' operating grants which support undergraduate teaching, research and research training activities.

The estimate of the total research and research training component of the operating grant is based on the Australian Bureau of Statistics (ABS) survey of research expenditure of universities by source of funds (the ABS methodology is outlined in *Research and Experimental Development - Higher Education Organisations* (8111.0)). One of the sources of funds for research expenditure identified by the ABS is General University Funds (GUF). Universities' operating grants comprise the major part of GUF, and can be estimated by using the operating revenue figures available in the DETYA Selected Higher Education Finance Statistics. Using this method, the research and research training component of university operating grants for both calendar years 2000 and 2001 is estimated to be at $1,300 million.

Within this estimate, three elements of operating grant funding can be identified:

- *The Research Quantum (RQ)*: The RQ is a component of universities' operating grant which is allocated to institutions on the basis of research performance, as measured by the Composite Index. In 2000, RQ funding will total $223 million. In 2001, the RQ will cease and its funding will be incorporated into a new Institutional Grants Scheme.
- *Support for research training*: Support for research training is also provided through universities' operating grant. From 2001, this portion of the operating grant will be separately identified under a new Research Training Scheme. The quantum of this support will depend on the final number of degree research places universities choose to fund under the new higher education research and research training framework announced in Knowledge and Innovation.
- *Funding for the schools and centres of the Institute of Advanced Studies (IAS)* of the Australian National University. The block grant for the IAS is estimated to be approximately $151 million for 2000. As outlined in Chapter 2, the new framework makes provision for the IAS to access performance-based funding, through a contribution from this block grant.

Support through other *HEFA* Initiatives and the Budget

Support for science and innovation is also provided through other *HEFA* initiatives and the annual Appropriation Acts. Support for the Science Lectureships initiative, funded under the *HEFA* Higher Education Innovations Program, will be $4.9 million in 2000. In 2000, support through the Budget includes that for the Anglo-Australian Telescope Board ($3.7 million); the Learned Academies ($1.6 million); and the Research Evaluation Program ($0.7 million). These elements will total $16 million in the financial year 2000-01.

Arrangements for calendar year 2000

Department of Education, Training and Youth Affairs managed schemes

Small Research Grants Scheme
The Small Research Grants Scheme provides block grants to universities to enable them to offer research grants at less than the minimum value of Large Grants. Eligible universities receive a base grant of $50,000. The remaining funds are distributed according to a formula that takes into account institutional success in obtaining Large Grants and the distribution of Small Grants in the previous year. In 2000, $28.4 million will be provided under this Scheme. At the end of 2000, this Scheme will conclude and funding will be transferred to the Institutional Grants Scheme.

Research Infrastructure Block Grants Scheme
The Research Infrastructure Block Grants (RIBG) Scheme will provide funding of $80.3 million to universities to assist in the development and maintenance of research infrastructure in 2000. Consistent with the priority of providing infrastructure support for Commonwealth competitive grant schemes, the RIBG is allocated to institutions on the basis of the National Competitive Grants Index (NCGI).

Australian Postgraduate Awards Scheme
A total of $80.9 million is available under the Australian Postgraduate Awards (APAs) Scheme in calendar year 2000. Around 4,800 APAs provide a stipend of up to $16,743, mainly for students undertaking postgraduate research degrees. They are tenable for up to two years for a Masters student, and three and a half years for a student undertaking a PhD. One thousand five hundred and fifty new awards are available in 2000. APAs are allocated to institutions on a formula reflecting research student load, research degree completions and comparative research strength measured by the Composite Index.

International Postgraduate Research Scholarships Scheme
The International Postgraduate Research Scholarships Scheme supports high quality overseas postgraduate students in areas of research strength in higher education institutions. The scholarships offer students the opportunity to acquire a postgraduate qualification and experience with leading Australian researchers. In 2000, $16.2 million will be available to the Scheme, with three hundred new scholarships being made available.

Australian Research Council managed schemes
The majority of targeted research funding is allocated on the advice of the ARC, which conducts competitive peer review through its committees and panels. The primary criterion for allocating funding is excellence. As appropriate, some weight is given to other priorities such as links to industry.

Large Research Grants Scheme

The Large Research Grants Scheme supports basic and applied research projects in all disciplines except clinical medicine and dentistry. Grants range from a minimum size of $20,000 a year for the social sciences, humanities, mathematics and theoretical sciences, and from $30,000 a year for other disciplines. In 2000, allocation for this Scheme (including new and ongoing grants) is $103.8 million.

Strategic Partnerships with Industry - Research and Training Scheme

The Strategic Partnerships with Industry - Research and Training (SPIRT) Scheme supports research collaboration between universities and industry. It covers projects in basic, strategic, applied and developmental research and training in all fields, funded on a matching arrangement with industry collaborators.

Funds are available under three categories for a combination of research and training opportunities: Collaborative Research Projects; Australian Postdoctoral Fellowship Industry Awards (APDI); and /or Australian Postgraduate Awards (Industry) (APA(I)). Funding single grants from one or more of these components leaves researchers free to negotiate with industry for a customised package suited to their particular activity.

In 2000, approximately $20 million has been awarded to 441 new SPIRT projects. This includes funding for 225 Collaborative Research projects, 18 Australian Postdoctoral Fellowship Industry Awards and 335 APA(I)s. Pledged industry contributions to new SPIRT projects total $30.6 million. Total funding of $56.8 million will be provided by the Commonwealth for new and ongoing projects in 2000.

The 2000-01 Budget provides for additional SPIRT funding of $62.8 million over three years, commencing in 2002, to ensure that the total number and value of new SPIRT projects are maintained at 1998 levels on an ongoing basis.

Research Fellowships Scheme

Fellowships provide support for individuals to undertake research at postdoctoral level and above. In 2000, $27.4 million has been allocated to the Scheme.

There are four types of Fellowship:

- *Australian Postdoctoral Fellowships (APDs)* are for researchers with less than three years of postdoctoral experience. Fifty-five new APDs have been awarded in 2000.
- *Australian Research Fellowships (ARFs)* are for researchers with at least three years', but no more than eight years' postdoctoral experience. Fifteen new ARFs have been awarded in 2000.
- *Queen Elizabeth II Fellowships (QEIIs)* are for outstanding researchers who would usually have, at most, eight years of postdoctoral experience. Fifteen new QEIIs have been awarded in 2000.

- *Senior Research Fellowships (SRFs)* are for researchers with established reputations who would normally have a maximum of fifteen years of postdoctoral experience. Fifteen new SRFs have been awarded in 2000.

International Researcher Exchange Scheme

The *International Researcher Exchange (IREX) Scheme* will provide funding in 2000 of $2.6 million to support the movement of researchers between Australian research institutions and centres of research excellence overseas. The Scheme has two elements:

- IREX Fellowships under bi-national agreements for reciprocal exchange of researchers (with France, Germany, the Republic of Korea and the United Kingdom); and
- IREX Awards to build links between research centres of excellence in Australia and overseas by funding extended collaborations.

In 2000, funding of $2.6 million will support 19 Fellowships and 89 Awards. The Awards cover collaboration with 23 countries, with 18 Awards involving collaboration with more than one country.

Research Centres Scheme

A total of $25.1 million is being provided to Research Centres in 2000. Two types of centres are supported:

- *Special Research Centres (SRCs)*are established on the basis of research excellence and their potential to contribute to the economic, social and cultural development of Australia. The Centres are funded as recognised sources of expertise that promote cooperative links with government, industry and relevant communities. In 2000, funding of approximately $19.5 million is being provided to nineteen SRCs, including eleven new Centres arising from a selection round which took place in 1999.
- *Key Centres of Teaching and Research* aim to promote excellence in teaching and research activities in higher education institutions, particularly in areas of national importance, and to encourage interaction with industry and other user groups. Key Centres receive an average grant of $360,000 a year from the Scheme, but most obtain additional funding from other sources. In 2000, funding of $5.6 million is being provided to seventeen Key Centres.

Research Infrastructure Equipment and Facilities Scheme

The Research Infrastructure Equipment and Facilities (RIEF) Scheme funds relatively large-scale initiatives which develop major research infrastructure on a cooperative basis across groups of institutions and with organisations outside the higher education sector. Grants can also be made to individual institutions in cases where cooperative arrangements are impractical or inappropriate. In 2000, RIEF will provide funding of $22.1 million.

The Budget provides for additional funding of $16.3 million over four years, commencing in 2001, to boost RIEF base funding to $24.6 million.

Other Schemes

The ARC also administers the Indigenous Researchers' Development Scheme, the Special Research Initiatives Scheme and the Learned Academies' Special Projects.

- The *Indigenous Researchers' Development Scheme* aims to encourage participation in research by indigenous Australians. The key objective of the scheme is to develop the performance and the expertise of successful grantees to a level that would enable them to be competitive in applying for other ARC schemes.
- The *Special Research Initiatives Scheme* provides support for networking activities among Australian researchers. The scheme aims to develop collaboration among researchers already supported by ARC schemes so that the quality and effectiveness of that research may be enhanced. It also seeks to support research capacity in innovative areas.
- *Learned Academies' Special Projects* provides support on a competitive basis to the Learned Academies and the National Academies' Forum.

Arrangements for 2001

The Government's policy statement on research and research training, *Knowledge and Innovation*, announced major changes to the funding framework for higher education research (see Section 2). These new arrangements will be introduced from 2001.

DETYA managed schemes

Institutional Grants Scheme

The Institutional Grants Scheme (IGS) will support the general fabric of institutions' research and research training activities, and assist institutions in responding flexibly to their environment in accordance with their own strategic judgements. Funding under the IGS will be allocated on the basis of a formula that reflects success in attracting research income from a diversity of sources (60 per cent), in attracting research students (30 per cent), and in the quality and output of its research publications, through a revised publications measure (10 per cent). Research income from all sources will be equally weighted. The Scheme absorbs funding previously allocated for the Research Quantum and the Small Research Grants Scheme.

Research Training Scheme

This Scheme will provide funding for research training according to a performance-based formula. Institutions will attract a number of scholarship places based on their performance through a formula comprising three elements: numbers of all research students completing their degrees (50 per cent), research income (40 per cent) and a revised publications measure (10 per cent). The value for each element will be the average of the latest two years' data. While the Scheme will be introduced in 2001, the formula will first be applied to 2002 funding allocations.

Funding for the Research Training Scheme willbe provided from the research training component of the universities' operating grant, which takes into account the relative costs of teaching across fields and levels of study. Students will be eligible for a Commonwealth-funded place for up to four years for PhD study and up to two years for Masters study, on a full-time equivalent basis. All commencing Commonwealth-funded research places will be HECS-exempt from 2001 (see also Chapter 2).

Final funding for 2001 is yet to be determined and will depend on the number of higher degree research places universities choose to fund under the new framework. A decision has not yet been made on whether the Australian Postgraduate Awards Scheme and International Postgraduate Research Scholarships Scheme will continue as separate schemes, or become elements of the proposed Research Training Scheme.

Research Infrastructure Block Grants Scheme
A separate Research Infrastructure Block Grants Scheme will continue under the new framework.

ARC managed schemes

National Competitive Grants Program
The new National Competitive Grants Program (NCGP) is expected to become operational in 2002 (from the selection of applications in 2001). The NCGP will subsume all schemes currently administered by the ARC.

Under the NCGP, the Large Research Grants Scheme will be amalgamated with the Australian Research Fellowships Scheme under the *Discovery* element of the Program. *Discovery* will support excellent fundamental research by individuals and teams with funding ranging from $20,000 to $500,000 per annum for a period of up to five years. *Discovery* will also offer a range of Fellowships; support early career researchers; and support highly innovative and promising ideas and approaches to research.

The SPIRT Scheme will form part of the *Linkage* element of the Program. *Linkage* will provide opportunities for research collaboration between universities, public research organisations and industry to maximise the economic, social and cultural benefits of research. The opportunities for collaborative research will range from small projects to larger multi-faceted research projects involving several collaborative partners.

Also under the umbrella of the NCGP, a proposed Centres of Excellence Scheme will span the two elements (*Discovery* and *Linkage*) to support research requiring significant national and international collaboration.

2000-01 Science and Innovation Priorities

Knowledge and Innovation

New framework for higher education research and research training priorities

The new funding and policy framework for research and research training announced in *Knowledge and Innovation* is designed to:

- ensure Australia is able to maintain and develop its research competence and international credibility across a wide range of fields of knowledge;
- facilitate the provision of diverse, high quality research training environments;
- expand opportunities and choice for research students;
- encourage the expansion of the total national investment in research;
- enable research organisations to respond flexibly to changes in the development of and demand for knowledge;
- extend the contributions of higher education research to the national innovation system through closer links with industry; and
- support the development and dissemination of knowledge for its own sake as well as the economic, social and cultural benefits it will bring to the wider community.

Regional priorities

The regional package announced in *Knowledge and Innovation* will assist universities to develop regional connections, foster a shift towards a more entrepreneurial framework, concentrate research activity into areas of strength, and assist institutions to take advantage of opportunities presented through new fields of research (see also Chapter 2). Key elements are:

- from 2001, $10 million of the existing SPIRT Scheme, will be dedicated to supporting research on issues of concern and benefit to rural and regional communities. Research projects funded under this element will be consistent with the Government's regional priorities; and
- also from 2001, $6 million will be available to support to regional institutions over a three-year transitional period, to enable them to adapt to the new arrangements.

ENVIRONMENT AND HERITAGE

Science and Innovation in the Portfolio Budget

The portfolio consists of the Australian Antarctic Division, Australian Greenhouse Office, Bureau of Meteorology, Environment Australia and the newly formed National Oceans Office.

Australian Antarctic Division

The Australian Antarctic Division has a total projected accrual budget of $93.9 million in 1999-2000 and $97.9 million in 2000-01. The Division directly undertakes and supports scientific research in the Australian Antarctic Territory, the Southern Ocean and Australia's sub-Antarctic islands. In addition to the goal of maintaining the Antarctic Treaty System and enhancing Australia's influence within the System, the Division's priorities, as defined in the Government's response, *Australia's Antarctic Program Beyond 2000 - A Framework for the Future*, are to:

- protect the Antarctic environment;
- understand the role of Antarctica in the global climate system; and
- undertake scientific work of practical, economic and national significance.

Through the Antarctic Science Advisory Committee (ASAC) Grants Scheme, the Australian Antarctic Division provides research funding to support high-quality research projects that will make a significant contribution to Australia's Antarctic research program. The Scheme supports research by investigators based at Australian organisations, such as tertiary institutions, that are not primarily funded by government to undertake research. In 1999-2000, a total of $570,000 was provided for 49 projects.

Australian Greenhouse Office

The Australian Greenhouse Office (AGO) is the lead Commonwealth agency on greenhouse matters, providing a major focus for greenhouse policies and programs including research. The Office reports to the Ministerial Council which includes the Minister for the Environment and Heritage, the Minister for Industry, Science and Resources and the Minister for Agriculture, Fisheries and Forestry, and is supported by the Secretaries' Committee on Greenhouse. AGO is responsible for:

- Australian Greenhouse Science Program;
- National Greenhouse Gas Inventory Program;

- National Carbon Accounting System;
- Renewable Energy Commercialisation Program (RECP); and
- Renewable Energy Equity Fund (REEF).

Within the AGO, the Australian Greenhouse Research Program continues to provide national level focus and direction for greenhouse science research. The Program's objectives are to:

- provide an overarching framework for Australian greenhouse scientific research;
- enhance the interface between greenhouse science and government to ensure the scientific basis for relevant policies and programs nationally and internationally;
- maintain and enhance scientific and technical proficiency, expertise and standing in greenhouse science;
- identify strategic impacts, risks and opportunities arising from climate and atmospheric change for economic, social and environmental systems;
- identify strategic options for adaptation and mitigation; and
- monitor and influence international developments to proactively meet international obligations under the Climate Change Convention and the Kyoto Protocol.

Inventory

The National Greenhouse Gas Inventory (NGGI) is a database of human induced emissions of greenhouse gases from sources and removals by sinks completed on a sectoral basis. Annual national inventories provide a trend line that may be used to monitor and review response actions and may be used as a base to develop emissions projections.

Bureau of Meteorology

The Bureau of Meteorology, as the national meteorological authority for Australia, has primary responsibility for research directed at the broad delineation of the characteristics of Australian weather and climate, and for liaison with the World Meteorological Organization (WMO) in relation to relevant research in Australia. The Bureau maintains a wide involvement in atmospheric, hydrological and oceanographic research at both national and international level, encompassing partnership in three Cooperative Research Centres (CRCs), collaboration in research and development projects with several Australian and overseas universities and government agencies, as well as through bilateral and multilateral agreements with overseas governments and National Meteorological Services.

To fulfil its research objectives, the Bureau:

- encourages high quality research in-house as a foundation for effective collaboration with the external research community and for the implementation of improved systems and techniques for the

provision of services;

- fosters meteorology in the tertiary education sector to ensure access to well-trained graduates and maintenance of the national research infrastructure for atmospheric sciences; and
- ensures effective coordination with the research programs of other relevant institutions both within Australia and overseas.

Environment Australia

Environment Australia consists of six groups: Australian and World Heritage Group, Biodiversity Group, Environment Protection Group, Portfolio Strategies Group, Science Group and Marine Group. This structure includes several research organisations and programs, for example, the Environmental Research Institute of the Supervising Scientist, the Australian Biological Resources Study and the National Wetlands Research and Development Program.

The Australian Biological Resources Study (ABRS), which forms part of the Biodiversity Group, promotes taxonomic and biogeographic studies of biodiversity through two programs:

- the Participatory Program, a unique research grant scheme which provides funds towards taxonomic and biogeographic research; and
- the Publications Program which brings together taxonomic information to produce major national series of books, CD-ROMs and web-delivered databases on Australia's plants, animals and other organisms.

The Australian National Botanical Gardens conduct research on the horticulture of Australian plants; and through the Centre for Plant Biodiversity Research, undertake research on the taxonomy, systematics, identification, genetics and biology of the Australian flora. Anew agreement is being negotiated between CSIRO and Environment Australia to extend the life of the Centre for an additional term. The Centre contains the Australian National Herbarium and its resources underpin the Commonwealth's botanical information. A particular priority is the capture and maintenance of reliable data for environmental management and decision-making.

The Biodiversity Group is also responsible for the management of parks and reserves owned or leased by the Commonwealth. To assist in this management, research is conducted in a number of parks, including Kakadu and Uluru-Kata Tjuta National Parks.

The $18.5 million Air Pollution in Major Cities Program, funded from the Natural Heritage Trust and administered through Environment Australia's Environment Protection Group, is developing national strategies to minimise the impact of air pollution.

National Oceans Office

The Office has a total projected accrual budget of $32.5 million over the three years to 2002. Information on the National Oceans Office is available at *www.oceans.gov.au*.

Great Barrier Reef Marine Park Authority (GBRMPA)

The Authority is responsible for the management of the Great Barrier Reef Marine Park and is involved in the management of the Great Barrier Reef World Heritage Area. The Authority works jointly with a number of Commonwealth and Queensland government agencies, such as Queensland Parks and Wildlife Service, Queensland Environment Protection Agency, Queensland Fisheries Management Authority and the Queensland Department of Primary Industries to achieve more effectively the Marine Park's management objectives. The Authority will continue to focus on issues that are critical for appropriate protection and use of the Great Barrier Reef Marine Park and World Heritage Area.

These critical issues, as identified in the Authority's Strategic Business Plan are conservation, biodiversity and world heritage, tourism and recreation fisheries and water quality.

2000-01 Science and Innovation Priorities

Australian Antarctic Division

The Australian Antarctic Division's science program for the next five years will be guided by the *Australian Antarctic Science Strategies Plan 2000-05*. The Plan aims to integrate and consolidate the work of all agencies and universities that conduct scientific research in the Antarctic under Australia's Antarctic Program. This Program focuses on the following Government goals:

- maintaining the Antarctic Treaty System and Australia's influence in the System;
- protecting the Antarctic environment;
- understanding the role of Antarctica in global climate change; and
- undertaking scientific work of practical, economic and national significance.

The Australian Antarctic Division will continue to maintain its support of the Bureau of Meteorology, Ionospheric Prediction Service and AGSO in obtaining meteorological, ionospheric, magnetic and seismological observations that are of practical importance to their functions in Australia.

Bureau of Meteorology

The Bureau of Meteorology's science and innovation priorities for 2000-01 apply to activities contributing to its four Output groups: Meteorological and related Data and Products, Meteorological and related Research, Meteorological and related Services, and International Meteorological Activities. Within this context, for 2000-01 the Bureau of Meteorology will:

- maintain the Bureau's basic observational networks to the standard possible through the additional funds provided under the continuing 1999-2000 budget measure, *Providing World-Class Weather Forecasting*;
- further enhance the efficiency and effectiveness of forecasting operations through consolidated and upgraded IT infrastructure such as supercomputer access, data archival and retrieval methods, high speed communications and regional computing capacity;
- improve further the scope, accuracy and reliability of the Bureau's numerical weather and climate prediction systems;
- maintain a program of climate research directed towards improved understanding of the natural variability of Australia's climate and reducing uncertainties in simulated changes to climate;
- work on developing very short range forecasting capability with a view to carrying out a demonstration project during the Sydney Olympic Games;
- trial the existing El Niño-Southern Oscillation ocean forecasting model and work towards improving the model's predictive capability;
- promote the application of meteorological and related services within the community and redesign and develop these in response to community needs, particularly in rural and regional areas;
- review the impacts of climate variability on agriculture during the past century;
- improve generalised Probable Maximum Precipitation (PMP) design rainfall methods in Australia by continuing the revision of the Generalised Tropical Storm Method (GTSM) in association with Australian water industry partners; and
- collaborate with AusAID, as a major funding source for supporting activities in the region of the SW Pacific and South-East Asia, to undertake activities including participating in the WMO-ESCAP project on smoke haze for the ASEAN countries, providing meteorological support for Vietnam particularly in relation to typhoon warning systems, and contributing to an analysis of the meteorological needs of South Pacific countries.

Environment Australia

The **Biodiversity Group** will continue to implement its obligations under the Convention on Biological Diversity including the application of the Cartagena Biosafety Protocol and the management of its recently established clearing house mechanism for biodiversity, a web site at

www.environment.gov.au. The Group will continue conducting related research activities which contribute to the conservation and sustainable use of biological diversity.

The **ABRS** will continue to coordinate, fund and disseminate taxonomic information on Australia's plants, animals and other organisms. A priority is to broaden the scope of ABRS publications to make taxonomic information available to the widest possible user base, utilising a variety of delivery mechanisms. Partnerships will be developed with individuals and other organisations to tailor outputs to user requirements.

The **Environment Research Institute of the Supervising Scientist (ERISS)** will continue to carry out research in the principal programs on the impact of mining on people and ecosystems in the Alligator Rivers Region and on the ecology and conservation of tropical wetlands. Priorities include:

- assessing the impact of the possible development of Jabiluka. ERISS will continue collecting radiological, sediment transport and hydrology data from the area around the Jabiluka mine site, in particular Swift Creek, the catchment of which contains the mine site;
- providing detailed analyses of rehabilitation and revegetation options and processes at the Nabarlek mine site;
- providing support for and further developing the National Centre for Tropical Wetlands Research;
- developing techniques for and undertaking inventory and assessment of tropical wetlands including assessing changes to wetlands as a consequence of climate change and sea level rise; and
- undertaking risk assessment of major pest species in northern Australian wetlands.

The **Marine Group** administers programs under the Natural Heritage Trust, Coasts and Clean Seas (C&CS) and *Australia's Oceans Policy*.

- Under C&CS, priorities will focus on developing alternatives to organotin-based antifouling paints in response to the Government's proposed ban on these paints in 2006 and the development of improved evaluation of the effect of toxic antifoulants on the marine environment to assist management of dredge spoil.
- Under *Australia's Oceans Policy*, the Coastal Acid Sulfate Soils Program (CASSP) has allocated approximately $3 million for demonstration projects to illustrate a range of innovative techniques for the management of coastal acid sulfate soils including remediation/rehabilitation technologies.

National Oceans Office

Priorities for 2000-01 for the small National Oceans Office now being established in Hobart will include:

- refinement of the Regional Marine Planning process and its application in the South-east Region, including the development of

regional assessments of environmental, economic and social and cultural values;

- integration of regional assessment for the South-east Region Regional Marine Plan with existing Commonwealth and State government and sectoral programs, particularly those in coastal zone management; and
- completion of the Oceans Policy Implementation Strategy, required to coordinate action on the wide range of commitments and proposals, including linkage with initiatives related to the implementation of the *Marine Science and Technology Plan*, launched in June 1999.

Great Barrier Reef Marine Park Authority

Key priorities for GBRMPA during 2000-01 will be:

- to develop a framework for selecting, and implementing the protection of, candidate areas for consideration in the comprehensive network of representative areas within the Great Barrier Reef World Heritage Area;
- protection of threatened species such as dugongs, turtles, whales and dolphins and conserving biodiversity;
- inclusion of 28 new areas into the Great Barrier Reef Marine Park;
- management to ensure sustainable fisheries in the Great Barrier Reef World Heritage Area and to determine levels of fishing effort that are ecologically sustainable;
- identifying the source, trends, fate and consequences of pollutants (nutrients, sediments, pesticides and heavy metals) in the Great Barrier Reef lagoon.
- tourism use management;
- continued development of mechanisms and methods of reporting on social, economic and cultural heritage values in the Great Barrier Reef World Heritage Area; and
- development of communication strategies and mechanisms to communicate with stakeholders and the general public more effectively to improve their awareness ofthe major issues relevant to the Great Barrier Reef Marine Park and its management. This will include the establishment of a new Communication and Education Group to specifically address these issues.

HEALTH AND AGED CARE

Science and Innovation in the Portfolio Budget

The Health and Aged Care Portfolio is committed to achieving better health outcomes through:

- improving access to and use of health information by consumers, providers and planners; and
- supporting 'world class' knowledge creation and research capacity - and the translation of this knowledge, information and training for the benefit of all Australians.

The Portfolio, through the National Health and Medical Research Council (NHMRC) and its Office, Portfolio Strategies Division, Corporate Services Division and the Australian Institute of Health and Welfare, will manage the achievement of this outcome through:

- funding support for health and medical research;
- facilitating national effort to reduce the public and personal burden within National Health Priority Areas;
- monitoring and improving the training and distribution of the medical workforce;
- providing access to quality health information for consumers through the Healthlnsite Internet facility;
- improving the delivery and quality of health care through the National Council for Quality and Safety and effective and innovative use of health information and information technology;
- effective use of information and knowledge to support evidence-based advice on policy issues;
- providing the opportunity for community involvement in policy and delivery of the programs; and
- informing community discussion and decision making through national leadership in the development and provision of authoritative and timely information and analysis on the health and welfare of Australians.

The NHMRC is a major contributor to the achievement of this outcome. The NHMRC was established under the *National Health and Medical Research Council Act 1992* and has the following statutory obligations to:

- raise the standard of individual and public health throughout Australia;
- foster the development of consistent health standards between the various States and Territories;

- foster both medical and public health research and training throughout Australia; and
- foster consideration of ethical issues relating to health.

To meet these obligations the NHMRC works through three major programs– research, advice and ethics.

2000-01 Science and Innovation Priorities

During 2000-01, the Department will continue to support the work of the NHMRC, with a major focus being the implementation of changes to the way NHMRC funds research, to better reflect contemporary health research and better achieve the strategic aims of the NHMRC in health research.

During the year, a Departmental restructure is expected to separate the Council activities of the Office of the National Health and Medical Research Council from its other responsibilities. The new Chief Executive Officer, who is to be appointed as part of the restructure, will have responsibility for Council support activities.

A key priority for the Department will be the continued implementation of the Government's response to the findings of the *Health and Medical Research Strategic Review*. The *Review* identified the threats to our health and medical research sector, investigated the likely future opportunities and developed recommendations on the most appropriate strategy to deliver the best health outcomes for Australia.

INDUSTRY, SCIENCE AND RESOURCES

Science and Innovation in the Portfolio Budget

Portfolio activities in science and innovation are focused on:

- developing Australia's science and technology capabilities and infrastructure;
- ensuring public sector scientific research delivers effective benefits; and
- stimulating innovation in the Australian business sector.

The major objectives and planned achievements for the Department of Industry, Science and Resources (ISR) in 2000-01 include the:

- provision of strategic leadership in industry and science;
- development and implementation of industry, science and innovation policy;
- effective design and management of industry and science programs;
- promotion and facilitation of investment in Australia; and
- delivery of effective scientific business services.

Policy advice and analysis across a broad front relating to science, technology, innovation, research and development are provided by the Science and Technology Policy Branch, the Innovation Policy Branch and the International Relations and Technology Diffusion Branch of the Department's Innovation and Science Division to meet Government, community and international needs.

Cross-portfolio advice and coordination of science, technology, engineering and innovation are provided by the combination of the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), the Chief Scientist and the Coordination Committee on Science and Technology (CCST).

The portfolio manages Austalia's participation in international multilateral and bilateral science and technology activities to enhance economic and social benefits through a strengthened national system of science and innovation. This includes participation in the OECD Committee for Science and Technology Policy (CSTP), the APEC Industrial Science and Technology Working Group (IST WG) and in the development of international megascience projects such as the Global Biodiversity Information Facility.

The portfolio contains four scientific research organisations and three scientific service providers. The former four are the Commonwealth

Scientific and Industrial Research Organisation (CSIRO), the Australian Nuclear Science and Technology Organisation (ANSTO), the Australian Institute of Marine Science (AIMS) and the Australian Geological Survey Organisation (AGSO), with the latter three being the Australian Surveying and Land Information Group (AUSLIG), the Australian Government Analytical Laboratories (AGAL) and the Ionospheric Prediction Service (IPS). The portfolio also includes the National Standards Commission (NSC).

The Industry Research and Development (IR&D) Board, comprising industry and government representatives, promotes research and development activities within the portfolio so as to improve the efficiency and international competitiveness of Australian industry.

Budget support for these programs is shown in the table below.

Program or agency	Estimated accruals 1999-2000 $m	Estimated accruals 2000-01 $m
CSIRO	617.1	610.0
ANSTO	104.6	158.9
AIMS	25.0	26.1
AGSO	62.1	62.4
AUSLIG	26.8	26.1
Ionospheric Prediction Service	3.8	3.6
CRC Program	142.9	134.4
National Research Facilities	5.1	4.6
Industry Innovation (Incl. R&D Start & COMET)	155.5	154.5
Innovation Investment Fund	48.7	31.5
Technology Diffusion Program	18.6	20.5
Shipbuilding Innovation Program	9.1	9.5
Pharmaceutical Industry Investment	34.0	55.1
STAP	2.2	3.6

It should be noted that IP Australia is not included in the figures as it operates on full cost recovery.

Innovation, science and technology policy

Innovation and international competitiveness can be achieved by R&D investment and encouraging better use of Australia's research infrastructure. The improvement of conditions for the commercialisation of new processes and product technologies developed by Australian companies and the development of a greater capacity for adaptation of

foreign technology will help Australia achieve competitiveness in leading technological and emerging markets.

There is a significant effort to provide policy advice and conduct research to enhance awareness of the importance of the acquisition, management and promotion of knowledge to the Australian economy. This emphasis links into initiatives in other Federal Government Departments that encourage investment in knowledge-based economy (KBE) activities and establishes links with industry, researchers and other countries on KBE-related issues for effective dissemination of information on drivers of competitiveness.

Scientific research organisations

Scientific research organisations within the portfolio make a substantial contribution to national research and development activities.

- CSIRO's primary functions are to: carry out scientific research for the purpose of assisting Australian industry, furthering the interests of the Australian community, contributing to the achievement of national objectives or the performance of national and international responsibilities; facilitate the application or utilisation of the results of scientific research; and carry out services, and make available facilities, in relation to science. Its secondary functions include liaison with other countries in matters connected with scientific research; training of research workers; establishment and maintenance of standards of measurement; collection, interpretation and dissemination of information on scientific and technical matters; and publication of scientific and technical reports, periodicals and papers.
- ANSTO is Australia's only nuclear research organisation and the centre of Australian nuclear expertise. Through its baseline funding, ANSTO maintains and manages its nuclear research infrastructure and operates core nuclear facilities in Australia and overseas for the benefit of the Australian research and development community and industry. These include the National Medical Cyclotron, the Australian National Tandem Accelerator and the High Flux Australian Reactor (HIFAR). ANSTO is responsible for delivering specific advice, scientific services and products to government, industry, academia and other research organisations. It does so through the development of new knowledge, delivery of quality services and support for business opportunities.
- AIMS is one of Australia's key research agencies and the only one committed primarily to marine research and with an emphasis on tropical marine science. Its objectives are to promote the conservation and sustainable development of Australia's marine resources and to support internationally competitive Australian industries.
- AGSO is Australia's national geoscientific research and information agency. Its main objective is enhanced potential for the Australian community to obtain economic, environmental and social benefits through the application of first class geoscientific research and information. AGSO achieves this outcome through facilitation of enhanced global attractiveness of Australia's offshore and onshore exploration investment opportunities, improved resource

management and environmental protection, and safer communities and transportation.

Scientific service providers

Scientific service providers within the Department provide strategic support to the Government and industry.

- AUSLIG is Australia's national mapping agency, providing fundamental geographic information to support the mining, agricultural, transport, tourism and communications industries; and defence, education, surveillance and emergency services activities. AUSLIG is responsible for:

  - policy, standards and coordination of spatial information matters; and

  - management of the national mapping, maritime boundary, remote sensing and geodesy programs.

  AUSLIG is also responsible for the implementation of the Australian Spatial Data Infrastructure (ASDI) at the Commonwealth level. The ASDI aims to provide better access to essential geographic information about Australia to Government, the private sector and the broader community. This increased accessibility is necessary to improve decision making in such areas as environmental assessment, natural resources management, socio-economic studies and physical infrastructure development such as mobile communications networks, roads, railways, power grids and airports.

- AGAL plays an important strategic role in protecting Australian public health and safety, the environment and international trade through its quality analytical services in analytical chemistry, microbiology, fire safety and physical testing. AGAL's operations are aimed at providing support for government and industry and, in particular, they maintain an analytical crisis-response infrastructure.

- IPS offers a comprehensive range of services to Australian and overseas agencies operating in the fields of radiocommunications, land, sea and air transport, broadcasting, defence applications, spacecraft operation and geophysical exploration. IPS warns of changes in the ionosphere and the near-earth space environment that may affect the performance of the customers' systems. A network of observatories in Australia, Papua New Guinea and Antarctica, which monitors solar, geomagnetic and ionospheric behaviour, backs up the services that IPS provides. IPS also exchanges information with a worldwide net or similar observatories. IPS provides consulting services to optimise the planning and operation of radio networks and presents training courses, customised to meet customers' needs, throughout Australasia.

- NSC is responsible for the administration of the *National Measurement Act 1960*: for advising the government on the needs of the national measurement system; for coordinating the system; and representing Australia on international and regional legal metrology committees. The Commission's principal aim is to ensure confidence in physical measurements so as to reduce disputation and minimise transaction costs. This is achieved by the Commission by ensuring there is an

appropriate metrological control system in place for a wide range of trade regulatory and chemical measurements.

Science, technology and industry linkages

Cooperative Research Centres (CRC)

The CRC Program seeks to maximise the capture of the benefits of research through the development of enhanced cooperative linkages between researchers and research users in the public and private sectors. It provides support for long-term collaborative ventures linking researchers from universities and government research organisations with business enterprises and public sector research users. It promotes high quality cooperative research and education programs through centres of research concentration, which strengthens the links between research and its commercial and other applications.

CRCs are established under formal contracts with the Commonwealth, normally for seven years, to undertake long-term strategic research focusing primarily on the natural sciences, engineering and their application. The CRC Committee, which is appointed by the Minister for Industry, Science and Resources, provides advice on the CRC Program.

The Program requires that the participants in an individual CRC contribute resources to at least the value of the program funding provided to the CRC. In practice, the participants contribute an average of 2.3 times the program funding. Industry is a major contributor in those CRCs that have an industry focus, averaging 25 per cent of resources overall.

CRCs are subject to a formal independent performance review after the completion of the second and fifth years of operation. A strong focus of the fifth year review is the progress against milestones in the achievement of the outputs for the CRC identified in the business plan.

Major National Research Facilities (MNRF) Program

The MNRF Program is directed at keeping Australia at the leading edge of scientific and technological developments. Under the Program, funding is provided for facilities in a range of key scientific fields where the establishment costs are beyond the capacity of any individual Australian institution. These facilities create centres of capability for pursuing research with state-of-the-art equipment.

IP Australia

IP Australia provides property rights and associated services for inventions, trade marks and designs. Legal protection provided by the rights encourages industry to develop and exploit new technologies as well as facilitating the transfer of overseas technology to Australia. The organisation operates on full cost recovery.

Science Awareness

The Science and Technology Awareness Program (STAP) aims to increase awareness and understanding of the central role which science and

innovation play in enhancing Australia's economic and social well-being. STAP was reviewed in 1999, and the review provided a range of options for improving awareness about the important contribution science and innovation make to the nation's well-being. It recommended ongoing support for the program. STAP's appropriation is $3.6 million in 2000-01, compared with $2.2 million in 1999-2000.

Programs supporting research and innovation by business

R&D Tax Concession Program

A deduction of 125 per cent is allowable for qualifying expenditure incurred on R&D carried on in Australia. Acompany's total research and development expenditure for the year must be greater than $20,000 to qualify for the concession, unless the R&D is carried out by a Registered Research Agency, in which case the expenditure threshold is waived.

The program is effectively market driven, being structured in a manner which is neither industry nor product specific, allowing companies to determine both the area of innovation and the direction of their R&D activities.

R&D Start Program

The *R&D Start* program, introduced in November 1996, is a competitive, merit-based program, which supports businesses in their industrial research and development, and related activities. *R&D Start* aims to:

- increase the number of projects involving research and development activities with a high commercial potential that are undertaken by companies;
- foster greater commercialisation of the outcomes of those projects;
- foster collaborative research and development activities in industry and between industry and research institutions;
- encourage successful innovation in small companies by supporting commercialisation of internationally competitive products, processes and services;
- increase the level of research and development activity in Australia that is commercialised in a manner that will benefit the Australian economy; and
- increase the level of research and development activity conducted that provides national benefit.

The R&D Start program has five elements of financial assistance.

- *Core Start* provides grants of up to 50 per cent of project costs for companies with group annual turnover of less than $50 million to undertake R&D projects;
- *Start Plus* provides grants of up to 20 per cent of project costs for companies with group annual turnover of $50 million or more to undertake R&D projects;
- additional assistance is available for high-quality projects through *Start Premium*, which offers companies an additional, repayable amount, which 'tops up' either *Core Start* or *Start Plus* assistance to a maximum of 56.25 per cent of project costs;
- *Start Graduate* grants are available for companies with annual turnover of less than $50 million to engage a graduate on a R&D-related project that is undertaken in collaboration with a research institution. The project may be for a maximum of 2 years in duration; and
- *Concessional Loans* are available to companies/groups which employ fewer than 100 persons and are involved in the early commercialisation of technological innovations. Loans are for 50 per cent of project costs, with interest waived during the first three years of the project and the loan repaid in the following three years.

The IR&D Board expects to approve between $150 million and $180 million of new grants and loans during 1999-2000.

Innovation Investment Fund (IIF) Program

The IIF aims to provide access to equity capital to encourage new technology companies to improve the commercialisation outcomes of Australia's strong research and development capabilities and to create a self-sustaining, early-stage technology-based venture capital market. Together with private sector funding, the $221 million in funding provided by the Government over the ten years of the program will create an overall investment pool of over $330 million for early-stage venture capital investments.

Renewable Energy Equity Fund (REEF)

REEF is a specialist renewable energy fund to provide venture capital to small enterprises at the seed, start-up or early expansion stage of investments leading to the commercialisation of renewable energy technologies. The Government has provided almost $20 million for REEF. This will be invested along with private sector funding on a 2:1 basis.

REEF is based on the existing IIF Program and is administered by the IR&D Board through Auslndustry, on behalf of the Australian Greenhouse Office. CVC REEF Ltd, which has recently been offered the licence to operate as the REEF fund manager, is expected to commence formal operations in mid-2000.

Commercialising Emerging Technologies (COMET) Program

The COMET program has a program budget of up to $30 million over three years from 1999-00. Two forms of assistance are offered to clients of the program:

- *Tailored Assistance for Commercialisation* (TAC) provides individually tailored assistance developed to meet a client's specific needs with regard to commercialisation; and/or
- *Management Skills Development* (MSD) provides financial assistance to undertake an existing program of management development which will enable clients to increase their capacity for innovation and commercialisation.

National Business Information Service (BIS)

The BIS is an integrated suite of information delivery services using modern web technologies as the basis for the provision of comprehensive and up-to-date Government information relevant to business. This information is provided through: www.business.gov.au and a Business Call Centre service (freecall l3 28 46).

Technology Diffusion Program

The Technology Diffusion Program (TDP) helps industry and researchers to access and adopt new and leading-edge technologies developed in Australia and overseas, thereby promoting innovation and competitiveness. Over the period of July 1998 to June 2002, about $75 million will be provided to the industry and research community for international S&T collaboration and nationally focused technology diffusion activities.

Shipbuilding Innovation Scheme

The Shipbuilding Innovation Scheme (SIS), introduced in July 1999, is designed to develop a stronger, sustainable and internationally competitive Australian shipbuilding industry by encouraging product research and development and design innovation. $9.5 million has been committed for 2000-01.

Under SIS, shipbuilders registered under the relevant legislation will be entitled to the payment of a benefit, at the rate of 50 per cent of eligible R&D expenditure, up to a total of 2 per cent of eligible production costs of a bountiable vessel. Eligible R&D expenditure includes adaptive engineering directed at product and process innovation in the shipbuilding industry.

TCF Strategic Investment Program

The Textiles Clothing and Footwear Strategic Investment Program (TCF SIP) came into operation during the latter part of 1999-00 and is the major element of the Government's post-2000 initiatives for the TCF industries in Australia. The scheme is designed to provide a major incentive for TCF firms to invest

and innovate to enhance their competitiveness in preparation for the more open global trading environment that will exist after 2005.

Under TCF SIP, $680 million (capped) willbe available in the form of grants to eligible firms in the TCF industries for the five years from July 2000 and, for certain activities, for the two preceding years. Subject to minimum thresholds and specified limits, grants will be payable to firms registered under the scheme that invest in new plant and buildings, undertake R&D including innovative product development, undertake value-adding activities, or take part in restructuring initiatives relating to TCF dependent communities. Among other aspects of the scheme, claims for grants to the value of 45 per cent of eligible R&D expenditure incurred can be made under TCF SIP.

Automotive Competitiveness and Investment Scheme

The Automotive Competitiveness and Investment Scheme (ACIS), the centrepiece of the Government's post-2000 transitional arrangements for the automotive industry, will become operational during 2000-01. The scheme is directed towards encouraging the development of internationally competitive firms in the automotive industry through rewarding eligible production, strategic investment and research and development.

ACIS will provide to registered industry participants benefits capped at $2.0 billion in the form of import duty credits over the five years to 31 December 2005. Amongst other benefits offered by the scheme, registered firms willbe able to claim duty credit on a quarterly basis equal to 45 per cent of the value of investment in R&D, subject to certain specified limits.

Pharmaceutical Industry Investment Program (PIIP)

The Pharmaceutical Industry Investment Program (PIIP) contributes to the development of an internationally competitive pharmaceutical industry in Australia. The PIIP supersedes the Factor (f) Scheme, a similar investment program that concluded in June 1999. The purpose of the PIIP is to compensate participating manufacturers for the reduced prices received under the Pharmaceutical Benefits Scheme (PBS) in return for commitments to undertake specific activities in Australia such as manufacturing, research and development.

The PIIP is expected to generate $1.1 billion in R&D expenditure and $5 billion in value-added production by participating companies over the life of the program.

2000-01 Science and Innovation Priorities

To achieve enhanced economic and social benefits through a strengthened national system of science and innovation, the Department will:

- provide strategic leadership in science and innovation;
- develop and implement science and innovation policy;
- undertake effective design and management of science and innovation programs; and
- deliver effective scientific business services.

The Department will provide policy advice and analysis in relation to science, innovation, research and technology.

Science and Technology Policy

Key priorities during 2000-01 will be:

- the release at the end of 2000 of the final report on Australia's science, engineering and technology capability by the Chief Scientist;
- policy advice to Government on nuclear science and technology, including oversight of the operation of the existing research reactor at Lucas Heights and construction of its replacement, and the management of spent reactor fuel;
- policy advice to the Government on matters relating to the operation of ANSTO, CSIRO and AIMS, including the introduction of output pricing agreements with effective performance indicators for the 2000-01 to 2002-03 triennium;
- secretariat support to the National Synchrotron Steering Group to assist with the development of a study investigating the feasibility of an Australian synchrotron facility;
- policy advice to the Government on matters relating to public sector research and research training;
- the *Science and Technology Budget Statement 2001-02*, which will provide an account of Commonwealth science and innovation expenditure, priorities and recent outcomes;
- analysis of macro indicators of science, technology and innovation with particular regard to decisions arising from recommendations of the Innovation Summit Implementation Group;
- policy advice to the Government on marine science and technology, in the context of the *Review of Tropical Marine Research, Australia's Marine Science and Technology Plan* and *Australia's Oceans Policy*; and
- policy advice to Government on the CRC Program, including conducting an evaluation of the program outcomes to date; the findings of this evaluation will feed into the full 10-year review of the Program to be conducted in 2001.

Innovation policy

Key priorities during 2000-01 will be to:

- develop and respond to recommendations of the National Innovation Summit;
- establish the National Entrepreneurship Competition;
- undertake the second phase of the Venture Awareness Program;
- complete evaluation of the R&D Start Program; and
- conduct a research project on issues relating to the measurement and reporting of intellectual capital, including examination of international experience. The project will also explore the impact on firm values of increased investment in intangible assets.

International Science and Technology

During 2000-01, international science and technology activities will include:

- effectively managing Australia's international science and technology relationships;
- coordinating Australian participation, and representing Australia in the APEC Industrial Science and Technology Working Group and other international organisations;
- supporting Australian participation in OECD science, technology and innovation forums and megascience projects, and monitoring key OECD studies of policy relevance, particularly the innovation and growth projects;
- working with AusIndustry to develop and manage the Technology Diffusion Program; and
- developing policy advice on international S&T collaboration and technology diffusion to achieve the government's economic and social objectives.

Biotechnology Australia

Key priorities for 2000-01 are:

- developing and implementing the National Biotechnology Strategy;
- enhancing the public's understanding of biotechnology and its applications, including areas of potential risk and their management;
- improving the management and use of biotechnology intellectual property in Australia; and
- developing a strategy to improve the policy and regulatory framework for enhanced access to biological resources.

CSIRO

CSIRO seeks to secure maximum benefits from R&D for Australia by assembling strong interdisciplinary teams that are internationally

competitive and focusing effort on those areas where there are firm signals of strong commercial or community support for CSIRO's research. CSIRO's planned investment of appropriation funds for its output groups are in the accompanying table.

Some major objectives for CSIRO in 2000-01 are:

- implementation of the research strategies and directions expressed in the *CSIRO Strategic Research Plan 2000-01 to 2002-03*, including:
  - development, with the food processing industry, of a'Virtual R&D Centre' for the substantiation of health claims and studies of microbiological food safety;
  - acceleration of the 'Glass Earth' research program to discover the next generation of giant ore deposits in Australia;
  - significant expansion of activities in biomineral processing and design of mine site remediation principles;
  - further consolidation of CSIRO's strength in building, testing and demonstrating multi-disciplinary, large scale, integrative land and water management solutions, e.g. Heartlands project for the Murray-Darling System; and
- establishment of a program to enhance the incubation of CSIRO technologies for the creation of new start-up companies, following the successful creation of equity in the Preston Group, PolyU and GroPep.

CSIRO's Planned Investment Profile 2000-01

CSIRO Output Grou p	**1999-2000 Estimated accrual $'000**	**2000-01 Estimated accrual $'000**
Manufacturing, Information and Services	119,299	195,464
Minerals and Energy	111,077	103,035
Environment and Natural Resources	111,077	129,405
Agribusiness	203,640	182,128
Total Appropriation	**617,093**	**610,032**
Revenue from other sources	258,781	276,169
Total Estimated Resourcing	**875,874**	**886,201**

Australian Nuclear Science and Technology Organisation (ANSTO)

The financial year 2000-01 is the first in ANSTO's new five-year strategic plan. At the end of five years, a replacement nuclear research reactor will be ready to provide much improved services to industry and the research community. The replacement reactor will be able to accommodate a range of advanced industrial applications because it will have a higher neutron flux, improved irradiation facilities, and better quality beams. The reactor will also better service the community's health care needs in securing sufficient

supply of diagnostic and therapeutic radiopharmaceuticals to satisfy Australia's requirements over the next 40 to 50 years. During 2000-01, reactor construction and instrument development will move into an active phase once a successful tenderer has been appointed.

ANSTO is further strengthening its collaborative approach to R&D and is streamlining the innovation process to improve delivery of results to participants and clients across Australia. Partnerships, through CRCs, with other research providers and industry and direct links with the mining industry provide key areas of collaboration.

Some key activities planned for ANSTO in 2000-01 include:

- development and commercialisation of technologies to remove and immobilise contaminants from industrial process effluents and groundwater in partnership with the CRC for Waste Management and Pollution Control;
- undertaking strategic R&D on the safety and life of welded structures in partnership with the CRC for Welded Structures;
- development of a generic problem-solving capability to provide new and important information on the nanostructure of selected materials using nuclear-based science and technology in partnership with the CRC for Polymers; and
- creation of a commercial entity to facilitate adoption of process and environmental management methods developed by ANSTO to assist the mining industry.

Australian Institute of Marine Science (AIMS)

The outcome and broad output proposed by AIMS represents an ongoing contribution to understanding the marine environment. Details of the output for 2000-01 are identified in the *Australian Institute of Marine Science Research Plan: 2000-2003* that will be published early in July 2000 and will be made available on the web at *www.aims.gov.au/research-plans*.

AIMS is refining its focus for the new triennium (2000-03) to 6 research projects which target priority areas for marine research:

- predicting climate effects upon tropical marine ecosystems;
- understanding and conserving tropical marine biodiversity;
- monitoring living marine resources of the Great Barrier Reef;
- mitigating human effects in the tropical marine coastal zone;
- deriving economic and social benefits from marine biotechnology; and
- exploring the marine resources of northern Australia.

These projects will be described in the *Australian Institute of Marine Science Research Plan: 2000-2003*.

In 2000-01 AIMS will:

- provide government, industry and the community with high quality scientific information relevant to the effective use and protection of Australia's marine resources;
- complete production of *Corals of the World*, a comprehensive, authoritative publication that will underpin research and heighten public interest in coral reefs;
- continue the construction of a new south wing, and the refurbishment of its main building; complete a project for the construction of a new research vessel to replace the *RV Harry Messel*, providing enhanced capabilities for research of Australia's coastal waters; and
- appoint a new Director.

Australian Government Analytical Laboratories (AGAL)

The key priorities for AGAL during 2000-01 will be to:

- deliver the Sydney 2000 Olympics Drug Testing Program;
- enhance capability and capacity in response to national needs in two specific areas of chemical measurement: dioxins and genetically modified food testing; and
- expand the National Analytical Reference Laboratory program of certified reference material production with a focus on agricultural and veterinary chemicals.

Australian Surveying and Land Information Group (AUSLIG)

AUSLIG contributes to the departmental output 'Scientific Business Services' which supports *Outcome 2*. AUSLIG's key initiatives include:

- determination of the Antarctic Baseline and Maritime Zones (year 1 of a 3-year program);
- installation of a second antenna at AUSLIG's remote sensing data acquisition facility in Alice Springs; and
- development of an online absolute GPS positioning service.

Ionospheric Prediction Service - Radio and Space Services (IPS)

The IPS budget for 2000-01 is expected to be $3.6 million.

The strategic goals of IPS are: to be recognised as a centre of expertise for space weather; andto provide timely radio propagation, geophysical and space weather services that customers will rely on to perform their operations, which are appropriate to the needs of the Australasian community, and that use best technical and business practices.

Providing outputs in scientific business services, IPS has two key activities:

- monitoring and analysis of space weather phenomena through a network of national and regional solar, ionospheric and geomagnetic observatories; and
- the provision of online and consultancy services in radio propagation and space weather.

The IPS priorities include:

- establishing the Australasian World Data Centre for Solar-Terrestrial Science;
- maintaining a world-class monitoring network for the provision of space weather services;
- marketing IPS services and expertise to customers, stakeholders and the space weather community;
- extending and developing services to meet customer needs;
- increasing the ability of staff to meet IPS needs; and
- increasing leadership and management capability.

National Standards Commission (NSC)

The Commission will seek to ensure enhanced confidence, both nationally and internationally, in the Australian measurement system.

In 2000-01, NSC will

- finalise requirements for certification and verification of electricity meters in support of the national electricity market;
- finalise an Australian standard for evidential breath analysers to allow certification of these instruments and provide a sound evidential basis for their measurements;
- contribute to international standards and develop national testing facilities for the certification of compressed natural gas (CNG) dispensers in support of the Government's greenhouse gas priorities;
- appoint certifiers of traceable certified reference materials in support of a wide range of chemical and environmental measurements; and
- finalise a mutual recognition agreement with New Zealand on pattern approval test results to facilitate trade in measuring instruments manufactured in the two nations.

Cooperative Research Centres (CRC) Program

Following the 5 July 2000 closing date for applications, the CRC Program will focus on the assessment of eligible applications for the 2000 selection round. The applications will be assessed in a three stage process, against nine selection criteria. The CRC Committee will make recommendations on funding to the Minister, based on the advice of two Expert panels appointed to assess the technical merits of each application.

The revised program guidelines place a greater emphasis on improving commercialisation and outcomes of the CRCs and seek to encourage greater levels of self sufficiency. The new Centres' contracts with the Government will implement these changes.

In addition, during 2000-01 the CRC Program will focus on:

- fifth year reviews of Fourth Round Centres;
- negotiation of contracts for those CRCs successful in the 2000 selection round; and
- wind-up of 2nd and 3rd Round Centres not continuing beyond their current funding terms.

Science Awareness

Key activities undertaken to increase awareness and understanding of the central role which science and technology play in Australia's economic and social well-being will include National Science Week; Science Olympiads; Michael Daley Awards; and S&T Awareness Grants.

Science Prizes include the Prime Minister's Prize for Science ($300,000); the Malcolm Mclntosh Prize for Achievement in Physical Sciences ($35,000); and the Minister's Prize for Achievement in Life Sciences ($35,000).

Auslndustry

The key priorities for Auslndustry in 2000-01 are:

- focusing on improving its customer focus and service delivery. This includes the establishment of Customer Service Managers in areas closer to customers. Priority will also be given to improving customer service skills, and particular effort will be put into improving service delivery, including adhering to Auslndustry's Customer Service Charter; and
- focusing on improving the information systems that support all programs to ensure greater access to management information and to improve services that can be supplied to customers.

R&D Tax Concession Program

Improved delivery of the Concession will continue with the progressive implementation of the TaxRED (Regional Delivery of the Tax Concession) initiative. TaxRED was designed to focus on companies making claims of less than $2.5 million per year, with a shift in administration from compliance to an advisory role.

The IR&D Board will continue to monitor active R&D syndicates remaining after syndicate access to the Concession ended in 1996. The stated policy of the IR&D Board is to ensure that, where possible, commercialisation of successful R&D outcomes is genuinely pursued.

R&D Start Program

To reduce the administrative burden on customers, Auslndustry will be simplifying agreements and other program documentation. It will also be monitoring the time taken for the various administrative processes such as: decisions on applications, finanalisation of agreements and approval of payments on receipt of satisfactory reports. Auslndustry and the IR&D Board will be strengthening post-project monitoring, particularly with regard to project outcomes in the commercial phase.

Through the IR&D Board, projects of a high quality are continuing to be selected for funding under the R&D Start program. The IR&D Board approved projects totalling around $109.6 million to the end of March 2000. Grant and loan approvals are expected tobe up to $180 million for the 2000-01 financial year.

Innovation Investment Fund (IIF) Program

The priority for 2000-01 is to finalise the second selection round for IIF fund managers. Applications for Round Two of the IIF were called for in December 1999 and it is expected that the successful managers will be announced in the second half of 2000. This will involve further Commonwealth funding of around $91 million, to be matched by the private sector up to a maximum 2:1 Commonwealth to private capital ratio. Through Round Two it is expected that an additional three or four funds will be established during the second half of 2000.

National Business Information Service (BIS)

The major focus areas for the Business Information Service Program for the next 18 months are:

- the BizLink CD-ROM product will be launched to provide business advisers, particularly in regional Australia, with the ability to obtain offline access to the full breadth of information currently provided through the Internet by BIS;
- the first phase of a Regional Information Project will soon commence, subject to the successful assessment of the pilot, and will involve individual local government and regional development bodies initially spanning two States; it will identify and collect for the first time nationally the business information these bodies create and hold;
- for the first time a collected set of National Codes of Practice will be made available to all Australians through the Internet;
- significantly more information will be available online and systematically searchable;
- authoring tools will be enhanced to make it even easier for their information to be made discoverable through the BEP site;
- Commonwealth, State and local government agencies will continue their involvement in further enhancing the information content of the site; and

- prototype projects will be undertaken to develop information brokerage facilities for the BIS. This will enhance the BIS facilities to actively support the information needs of business by suggesting information and making linkages according to particular needs.

TRANSPORT AND REGIONAL SERVICES

Science and Innovation in the Portfolio Budget

Areas in the portfolio dealing with science and technology relate to road safety and motor vehicle emissions research conducted by the Australian Transport Safety Bureau (ATSB) and the Land Division, and transport sector research conducted by the Bureau of Transport Economics (BTE). Expected aggregate expenditure outcomes for major projects are $2.3 million for 1999-2000 and $2.3 million for 2000-01.

2000-01 Science and Innovation Priorities

Priorities for 2000-01 include:

- researching emissions for petrol and diesel vehicles and improved vehicle design for pedestrian safety, frontal and side impact, and vehicle compatibility;
- undertaking research and analysis integrated with national strategies including research on vehicle safety standards, speed management, heavy vehicle driver fatigue and alcohol and drugs;
- development of common vehicle design rules between Australia and New Zealand, emphasising the role of vehicle standards harmonisation for improved export prospects and promotion of Australian road safety expertise in APEC and ASEAN region;
- progressing road transport reform, including the national road transport reform program strategy, the second Heavy Vehicle Reform Package and alternate compliance schemes for industry;
- facilitating the development of Intelligent Transport Systems (ITS) through involvement in implementing the national ITS strategy, including supporting trial of electronic heavy vehicle special road access, and a study of greenhouse and air quality impact of ITS;
- implementation of the review of the *Motor Vehicle Standards Act 1989* and full implementation of the new vehicle certification system with electronic lodgement and processing; and
- managing a project to strategically assess the effect of climate change on the long-term provision of major road system infrastructure in Australia using CSIRO climate models.

SECTION

6

Research Achievements

Introduction

This Section complements the discussion in other sections with an account of recent achievements for the major research agencies and programs. While necessarily selective, these are intended to be illustrative of the discoveries, advances in understanding, improvements in techniques, or steps in commercialisation which are the outcomes of the financial support received.

Where contact details have been provided by contributors, these are included after each achievement.

AGRICULTURE, FISHERIES AND FORESTRY

Australian Bureau of Agricultural and Resource Economics (ABARE)

Role *To efficiently and effectively provide high quality economic information of direct relevance to Australia's primary and energy industries in order to enhance their economic performance and that of Australia as a whole.*

Recent Achievements

Water modelling
ABARE has designed a set of optimisation network modelling tools that incorporate economic decision-making with hydrological and biological processes. The model is being applied to evaluate salinity management options in the Murray-Darling Basin.

Bureau of Rural Sciences (BRS)

Role *To provide professional, independent scientific advice to support the profitability, competitiveness and sustainability of Australian agricultural, food, fisheries and forestry industries to achieve greater national wealth and stronger rural and regional communities. At the interface between science and policy, BRS has a unique role in analyzing, assessing and packaging science for decision-making and evidence-based policy development.*

Recent Achievements

Land cover change
BRS has used satellite data to quantify the extent of land cover change - a critical activity in understanding Australia's sources and sinks of greenhouse gas emissions, and in meeting Kyoto commitments – publishing

a report on land cover change for the Australian continent between 1990 and

1995.

Land use and water resources
The Australian National Groundwater Data Transfer Standard has been developed by BRS. This is a public domain standard which allows simplified data transfer between agencies or individuals dealing with groundwater data.

BRS has developed a steady-state groundwater model of the Great Artesian Basin (GAB). This model has been extensively used to underpin sustainable management scenarios to be implemented under the GAB Sustainability Initiative.

BRS plays a role in improving the understanding of processes underlying dryland salinity. A national hydrogeological framework for future research management and monitoring of dryland salinity has been developed for the National Land and Water Resources Audit.

Australian Wool Research and Promotion Organisation (AWRAP)

Role *Select and manage a balanced portfolio of projects to:*

- *increase woolgrower productivity, reduce costs and improve wool quality; and*
- *deliver process and product innovation to improve wool's competitive position.*

Recent Achievements

Testing wool for lice and chemicals
A new test to easily and accurately detect lice at shearing time has been developed with CSIRO. This test provides growers with a diagnostic tool to better determine their lice control strategy. The result will be better lice control and a reduction in the use of chemicals in wool production.

CSIRO and Woolmark have developed a low-cost test for chemical residues on wool. This test will enhance the industry's ongoing approach to minimising residues and marketing our clean wool to the world.

Wool Profit Map
For the first time, the wool industry has undertaken a major review of the impact of management strategies on wool production profitability. This review resulted in the Wool Profit Map, a diagnostic tool to help individual growers to identify what management strategies top performers undertake

and provide practical advice on their next steps to improve their profitability.

Non-woven fabrics
A range of new wool-blend fabrics has been developed using the non-woven textile manufacturing route. High levels of productivity and low cost processing are key features.

The new fabrics developed include a total easy-care pure new wool doona; a wool-rich blend casual coating and wool fleece fabric; a 50/50 wool-polyester blend fabric targeted at the lining market; and a laminated fabric targeted at the casual outdoor apparel market. Commercial partners are already trialling these new fabrics to launch retail products in the next 6 to 12 months. The R&D partners working on these projects are Leeds University in the United Kingdom and Wool Research Organisation of New Zealand (WRONZ).

Easy-care wool
A new technology package, developed with CSIRO, is proving to be a major break-through enabling pure new wool formal garments to be machine-washed and tumble-dried with no need for ironing. The technology significantly increases crease retention in men's and women's trousers after machine-washing and tumble-drying. The very high total easy-care performance offered by the technology outperforms competing synthetic and other natural fibre products. Commercial proving trials are in progress with partners expressing strong interest.

Cotton Research and Development Corporation (CRDC)

Role *The Cotton Research and Development Corporation's mission is to enhance the contribution research and development makes to the cotton industry for the benefit of theAustralian community.*

Recent Achievements

Area-wide management of insects
Chemical pesticides are a major cost associated with growing cotton. Integrated Pest Management involves using predatory and parasitic biological agents to assist in the control of pest species. By coordinating operational activities and cropping options across several neighbouring

farms, growers are able to reduce the amount of chemical pesticides required during production of cotton. The adoption of this strategy should see farm profitability improve while environmental effects are decreased.
{Contact: Mr Bruce Pyke, Cotton Research and Development Corporation; tel: +61 (0) 2 6792 4088; fax: +61 (0) 2 6792 4400; e-mail: bruce@crdc.org.au}

Dairy Research and Development Corporation (DRDC)

Role *The Dairy Research and Development Corporation's mission is to maximise the economic, environmental and social benefits for stakeholders through targeted investment in R&D.*

The DRDC plans to achieve its mission through:

- increased industry competitiveness and profitability;
- improved social and environmental sustainability; and
- improved dairy industry resources capability.

Recent Achievements

Innovation days for farmers

Dairy farmers are getting the opportunity to see leading-edge research first hand in a series of special innovation days being staged around Australia. Innovation days have already been staged in South Australia, Tasmania and Victoria (Gippsland). Further days are scheduled for Western Victoria and Western Australia. Genetic merit, nutrition, food safety, robotics, power supply, mastitis control, pasture production and farm management are some of the topics covered. The innovation days give farmers the opportunity to meet researchers and extension people and to see the latest results from R&D projects.

Dried Fruits Research and Development Council (DFRDC)

Role *To enhance the dried fruits industry's competitiveness and profitability in a manner harmonious with the social and ecological climate of the community by effectively investing in research, the funds provided by dried fruits producers and the Commonwealth.*

The Council aims to achieve this by developing and funding research strategies, managing research programs and facilitating industry adoption of research outcomes.

Recent Achievements

Trellis drying

Trellis drying is a cost effective management system that reduces reliance on seasonal labour and hastens the drying process, thereby enabling improved risk management. The Council developed an industry strategy for the accelerated adoption of trellis drying and advanced mechanised production systems in 1997. The implementation of this strategy by the DFRDC, other industry stakeholders and Riverlink research agencies has seen the number of growers using trellis drying double in 1998 and again in 1999. 30 per cent of producers are now using these advanced harvesting techniques.

Harvesting sultanas

The DFRDC/Shaw dried grape harvester manufactured by Mildura Cooperative was launched on 29 April 1999. The harvester is designed specifically to harvest Shaw sloping trellis systems that are considered world's best practice. Its rate of harvest is comparable to large capacity wine grape harvesters. The radial picking head provides an excellent clean pick of the grapes dried on the trellis.

Fisheries Research and Development Corporation (FRDC)

Role *The FRDC is a national organisation responsible to its stakeholders (the fishing industry, the Government and the people of Australia) for: planning, funding and managing fisheries R&D, and facilitating the dissemination, adoption and commercialisation of the resultsof R&D.*

Recent Achievements

Environmental effects of prawn trawling
This project, undertaken by the CSIRO and the Queensland Department of Primary Industries with funding from the FRDC, the Great Barrier Reef Marine Park Authority (GBRMPA) and the Australian Fisheries Management Authority, was undertaken to determine what sort of impact prawn trawling has on the seabed within the Great Barrier Reef Marine Park. Because commercial prawn trawling is never carried out on coral reef, the research was focused on the five main seabed types, which comprise mud, sand and gravel in varying proportions.

The research showed that, contrary to public perception, and also the prior expectations of the scientists involved, a single pass of a trawl net results in no detectable change in seabed habitat. Even areas regularly trawled showed no significant differences in seabed habitat to areas not open for trawling. Of the areas open to trawling, most are either very lightly trawled (less than 2 passes per year) or not trawled at all - commercial trawling is nothing like a wheat paddock for instance, in which the entire paddock is covered. There is virtually no bycatch of recreational or commercial fish species.

Forest and Wood Products Research and Development Corporation (FWPRDC)

Role *The FWPRDC invests in R&D activities which advance an internationally competitive, profitable, sustainable and environmentally responsible forest and wood products industry in Australia.*

During 1999-2000, the FWPRDC has been working with industry to develop a new direction for the Corporation.

Recent Achievements

Improved timber flooring construction
During the past year, the FWPRDC undertook national marketing of the *TimberTech Simple Adapted Flooring Engineered (SAFE) System*, a new cost-effective system for constructing footings, sub-floors, timber framing and floor sheeting for residential buildings. *TimberTech* ensures that timber floors perform to expectations in new building constructions and covers site preparation, footing and support, and flooring platforms. A technical manual on *TimberTech* was produced and several prototype installations were completed in Victoria and New South Wales. In addition, a series of seminars were held to educate builders on the system.

Microwave wood modification technology
In conjunction with the University of Melbourne, the FWPRDC developed an internationally patented technology involving the microwave modification of wood. This technology reduces the drying times for commercial hardwood species from over 3 months to about a week. The technology will give the Australian forest and wood products industry significant commercial advantage in international markets through reduced production costs and faster drying times.

There are potential applications for the pulp and paper sector and the wood preservation sector. It will improve wood permeability and facilitate the penetration of preservatives, thereby increasing durability and utility.

The technology can also be used to produce engineered wood products with improved strength, durability and dimensional stability. These engineered wood products can be treated with commercially available resins to improve their resistance to termites, enhance their acoustic properties and make them more fire-resistant.

Using a naturally occurring fungus to destroy termites
Termites are a severe pest in parts of Australia, threatening the long-term viability of timber as a construction material. Recent changes in pesticide legislation mean that once-off 'apply and f orgeCchernical treatments may no longer be available, suggesting a need to find more environmentally acceptable methods for termite control.

Scientists at CSIRO Entomology have identified strains of the naturally occurring fungus *Metarhizium* that have the potential to control termites in buildings and other structures. The formulations have shown promise in the laboratory, and various bait systems are being tested extensively under field conditions in New South Wales.

Grains Research and Development Corporation (GRDC)

Role *The GRDC's mission is to invest in research and development for the greatest benefit to its stakeholders – graingrowers and the Commonwealth. The Corporation links innovative research with industry needs. The GRDC's vision is a profitable, internationally competitive and ecologically sustainable grains industry.*

Recent Achievements

Storing grain

Grains storage has in the past relied heavily on pesticides to prevent insect infestations. This is increasingly becoming incompatible with the demands of discerning grain markets and Australia's 'clean green image'. Insects are also building resistance to existing pesticides, such as phosphine. GRDC-supported research has adopted a two-fold approach to pest control in grains storage: identifying alternative fumigants and developing improved aeration controls. Research has identified three alternative pesticides, all of which have been developed and subsequently accepted for use. A new aeration control strategy is being field tested in Western Australia, New South Wales and Queensland. This promises to deliver non-pesticide controls against grain pests.

{Contact: Drjane Wright, Stored Grain Laboratory, CSIRO Entomology; tel: +61 (0) 2 6246 4207}

Wheat varieties

Wheat is Australia's most valuable grain crop. Developing varieties that suit increasingly demanding quality standards is vital to winning export market shares. Eleven new wheat varieties were released in 1998-99, of which six were classified as premium grade, for export to discerning quality markets. Targeted breeding is being accelerated by the development of double haploid technology. This is being done on a commercial basis to increase the speed and precision of breeding.

Testing new varieties for quality

CSIRO scientists, together with colleagues at the Quality Wheat Cooperative Research Centre and BRI Australia, are accelerating breeding times for wheat through a new approach to test baking. Testing for some wheat quality characteristics is done through baking loaves of bread; however experimental varieties often do not deliver enough grain for this. Growing more grain increases the breeding time, often by one or more years. CSIRO scientists have developed a process of baking thimble-sized loaves, using tiny amounts of grains. This leaves enough grain to continue breeding immediately. The test baking has the added benefit of revealing more about the relationships between wheat, dough and bread quality, and the impact of

environmental factors on quality. An increase of 1 per cent in quality improvements boosts annual income derived from wheat exports by almost $50 million, according to independent estimates.

{Contact: Dr Peter Gras, CSIRO Division of Plant Industry, Grain Quality Research Laboratory;
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Grains in aquaculture

As world fisheries increasingly become depleted, while demand for seafood rises, the potential of fish farming - freshwater and marine - is becoming a reality. A major drawback is the cost of high-quality fishmeal, especially when combined with the fluctuations in the availability of soybeans, the traditional source of grain protein meal for fish. Researchhas identified a role for lupin seed and canola meal in aquaculture diets. Feed utilisation of both these grains is revealing the optimal dietary measures of grains in fishmeal for optimal growth. Nutritive values and protein equivalents have also been identified.

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Molecular markers in barley breeding

The National Barley Molecular Marker Program has developed 10 markers that identify disease resistance, quality traits and climate tolerances for barley breeding. These allow breeders to screen for and identify desired quality traits for incorporation into elite breeding lines, accelerating breeding times. Mapping of quality traits of greatest importance to the local industry is also under way. In 1998-99, four new barley varieties were released, two of which target discerning market requirements.

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tel: +61 (0) 8 8303 7368; e-mail: plangridge@waite.adelaide.edu.au}

Biocontrols for weeds

Spiny emex, or doublegee, is a major problem weed in Australia's southern and western grain growing regions. A biocontrol agent, the red apion (a weevil) has been identified and released under controlled conditions. Field trials have resulted in a 30 per cent reduction of doublegee seed output and shown that red apion populations can be self-sustaining. The trials have lowered herbicide usage and increased crop yields.

{Contact: Mr Tim Woodburn, CSIRO Entomology;
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Grape and Wine Research and Development Corporation (GWRDC)

Role *The GWRDC's mission is to realise for Australia the excellent returns available from strategic investment in wine industry research and development. The Corporation is accountable to the grape and wine industries via the peak industry bodies and the Government. It assumes a strong leadership role aimed at ensuring coordination and cooperation of key R&D provider groups and other R&D investors to optimise the focus of and returns from R&D.*

Research Achievements

Improving grape quality with less water

Water use is constantly on the agenda when looking at the industry's future, and techniques to reduce water use are welcome. A major project on partial rootzone drying – alternate wetting and drying of part of the rootzone achieved through a simple adaptation of irrigation systems – is providing significant benefits for grapevine management. The technique developed under the direction of CSIRO Plant Industry is now commercially viable and is expected to contribute to increased water use efficiency for the production of quality wine grapes.

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Complex wines from simple yeasts

Fermentation technologies have been developed for the use of novel yeasts to increase the complexity of the flavour of wine in a controlled way. When compared to the commercial standard yeast, the resultant wines had less 'fruit' and different sensory properties, with more complex aromas, better developed flavours and a richer middle palate. During 1999 vintage, five winemakers performed trials to assess the performance of selected novel yeasts under winery conditions. The overwhelming consensus from those who have assessed the wines is that these yeasts have significant potential for blending to enhance complexity in wines.

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Screening for chemical residues in grapes

Monitoring for chemical residues in wine grapes and wine forms a key element of quality assurance. As Australia's wine exports continue to expand, our wine comes under increasing scrutiny by competitors and buyers alike. An accurate, simple and cost-effective test has been developed to screen wine grapes and grape juice for residues of major insecticides and fungicides. The kits are an antibody and enzyme-based test, which will be commercially available to industry. A commercial partner has produced the

prototype kits and 18 wineries have participated in successful industry trials.
{Contact: Ms Amanda Hill, Principal Experimental Scientist, CSIRO Plant Industry; tel: +61 (0) 2 6246 5028; fax: +61 (0) 2 6246 5345; e-mail: a.hill@pi.csiro.au}

Horticultural Research and Development Corporation (HRDC)

Role *To fund and manage R&D to advance Australian horticultural industries, including fresh and processed fruits, vegetables, turf, nuts, nursery products and cut flowers and foliage.*

Recent Achievements

Crop loss in macadamias

Researchers at Queensland University of Technology demonstrated that efforts to clear weeds such as lantana from land adjoining macadamia plantations could reduce losses by 65 per cent. Black rats, responsible for serious crop loss in macadamias, thrive in thickets of lantana. The removal of these weeds provided an extremely cost-effective and environmentally friendly solution, paying for itself several times over within the first season. A recent straw poll of growers indicated that at least two-thirds of growers had adopted the recommendations from the three-year study.
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Nashi by-products

Nashi fruit is a potential growth commodity for both the domestic and export markets. A project conducted by Food Science Australia evaluated the technical feasibility of producing high-quality dried and semi-dried 'nashi chips' and juices based on low grade nashis that are blemished, undersized or oddly shaped. A preliminary sensory evaluation was conducted in order to assess the market potential of the products developed.

Three products, dried, semi-dried and juiced nashis, were produced. Preliminary taste panel results indicate that these have commercial potential. The manufacture of two of the products relies upon conventional technologies. The production of the third product relies upon new technology and will require additional fine-tuning to make it viable for industry to produce and market.
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Papaw Ring Spot Virus: a major threat to the papaw industry
Papaw Ring Spot Virus (PRSV-P) is a serious disease that was first recorded in Australia in South-East Queensland in 1993 and poses a major threat to the industry. A program was initiated to develop transgenic plants with resistance to the disease.

Three lines were transformed and have been evaluated in the glasshouse and are now under field evaluation. One line has consistently remained resistant to inoculation with PRSV-P in the glasshouse and has not shown any signs of susceptibility under field conditions at this stage. If sustainable resistance can be demonstrated in this line, the industry will have a source of PRSV-P resistance that can be incorporated into commercial breeding lines.
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Land and Water Resources Research and Development Corporation (LWRRDC)

Role *To identify, fund and manage a portfolio of R&D programs to help achieve better and more sustainable use of natural resources and to help maintain the industries reliant on those resources.*

Recent Achievements

RAINMAN
In conjunction with the Rural Industries R&D Corporation, the Climate Variability in Agriculture Program (CVAP) has produced a new version of Australian RAINMAN, providing thousands of farmers with regionally specific climate information for resource management decisions. The Program has also released a range of grazing management tools in the DroughtPlan CD-ROM.

Riparian demonstration sites
Local landholders on the Mary River in Queensland are conducting 30 river restoration projects in the Upper Mary River, visited by people from throughout Australia and internationally. The project has promoted community strength as well as solid physical benefits. Landholders are convinced that these riparian demonstration sites are as good as 'gold in the bank' for the long-term sustainability of their farms.

Pig Research and Development Corporation (PRDC)

Role *A profitable, world competitive and environmentally sustainable Australian pig industry which maximises returns on research and development funds invested through programs consistent with stakeholders' and market priorities.*

Recent Achievements

Vaccine development
Porcine Proliferative Enteritis (PPE) is considered to be one of the major economic diseases of pigs worldwide. Although the disease can generally be controlled by the use of in-feed antibiotics, a vaccine approach is preferable. New antigens have been discovered for which provisional patents are being sought. Amultinational pharmaceutical company has been granted a license over the intellectual property.

Sugar Research and Development Corporation (SRDC)

Role *To foster an internationally competitive and sustainable Australian sugar industry through directed funding to meet the strategic research and development needs of the sugar industry.*

Recent Achievements

Natural resource management in the sugar industry
A combined research and community study has defined and quantified the problems of nutrient and sediment losses to the waterways of the Herbert River Catchment in coastal north Queensland.

The study collected data on soils, land cover, rainfall, terrain, land use, farm management practices, water quantity and water quality in the catchment. While models predict that sugarcane areas contributed only 1 per cent to sediment in waterways, these results point to sugarcane and urban land uses as the major contributors to soluble nitrogen yields in waterways. The catchment study was conducted by CSIRO Tropical Agriculture and the

Cooperative Research Centre for Sustainable Sugar Production and funded by the SRDC and the CRC.

{Contact: Dr Andrew Johnson, CSIRO Tropical Agriculture, Brisbane;
tel: +61 (0) 7 3214 2383; e-mail: andrew.johnson@tag.csiro.au}

New generation juice clarifier improves sugar quality

A new generation clarifier is quickly being adopted by sugar mills keen to beat the cost squeeze following low world sugar prices and the ever-increasing capital costs of increasing sugar throughput. Raw sugar juice is clarified after crushing to remove impurities including dirt, so the standard of clarification directly influences sugar quality and profits. A new computational fluid dynamics (CFD) software package was used by the Sugar Research Institute to design the new generation clarifier. It was trialed in Mourilyan Mill in 1996 and 1997. Juice throughput rates more than doubled without any deterioration in clarifier performance. Raw sugar quality improved and sugar losses were reduced. By 1999 a further 11 mills had adopted the new clarifiers. The rate of uptake of this technology is unprecedented in the recent history of the Australian sugar industry.

An independent economic analysis determined that modifying a clarifier to incorporate the new generation design would result in capital savings in excess of $1 million and operational and maintenance savings of $35,000 per annum, not to mention the benefits from improved sugar quality.

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Sugarcane irrigation

A new-look analysis of how water can best be used to irrigate sugar has produced a shift in the way the sugar industry views its irrigation supply. The focus is on enhancing economic return per unit of water resource used, and applying water efficiently for sustainability. Because of competition from other industries, urban communities and the environment for water resources, a systems approach was developed, which integrated biophysical, economic and human dimensions of the production system. The analysis is encapsulated in CSIRO Tropical Agriculture's APSIM Sugarcane growth simulation model, and in economic optimisation and investment analysis models. These models allow evaluation of the most profitable irrigation options and provide estimates of water use efficiency, run-off and environmental effects, including deep drainage. Implementation strategies are developed in consultation with the industry, considering all elements of sustainability.

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DEFENCE

Defence Science and Technology Organisation (DSTO)

Role *To give advice that is professional, impartial and informed on the application of science and technology that is best suited to Australia's defence and security needs.*

Recent Achievements

Increasing aircraft life

Reworking is used to remove cracks at critical locations in airframe structures to extend their life. DSTO has recently developed and implemented novel procedures for determining optimal rework shapes, based on an analogy with the growth behaviour of biological structures. These shapes provide significantly reduced peak stresses, thereby extending the fatigue lives of critical components in aircraft.

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Very high fatigue stresses can cause serious cracking problems in the Royal Australian Air Force (RAAF) F/A-18 aircraft inboard aileron hinge. DSTO has developed a cost-effective solution that combines structural optimisation with bonded reinforcement. This technique reduces the stresses at the critical location by 16 per cent, and has commercial as well as military applications.

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e-mail: david.arnott@dsto.defence.gov.au}

A prototype sensor has been developed to detect and measure corrosion in aircraft. The device is based on electrochemistry, and helps reduce costly unscheduled maintenance that results from corrosion. Through a licensing arrangement, the device isbeing miniaturised and developed for commercial application in the aircraft industry.

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3-D audio display research

DSTO has enhanced the performance of aircrew in combat by giving them sound cues that help them to rapidly detect the direction and type of threats and targets. Synthesised three-dimensional (3-D) sound, mimicking the real world, is developed from records taken from within the 'ears' of individual crewmembers, then reproduced digitally to provide the critical directional information. 3-D sound technology will reduce the high visual workloads experienced by aircrew and provide them with more time to respond to threats and targets.

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Analysing illegal fishing activities

DSTO has developed tools to improve the detection of illegal fishing activity off Australia's coast. By analysing the frequency and pattern of illegal fishing activities detected and recorded by Coastwatch over four years, DSTO scientists have been able to predict when the various areas are likely to be illegally fished. This information will allow surveillance to be undertaken more effectively and increase the likelihood of interception.

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Electro-optical analogue-to-digital converter technology

DSTO, in collaboration with Stanford University in the United States, has developed a novel electro-optic device that can be used to modulate optical beams at rates that are predicted to exceed 100 GHz. Such a device has implications for analogue-to-digital converters that currently operate at relatively slow rates, and has the potential to enhance Defence capabilities in surveillance, communications, imaging and remote sensing, optical sensing and computing.

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Low probability-of-intercept simulator

Low probability-of-intercept anti-ship missiles are likely to pose a major threat to warships within the next decade, and recent developments overseas are making them even more difficult to detect. DSTO has developed a high sensitivity detection system based on digital receivers to combat this threat. This system is able to detect targets that have signatures significantly less than the background, and has direction finding algorithms that produce target detection times similar to existing anti-missile systems.

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WOODS airborne infrared signature measurement pod

DSTO has developed a pod, called the WOODS Pod, for airborne measurements of infrared signatures. The pod is carried on a Learjet 36 aircraft and has a payload comprising compact video cameras and thermal imaging devices. Control and signature data are passedbetween the pod and a control console within the Learjet cabin. The pod has been used successfully for measuring the infrared signatures of military aircraft, vehicles, ships, buildings and background scenery in both land and sea environments.

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EDUCATION, TRAINING & YOUTH AFFAIRS

Research activity in universities is supported by all of the programs listed in the Department of Education, Training and Youth Affairs (DETYA) entry in Section 5 as well as funds from other sources including Commonwealth Government agencies, State Governments, business, private non-profit organisations and international sources. Any given group of researchers is likely to receive support from several sources, including more than one Australian Research Council (ARC) or DETYA scheme. The recent research achievements listed below have all benefited from research support programs within the ETYA portfolio and are arranged by broad divisions of Research Fields, Courses and Disciplines of the *Australian Standard Research Classification*. Given the increasingly multidisciplinary nature of research and technology, some activities would involve major inputs from more than one major field of research. In most cases, researchers themselves have indicated the appropriate field of research classification for each research achievement.

Recent Achievements

Agricultural, Veterinary and Environmental Sciences

Role of boron in cereal male fertility
Researchers at Murdoch University have studied the critical stages of anther development of wheat (cv. Wilgoyne). It is at this stage that boron deficiency causes a significant and irreversible decrease of floret fertility. Researchers have been seeking timely measures for correcting or preventing this problem. Their results suggest that two phases of pollen development are sensitive to this boron deficiency: the first leading to the formation of infertile pollen; and the second coinciding with the starch accumulation in pollen grains.
{Contact: Dr Richard Bell, Murdoch University;
tel: +61 (0) 8 9360 2370}

Slow-release pasture fertiliser for graziers
One of Australia's largest and longest-running rural research projects, which commenced in 1991 to evaluate the use of a new fertiliser on different pastures, has been completed. The study, conducted by La Trobe University in collaboration with government and industry participants, has found that reactive phosphate rock (RPR) is suitable as an alternative fertiliser, instead of superphosphate, on certain soils. A computerised decision support

system hasbeen developed to advise whether RPRs are suitable for particular

pastures (see *www.latrobe.edu.au/www/rpr/*).
{Contact: Dr Peter Sale, Department of Agricultural Sciences, La Trobe University; tel: +61 (0) 3 9479 2188; e-mail: p.sale@latrobe.edu.au}

A cool strategy for preserving stored grains

Food grain often has to be stored for long periods, during which it may lose quality and become infected with insect pests and moulds. One effective solution, which avoids the use of chemical pesticides, is to cool the grain, as this slows the rate of insect population growth, preserves grain quality and helps to prevent mould growth. Researchers at Victoria University of Technology have developed a new system for accomplishing this cooling, based on blowing dry air through the stored grain which is dried slightly during the process and as a result cooled, just as human beings are cooled when they perspire. Simple to construct and with few moving parts, it has been successfully field tested in New South Wales and Queensland. The system is being commercialised by two manufacturers in regional Victoria.
{Contact: Associate Professor Graham Thorpe, School of the Built Environment, Faculty of Engineering and Science, Victoria University of Technology; tel: +61 (0) 3 9688 4964; *e-mail: graham.thorpe@vu.edu.au}*

Waxflower industry rescued

Grafting techniques have been used to produce a new fungi-resistant waxflower variety. University of Queensland research has helped save the State's $12 million-per-year floral waxflower industry from destruction by a virulent fungus *Phytophthora* which was poised to ruin the State's entire crop of waxflower, leaving florist shops without supplies. The University of Queensland is the first in the world to develop grafting techniques for Australian wildflowers and the technology is now available for other commercially grown species. Conducted by the University's Gatton College, the research was also funded by waxflower grower Ebonybrook and the Queensland Department of Primary Industries.
{Contact: Ian Gordon, School of Land & Food, University of Queensland; tel: +61 (0)7 5460 1235; fax: +61 (0) 7 54 60 1283; e-mail: i.gordon@mailbox.uq.edu.au}

Dryland agroforestry

Research at the University of Western Australia has resulted in a range of techniques suitable for assessing water and nutrient use and growth of plantation species, and of species planted in agroforestry settings. The knowledge gained will be used to improve site and species matching in agroforestry. The research also established that trees transport water downwards through soil profiles (as well as from the soil to the atmosphere). This discovery has considerable implications for hydrologists who seek to predict the effect of planting trees on water tables and salinity.
{Contact: Associate Professor Mark Adams and Professor John Pate, Department of Botany, University of Western Australia; e-mail: adamsma@cyllene.uwa.edu.au}

'Green' pesticide

A special 'green' pesticide to control one of the world's most common agricultural insect pests will soon be available to farmers, thanks to University of Queensland research. The pesticide targets the caterpillar stage of the *Heliothis* moth, also known as the cotton boll worm, which causes billions of dollars of damage worldwide to crops such as cotton, sorghum, chickpea and various vegetables. The fermentation process for the new pesticide is being perfected in a multi-million dollar project involving the University's Chemical Engineering Department and industry partner, Agrichem.

{Contact: Dr Steven Reid, Chemical Engineering Department, University of Queensland; id: +61 (0)7 3365 4001;fax: +61 (0) 7 3365 4199; e-mail: stever@cheque.uci.edu.au}

Bio-engineered waste water re-use

The environmentally sustainable re-use of domestic waste water in rural Australia has become a major issue. According to the Australian Waste Water Association, about one-half of backyard waste water systems malfunction, posing immediate health and environmental risks. To address this, the Central Queensland University, with assistance from industry and the State Government, has developed an alternative system which combines hydroponic principles with existing septic and grey water disposal technology. The system is fully contained and any excess water not used in plant transpiration returns to the holding tank. Hence the waste water does not contribute to contamination of groundwater or stream flow. This system of modified hydroponics also helps plants become resilient to otherwise toxic levels of nutrients. A prototype site has been running successfully for over two years, and is now complemented by an extensive network of test sites throughout central Queensland.

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Architecture, Urban Environment and Building

Predicting failure of timber framed walls in fires

Building fire regulations around the world are being changed from a prescriptive to a performance basis. Prescriptive regulations often required expensive building designs with excessive fire protection systems. Performance regulations have opened up new opportunities for novel timber construction. However, to make full use of the regulations, computer models are required that predict the behaviour of timber buildings in fire. Models for estimating the probability of collapse and the time to collapse of timber framed walls on exposure to fire have been developed by Victoria University of Technology, and funded under the SPIRT Scheme. These include Fire

Barrier used for research into the behaviour of timber walls in fire and EZ-Barrier specifically developed for use in engineering practice.
(Contact: Mr P Clancy, School of the Built Environment, Faculty of Engineering and Science, Victoria University of Technology;
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Biological Sciences

Antibiotic peptides offer a new weapon against disease-causing bacteria

Antibiotics, when fighting diseased cells, literally punch holes in the cell membrane. Chemists at the University of Melbourne are shining new light on antibiotic peptides and how they kill infected cells. Their research is the first to demonstrate that peptides can have a different structure in the membrane compared with in solution, and also shows how peptide antibiotics kill bacteria. Scientists are now developing biosensors based on this technology, in particular, the gramicidin ion channel. By fitting receptors for particular drugs to the peptide, when the presence of that drug is indicated it binds to the receptor, closing the ion channel and hence reducing ion current through the membrane.
{Contact: Professor Frances Separovic, School of Chemistry, University of Melbourne;
lei: +61 (0) 3 8344 6464}

Understanding plant hormone interactions

Understanding the control of crop growth is a crucial goal which has attracted the attention of researchers for decades. Two 'classical' plant growth hormones, auxin and gibberellin, have been well-characterised but until recently, the nature of their interaction has remained obscure. Now researchers in the School of Plant Science, University of Tasmania, have shown that auxin is necessary for the normal synthesis of gibberellin in the garden pea, *Pisum sativum* L. This simple relationship was previously unsuspected. The Tasmanian scientists have gone further, examining the molecular basis of the auxin / gibberellin interaction. It appears that auxin is necessary for the expression of a gene which controls the conversion of an inactive form of gibberellin to an active form. Remarkably, this gene (LE) was one of those studied by Mendel in his classical experiments on inheritance. This gene therefore forms a link between the two original growth hormones. These discoveries will revolutionise our understanding of the hormonal control of plant growth.
{Contact: Dr J Ross, School of Plant Science, University of Tasmania;
tel: +61 (0) 3 6226 2602; e-mail: John.Ross@utas.edu.au}

Understanding muscle function

An understanding of the role played by muscle proteins in muscle contraction, and the cellular mechanisms by which muscle function is controlled by carbohydrates, is important in studying the function of normal and diseased muscles. Victoria University of Technology has made two notable advances in this area following research funded by the National

Health and Medical Research Council (NHMRC) and the ARC. Firstly, a technique has been developed using fluorescent microscopy which allows the rapid measurement of glycogen in single muscle cells - where glycogen is the major carbohydrate fueling muscle contraction. Secondly, an electrophoretic method has been developed, which, for the first time, enables different forms of myosin (the molecular motor in muscle contraction) to be separated in amphibian skeletal muscle.

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How eucalypts gain scarce nutrients

Understanding how eucalypts, the most characteristic of Australian trees, obtain scarce mineral nutrients has been further assisted through the results of an ARC-funded project at Sydney University. The roots of eucalypts associate with certain fungi, which take up phosphate from the soil and pass it on to the tree. The research found that spreading fungal threads have a transport system inside the cells. This system contains abundant phosphorus, potassium and other elements. which occur in dispersed form capable of being transported. An internal transport system is essential, as most of the cell walls have restricted permeability. Damp parts of the fungal network have permeable walls, and are probably sites of uptake.

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The Mulgara and diversity in the desert

Australian deserts are renowned for the extraordinarily high diversity of lizards and insectivorous mammals that occur there, and for the propensity of native rodents, after years of virtual absence, to irrupt into high numbers after rain. Researchbeing carried outby a University of Sydney researcher in the Simpson Desert of Western Queensland suggests the predatory effects of a small native carnivore marsupial, the Mulgara (*Dasycercus cristicauda*), may contribute to this diversity by eating other potentially dominant species, thus allowing subordinate species into local communities. This keystone role, and the fact that it is a vulnerable species, means that its loss from much of the continent could lead to a reduction in the richness of vertebrates over large areas.

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Low-allergen ryegrass

Grass-induced hayfever could soon become a thing of the past, thanks to University of Melbourne scientists who have genetically engineered the world's first low-allergen ryegrass. Pollen in ryegrass is responsible for causing hayfever symptoms in up to one in four people living in temperate countries. Researchers at the University's Institute of Land and Food Resources have managed to genetically engineer ryegrass to switch off the gene responsible for a major allergen. The allergen concerned is responsible

for 90 per cent of ryegrass-induced hayfever cases reported to doctors. The research has been funded by the ARC and Valley Seeds Pty Ltd.

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Australian microbes clean up drinking water

Worldwide, 65 million people are at risk through what is now viewed as the world's biggest mass poisoning - arsenic in drinking water. The arsenic occurs naturally in the form of arsenopyrite bedrock in underground aquifers. For example, drinking water in Bangladesh has massive concentrations of arsenic of 3,000 parts per billion (ppb) and higher, compared with World Health Organisation (WHO) recommendations of 10 ppb. Research at La Trobe University, funded by an ARC grant, tackled the problem of arsenic-contaminated water in an innovative way by using bacteria to assist in the removal of the arsenic. Several new bacteria, discovered in the waste water from gold mines in Bendigo and the Northern Territory, not only tolerate the toxic conditions but actually feed on arsenic. Collaboration is planned with the CSIRO and an Australian company to harness these bacteria in the development of a bioremediation system to purify drinking water and clean up mining waste water before it is released back into the environment.

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Pollution-attacking bacterium discovered

Researchers from the University of Queensland, the Delft University of Technology and the Netherlands Institute for Sea Research have found the 'missing' bacterium believed responsible for helping to clean up high ammonia concentrations that pollute rivers and waterways throughout the world. The bacterium belongs to the planctomycetes group of organisms, which clear ammonia nitrogen from waste water without requiring the presence of oxygen. In a process known as anammox, the ammonia nitrogen is converted into nitrogen gas by the bacterium. The breakthrough will have ma)or environmental effects, as many densely populated countries face serious problems associated with ammonia emissions through the increased use of chemical fertilisers in agriculture.

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Biotechnology research boosts gene and cell therapies

Embryonic stem cells, arising in the first few days of life, are the starting point for the many different kinds of cells that eventually make up the body. Discovering how they differentiate has considerable implications for understanding the molecular basis of animal development. Research in Adelaide University's Department of Biochemistry is revealing what controls stem cell differentiation. The research, supported by ARC grants, has led to the development of new gene and cell therapies for human disease.

Patents of major commercial and therapeutic value are being developed in conjunction with the commercial organisation Bresagen.
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Chemical Sciences

Mirror image molecules
University of Melbourne chemists are synthesising molecules without their potentially dangerous mirror images — manifested as chirality, or as having a left and right hand form. For example, thalidomide has molecular chirality, where one form helps morning sickness, the other causes birth defects. Commonly, when chemists synthesise many drugs, it is difficult for them to make just one chiral form of the molecule. Rather, they end up with both forms, which then need to be separated. University of Melbourne researchers, in collaboration with Deakin University, are developing reagents based on free-radical chemistry which, when used in synthesis, create just one form of the molecule. Reagents developed to date have led to synthesised molecules reaching 98 per cent of the desired chirality. Researchers are confident that reagents with 100 per cent success are achievable and that the findings could save industry millions of dollars.
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Commerce, Management, Tourism and Services

Predicting the impact of transport strategies
The Institute of Transport Studies at the University of Sydney, under the auspices of the Australian Key Centre of Transport Management, has developed an advanced system for evaluating the impact of a broad set of transport strategies. Called the Transportation and Environment Strategy Impact Simulator, the system enables an objective, scientific and independent assessment of the impact of policy instruments, such as new public transport, tollroads, congestion pricing, gas guzzler taxes and increasing residential densities, on a variety of factors including land use, air quality, safety and traffic congestion. The system has already been tested on the demand for patronage on the proposed transit way between Parramatta and Liverpool in Sydney.
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Asia-Pacific tourism forecasts 2000-2004
Planning in the hospitality, travel and tourism sectors relies on accurate and detailed forecasts, so that companies can take advantage of the prevailing trends. Research carried out by Victoria University of Technology and

published in a report, *Asia Pacific Tourism Forecasts 2000-2004*, provides a detailed, wide-ranging and independent view of the developments in this crucial growth region. Twenty-three destinations were covered in total, with arrivals projected for the years 2000, 2001 and 2004. The report details the methodology and a wealth of historical information, such as seasonality and purpose of visit.

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Earth Sciences

New uses for airborne geophysical data

Researchers at Murdoch University have suggested that airborne geophysical data could be used to identify the main geophysical themes (major faults, mafic dykes, tertiary sediments and granite) with hydrological significance for the management of dryland salinity in the Western Australian wheatbelt. They have completed an investigation into geologically-related variation in hydraulic conductivity differences in the regolith of Western Australian wheatbelt landscapes. The results showed that geology-related differences in hydraulic conductivity need to be taken into account in computer-based groundwater models for salinity control using revegetation.

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Ocean circulation in the Great Australian Bight

Researchers from the School of Mathematics, University of New South Wales, have developed the first sequence of high-resolution models of ocean circulation within the Great Australian Bight, including a detailed description of the seasonal shelf slope circulation and dynamics. Supported by an ARC Large Grant, results included the demonstration of an equatorward boundary current that flows from the west Tasmanian coast to Western Australia, the existence of poleward coastal currents during winter, and both equatorward and poleward currents during summer when the winds reverse. Findings have also overthrown long-held views on the dynamics of upwelling; a process that supplies the major fisheries of the world with nutrients for marine plant growth.

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Economics

Dealing with uncertainty

Economists have to use non-experimental data, which often leads to parameter estimates about which there is a great deal of uncertainty. An

important issue is how to best reflect this uncertainty when designing policy and offering advice to policy makers. Research completed in the School of Economic Studies at the University of New England, as part of a project financed with an ARC Large Grant, has resulted in statistical techniques that make it possible to attach probability statements to different policy outcomes. The methods have been applied in determining appropriate levels of investment in research and promotion in the Australian beef industry. For example, one can find the probability that investment in on-farm research will benefit beef producers more than investment in domestic promotion of beef products. The scope for using the methods extends to many other contexts.

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Living standards and WA agriculture

Research at the University of Western Australia has analysed the direct and indirect benefits that Western Australian agriculture generates for the state economy by estimating the economy-wide effects of growth in agriculture; and quantifying the effects of policies (for example, tariffs and input taxes) which discriminate against agriculture, and the broader effects of structural change in world markets due to the Uruguay Round resolutions and the Asian crisis. A general-equilibrium econometric model for Western Australia (called WAG) has been developed to carry out the above studies. WAG now provides the State Government Department, Agriculture Western Australia, with a state-of-the-art research tool for analysing policy actions and other exogenous events.

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Education

VisChem success

The University of Western Sydney, together with the University of Technology, Sydney, and the University of Western Australia, has developed an innovative multimedia resource which revolutionises the way chemistry is taught in schools and universities. VisChem delivers molecular animations that help students visualise the invisible molecular world of chemical reactions by showing images of molecules moving, bouncing off one another or vibrating around each other. The research was funded by two grants from the Committee for Advancement of University Teaching. The success of VisChem has resulted in the licensing of animations by WH Freeman, a member of one of the USA's largest publishing houses. There is

also a range of videos and a CD-ROM distributed in Australia by Video Education Australasia.

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Engineering and Technology

Lighting the way to the Sydney Olympics

Research at the Department of Mechanical Engineering at Adelaide University has earned it the contract to design the combustion system for the Sydney Olympic Games Torch, which produces a bright flame with few emissions, while withstanding strong winds and driving rain. The Department specialises in fundamental research on turbulence, energy and combustion with industrial applications aimed at improving combustion. The group has produced patented jet technology, installed in many industrial plants, which reduces nitrogen oxide emissions by 50 per cent while improving fuel savings by as much as 10 per cent.

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New minerals processor a winner

A new mineral separation machine, called JKFrothCam, has already found commercial success in the Australian mining industry. Developed at the Julius Kruttschnitt Mineral Research Centre, University of Queensland, it consists of a video camera and software package positioned in vats used to separate wanted minerals from tailing waste. BHP Coal in Central Queensland has bought several of the $30,000 machines, with many more on order. Other companies in Australia and Canada have requested evaluations.

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High temperature measures

Putting a thermometer in an environment at a temperature of 3000° K and having the thermometer survive is a highly unlikely prospect. However, by using laser techniques, researchers at the Department of Physics at the ANU have been able to measure temperatures of that order in highly complex flows travelling much faster than the speed of sound. In previous work, researchers produced maps of temperature by using a technique known as planar laser-induced fluorescence, which required two laser systems and two digital cameras. Researchers at the ANU's Aerophysics and Laser-based Diagnostics Research Laboratory have been able to significantly improve this previous technique, so that only a single laser and single camera system is required, thus significantly reducing the costs and complexity of

temperature imaging experiments.
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Solar research unveils 'round-the-clock' power

The Solar Thermal Group of the Centre for Sustainable Energy Systems at the Australian National University (ANU) has demonstrated a world-first solar thermal system that is capable of producing power day and night. The system, which recently won an ACT Government New Technology and Innovation Award, combines technologies from the ammonia production and gas pipeline industries with the ANU's own solar concentrators.
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Better treatment of industrial sludge

A new technique for treating industrial sludge, devised by researchers at the University of Melbourne's Advanced Mineral Products Research Centre, is set to save industry money, while protecting the environment. Part-funded by an ARC SPIRT grant, this technique allows chemical engineers to predict, for the first time, the optimum level of liquid extraction from industrial sludges. Many industrial processes produce sludges — mixtures of solid particles and liquid. Generally the most efficient way to treat them is to separate the liquid and solid and to deal with each. However, the more complete the separation, the more time and energy it takes, and there comes a point when further treatment cannot be justified. The team has shown the optimum point is a trade-off between how quickly water can be squeezed from the sludge — that is, how permeable the sludge is — and how compressible the solid residue is. The team has developed an instrument to measure both, and a mathematical model to predict the optimum levels.
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Images of armed robberies

Photogrammetry, the science of obtaining accurate measurements from photographs, is making its mark in the high profile world of police f orensics. Work at the University of Newcastle, which was supported under the ARC Small Grants Scheme, and recognised by the New South Wales Police, has shown that a series of computerised low-resolution images could be joined together to create a high-resolution picture. As a result, new techniques for traditional photogrammetric processes were developed. New South Wales Police subsequently requested help on investigations into a number of armed robberies at building societies. The new photogrammetric techniques were used to examine surveillance videos and make various determinations about the weapons, clothing and appearance of the alleged criminals. This forensic work, assisting conviction in court cases, was a totally unexpected outcome

from the research conducted into the area of image enhancement using computer modelling.

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Intelligent flexible robotic assembly system

Assembly machines can represent a significant capital investment for manufacturers. Developing durable assembly machines that can be reconfigured easily for new tasks poses considerable design challenges. Researchers at the University of South Australia's Centre for Advanced Manufacturing Research (CAMR) have developed an automation strategy for the development and implementation of intelligent and flexible assembly systems. A key feature of the automation strategy is the integration of the product design and assembly functions into a single functional unit. This strategy was implemented with CAMR's industrial partner, resulting in the development of intelligent and flexible assembly systems with three times the current capacity, for less than the cost of a system developed and commissioned from abroad. This project is being funded by the ARC in conjunction with Philmac Pty Ltd.

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Miniature pH electrodes for medical use

Researchers at the University of South Australia have fabricated antimony oxide electrodes in several different forms suitable for medical uses. One use is the monitoring of pH in donor hearts during transport prior to heart transplant surgery. Another is oesophagal pH monitoring, especially in cases of gastric reflux. The electrodes are easily sterilised, either by high pressure steam or by exposure to radiation, and can be conveniently packaged for storage. Recent attention has been given to manufacturing and testing procedures, to streamline them for small batch production. Several opportunities for commercialisation are currently being explored. This inter-disciplinary project was funded by the ARC, in conjunction with Dynek Pty Ltd, Dentsleeve Pty Ltd, Baker Medical Research Institute and the Royal Perth Hospital (Cardiothoracic Unit).

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Quantitative Mobility Spectrum Analysis

Research at the University of Western Australia has resulted in a new technology called Quantitative Mobility Spectrum Analysis (QMSA), which relates to characterisation of the electrical parameters in advanced semiconductor micro-electronic and opto-electronic device structures.

These structures typically consist of many layers of different types of semiconductor materials. The structures are used in virtually all high performance micro-electronic and opto-electronic devices, such as leading-edge systems for military, telecommunications, consumer, and aerospace applications. QMSA is the first fully automated and accurate procedure for evaluating the electrical parameters of such structures in a reliable and unambiguous way. The technology was developed in collaboration with the Naval Research Labs in Washington DC, and patents have been licensed to Lakeshore Cryotronics (USA).

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Lasers expand antenna array capabilities

Broadband high-frequency arrays with thousands of antennas are envisioned for radio astronomy and defence applications. However, for such large arrays, the beam-forming network requires around a million interconnects. Researchers at the School of Electrical and Information Engineering, University of Sydney, have discovered a new technique to solve this problem. Multiple wavelengths or 'colours' of laser light are mapped onto individual array elements. The antenna signals are thus coded onto different wavelengths and these can then be processed by sets of in-fibre gratings, each of which interacts with only one wavelength. The result is that each fibre can process around a thousand signals from the array in parallel simultaneously, instead of one signal only. This work makes high resolution, multiple-beam phased array antennas feasible.

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Infrared camera

The Micro-electronics Research Group at the University of Western Australia has recently developed a high performance, low cost, infrared sensor with less stringent power requirements, which has the potential for use in the commercial market. Infrared detector imaging technology is important for a large number of applications, including resource exploration, mine site rehabilitation monitoring, coastal and fisheries surveillance, bush fire detection, environmental monitoring and pollution identification, and for surveillance/night vision. The application of high-quality infrared detectors to such commercial applications has been restricted due to the high cost of the detectors. A lightweight prototype infrared camera, based on the newly developed technology, has been developed to study the viability of the camera for airborne and portable remote sensing applications. The research for the sensor development has been funded by a number of Large Research Grants from the ARC.

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Structural applications of fibre composites

The unique mechanical and chemical characteristics of fibre composites, such as strength, weight and durability, will increasingly challenge the supremacy of conventional materials such as steel and concrete, particularly in weight sensitive applications and corrosive environments. The University of Southern Queensland, in collaboration with Connell Wagner Pty Ltd, consulting engineers, recently developed Australia's first fibre composite bridge deck. It makes use of a new innovative fibre composite truss structure, is lightweight, non-corrosive and very cost competitive. Other research has resulted in the development of a composite construction beam capable of supporting the same load as a steel beam, which is 70 times heavier.

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Mechanical handling of glass bottles

A device, AVATAR®, has been developed by Victoria University of Technology in conjunction with Satellite Telemetry to measure, store and analyse the impact forces between glass bottles during mechanised handling and transport operations. AVATAR® is an electronic replica of a glass bottle containing the latest in miniature electronics and sensor technologies to provide a fully configurable self-contained data acquisition system. The device automatically detects and records a large amount of impact data, which are then transferred to a computer for analysis via an infrared link. The device, developed with the sponsorship of ACI Glass Packaging, will assist in optimising the design and manufacture of glass bottles as well as the configuration and operation of mechanised handling lines.

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Structural optimisation

Structural optimisation is a process of searching for the best shape and topology of a structure that has the minimum weight or minimum manufacturing cost while satisfying restrictions on such factors as stress, displacement and frequency. A simple method called Evolutionary Structural Optimisation (ESO) has been developed at Victoria University of Technology in conjunction with the University of Sydney under an ARC grant. The ESO method is based on the simple concept of slowly removing inefficient material from a structure so that the resulting shape of the structure evolves towards an optimum. The ESO method has proven effective in solving a wide range of engineering design problems including the conceptual structural design of a high-rise building in Melbourne and a new and improved design for a mechanical component in an airconditioning unit.

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Environmentally friendly protective packaging

Research at Victoria University of Technology has led to the development of a new composite cushioning material, Enviro-Cushion™, made entirely from paper-based corrugated fibreboard to replace polymeric materials such as expanded polystyrene. Normally corrugated fibreboard is too rigid to offer continuing protection against shocks. However, the protective capability of Enviro-Cushion™ and the environment-friendly appeal of a package made entirely of paper havebeen demonstrated in optimised packaging developed for a Vision Systems' laser smoke detector. The device has been successfully protected against multiple impacts from drop heights of up to two metres.

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Alzheimer's effects shown in 3-D

University of Queensland scientists have produced ground-breaking 3-D images showing how brain tissue deteriorates in sufferers of Alzheimer's disease. This is an important breakthrough as it has allowed researchers to scientifically diagnose and follow the progress of Alzheimer's disease for the first time. The computer-generated images, produced with the aid of a supercomputer and fast magnetic resonance imaging, show the progress of Alzheimer's disease in patients over a six-month period. Only a handful of research groups worldwide are studying brain function using fast magnetic resonance imaging. The research project has received funding from SmithKline Beecham Pharmaceuticals.

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History and Archaeology

Torres Strait archaeology

James Cook University has initiated the first archaeological investigations of the Murray Islands in the Torres Strait. In collaboration with local landowners, a range of coastal occupation sites has been surveyed, excavated and subjected to detailed analyses. The research has produced the oldest evidence for occupation of the Torres Strait — in the order of 3,000 years. Pottery recovered from one site of this age is the first pre-European pottery to be recovered from the Torres Strait.

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Information, Computing and Communication Sciences

New computer translating tool

The ability to run software programs on different computer systems has come one step closer, thanks to a successful international research project by the University of Queensland. The project, in collaboration with the University of Virginia, involved developing an automatic translator program known as the University of Queensland Binary Translator (UQBT). The new tool will benefit not only computer users, but also computer developers and software designers, with less source code required, and lower costs. It will also help remove a major barrier to diversity in computer hardware — that different computer systems are not able to talk to each other. The research was carried out with a grant from the ARC and industry funding from Sun Microsystems.

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Efficient high-precision information retrieval

On the World Wide Web people use search engines to find the information they want from amongst hundreds of millions of web pages. These engines must be able to answer queries extremely quickly, and must make accurate guesses as to which pages the user is most likely to want. Similar search engines are used by corporations, which have large repositories of documents such as legislation or reports. A research team from RMIT University has developed new variants of these efficient indexes and new ways of using them. A particular success has been the development of techniques for finding documents based on whether they contain relevant passages, so that it is possible to identify pertinent pieces of text rather than having to fetch whole documents. Such retrieval is valuable when there are many long documents, which can confuse current retrieval methods. It also allows the user to more rapidly assess the relevance of documents fetched by the search engine.

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Medical and Health Sciences

Quelling the risks of early pregnancy

Research at Adelaide University's Department of Obstetrics and Gynaecology is improving understanding of the immunological events of early pregnancy. A cellular and molecular biological study of the female immune response to semen is revealing how the immune response affects embryo implantation and development. The work has important implications in both clinical and veterinary medicine and in the commercial sphere, where it is already the subject of two patents. The improved

understanding of immunological events in early pregnancy is vital for the management of implantation failure. This failure is a major cause of miscarriage in humans, and a source of large public health costs as problems which compromise foetal growth contribute to diminished health in adult life. It is also a significant constraint in livestock breeding programs.

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Cultured skin and diabetes

A University of Western Sydney research team has made significant biotechnological advances in the use of cultured skin for delivering a range of antigens, hormones, enzymes, cytokines and novel gene products to graft hosts. Of great significance is the incorporation of the insulin gene into cultured skin for use in ameliorating the effects of diabetes in mice. This has potential implications for the treatment of human diabetes, particularly as skin grafts can be easily grown, applied, maintained and removed if problems arise. As a first step to commercialisation, the team's work was showcased internationally in October 1999 as part of Australia's mission to Biotechnica 99, Europe's premier biotechnology trade fair for innovative products, processes and applications.

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Exercise proves positive for dystrophy patients

Duchenne's muscular dystrophy is the most severe of all the muscular dystrophies. Characterised by progressive muscle weakness, sufferers are wheelchair bound by their early teens and die by their early 20s. Although the genetic defect behind the disease is now known, there is still no cure. Research at Victoria University of Technology has targeted ways of improving quality of life. While it was always thought that activity would be deleterious for such wasted muscles, the research has shown that dystrophic muscles respond positively to controlled, non-weight bearing exercise, with increased force output and resistance to fatigue. The work suggests that prescription of effective exercise could lead to improved activity levels in dystrophic patients.

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Out of bed quickly

University of Queensland research has concluded that the traditional rest in bed to recover from illness or surgery actually contributes little to the healing process, and could in fact be harmful. The research is significant because it may lead to new approaches in recovery therapy and policies, and better and quicker healing processes. The researchers, who based their findings on a study of almost six thousand patients, recommend that patients get out of bed as soon as they feel strong enough. Contrary to the popular belief held by

patients and most doctors, bed rest had no real benefit in treating conditions such as tuberculosis, infectious hepatitis, lower back pain or heart attacks.
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Cone shell poison turned into pain-killer

Research inspired years ago by academic curiosity about the venom of Great Barrier Reef cone shell snails has produced a commercial outcome in the form of a new family of long-lasting pain-killers. A joint project between the University of Queensland and Australian pharmaceutical company, Amrad Operations, has helped isolate tiny proteins, or peptides, from the venom of 50 species of the snails. The snails inject fish and worms with the venom during their nightly hunt for prey. The venom contains conotoxins that work by blocking specific calcium channels connected to nerve cells. These channels are missed by current pain-relieving drugs, with the effect that relief wears off quickly.
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Physical Sciences

Electron scattering

Research at the University of Western Australia, under an ARC Special Investigator Award, has shown how to manipulate electrons in their atomic orbits, so extending the concepts of nanotechnology into single atoms. Observations are revealing new phenomena, establishing the strengths of electronic interaction and collision mechanisms, explaining new observations and providing challenges to theoretical models. New scattering experiments, instruments and methods have enabled observations which only a short time ago were thought to be unattainable. These electron scattering experiments are at the leading edge of explorations of reaction and structure phenomena in atoms and of associated experimental techniques.
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New source provides a low-budget approach to X-ray imaging

A state-of-the-art X-ray source has been designed and built at the University of Melbourne, offering unrivalled X-ray stability at a fraction of the cost of a synchrotron facility. This new source, funded by the ARC, is 50 times more stable than conventional systems, meaning experiments canbe repeated over time without scientists having to worry that results are affected by the changing strength of the X-ray source. The machine is crucial for any Australian research which requires an understanding about how X-rays and

matter interact. The new facility is an essential test-bed for a synchrotron alternative.

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Measuring the atmosphere's temperature

Using ARC funding, researchers at Adelaide University's Atmospheric Physics group have developed new technologies for measuring winds and studying clear-air turbulence. In combination with acoustic techniques, these technologies measure temperatures in the lower atmosphere using the speed of sound, and in the upper atmosphereby the diffusion of meteor trails. The technology is produced commercially and has been installed in meteorological facilities in Australia and overseas, and will also play a role in air traffic control and weather forecasting for the Sydney Olympics.

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Pulsar Iglitches'

Radio astronomers at the University of Tasmania have for 20 years studied the Vela pulsar, a rapidly rotating neutron star. In January 2000, their efforts were rewarded when the pulsar was observed to undergo a sudden decrease in rotation period or'glitch'. This glitch was by far the largest so far observed and, with the aid of recent improvements in observing equipment, promises to provide new insight into the nature of neutron stars. By sampling the radio emission from the pulsar 2000 times a second, the research team found that the spin-up occurred over a time span of less than 16 seconds. This rapid change in rotation rate, of three parts in a million, is remarkable when one considers that the pulsar is 1.4 times as massive as our Sun and is rotating 11 times a second.

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Controlling quantum noise in optics

Optics is used in many sensor applications such as measuring air or water purity, and in communication of signals, such as in optical telephone links. All these applications suffer from limitations due to the intrinsic noise of light, a side effect of the quantum nature of light. Experiments at the ANU have demonstrated ways of improving optical sensors and amplifiers beyond the limit set by conventional lasers. ANU researchers have shown the strongest suppression of this noise seen to date, and have demonstrated a way of using and transporting this precious information along optical communication lines. The way is now open to include these novel results from fundamental physics into practical instruments.

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Studies in Human Society

How Aboriginal and Torres Strait Islanders help each other

Researchers from james Cook University's School of Social Work and Community Welfare, in collaboration with sectors of the Aboriginal and Torres Strait Islander community, have carried out a pioneering study of the way in which Aboriginal and Torres Strait Islander social welfare workers help their own people. The study, f unded by the ARC, identified a culturally appropriate alternative model of helping. It provides an alternative to the western models of helping used in social/welfare work courses that have been shown to be ineffective. This model of helping is an important step in addressing and improving the present position of Aborigines and Torres Strait Islanders in Australian society, and is also beginning to be adopted by professional social work and welfare programs around Australia, in New Zealand and elsewhere internationally.

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Employment and society

We now know a lot about the changing patterns of the Australian labour market, but very little about the meaning of these changes in people's lives. A project conducted by the Centre for Applied Social Research, has explored ordinary people's ideas about the meaning of work, and about the ways work and gender identity are related. At the core of the research were 200 interviews, half with older men and women of prime working age in the mid-1950s, and the other half with men and women in the same position today. This research has resulted in a detailed description of how ordinary people are experiencing profound transformations in Australian society and economy and provides a basis for evaluating government policies in a number of labour market and income security areas.

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Child care outcomes

Researchers at the University of New South Wales, working in collaboration with Barnardos Australia, have developed and implemented a framework to assess outcomes for children under the care of public agencies. Research, funded under the ARC's SPIRT Scheme, has provided the basis of a training package for child welfare practitioners and administrators throughout Australia, and has stimulated interest from the United Kingdom and New Zealand. The framework was researched and adapted to the Australian legal and practice context, and has been implemented by Barnardos.

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The Arts

Recordings place Stuart Piano on the world stage
The University of Newcastle-designed Stuart Piano combines the power of a modern instrument with the clarity of the early pianos. It has achieved worldwide recognition following the recent release of selected Beethoven Sonata recordings by ABC Classics. This recording project has enabled the evaluation of the Stuart Piano as a medium for music from the late Classical/early Romantic period, the period in which Beethoven was composing. Research has led to a number of significant findings related to recording techniques, positioning of the piano and the ways in which the piano is played.
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Institute of Advanced Studies, Australian National University

Role *To be one of the world's great research institutions, distinguished also by outstanding teaching, guiding students to the frontiers of knowledge and the best standards of scholarship.*

The Institute of Advanced Studies aims to maintain and enhance the University's world class standing and excellence by:

- engaging in research and scholarship at the highest international standards;
- strengthening Australia's capacity to undertake fundamental research both generally and in relation to subjects of national importance;
- providing outstanding postdoctoral and graduate training in all areas of the Institute's research activity;
- encouraging collaborations which allow other Australian universities to benefit from the concentration of research resources available at the Institute;
- fostering international exchanges and collaborations which enable Australia to contribute to and benefit from the latest advances in front-line research;
- encouraging links which make the scholarship and research resources of the Institute accessible to the Australian community, industry and government;
- being well-placed to respond rapidly to a changing environment and new opportunities; and

- optimising use of its resources by promoting internal links, including those with The Faculties, based on shared or complementary technologies and interests.

The Institute of Advanced Studies (IAS) of The Australian National University consists of nine research schools and one research centre. In addition, staff of the Institute participate in several cross-campus research groupings and centres. The Institute's fields of academic inquiry include biological sciences, chemistry, bio-medical sciences, physical sciences including mathematics, astronomy and the earth sciences, information technology and cognate areas of engineering and broad interests in the social sciences and environmental sciences.

The Institute has a distinctive place in the Australian higher education system. Uniquely, it is block funded to undertake full-time research at the highest international standards and to provide postgraduate and postdoctoral research training. Further, it has a special responsibility to be a resource for the Australian higher education system and for Australian research as a whole. The Institute has a major role in carrying out basic research, as a resource for Australian research as a whole, and as a world leader in the research fields in which it is engaged.

Recent Achievements

Chemical Sciences

Environmentally friendly agrochemicals

Cereal crops grown in Europe, such as wheat and barley, give very high yields of grain, but the seed heads are very heavy and the plants are easily blown over in adverse weather conditions. They are therefore treated with a growth inhibitor to shorten and strengthen the supporting stalks. Researchers at the Research School of Chemistry in collaboration with groups at CSIRO Plant Industry and the University of Calgary, Canada, have developed a new inhibitor that is approximately 200 times as potent as the synthetic chemicals presently in use. It is obtained by modifying a naturally occurring substance, gibberellic acid, and will offer the important and considerable advantage of having minimal environmental impact, through reduced application rates and absence of detectable side effects.

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Simple synthetic anti-cancer compounds

Anti-cancer drugs Taxol and Taxotere, which are used clinically in the treatment of breast and ovarian cancers, are potent but structurally complex, and very expensive. Simple compounds which mimic the cellular effects of

these have now been synthesised in the laboratory. Biological testing conducted at the Research School of Chemistry reveals that these simpler compounds exhibit the same unusual mode of action as the commercial drugs. This work is the subject of a recent provisional patent filing, and industry collaboration is now underway.

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Electrolysis now compatible with nuclear magnetic resonance

Electrolysis (passing an electric current) is widely used in manufacturing research and production. Two specialist research groups in the ANU's Research School of Chemistry have combined to develop the world's first practicable device for identification of electrolysis by nuclear magnetic resonance (NMR) spectroscopy. The device fits in a standard spinning sample tube and is capable of obtaining well-defined high-quality spectra. The precise nature of NMR measurement has many advantages. The design was announced at the AISAS conference in Melbourne in July 1999, and many enquiries have followed concerning commercial developments and new applications.

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Antimalarials from a birdbath

Cyanobacteria are probably the largest, most diverse, and most widely distributed group of prokaryotes on earth. However, the pharmacological potential of their metabolites has not been extensively studied. Collaboration between biologists and chemists at the Australian National University has resulted in the isolation and characterisation of compounds with novel structures from laboratory cultures of a cyanobacterium obtained from a Canberra garden birdbath. The compounds show potent in-vitro activity against malaria parasites and human HeLa cancer cells.

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Earth Sciences

Additional source of acid rain

Most acid rain is produced when sulfur dioxide in the atmosphere dissolves in water droplets which coalesce and fall to earth. Acid rain has produced major changes in aquatic and soil ecology and productivity, particularly in Europe and North America. There are two known sources of sulfur dioxide: from burning fossil fuels containing sulfur compounds; and from volcanic eruptions. Collaborative work involving the ANU, the University of New

South Wales, and CSIRO has identified an additional source of sulfur dioxide emissions: Holocene coastal soils containing iron sulfides minerals (acid sulfate soils). The team measured sulfur dioxide above bare sulfidic soil and found concentrations of up to 5 parts per billion, well in excess of background levels.

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Engineering and Technology

New laser set to revolutionise telecommunications

Researchers at the Research School of Physical Sciences and Engineering have recently used quantum physics to produce a novel quantum well solid-state laser with enhanced performance. This tiny device, used in optical amplifiers for fibre optic communications, produces more useable power than any other similar laser to date. The novel techniques used make these lasers increase power output and offer extremely good wavelength control. As a result, many light signals, each of slightly differing wavelength, may soon be transmitted down existing fibres simultaneously. Potentially, this could increase the capacity of our networks by as much as a hundredfold, thus removing Internet congestion and bringing high-resolution video phones a step closer to reality. In order to commercialise these high-value devices, a company, Acton Lasers, has been set up, with plans to manufacture the lasers in Australia to meet global demand.

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'Invisible' antenna

A significant problem in military communications is that traditional metal radio antennas have a very high radar cross-section, rendering them easily visible to the enemy. Scientists at the Plasma Research Laboratory, Research School of Physical Sciences and Engineering, have come up with a novel solution to this problem. Instead of a metal antenna they use a plasma, which by virtue of all the free electrons it contains, is an excellent conductor of electricity. In operation, the antenna behaves like conventional systems, but as soon as you stop transmitting, it effectively disappears. DSTO are currently undertaking field trials of the new 'invisible' antenna, which has civil radar, as well as military applications.

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Light guides light in optical computing

Non-linear optical materials have the peculiar property that the extent to which they bend light is dependent on the intensity of that light. Researchers at the Research School of Physical Sciences and Engineering have discovered

a novel application for such materials – optically written dynamic waveguides. In a normal waveguide, a region of high refractive index in a medium such as glass or plastic guides light along in the same way as the copper tracks on circuit boards guide the flow of electricity. Like those copper tracks, once written, they're fixed. The dynamic waveguide uses one laser to write the guide that directs the path of another. Turn off the light and the guide disappears. The ultimate goal of such technology, which has enormous potential for optical computing, is a computer with continually changeable circuits in a single piece of glass.

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History and Archaeology

Chronology for Mungo Man

A new chronology for Mungo Man has recently been established. Mungo Man constitutes the earliest evidence for human presence in Greater Australia, and the site shows the oldest known use of cremation and the scattering of red ochre in the disposal of the dead. In 1999, three dating methods were applied to the burial of the Lake Mungo 3 individual from western New South Wales indicating that it took place between 56,000 and 68,000 years ago, with 60,000 years the most probable. Since the site is in the southeast of the continent, the earliest possible arrival of humans is likely to have occurred more than 70,000 years ago. This new date for human presence in Australia expands the period of time that humans shared the continent with a range of now extinct animals, the so-called megafauna, rekindling the debate over the possible role of humans in late Pleistocene extinctions.

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Medical and Health Sciences

Biotechnology leads to anti-cancer drug

In cancer, the primary tumour rarely kills the patient. It is the spread of the cancer cells to other organs, called metastasis, that is usually the cause of death. Thus the development of drugs that block cancer metastasis are of great clinical importance. Researchers at the John Curtin School of Medical Research, in collaboration with the Brisbane-based biotechnology company Progen Industries, have cloned an enzyme called heparanase which plays a key role in allowing cancer cells to escape from the primary tumour and invade other tissues. Although the existence of heparanase has been known for many years, cloning and characterisation of the enzyme has eluded cancer researchers for almost 20 years. An extensive drug screening program by the

ANU team has resulted in the identification of a drug, PI-88, that is a potent heparanase inhibitor. The drug is now being tested in cancer patients.
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Physical Sciences

The expansion rate and age of the Universe
The Hubble Space Telescope Key Project team, an international group of 27 scientists, announced in May 1999 that they had completed eight years of intensive work to measure precise distances to galaxies. The team used the Hubble telescope to observe 18 galaxies out to 65 million light-years. The expansion rate has been calculated to be 70 kilometres per second per megaparsec (a megaparsec is 3.26 million light-years), with some uncertainty. Combining the Hubble measurement with estimates for the density of the universe, astronomers have deduced that the universe is approximately 13 billion years old.
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The Anglo- Australian Telescope Board

Role *The Anglo-Australian Telescope Board (AATB), through its operational arm, the Anglo-Australian Observatory, facilitates the best possible science through provision of world-class optical and infrared observing facilities for British and Australian astronomers. It also takes a leading role in the formulation of long-term plans and strategies for astronomy in both countries and, through its research and development of new instrumentation, to the advancement of astronomy internationally.*

The Anglo-Australian Telescope Board operates under an agreement between the Governments of the United Kingdom and Australia and is equally funded by them. The Australian Government will contribute approximately $3.6 million in 2000-01. The facilities include the Anglo-Australian Telescope (AAT) and the UK Schmidt Telescope (UKST) at Siding Spring Observatory outside Coonabarabran, and a laboratory in Sydney.

The AAT was state-of-the-art when officially opened in 1974. It remains at the leading edge in astronomical research against considerable international

competition. Since 1975, many significant discoveries have been made using the Observatory's telescopes, and as a consequence Australian and British astronomers have a very high standing in the international scientific community. One of the reasons for this continued excellence is the vision and expertise of the Observatory's scientific and engineering staff, who have constantly upgraded the telescopes by incorporating the latest technological developments into instrument design. Staff at the Observatory are considered world leaders in many areas of astronomical instrumentation.

Recent Achievements

Weather outside our solar system

A special instrument, the Taurus Tunable Filter, has been used on the AAT to discover the first example of weather systems outside our solar system, on a special type of 'failed' star known as a brown dwarf. Although brown dwarfs form in the same way as stars, they share many of the same properties as planets. In particular, they rotate very rapidly, and solids and liquids condense out in their atmospheres. Astronomers have predicted that they should show weather patterns, just like planets - and observations made by the AAT have confirmed this.

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Quasar nebula

The Taurus Tunable Filter was used in the discovery of an extended cloud of hydrogen gas, 600,000 light years across, surrounding a quasar. This is the largest gaseous nebula seen around a quasar, and provides further information on the interaction between these enigmatic objects and their immediate environment.

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ENVIRONMENT AND HERITAGE

Australian Antarctic Division

Role *To contribute to knowledge of the global environment through research in the Antarctic region; to provide scientific knowledge of the effect management of the Antarctic environment; and to increase Australia's influence in Antarcic matters by participating in international scientific programs and by contributing to international scientific forums.*

Recent Achievements

BROKE

The vast collection of data from the BROKE (Baseline Research on Oceanography, Krill and the Environment) survey has formed the basis of eleven papers, which have been accepted for publication in the international journal *Deep Sea Research*. These papers detail the ecology of a large proportion of the Australian Antarctic Territory coastline. They present a comprehensive picture of how the circulation of the surface waters determines both the physical characteristics, such as the amount of sea ice, and also the distribution of the plankton, krill, whales and seabirds. The unique combination of data from observations of organisms as diverse as bacteria and whales has allowed scientists to develop new theories about how the physical features of the Southern Ocean interact with the ecology. These new theories will facilitate better prediction of the effects of changes — whether they be due to global warming, increased UV-B or increased fishing pressure — on the Antarctic marine ecosystem.

The Lambert Glacier

New evidence of the state of balance of the vast Lambert-Amery ice drainage basin has been obtained from a combination of field observations, analysis of satellite data, and computer modelling. The ice flow required to exactly balance total snow accumulation was computed using a Digital Elevation Model (DEM). This was compared with the measured flow, derived from measurements of ice thickness and velocity made during trips across the Lambert Glacier Basin. These results suggest that overall the basin is presently gaining mass, predominantly in the coastal areas.

Biodiversity Group of Environment Australia

Role *To assist the Minister and Environment Australia in the conservation and appreciation of Australia's biological diversity and associated cultural heritage, through leadership and cooperation.*

Recent Achievements

Taxonomic research and delivery

Through partnerships and collaborative arrangements with the taxonomic community in Australia and overseas, the Australian Biological Resources Study (ABRS) is delivering consolidated taxonomic information and identification tools to scientists, environmental managers, community groups, and individuals. These outputs include new parts of major long-term series such as *Flora of Australia* and the *Zoological Catalogue of Australia*, occasional works on individual groups of organisms, such as lichens and rushes, or on taxonomic aspects of regional ecosystems, CD-ROM delivery of interactive identification guides to plants, fungi and animals, and online delivery of interactive databases and electronic information resources.

The *Flora of Australia* series published descriptions and keys to 322 species of the family Proteaceae, including the familiar genera *Hakea*, *Banksia* and *Dryandra*, with descriptions of over 20 new taxa. The *Zoological Catalogue* provided a complete nomenclator for some 2400 species of primitive flies, including the economically and medically important biting flies such as mosquitoes and midges. In addition, the publication during 1999 of the first four parts of *Species Plantarum: Flora of the World*, signalled the first outputs from a major international project in which ABRS has taken a leading role.

The first stage of the Australian Biodiversity Information Facility was launched, a major advance in providing easy-to-access information on flora, fauna and biodiversity. This is an umbrella Internet site providing free access to a number of databases of names of organisms, bibliographic information, distribution, and other data.

Botanical research

With support from the Natural Heritage Trust, the Australian National Botanical Gardens (ANBG) has conducted extensive and successful trials of native grass seed germination with a view to maximising the revegetation potential of these species in the upper Murrumbidgee.

Through its partnership with the CSIRO Division of Plant Industry in the jointly resourced and managed Centre for Plant Biodiversity Research, the ANBG participates in botanical systematic and taxonomic research. Computer-based plant identification was enhanced, including the

publication of keys to *Angiosperm* plant families, tropical rainforest and shrubs. Major advances in the sharing of biological data between State and Commonwealth herbaria was achieved during the year with the implementation the prototype *Virtual Australian Herbarium.*

Science Group of Environment Australia

Role *The Group performs a number of functions, namely:*

- *supervision of uranium mining activities in the Alligator Rivers Region of the Northern Territory and the conduct of related research;*
- *provision of environmental supervision regulation and policy functions;*
- *coordination activities to maximise the benefits which may be derived from the use of science in the formulation of policy and programs;*

Recent Achievements

Paragrass
The Environmental Research Institute of the Supervising Scientist (ERISS) was a collaborating partner in a project funded by the National Wetlands Program on ecological effects of Paragrass and control measures on floodplains in Kakadu National Park. ERISS provided logistic support and carried out the component of the study on freshwater fish. Other components examined aquatic macroinvertebrates, whole ecosystem metabolism and studies on food-chains using isotope analysis.

Wetland risk assessment of *Mimosa pigra* and its control
Risk assessment methodologies have been applied to the issue of the tropical wetland weed, *Mimosa pigra*, and the use of herbicides as a control measure. Chemical control has been targeted due to potential effects of herbicides to native animal and plant species, with information on toxicity and environmental concentrations being integrated to estimate the risks. Information from the assessments has been used to provide advice on control and management of mimosa to the managers of the Tram Chim National Park, in the Mekong River Delta, Vietnam.

Mining and wetlands in tropical Oceania
ERISS undertook a review of environmental effects and environmental management practices of 11 different large mines in northern Australia and New Guinea on behalf of the World Wildlife Fund Australia (WWF). There was a great contrast in the effects on wetlands between operations in the wet mountains of New Guinea and drier, flatter landscape of Australia. The

study was based on literature provided by mines and government agencies and published information. The information was used by WWF in their planning of operations for their community-based Tropical Wetlands of Oceania Program.

Bureau of Meteorology (BOM)

Role *To observe and understand Australian weather and climate and provide meteorological, hydrological and oceanographic services in support of Australia's national needs and international obligations.*

Recent Achievements

"Nowcasting" of short-term weather events
"Nowcasting", which describes an observation-intensive approach to local, very short-term weather forecasting, is a relatively new research program within the Bureau of Meteorology Research Centre (BMRC) but one which builds on the Centre's significant research skills in mesoscale meteorology. Successful trials of state-of-the-art nowcasting systems from the United States, Canada, the United Kingdom and Australia were carried out in Sydney in September 1999, during the official Olympics trial, and again in February 2000. The Sydney Olympics in 2000 will provide the first significant opportunity in Australia to demonstrate nowcasting capabilities in a real-time forecasting environment. This exercise has been chosen as a nowcasting demonstration project of the World Weather Research Program of the World Meteorological Organization (WMO).

Trends in climate extremes in the Asia-Pacific region
A consistent increase in the number of hot days and warm nights over the last thirty years has been identified in a study of trends in extreme climate events over the SE Asia -Western Pacific region. Daily rainfall and temperature data from 15 different countries in the region were quality controlled and analysed during an international workshop in December 1999 hosted by the Bureau of Meteorology Research Centre. A scientific report was prepared during the workshop for consideration in the preparation of the Third Assessment Report of the Intergovernmental Panel on Climate Change.

Role of clouds and water vapour in the enhanced greenhouse effect
A major source of uncertainty in understanding and predicting the effects of enhanced concentrations of greenhouse gases is the role of clouds in reflecting sunlight and absorbing infrared radiation. Clouds and water vapour throughout the atmosphere lead to feedback processes that can either amplify or reduce the effects of greenhouse gases. Scientists in the Bureau of Meteorology Research Centre have developed a technique to quantify feedback processes in the atmosphere's response to enhanced greenhouse

gas concentrations. Application of the technique shows that the total amount of water vapour in the air provides the main contribution to the positive feedback.

Space-time modelling of rainfall
As part of its involvement with the CRC for Catchment Hydrology, the Bureau of Meteorology has developed a new model of the spatial and temporal variation of rainfall, and demonstrated its ability to accurately reproduce the characteristics of observed storm rainfall events. Unlike current hydrological models that deal with rainfall time and space characteristics separately, the new model provides the capability to simulate both types of variability jointly, which is a much more realistic approach. The model has the potential to generate significant savings by enabling more appropriate design of hydrologic structures.

Great Barrier Reef Marine Park Authority (GBRMPA)

Role *The GBRMPA is the principal adviser to the Commonwealth Government on the care and management of the Great Barrier Reef. The Authority conducts and supports research to ensure best scientific and technical information is available for decisions:and policies relevant to the effective management of the Great Barrier Reef Marine Park.*

Recent Achievements

Flood plumes in the lagoon
The GBRMPA completed a project designed to characterise the movement and periodicity of flood plumes entering the Great Barrier Reef lagoon. The project involved the aerial mapping of flood plumes, followed by modelling the effect of variations in weather patterns that define the movement and dispersion of freshwater flood plumes. The research has determined that these episodic floods carry a large quantity of nutrients into the Great Barrier Reef lagoon. The GBRMPA has quantified the extreme water quality conditions which inshore reefs can experience. Following on from this initial research, the GBRMPA is identifying the effect these disturbances can have, and is attempting to link certain effects with specific events.

HEALTH AND AGED CARE

National Health and Medical Research Council (NHMRC)

Role *The objective of the National Health and Medical Research Council is to advise the community on the achievement and maintenance of the highest practicable standards of individual and public health and to foster research in the interest of improving these standards.*

Recent Achievements

Parasitic diseases

Parasitic diseases such as malaria and schistosomiasis are a significant cause of death, disability, chronic illness and impaired growth and are increasingly recognised as responsible for chronic illnesses in tropical and sub-tropical regions. There are no vaccines available for these illnesses and the parasites are increasingly becoming resistant to the available drugs.

A research team at the University of Queensland has identified two enzymes needed by the schistosomiasis flatworm to consume its main food, red blood cells. The flatworm, or fluke, transmitted through water snails to humans, settles in the blood vessels of the intestine or urinary tract, causing debilitating illness in the affected individual. Eggs released from female flukes lodge in other body tissues, with major damage being the result.

Further research is being undertaken by the team to develop compounds that will keep the enzymes from functioning. It is hoped that such compounds will starve the flukes, thus preventing illness and major organ damage.
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Keeping nerves alive

Neurotrophic factors are potent proteins that have the ability to keep nerves alive. They have been used in clinical trials to treat motor neurone disease, but so far without success. A major reason for this appears to be the way in which the neurotrophic factors are delivered. These proteins are normally provided by cells adjacent to the nerves, so direct injection into the bloodstream, although convenient, is ineffective.

A team at Flinders University of South Australia have designed a system that more closely resembles this physiological mode of action. This system

involves the delivery of genes for the neurotrophic factor to the affected nerves via the bloodstream. Once inside the nerves, the factors are produced "on-site" and, following their secretion, act locally and directly on the affected nerves.

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INDUSTRY, SCIENCE AND RESOURCES

MAJOR RESEARCH ACTIVITIES

Australian Geological Survey Organisation (AGSO)

Role *AGSO is Australia's national geoscientific research and information agency. Its main objective is enhanced potential for the Australian community to obtain economic, environmental and social benefits through the application of first class geoscientific research and information.*

AGSO will achieve its main objective through enhanced global attractiveness of Australia's offshore and onshore exploration investment opportunities, improved resource management and environmental protection, and safer communities and transportation.

Recent Achievements

Airborne geophysical techniques
AGSO, in collaboration with the Cooperative Research Centre for Australian Mineral Exploration Technologies (CRC AMET), the Bureau of Rural Sciences, the New South Wales Government and universities, has demonstrated the viability of using airborne electrical methods for mapping the regolith in three dimensions in a pilot study in central New South Wales. The project has shown that the regolith in the region is partly made of windblown dust (parna), originating as the ancient inland sea dried, forming the Murray basin. This dust blankets the windblown slope of the Great Divide, where it contributes to soil salinity levels.

Complete Magnetic Anomaly Map of Australia
In December 1999, AGSO released the first complete Magnetic Anomaly Map of Australia. Previous editions had gaps that have now been filled by airborne surveying. The data provide a geophysical method for portraying the geological framework of Australia, an understanding of which is vital for successful resource exploration.

Enhanced mineral prospectivity of the Pilbara

The ancient rocks of the Pilbara region of Western Australia, although famous for their iron ore deposits, are generally regarded as a poor source of other commodities such as gold, copper and zinc. It is assumed that as these rocks are so old, none of the mineralising processes common in younger rocks took place.

AGSO, in collaboration with the Geological Survey of Western Australia, has demonstrated that several small scale mineral deposits in the ancient Pilbara region have the same attributes as similar but much younger deposits elsewhere in the world. This implies similar processes have operated throughout the Earth's history and has therefore changed perceptions about the mineral prospectivity of the Pilbara, considerably enhancing its attractiveness to mineral explorers.

1 billion years older

Research undertaken by AGSO and the University of Sydney has been cited by the prestigious US journal Science as one of the top ten scientific breakthroughs in the world for 1999. The research found chemical traces of eukaryotic cells in rocks 2.7 billion years old. Eukaryotes are the group of organisms from which all multicellular life is descended. The findings are significant because they date life to 2.75 billion years, which is 1 billion years earlier than previously believed.

Possible new petroleum potential in the Fairway Basin

A major geological discovery has been made by AGSO just five hundred kilometres to the north of Lord Howe Island, which may lead to the identification of new petroleum potential. During a geological survey cruise, around one hundred large sedimentary domes were discovered buried under the seabed in the Fairway Basin, an area close to the Lord Howe Rise, where water depths are 2000-3000 m. Many of the domes are one thousand metres high and more than 10km long and contain sediment of possible Cretaceous or younger age. Such domes are a key component of many major petroleum fields such as in the Gulf of Mexico, offshore Brazil and off the West Coast of Africa. The domes usually consist of salt or organic-rich shale. Their presence in the Fairway Basin makes the area a very favourable one for exploration.

Seabed mapping program

AGSO, in collaboration with Environment Australia and the National Oceans Office, has undertaken a systematic seabed mapping program to support the first Regional Marine Planning activity conducted under the new Oceans Policy. This information will greatly enhance our ability to assess the biodiversity of Australia's southern seas.

The survey has mapped the slopes of Lord Howe Island, the upper slope of the Bass Canyon off south east Victoria, the uppermost slope off south east and south west Tasmania, the volcanic sea mounts south of Hobart, and the Otway Basin off north west Tasmania and Victoria. It also mapped the slope of the Great Australian Bight Marine Protected Area.

Assessing community risk from geohazards
ACSO's *Cities Project* has produced a multi-hazard risk assessment of the urban areas of South-East Queensland, extending from Caboolture in the north, to the Gold Coast in the south and as far west as Amberley. The report assessed and compared the risk to the community from the hazards that have a history of effect within the study area, including earthquake, landslide, flood and cyclone (both destructive winds and storm tide). In particular, the project investigated the vulnerability of key facilities such as essential services (police, ambulance, fire services, emergency services) and infrastructure (especially electric power, water and sewerage, and telecommunications) to geohazards and the interdependencies among the infrastructure utilities. Key collaborators included the Bureau of Meteorology, Emergency Management Australia, Queensland's Department of Emergency Services, Department of Mines and Energy and Department of Natural Resources, and local government councils.

Australian Government Analytical Laboratories (AGAL)

Role *To prepare a chemical and microbiological measurement infrastructure in support of trade and industry, environment, public health and safety and sport; and to support performance-based building codes through the provision of assessment, appraisal and listing schemes in the areas of coatings, and fire safety engineering and systems.*

Recent Achievements

Detection of genetically modified organisms in food
In response to commercial, regulatory and consumer concerns, AGAL has developed a capability for the testing of foods derived from known genetically modified organisms (GMOs). The detection of modified DNA sequences utilises Polymerase Chain Reaction (PCR) techniques. Scientists at AGAL are developing and trialing methods to test a variety of foods, including processed f oods, using PCR to amplify DNA extracted from f ood. These sensitive techniques are being extended as the number and range of GMOs increases. It is expected a final decision on labelling requirements for foods containing GMOs in Australia will bring about an increased need for GMO detection.
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Olympics drugs research program
The Australian Sports Drug Testing Laboratory (ASDTL) has been undertaking a research program designed to improve technical capabilities in preparation for the Sydney Olympic Games. This research program has led to the development of high-resolution mass spectrometry methods for the detection of significantly lower levels of anabolic agents, enabling their detection for a longer period after their use.

In addition, research over the last two years by ASDTL, and the Australian Institute of Sport has focused on the detection of substances naturally produced by the body, such as erythropoietin (EPO). Research has involved administering EPO to volunteer club-level athletes and measuring a range of parameters in blood, serum and urine. A number of statistical models were developed which can predict whether a subject has been injected with EPO. The proposed testing methodology must now be subjected to a comprehensive validation process before it can be implemented in routine analysis.
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Australian Institute of Marine Science (AIMS)

Role *To generate the knowledge to support the sustainable use and protection of the marine environment through innovative, world-class scientific and technological research.*

In pursuit of this objective, AIMS is working closely with some industries (e.g. offshore oil and gas, tourism and pharmaceuticals), works indirectly with others (e.g. fisheries) and has close links with management agencies (e.g. the Great Barrier Reef Marine Park Authority).

Recent Achievements

Mangroves filter waste
AIMS, with support from the Fisheries Research and Development Corporation, the Aquaculture CRC Ltd, the Australian Prawn Farmers Association and industry partners, has been investigating the fates and effects of nutrient and sediment discharged from land-based prawn farms. While dilution and mixing by tidal action allows some of this discharged material to escape into the coastal zone, much of it seems to be processed within the mangrove ecosystem. Bacterial decomposition releases some of the nitrogen to the atmosphere. Another portion is taken up and held within

the mangrove trees. Much of the rest seems to be processed through natural food-chains into potential fish food.

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Natural sunscreen a step closer to market

AIMS and an Australian company, Sunscreen Technologies Pty Ltd (STPL), have reached an agreement to develop a natural sunscreen, based on an ultra-violet (UV) blocking compound found in reef corals. In the 1980s, AIMS discovered that corals have developed natural sunscreens to cope with long-term exposure to the high intensity UV radiation penetrating shallow reef waters. A copy of the compound has been synthesised, allowing it to be produced without the need to use the natural resources of the marine environment.

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Hydrocarbon dispersal

AIMS, in collaboration with the Australian Geological Survey Organisation (AGSO), has conducted a study of the distribution and dispersal of petroleum hydrocarbons released from a shallow-water oil production platform on the North West Shelf. The main source of hydrocarbons is from Produced Formation Water (PFW), which is extracted along with the oil from underground. Using a wide variety of sensitive measurements taken around the platform, a three-dimensional model was developed to predict the dispersion of the PFW plume discharged into the ocean. The model, which was validated, predicted an area of potential biological impact up to 1km downstream of the platform. The greatest effects should occur in surface seawater; however, dispersion and degradation processes are fast enough to prevent any long-term build-up of contamination within the ecosystem.

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Oil spills in mangroves and salt marshes

With support from the Australian Maritime Safety Authority (AMSA) and the Australian Petroleum Production and Exploration Association (APPEA), AIMS simulated oil spills within a condemned construction area near the Port of Gladstone. This study tested the toxicity of different oils on mangroves and the impact of adding nutrients to stimulate bioremediation. The toxicity tests showed that it would be better to disperse oilbef ore it enters the littoral zone but not if the dispersed oil would contact reef communities. The addition of nutrients to stimulate bacteria was found not to improve the breakdown of oil in mangroves because that environment is so anoxic but it did improve survival of the trees. In contrast, the addition of the same nutrients did improve the degradation of spilled oil within salt marshes. All

of these findings have been incorporated into AMSA's response plans for dealing with coastal oil spills.

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Measuring food-chains on the North West Shelf

The abundance of large pelagic plankton feeders such as whale sharks and manta rays in the North West Cape region of Western Australia may be linked to El Niño/La Niña climate variations. Viewing these large animals has become an important part of a valuable local ecotourism industry, but operators had observed that numbers of whale sharks fluctuated from year to year. In March 1999, AIMS completed 10 cruises (over 2 summers) of *RV Lady Basten* to the North West Cape region. On each cruise, a multi-disciplinary team surveyed plankton communities and measured ecosystem productivity. These in-situ measurements allowed comparison with satellite observations of water temperature and ocean colour collected at the same time, enabling correction of remotely collected data. Simultaneous oceanographic measurements of water currents and temperatures on the continental slope adjacent to North West Cape revealed the physical mechanisms by which nutrient-rich water from below the surface layer is drawn up and pumped onto the adjacent continental shelf. Differences observed between the two summers covered by the AIMS cruises suggest that oceanographic and meteorological processes affected by El Niño/La Niña have a strong impact on the strength of upwelling in this region, and hence on the supply of plankton to these large marine animals.

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Australian Nuclear Science and Technology Organisation (ANSTO)

Role *To contribute to innovation, sustainability and public health through research and development in nuclear science and associated technologies in support of the Australian community and Australian industry. To maintain an essential core of nuclear expertise to support Australia's national and international strategic and nuclear policy objectives and of nuclear facilities for the benefit of industry and the Australian research and development community.*

Recent Achievements

Management of coastal marine environments

Better management options for the coastal marine environment have been developed through ANSTO's work to trace the origin and behaviour of effluent streams. A model is now available to enable environmental authorities to predict, for any oceanographic condition, the level of pollution in the vicinity of an ocean sewage outfall. Also, by measuring concentrations of radioisotopes, rates of transportation of sediments from rivers into the ocean have been determined. Results have already been utilised in the Sydney area, in Hong Kong and in the management of the Great Barrier Reef.

Lead in crocodiles

Using sensitive isotopic methods ANSTO has studied the bioaccumulation of lead and other metals by estuarine crocodiles in Kakadu National Park. Crocodiles thathad eaten waterfowl shot with lead ammunition had elevated lead levels that could be toxic and might even cause death. Statistical analyses of metal levels also demonstrated water catchment specific signatures in their bone structures illustrating the value of the crocodiles as indicators of environmental pollution.

Arsenic in drinking water

The presence of arsenic in groundwaters is a serious health problem in the Indian subcontinent. ANSTO carried out field trials to demonstrate arsenic removal from waters collected from five tubewells near Dhaka in Bangladesh. The treatment process involved the use of sunlight and iron compounds to oxidise and immobilise the arsenic. More than 90 per cent of the initial arsenic was removed from the tubewell water to give residual concentrations within the safe limit for drinking water.

Gentech® - the new delivery system for radiopharmaceuticals

Nuclear medicine is essentially about combining a suitable imaging 'tag' with a bioactive molecule to take the tag to a specific site in the body. To facilitate administration of the drugs, ANSTO has recently completed the

development of a new delivery system called Gentech® and launched the system on the market. The new system provides an easier, more accurate and much safer method of administering radiopharmaceuticals. This technique provides a means to image tumours, their exact location and estimate their malignancy. Similar methods can be utilised to develop radioactive therapeutic agents with very localised effects.

Managing mine wastes
Earthen covers are used widely within the mining industry for reducing heavy metal pollutants by minimising drainage from sulfidic waste piles. Field measurements conducted by ANSTO over the past 20 years, combined with numerical modelling, have allowed scientists to quantify the effectiveness of earthen covers in a variety of climates. Computer codes, developed in conjunction with CSIRO, and proven measurement techniques now provide powerful tools to the mining industry for improving the design of cover systems and monitoring their performance.

CSIRO

Role *CSIRO's primary functions are to carry out scientific research to:*

- *assist Australian industry;*
- *further the interests of the Australian community*
- *contribute to the achievement of Australian national objectives or the performance of the national and international responsibilities of the Commonwealth;*
- *encourage or facilitate the application or utilisation of the results of this or any other scientific research; and*
- *carry out services, and make available facilities, in relation to science*

Recent Achievements

Agribusiness

Soybean improvement
CSIRO scientists have developed a new soybean variety, *Melrose*, with levels of isoflavones three times higher than those found in other varieties. Isoflavones have been shown to have beneficial human health properties (antioxidant, anti-carcinogenic, pro-oestrogenic). Since genes bred into *Melrose* also include a long juvenile trait, the variety can be sown over a very

wide planting window (October to February). Sown in high density under irrigation, *Melrose* is 10-50 per cent higher yielding than existing varieties, thus improving the profitability of soybean production and its attractiveness as a commodity in northern farming systems.

Fire behaviour and management
CSIRO has developed a more accurate system for predicting the behaviour of wildfires and a more sound basis for the design of prescribed burning programs. This information, added to the advances achieved in the understanding of physiological stresses experienced by firefighters and subsequent modification of equipment and training procedures, should help in saving firefighters' lives.

Design and maintenance of effluent-irrigated plantations
In August 1999, CSIRO launched its National Guidelines for environmentally sustainable plantations irrigated with municipal effluent, the result of ten years of research and experimentation. Effluent-irrigated plantations have become a popular solution to reducing nutrient pollution of Australian rivers and estuaries. But these plantations risk creating additional environmental degradation unless they are designed and managed sustainably. Trials were carried out in collaboration with two regional city councils and with Sydney Water and State Forests of New South Wales. An economic study estimates that the project could achieve a benefit-to-cost ratio of about 44, which translates into around $400 million over 17 years. The guidelines will be used by consultants in conjunction with rural councils.

New grape varieties to boost industry
In February 2000, CSIRO launched four new high quality wine grape varieties (*Cienna*, *Vermilion*, *Rubienne* and *Tyrian*) especially designed for Australian conditions. The researchers expect the first commercial wine to be made from the new grapes will be a *Tyrian* varietal wine, available from April 2000. Ten table grape selections (6 seedless, 4 seeded) have been selected and propagated for grower trials, resulting in a new CSIRO-led development for the 'Food into Asia' program with the table grape industry.

Newcastle disease in New South Wales poultry
Drawing on a long-running research program supported by the poultry industry, the CSIRO's Australian Animal Health Laboratory (AAHL) was instrumental in the diagnosis of Newcastle disease. This virulent poultry disease was detected in New South Wales during 1999. Testing at AAHL, using innovative gene sequencing techniques, demonstrated that the outbreak was caused by a local mild strain which had mutated into a more deadly form, rather than a foreign virus. Major eradication and control programs were set in place by New South Wales Agriculture, supported by the findings from AAHL.

Nipah virus in Malaysia
During 1999, a serious outbreak of the deadly Nipah virus was detected in Malaysia. More than 100 people died, and over 1 million pigs were destroyed

as a result of the outbreak. The virus is new to science. As part of the international effort to help control the outbreak, scientists at AAHL undertook a wide-ranging study of the Nipah virus. By applying skills in diagnosis and epidemiology, and undertaking research into how the virus can be transmitted from pig to pig and pig to human, scientists discovered key pieces in the puzzle, leading to discoveries on the behaviour of the virus and how it could be prevented or controlled.

Fine wool technology adopted
The new OPTIM™ process, developed jointly by CSIRO and The Woolmark Company, has been transferred to the wool processing industry. The technology is based on the creation of a new fibre from wool through a combination of chemical and physical processes and it opens the way to a new era in the use of wool. OPTIM™ produces two new and superior types of fibre from wool. One gives increased volume while actually reducing weight, thus producing warmer but lighter knitwear. The second product is a completely new textile fibre and has some properties of wool, some of silk, with a cool touch, a soft drape, and a fine lustre. X-rays show that the processed fibre is closer to silk in structure, and stronger and finer, than its parent wool.

Environment

Climate research outputs
Based on its major global climate model, CSIRO is making multi-seasonal predictions up to 12 months ahead and making these available to the Bureau of Meteorology. CSIRO has made inputs to the design of AusAID-supported work on sea level and climate monitoring activity in regions neighbouring Australia. Within Australia, CSIRO expertise is providing extensive inputs to the national carbon accounting system, providing the tools and information to back Australia's Kyoto commitments.

Soil of the Murray-Darling Basin
A major advance in natural resources information has been achieved with the creation of a spatially referenced database of the soil and geological resources within the Murray-Darling Basin. The Murray-Darling Basin Soil Information Strategy, which devised the database, has also released new lithology and soil-land form maps of the Basin area. More recently, extensive salinity data was released, helping in the identification and shaping of response measures in this sensitive area.

Water quality in estuaries
Based on experience gained from its collaborative Port Phillip Bay Environmental Study, the Swan/Canning reviews in Perth, and work in recent years for Hunter Water, South Australian Water and Sydney Water Corporations, CSIRO is providing sound guidance about factors leading to water quality problems in coastal embayments. This work is helping governments develop management and monitoring programs for major bay and estuarine areas.

Information Technology & Services

Quantm
Quantm is a spin-off company formed to commercialise CSIRO's Align3D software into global markets. Align3D has been proven by determining the most cost-effective route for the proposed $3.7 billion Canberra-to-Sydney Very High Speed Rail Service Project offering a cost saving of $50 million. Align 3D utilises data from digital maps, satellite and aerial photography to develop a program that can reduce the planning process by months.

RTSim
CSIRO has developed RTSim simulation software to help developers of innovative light rail systems plan and optimise their networks. Developers can explore how various design and operation scenarios affect the performance of the transport system, in terms of passenger's wait and journey times, passenger capacity and the power needs of the system. It can be used, for example, to investigate when scheduled services are useful and when on-demand services work best, to find optimal vehicle speeds and numbers and to determine how best to handle empty vehicles.

VERS: First complete archive solution for electronic documents
The continual loss of electronic documents and records is a survival risk for governments and business around the globe. CSIRO, in partnership with Ernst & Young and the Public Records Office of Victoria, created VERS, the first complete archive solution for electronic documents. VERS automatically turns documents used to make decisions into records of those decisions and guarantees, despite any amount of future change to office systems, that all records can be retrieved and displayed exactly as created, forever. The Victorian Government has now commissioned a $5 million deployment project to prove the solution within one of its agencies. If successful, it will be extended across all of government, as part of the Victorian Government's objective of implementing world-leading IT in its administration.

Wireless LAN
During this year Radiata Pty Ltd obtained $14 million in funding to create a start-up company, involving CSIRO staff, to develop wireless local area networking equipment based on CSIRO's patented technology. It is expected that over 90 per cent of Radiata products will be exported. Marketing alliances have been formed with CISCO (world's largest networking company) and Broadcom (emerging world leader in networking products for the home user). CSIRO's patent has been identified by the Institute of Electrical and Electronics Engineers (IEEE) as a component of the world standard for wireless LAN technology.

RoadCrack
CSIRO and the Roads and Traffic Authority of New South Wales have completed the development of an automated, prototype road pavement crack detection and classification system, called RoadCrack. RoadCrack can

detect and classify cracks of widths as small as 1 mm from a moving vehicle travelling as fast as 100km/h. The RoadCrack prototype system has recently completed 70,000km of road condition survey in New South Wales, South Australia, Victoria and Queensland. An Expression of Interest has been released world-wide to facilitate partnerships to commercialise the RoadCrack technology.

Tele-ultrasound
A unique tele-ultrasound system has been developed to allow rural and remote users of diagnostic ultrasound to obtain help from expert radiologists and obstetricians when they are confronted with difficult cases. Based on CSIRO's image compression technology and using inexpensive personal computers, the equipment is able to transmit live video ultrasound images over telecommunications links with limited bandwidth. An initial prototype was completed in February 2000, and a series of trials (supported by New South Wales Health) are planned to evaluate its technical performance, usability and cost-effectiveness.

Unveiling the Great Attractor
Using the innovative multibeam receiving system on the 64-metre diameter Parkes radio telescope, astronomers have made major progress in explaining the elusive "Great Attractor", a large concentration of mass, hidden behind the Milky Way. Astronomers had discovered that the gravity of the Great Attractor was dragging surrounding galaxies (including our own) towards it. This mass had evaded detection for more than a decade, but the Parkes results have unveiled many galaxies hitherto hidden in the Attractor, with an aggregate mass large enough to account in part for the motions of the surrounding galaxies.

CSIRO contribution to time-keeping in the Asia-Pacific region
The CSIRO National Measurement Laboratory (NML) has developed a new system for keeping atomic clocks in national timing laboratories on time with their counterparts in other parts of the world. These systems can be operated remotely by NML staff and are therefore especially suitable for countries with newly established timing laboratories. The NML systems have been installed in Fiji, the Philippines, Thailand, Vietnam, Malaysia and New Zealand with funding, in part, from AusAID.

Manufacturing

CSIRO polymer composites
A technological breakthrough by CSIRO scientists has resulted in valuable uses for the world's mountains of waste truck and car tyres. Recycled tyres can now be used in shoe soles, automotive components, building products, coatings/ sealants and containers for hazardous waste. This is the result of a comprehensive research program developed to address the bonding difficulties encountered with vulcanised rubber and takes advantage of

rubber crumb as a raw material that has outstanding properties for impact resistance, flexibility, abrasion and degradation resistance.

Cancer targeting antibodies
Engineered antibodies, designed for targeting cancer cells, have been successfully tested in pre-clinical trials for imaging and targeting of human tumours. The challenge now is to prove their effectiveness against breast cancers and other carcinomas in humans. CSIRO holds a key patent for the generic designs of these engineered antibodies and hopes to exploit this position with different antibodies that target other tumours, thromboses and blood clots.

Extended wear contact lenses
CIBA Vision, the eye care unit of Novartis AG, has announced the global marketing of a revolutionary contact lens, developed by Australian, Swiss and US scientists. The Australian research was conducted through the Cooperative Research Centre for Eye Research and Technology, which includes CSIRO Molecular Science and the University of New South Wales. The breakthrough soft contact lens can be worn continuously for up to 30 days. It is made with an entirely new contact lens material, capable of transmitting up to six times more oxygen to the eye than ordinary soft lenses.

High performance car paints
The CSIRO-Du Pont Strategic Alliance team has devised, patented and largely developed the most effective, versatile and convenient method of controlling free radical polymerisation that is currently available. The new technology will have a substantial impact on the polymer industry world wide. Du Pont Performance Coatings is applying the technology to the development of higher performance and more environmentally friendly automotive paints and has scheduled the beginning of full-scale commercial production of a pigment dispersant for May 2000. Pigment dispersants are critical components of paint formulations and the new dispersant is orders of magnitude more effective than the current ones used in automotive paints.

Clearer aircraft windows
CSIRO and Aeroclear Pty Ltd, an Australian company specialising in the refurbishment of aircraft windows, have developed a way to markedly reduce crazing (the development of very fine cracks that look like scratches) of aircraft windows. The research team has developed a process for plasma coating the windows with a thin water-repellent polymer, flexible enough to accommodate changes in shape that a window undergoes without itself crazing or becoming unstuck. The process has been successfully trialed in laboratory crazing tests and is expected to provide substantial savings to the aircraft industry as the time between refurbishment will be at least trebled and the need for replacing windows greatly reduced.

Die-casting technology cuts Nissan Casting costs
Collaboration between CSIRO and Nissan Casting Australia Pty Ltd has resulted in significant improvements in Nissan's die casting manufacturing performance. The new technology reduces metal loss in production by 40 per

cent, and production down-time due to molten metal attack on dies have been reduced by 60 per cent. In addition, a new material suitable for laser cladding, which resists molten metal attack on dies, has been patented. As a result of this project, Nissan Casting Australia have substantially reduced their operating costs.

Innovative tool coatings
In a collaboration with Swinburne University of Technology and Suttons Tools Pty Ltd, CSIRO has developed a commercial prototype tool coating facility for the deposition of advanced wear-resistant materials including titanium nitride and titanium aluminium nitride. The system is based on CSIRO patented filtered arc technology. Comparative tests, performed both in Australia by several tool manufacturers and by major tool users in the United States, have confirmed that tools coated in the new system are at the very least comparable and in a number of cases superior to tools coated in the best commercial equipment presently available. The machine has been installed at the Suttons plant since March 1999 and used extensively to coat a wide range of tools, including drills, inserts, milling tools etc.

Minerals & Energy

Pilot plant produces first tonne of magnesium hydroxide
CSIRO has produced the first tonne of flame retardant grade magnesium hydroxide in the Flamemag pilot plant. The $1.8 million pilot plant was constructed at CSIRO Clayton by Ausenco Limited for Flamemag International GIE, a joint venture between Queensland Metals Corporation and Mines de la Lucette, to demonstrate the commercial viability of a process developed by CSIRO to produce flame retardant grade magnesium hydroxide. The plant is intended to produce enough magnesium hydroxide within a six month operating period for world-wide market evaluation and to obtain design data for the full-scale plant. The initial tonne of material has been sent to European laboratories for testing, with initial results being very encouraging. The successful completion of the development program is expected to lead to commercial production of retardant grade magnesium hydroxide.

On-line cement analysis
CSIRO has developed a set of on-line analysers for Adelaide Brighton Management Ltd (ABML) and Fuel and Combustion Technology Ltd (FCT). These analysers are designed to improve cement processing in the Australian cement industry and have potential for other industries and overseas markets. CSIRO worked in collaboration with FCT to develop two key on-line analysis systems - an on-conveyor belt bulk elemental analyser for the raw cement materials, and an on-line analyser for determining the composition and phases in the cement. Prototype analysers were installed at the ABML Birkenhead plant early in 1999. The analysers will be marketed in Australia and overseas by FCT.

Supercapacitors

A supercapacitor developed by an Australian company, cap-XX Pty Ltd, from CSIRO research, is the highest powered and most potent commercially viable supercapacitor yet. Like ordinary capacitors in computers and television sets, supercapacitors store electrical energy and quickly charge and discharge as required. Global sales of supercapacitors are expected to top $100 million in the next few years and grow to well over $1 billion a year. Australia is poised to capture a large share of the market. Mobile phones, laptop computers and wireless modems are among products likely to be major users. Others include quick-charge portable tools, storage devices for photovoltaic cells and electric vehicles.

Safer oil platforms

CSIRO is helping the oil industry design stronger and safer platforms and pipelines in Australia's North West Shelf oil and gas fields. As most of Australia's $250 billion oil and gas resource is offshore, the oil platforms and pipelines must be able to withstand stresses and strains from bad weather and big seas. Drawing on years of ocean observations and data from satellites, CSIRO has developed sophisticated computer software for modelling currents in the North West Shelf, including the extreme ones created by tropical cyclones. Recent work with Perth-based industry consultant WNI Science and Engineering provided the basis for drawing up design criteria for WAPET's new Gorgon platform, and a proposed pipeline from Woodside's North Rankin platform to shore.

Underground signalling

An early warning device based on CSIRO research is helping save the lives of underground miners around the world. The Personal Emergency Device (PED) alerts miners to life threatening hazards like fires, floods and gas leaks. Each miner wears a PED receiver, powered by his cap lamp battery, on his belt. When there is an emergency, the lamp flashes and a buzzer sounds. The message, which can provide vital information like the location of a problem and an evacuation route, appears on the receiver's display. The system combines ultra low frequency signals, efficient antenna configuration and highly sensitive reception so that people working anywhere in a mine can be reached. PED enabled evacuation of miners from an area threatenedby major flooding in a Western Australian mine, and in a United States mine PED allowed safe evacuation of 50 miners threatened by fire. PED is manufactured by an Australian company, Mine Site Technologies Pty Ltd, and is in routine use in major mines in Australia, Canada, the United States and South Africa.

Underground mine vehicles

CSIRO has collaborated with the University of Sydney to develop an automation system for underground mine vehicles. This system will allow vehicles to operate without a driver to improve safety and productivity, and has successfully been demonstrated on an underground Load-Haul-Dump. This project was conducted through the CRC for Mining Technology and Equipment with industry funding from AMIRA. Commercial transfer of the

technology has begun to a new company (Dynamic Automation Systems) created for this purpose by Caterpillar Elphinstone and Lateral Dynamics.

Controlling mine cave-ins
A new way to bring the roof rock down "on demand" has helped save an underground colliery in New South Wales from closure, along with hundreds of jobs in the local community. CSIRO and Strata Control Technology Pty Ltd successfully introduced hydraulic fracturing at Moonee Colliery as a way to take some of the risk out of underground longwall coal mining. In some rock formations, tens of thousands of tonnes of material can stay up after mining for a period ranging from days to weeks. When the roof does collapse, it can send a high velocity windblast through the nearby mine roadways with the potential to cause injury to miners working in the area. Now hydraulic fracturing is being used to take control of the timing of such events so that men can be evacuated from the windblast affected area prior to a collapse. This ability to control when the cave-in occurs greatly improves the safety of the men working on the longwall face. The technology developed has broad application in both the metalliferous and coal mining industries.

The Cooperative Research Centres (CRC) Program

The objectives of the Program are:

- *to enhance the capture of the benefits of research by strengthening the links between research and its commercial and other applications through the active involvement of the users of research in the work and management of the CRCs,*

The benefits arise in various ways, including the commercialisation of specific outputs of individual CRCs, the delivery of improved technology to an industry sector as a whole, and improved knowledge applied to the management of the environment and natural resources. These different models are illustrated in the description of some achievements identified below.

A strong feature of the program is the stimulation of a broader education and training experience, particularly in graduate programs, through initiatives such as the active involvement of researchers from outside the higher education system, and to enhance the employment prospects of students through initiatives such as involvement in major cooperative, user oriented research programs.

As the program has matured, significant outcomes are becoming increasingly evident.

Recent Achievements

US company buys Australian biotech discovery
A Queensland biotechnology discovery which makes possible the more efficient and effective detection of genetic diseases has been sold to a major US company in a deal worth millions of dollars. First Nuceotide Change (FNC) enables the quick detection of gene mutations or gene sequences which are indicators of particular genetic diseases. It will have a significant impact on human health through better disease diagnosis and drug development. The international patent for the technology is controlled by the CRC for Diagnostic Technologies, based at Queensland University of Technology where the discovery was made. The buyer is Affymetrix, a $US6 billion company and industry leader. Affymetrix developed and markets a gene-chip which facilitates the analysis of thousands of gene sequences in a single test. The combined CRC technology and the Affymetrix gene-chip will become a more targeted and incredibly powerful tool for identifying and analysing critical gene sequences. The CRC/Affymetrix partnership will make the FNC technology available on a global scale.

Sugar industry benefits from CRC research
The CRC for Sustainable Sugar Production has helped the sugar industry on the north coast of New South Wales better manage the area's difficult acid sulfate soils, through a project that sampled soils on every New South Wales cane farm. The local industry has received the Rivercare Gold Award for Primary Industry for this work with the CRC on acid sulfate soils. More importantly, in a first for any agricultural industry, three local councils have now accepted memoranda of agreement on industry self-management of acid sulfate soils in NSW canelands.

Pond management software
Pondman2, a new pond management software developed by the CRC for Aquaculture, has helped the prawn farming industry adopt environmentally sustainable techniques. The software assists in the management of pond nutrient processes, resulting in improved productivity and less waste to be discharged into the environment.

Improved road design in Wet Tropics
The CRC for Tropical Rainforest Ecology and Management managed a project which produced a *Best Practice Manual on the Planning, Design, Construction, Maintenance and Operation of Roads in the Wet Tropics*. Through a series of workshops the project arrived at solutions to road design problems which were both economically and ecologically more sustainable. The Queensland Department of Main Roads published the manual and used it as the basis for developing a series of training workshops to introduce the need for new practices across a range of local and shire councils, government departments and other landholders. Some of this research on reducing road kills, design for new culverts and canopy bridges, has already produced useable results.

The Laser Plasma Spectrometer

The CRC for Clean Power from Lignite has begun trials of its Laser Plasma Spectrometer (LPS) in the laboratories of electricity generators in Victoria's Latrobe Valley. The LPS measures the chemical composition of lignite much more rapidly and economically than existing methods, allowing furnace operators to set conditions to ensure that lignite is burned more efficiently and with a minimum of fouling residues. Cost savings from reduced maintenance will be significant.

Redfern Photonics goes to China

Redfern Photonics, a spin-off company of the Australian Photonics CRC has entered a joint venture to make optical fibre with the Fasten Company of Jiangyin, China. The Chinese market, currently met largely by imports, was estimated to exceed ten million kilometres by 2002. Fasten President Zhou Jiangsong said that the technology transferred by the CRC and Redfern Photonics would give the company a product with superior performance and price to imports. The CRC has established a number of spin-off companies, created jobs and generated export income from sale of products developed. The CRC is reinvesting these profits as venture capital in other members of the Redfern group of companies and there are more in various stages of establishment.

Tracking movement of dangerous chemicals

The CRC for Waste Management and Pollution Control has developed revolutionary probes to track the movement of dangerous chemicals and petrol. The probes give a continuous, accurate on-site picture of petrol and other dangerous chemicals in the ground and water. Once in place, the system gives an instant assessment of pollution and changes over time. It overcomes expensive and time-consuming systems for taking water and soil samples back to the laboratory. Probes will be used to monitor more than 4000 sites in Australia. The probes may be worth more than $1 billion a year in potential export earnings, and are already proving their value at demonstration sites in Germany and the United States. The US alone has over 300,000 contaminated sites. The new probes are being marketed and distributed by a wholly-owned Australian company, International Environmental Management Pty Ltd, in association with the CRC.

Industry Research and Development Board

Role To *increase the level and commercial success of industry research and development undertaken in Australia.*

The Industry Research and Development Board (IR&D Board) was established on 1 July 1986 under the *Industry Research and Development Act 1986*. The Board has responsibility for administering several innovation programs including the Tax Concession for Research and Development, the *R&D Start* program, the Innovation Investment Fund (IIF) and the Commercialising Emerging Technologies Program (COMET). AusIndustry, a business unit of the Department of Industry, Science and Resources, assists the Board to administer the innovation programs, and the Innovation and Science Division is responsible for policy development for the programs.

Innovation Programs

IR&D Board achievements during 1999-2000 include:

R&D Tax Concession Program

The Board piloted an improved regional delivery mechanism for the Tax Concession, TaxRED (Regional Delivery of the Tax Concession). TaxRED was designed to focus on companies making claims of less than $2.5 million per year, with a shift in adminstration from compliance to an advisory role. The Auslndustry Regional Office network will be used to implement the TaxRED initiative.

The figure below shows levels of business expenditure on R&D between years 1968-69 and 1997-98.

The tables below show, as at 8 March 2000, the number of registrants and the value of R&D expenditure, by year by State for the period 1985-86 to 1997-98.

Figure 12 BUSINESS EXPENDITURE ON R&D

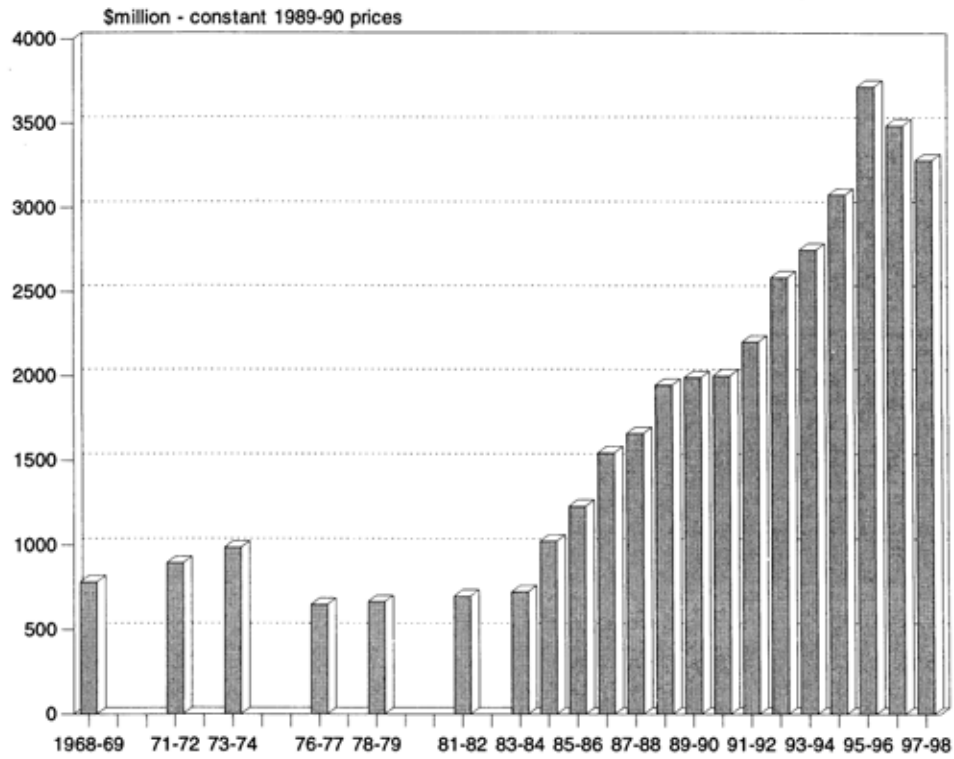

Table 11: R&D Tax Concession
Number of registrants by year when expenditure was incurred and State as at 8 March 2000*

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	**TOTAL**
1985-86	15	796	1	204	142	32	539	142	**1871**
1986-87	14	647	3	178	90	25	383	110	**1450**
1987-88	15	869	5	238	123	28	566	146	**1990**
1988-89	17	885	6	267	135	36	592	153	**2091**
1989-90	19	985	7	307	146	36	617	183	**2300**
1990-91	21	1057	7	320	157	32	693	196	**2483**
1991-92	30	1170	7	375	174	36	812	228	**2832**
1992-93	28	1217	10	393	169	46	851	243	**2957**
1993-94	34	1386	9	493	205	41	987	275	**3430**
1994-95	40	1406	6	550	217	42	1055	297	**3613**
1995-96	38	1414	8	561	228	45	1107	327	**3728**
1996-97	34	1234	12	488	206	36	990	289	**3289**
1997-98	34	1229	10	478	214	35	970	311	**3281**

* Given the retrospective nature of the Concession, the latest full-year figures available are for the 1997-98 financial year

Table 12: R&D Tax Concession
R&D expenditure by year when expenditure was incurred and State as at 8 March 2000 ($ million)*

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	**TOTAL**
1985-86	0.1	62.1	0.0	19.2	0.8	0.3	22.3	2.8	**107.7**
1986-87	1.4	293.2	0.0	76.5	19.5	4.7	251.4	44.5	**691.3**
1987-88	3.0	458.1	0.3	146.1	34.8	8.0	352.1	53.2	**1055.6**
1988-89	5.3	524.6	0.9	149.7	46.9	11.8	492.1	68.4	**1299.7**
1989-90	4.8	589.8	1.8	206.6	56.6	13.4	628.1	107.2	**1608.2**
1990-91	5.6	714.3	1.8	324.4	69.1	11.9	932.2	126.3	**2185.7**
1991-92	10.6	759.2	1.8	352.1	80.7	33.6	1312.6	146.7	**2697.4**
1992-93	12.1	846.7	2.2	488.9	79.0	18.0	1325.8	200.3	**2973.0**
1993-94	12.1	1098.5	36.9	533.1	97.9	28.2	1335.9	247.1	**3389.7**
1994-95	14.8	1381.9	0.9	566.0	140.2	28.7	1466.1	355.7	**3954.3**
1995-96	22.3	1439.1	1.3	762.3	139.6	33.8	1729.7	331.7	**4459.7**
1996-97	23.2	1285.4	4.8	541.7	167.7	34.1	1713.8	390.5	**4161.2**
1997-98	22.2	1277.6	17.1	517.4	201.7	34.0	1842.4	433.8	**4346.2**
TOTAL	**137.5**	**10730.5**	**69.8**	**4684.1**	**1134.4**	**260.7**	**13404.5**	**2508.1**	**32929.6**

* Given the retrospective nature of the Concession, the latest full-year figures available are for the 1997-98 financial year

Innovation Investment Fund (IIF) Program

As at 15 April 2000, thirty-two companies had received approximately $47 million in Commonwealth funding through the IIF. With the addition of private sector capital, a total of approximately $70 million had been invested in early-stage companies.

The IIF program has had its first major success with AMWIN's investment in LookSmart. The Commonwealth's contribution to the original investment was approximately $1.5 million. In June 1999, the Commonwealth received $5.3 million from the sale of part of the investment and, in February 2000, it received a further return of $45.8 million as its share of the distribution from the sale of AMWIN's remaining investment in the company.

R&D Start Program

The following are examples of research and development achievements from completed projects supported through the *R&D Start* Program:

Polymer fibre optic cable for lighting

Rofin Australia received a $327,500 grant for the development of a fibre optic cable, of single large diameter 5–16mm, which allows for more light to be transmitted than is possible with existing light guides. Competing polymer optic cable suffers from significant transmission losses over any significant distances. The project was successfully completed in October 1999, with the improved cable being targeted at special effects lighting and the piping of natural light into buildings. The company has recently completed the installation of decorative lighting in the Cheung Kong centre in Hong Kong

— this illuminated the facade of the building and was featured during the recent New Year celebrations. The company considers that the cable is technically superior to other fibre optic cable - the transmitted light is whiter than with other products, and it is able to transmit a greater range of colours. The company considers that the new cable will have a diverse range of applications, including use in domestic and commercial lighting.

Bridge monitoring system
A grant of $500,000 was provided to Infratech Systems Pty Ltd to fund a project for the development of data acquisition systems, transducers, software and the applications technology for the rapid and economical monitoring of the structural health of deteriorating bridges. The maximum loads carried by road are restricted by the load carrying abilities of the nation's bridges, thus preventing the introduction of larger trucks and trailers. Before the development of the HMX Bridge Health Monitor, load limits on the nation's more than 40,000 bridges had been determined theoretically, using simple conservative engineering procedures.
Establishing the real load carrying capacity of bridges enables the identification of the most critical structures for proof load testing. Bridges that are found to be in a critical condition can then be comprehensively assessed to determine load limit and remedial action. Testing of the HMX Bridge Health Monitor took place across Australia and New Zealand, showing it to be quicker, cheaper and more accurate than previous methods. The HMX Bridge Health Monitor was placed on the market in April 1999, following the success of this project, funded by the IR&D Board.

IPS Radio and Space Services (IPS)

Role *To provide timely radio propagation, geophysical and space weather advice that customers will rely on to perform their operations; that is appropriate to the needs of the Australasian community; and that uses best technical and business practices.*

Recent Achievements

Increase in solar activity matched by increase in services
The majority of IPS services are now provided online. Users can subscribe to alerts of significant events, reports of past conditions, and forecasts of future conditions. This is particularly important, as the sun is now entering an active phase known as solar maximum. IPS is well placed to provide quality services over this period as high solar activity can disrupt communications services.
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High frequency radio wave propagation

IPS has refined its ionospheric predictions and achieves a more realistic description of high frequency (HF) radio wave propagation through the upper atmosphere. IPS has developed a computer program called IPSRAY, which expands propagation predictions from an idealised set of conditions to those more closely resembling real conditions in the ionosphere. IPSPRAY complements the other IPS propagation prediction tool called ASAPS. IPS envisages applications in the real-time management of radar networks and reliable HF communications.

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TRANSPORT AND REGIONAL SERVICES

Australian Transport Safety Bureau (ATSB)

Role *To maintain and improve transport safety through excellence in: impartial transport accident, incident and safety deficiency investigation; safety data, research and pro-active systemic analysis; communication and education; and leading development of national and international safety strategies.*

ATSB's road safety research program is part of a systematic national strategy to reduce road trauma. The program underpins the Federal policy role in road safety, and provides input to policy formulation and review of the National Road Safety Strategy.

Recent Achievements

Development of perceptual speed control measures
Perceptual speed countermeasures are low-cost, unobtrusive road treatments, typically involving painted markings, which reduce travel speeds by influencing driver perceptions. Research completed in 1999 demonstrated the potential effectiveness of perceptual speed countermeasures. A key feature of the research program was the successful use of driver simulation technology to test a range of treatment designs.
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Bureau of Transport Economics (BTE)

Role *To provide expert advice to the Government and information to the community by conducting and disseminating the results of relevant, high quality applied economic reseach related to transport and regional services.*

Recent Achievements

Road and rail competitiveness

A report titled *Competitive Neutrality between Road and Rail* provides a broad analysis of the competition between road and rail freight on the intercapital corridors in Australia. The study considers all current taxes and charges, access to infrastructure, subsidies and externalities. Presented within the report are two scenarios estimating road and rail charges and input costs based on the effects of the Commonwealth Government's new tax system (ANTS), which are compared to a competitively neutral scenario promoting the economically efficient allocation of resources between road and rail.

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Competitiveness in regional aviation

A report on *Regional Aviation Competitiveness*, completed for the Aviation Working Group of the Standing Committee of Transport, critically examines the competitiveness of regional airlines through an analysis of industry structure, conduct and performance. The key areas of interest addressed in this report are the level of air services to regional areas, the monopolistic behaviour of airline operators, the cost structure of airfares and the impact of route-specific factors on service operators. These issues are considered particularly in relation to the objectives of regional aviation deregulation.

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Land Division

Role *The Land Division, in its role as the Government's adviser on national road safety policies, relies heavily on strategically applied research. This is to ensure that resources are directed towards achieving the most appropriate, cost-effective measures to minimise the national road toll.*

Recent Achievements

Side impact research

Australia chairs an international working group coordinating research to improve vehicle side impact protection. Recent research in this area has shown that the geometry of the striking vehicle has the most significant impact on injury risk to occupants in the vehicle being struck. The striking vehicle's mass and stiffness have only a secondary effect on injury risk. This research will be used to develop a new globally harmonised side impact regulation to take over from Australian Design Rule (ADR) 72/00 introduced in January 1999.

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Abbreviations

3-D	three-dimensional
AAHL	Australian Animal Health Laboratory
AAT	Anglo-Australian Telescope
AATB	Anglo-Australian Telescope Board
ABARE	Australian Bureau of Agricultural and Resouce Economics
ABRS	Australian Biological Resources Study
ACA	Australian Communications Authority
ADR	Australian Design Rule
AGAL	Australian Government Analytical Laboratories
AGLS	Australian Government Locator Service
AGO	Australian Greenhouse Office
AGSO	Australian Geological Survey Organisation
AIMS	Australian Institute of Marine Science
AIS	Australian Institute of Sport
AMS	accelerator mass spectrometry
AMSA	Australian Marine Safety Authority
ANBG	Australian National Botanical Gardens
ANSTO	Australian Nuclear Science and Technology Organisation
ANU	The Autralian National University
APLMF	Asia-Pacific Legal Metrology Forum
APPEA	Australian Petroleum Production and Exploration Association
ARC	Australian Research Council
ASDTL	Australian Sports Drug Testing Laboratory
ATSB	Australian Transport Safety Bureau
AWRAP	Australian Wool Research and Promotion Organisation
BA	Biotechnology Australia
BIS	Business Information Service
BITS	Building IT Strengths
BMRC	Bureau of Meteorology Research Centre
BOM	Bureau of Meteorolgy
BRS	Bureau of Rural Sciences
BTE	Bureau of Transport Economics
CAMR	Centre for Advanced Manufacturing Research
CCST	Coordination Committee on Science and Technology
CFD	computational fluid dynamics
CNG	compressed natural gas
COMET	Commercialising Emerging Technologies Program
CRC	Cooperative Research Centre
CROC	Cotton Research and Development Corporation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSRC	Combat System Research Centre
CVAP	Climate Variability in Agriculture Program

DEM	Digital Elevation Model
DETYA	Department of Education, Training and Youth Affairs
DFRDC	Dried Fruits Research and Development Council
DNA	deoxyribonucleic acid
DRDC	Dairy Research and Development Corporation
DSTO	Defence Science and Technology Organisation
EIS	Emerging Industries Section
EMR	electromagnetic radiation
EPO	erythropoietin
ERISS	Environmental Research Institute of the Supervising Scientist
ESO	Evolutionary Structural Optimisation
EU	European Union
FRDC	Fisheries Research and Development Corporation
FWPRDC	Forest and Wood Products Research and Development Corporation
GAB	Great Artesian Basin
GBRMPA	Great Barrier Reef Marine Park Authority
GMO	genetically modified organism
GRDC	Grains Research and Development Corporation
GWRDC	Grape and Wine Research and Development Corporation
HRDC	Horticultural Research and Development Corporation
IAS	Institute of Advanced Studies
IEEE	Institute of Electrical and Electronics Engineers
IGS	Institutional Grants Scheme
IIF	Innovation Investment Fund
IOGTR	Interim Office of the Gene Technology Regulator
IP	intellectual property
IR&D Board	Industry Research and Development Board
ISIG	Innovation Summit Implementation Group
ISR	Department of Industry, Science and Resources
IT	information technology
ITOL	Information Technology Online Program
JAG	Joint Advisory Group on Science and Technology
LAN	local area network
LDV	Laser Doppler Velocimetry System
LWRRDC	Land and Water Resources Research and Development Corporation
NHMRC	National Health and Medical Research Council
NML	National Measurement Laboratory
NMR	nuclear magnetic resonance
NOIE	National Office for the Information Economy
NSC	National Standards Commission
OGO	Office for Government Online
OIML	International Organisation of Legal Metrology
PBS	Pharmaceutical Benefits Scheme
PCR	Polymerase Chain Reaction
FED	Personal Emergency Device
PFW	Produced Formation Water

PIIP	Pharmaceutical Industry Investment Program
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
ppb	parts per billion
PPE	Porcine Proliferative Enteritis
PRDC	Pig Research and Development Corporation
PRSV-P	Papaw Ring Spot Virus
QMSA	Quantitative Mobility Spectrum Analysis
R&D	research and development
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RC	Research Committee of the NHMRC
RECP	Renewable Energy Commercialisation Program
REEF	Renewable Energy Equity Fund
RIEF	Research Infrastructure Equipment and Facilities Scheme
RIRDC	Rural Industries Research and Development Corporation
RPR	reactive phosphate rock
SPIRT	Strategic Partnerships with Industry - Research and Training
SRC	Special Research Centre
SRDC	Sugar Research and Development Corporation
TBT	tributylin
TDP	Technology Diffusion Program
TIGERS	Trials in Innovative Government Electronic Regional Services Project
UKST	UK Schmidt Telescope
UNCLOS	United Nations Convention on the Law of the Sea
UNDCP	United Nations International Drug Control Program
UQBT	University of Queensland Binary Translator
USGS	United States Geological Survey
UV	ultra-violet
WHO	World Health Organisation
WIPO	World Intellectual Property Organization
WMO	World Meteorological Organization
WRONZ	Wool Research Organisation of New Zealand
WTO	World Trade Organisation
WWF	World Wildlife Fund

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This Statement was prepared by the Science and Technology Analysis Section, Department of Industry Science and Resources, based on contributions from many Commonwealth agencies.

The Section also produces a number of other publications designed to promote informed public discussion on science, technology and innovation issues. If you require more information on these publications, please contact the Section by telephone (02) 6213 6417 or email mavila@isr.gov.au.

Australia is one of the most inventive countries in the modern world. Our achievements reflect the vision, talent and diversity of the Australian research community and profoundly affect the quality of all Australians' lives. This is illustrated by the prolific list of publicly funded scientific and technological achievements presented each year in the *Science and Technology Budget Statement.*

- Evidence uncovered by the Australian Geological Survey Organisation and the University of Sydney shows that life was present on earth 1 billion years earlier than previously believed. This discovery was hailed as one of the top ten scientific breakthroughs for 1999.
- Australia is poised to capture a large pait of the market for supercapacitors – the bits that store energy in mobile phones, lap-tops and wireless modems – as a result of CSIRO research developed by the Australian company capXX Pty Ltd.
- Good news for contact lens wearers! Research collaboration between the Cooperative Research Centre for Eye Research and Technology and CIBA Vision has resulted in contact lenses that can stay in for a month at a time.
- The Olympic torch bums brightly thanks to Adelaide University research. Not only can the torch withstand strong winds and driving rain; but it also produces few emissions.
- Other achievements include: an 'invisible' antenna; the discovery of anti-malarial compounds in a Canberra bird bath; the identification of a drug that can block the spread of cancer; a translating tool that allows software to be used across a variety of computer operating systems; and international praise for the revolutionary Stuart Piano, which combines a powerful sound with great clarity.

It is important to raise Australians' awareness of the contribution science and technology make to economic and social well being. Descriptions of Australia's research accomplishments, and the Government funding arrangements which underpin them, will continue to attract the interest of journalists, policy-makers, peak organisations, business interests and many others in the community.

Cover photograph:

A composite image showing a raft of bubbles confined within a thin hemi-spherical shell - part of work in Applied Mathematics at the Australian National University (ANU), in which the general study of flow through porous materials has shown direct outcomes for the petroleum and printing industries; a coil of High Temperature Superconductor (HTS) tape - made by Australian Superconductors, a subsidiary company formed to commercialise the results of 10 years of R.&D undertaken by the Metal Manufactures Group; and a visual model of acoustic reverberation - used by the ANU Telecommunications Engineering Group in work on the removal of acoustic reverberation through equalisation.