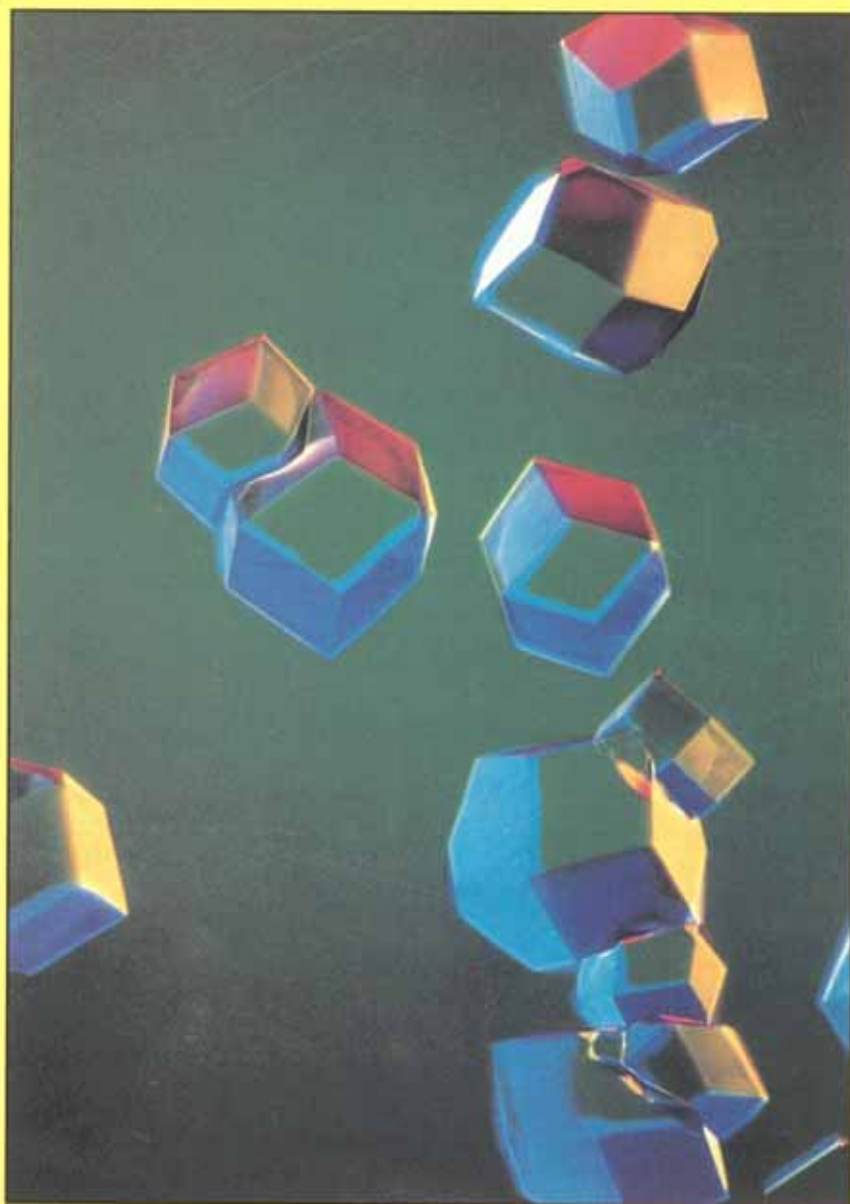




Science and Technology Budget Statement 1996-97



**The Honourable Peter McGauran, MP
Minister for Science and Technology**

SCIENCE AND TECHNOLOGY BUDGET STATEMENT 1996-97

CIRCULATED BY
THE HONOURABLE PETER McGAURAN MP
MINISTER FOR SCIENCE AND TECHNOLOGY

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HIGHLIGHTS

Commonwealth support for major programs of science and innovation in 1996-97 is estimated to be \$3.75 billion, an increase in real terms of 2.7% if the R&D tax concession is excluded, where significant changes tightening its availability have been made.

The adjustment to industry assistance does not reflect any lessening of its importance. There has been over a decade of strong growth in industrial research and innovation, reaching a level approaching the OECD average level. As well, tax concessions are less transparent to the Government and the community than budget outlays. The Government has introduced a competitive grants and loans scheme for industry, as more informed decision making and review is possible with a system of direct grants. This will see a threefold increase in this form of assistance to industry over the next four years.

The adjustment to public research, particularly to basic research, is positive in overall terms. The universities, most science agencies, and all major research granting agencies will have increased research budgets. The increase in basic research support is highlighted by the Australian Research Council's 11% real increase in funding base.

Increased exploitation by Australians of the results of public research is a priority of the Government. Public research programs that promote linkages with potential users or have specific useful purposes in mind have expanded. Promotion of linkages is highlighted by the 6% real increase in the CRC program, while CSIRO has received a real 3% increase in its funding base. Rural R&D receives a 5% increase and health research through the NHMRC increases by 3% in real terms.

Outcomes from Australia's publicly funded research continue to be impressive, and of value to Australia and the wider world:

- Australia is constructing a network of new natural gas pipelines, and research by the CRC for Materials Welding and Joining has allowed accurate identification and assessment of pipe welding defects in the network.
- A new weapon in the fight against the re-emergence of tuberculosis in humans is a rapid and sensitive test for the disease developed by CSIRO and Commonwealth Serum Laboratories.
- The Southern Bluefish Tuna generates around \$100 million pa for Australia and CSIRO has developed an archival tag for studying it and other fish movements. The tag comprises a miniature computer to collect and store information on the fish and its surroundings.
- Researchers at the University of Queensland have discovered the cause and developed a treatment for the second biggest killer disease of horses, *equine laminitis*.

SUMMARY NOTES

SUPPORT FOR SCIENCE AND INNOVATION IN 1996-97

- In 1996-97, Commonwealth support for major science and innovation programs, excluding the R&D tax concession, is expected to increase in real terms by 2.7%. Including the tax concession, where significant measures have been introduced to tighten its availability, Commonwealth support in 1996-97 decreases 5.1% in real terms, to \$3752m from \$3839m in 1995-96.
- The Australian Research Council will receive \$396m to support university research, a real increase of 11% (\$346m in 1995-96). Total funds for university R&D are estimated to rise by about 1%.
- Total support for industrial R&D and innovation, including both direct support through appropriations and the estimated effects of tax revenue forgone, is expected to be \$701m in 1996-97, a real decrease of 27%, due to the reduction in the effects on business R&D of revenue forgone through the R&D tax incentive, which reduces from \$810m to \$547m.
- Funding of the Cooperative Research Centres Program, aimed at promoting more effective interaction between researchers in industry, government agencies and universities, rises this year by 6% in real terms, to \$145m.
- Funds for specific purpose R&D grant schemes (rural R&D, National Health and Medical Research Council grants, other health R&D and some smaller R&D grant schemes) together rise to \$315m (down 2% in real terms).
- A total of \$963m will be provided to the major research agencies in 1996-97 (\$908m in 1995-96), which includes \$229m on defence R&D (\$248m in 1995-96) and a \$61m allocation for a new AGSO building. Budget support for CSIRO will be \$450m, and the Organisation's external earnings will bring its total income to around \$710m. Relative to GDP, appropriations for research in Government agencies in Australia are among the highest in the OECD.
- In common with trends in many countries with high levels of Government R&D, policy in recent years has sought to encourage greater reliance on external earnings, particularly those resulting from productive interactions with industry.
- Budget support is provided in the expectation of useful outcomes and applications, 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 & INNOVATION

	1995-96 \$m	1996-97 \$m est	Real change
AUSTRALIAN RESEARCH COUNCIL ¹	346.4	396.2	+ 11%
OTHER HIGHER EDUC. R&D	1204.8	1232.1	- 1%
CO-OPERATIVE RESEARCH CENTRES	132.7	145.1	+ 6%
INDUSTRY R&D & INCENTIVES ²	935.5	700.8	- 27%
RURAL R&D	126.5	136.7	+ 5%
NH&MRC	141.3	150.0	+ 3%
OTHER HEALTH R&D	21.7	14.1	- 37%
OTHER R&D GRANTS ³	21.8	14.1	- 38%
CSIRO ⁴	422.5	449.7	+ 3%
DSTO	248.2	228.8	- 11%
OTHER R&D AGENCIES	237.3	284.7	+ 16%
TOTAL	3839.0	3752.1	- 5.1%

NOTE: Estimated outlays and expenditure are at current prices, the real changes shown are based on constant price estimates.

1 Represents total of Budget and HEF Act funding.

2 Industry Innovation Program grants plus estimated effect of revenue forgone via the IR&D tax concession scheme.

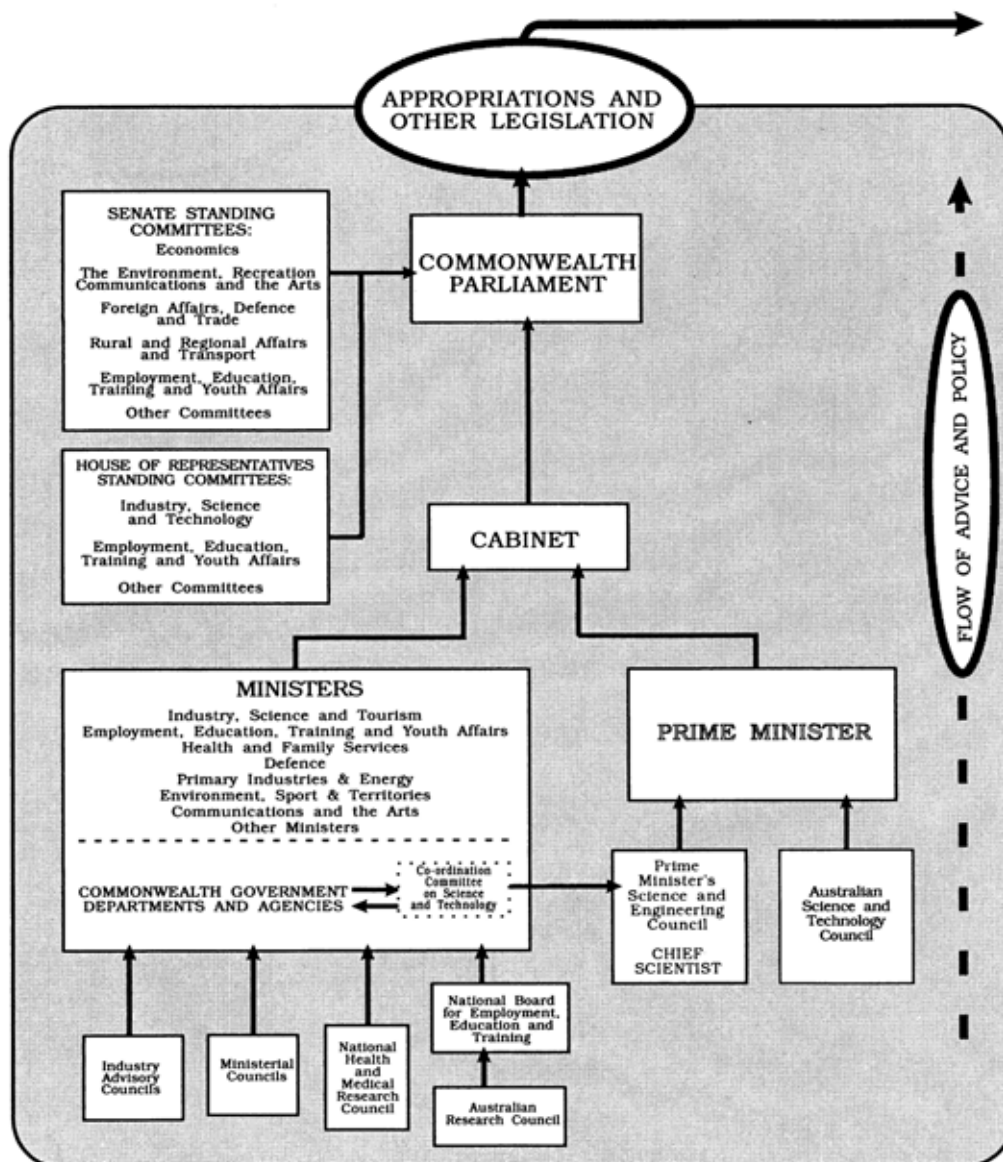
3 Australian Biological Resources Study, Greenhouse research grants, Energy R&D and Australian Road Research Board.

4 Includes funding through DPIE for Australian Animal Health Laboratories. Note that \$20 million from the 1995-96 allocation was borrowed in 1994-95. In addition to the budget funding shown, CSIRO expects to earn over \$262 million from external sources in 1996-97.

For more detailed information see Tables 2 to 6

Figure 1

MAIN CHANNELS OF ADVICE FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY

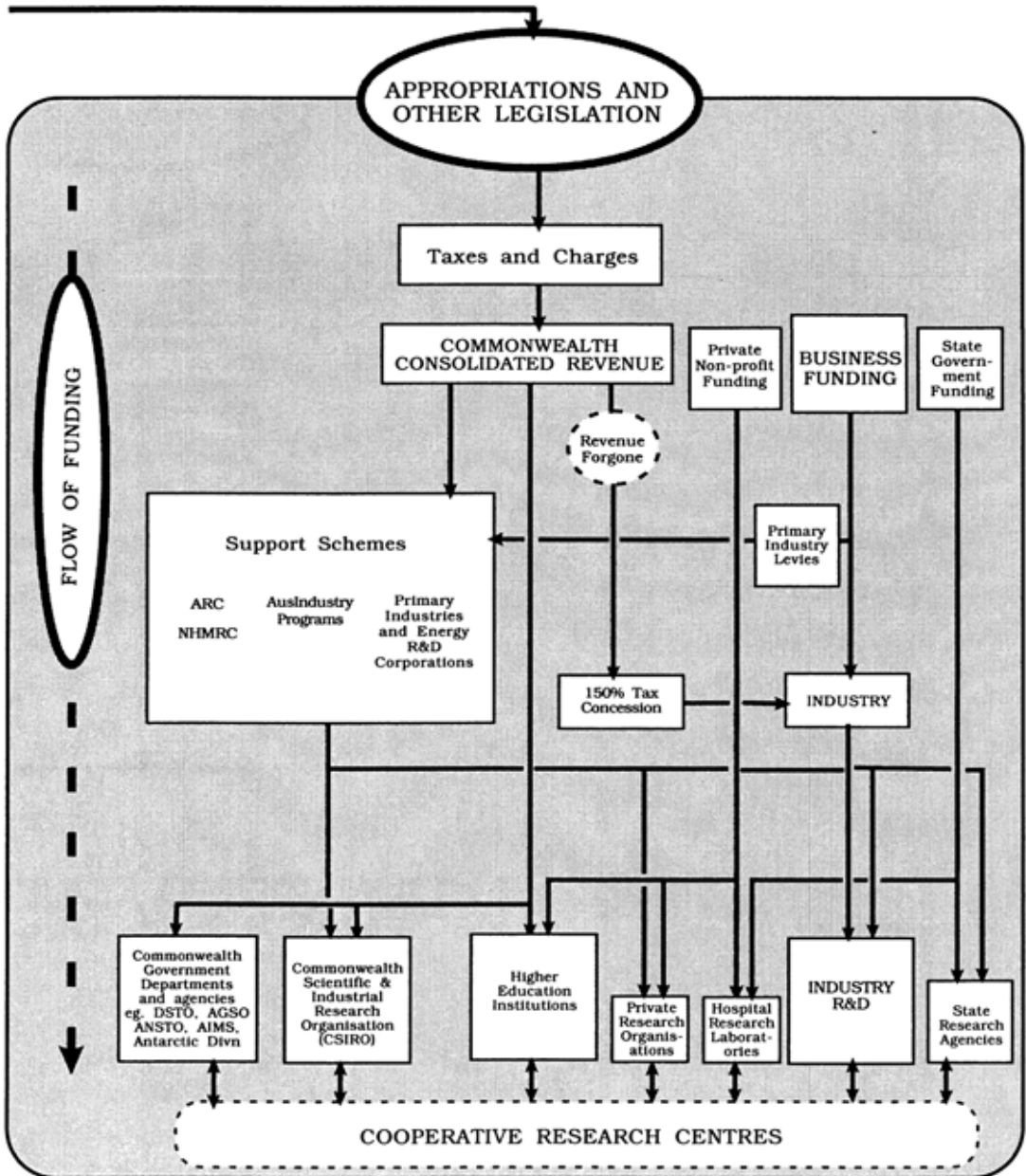


This figure is indicative of major bodies and principal channels for the flow of policy advice leading to Parliamentary and Cabinet decisions on science and technology issues. It does not purport to be other than illustrative.

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.

SECTION 1

The Budget Strategy for Science and Technology

This section outlines
the principal Budget outcomes
for science and technology and
how they relate to policy objectives

The funding envelope

Excluding the effects of indirect support measures - where changes have been made to a generous R&D Tax Concession Scheme that was becoming open to a range of abuse - the envelope of direct support for science and innovation in the 1996-97 Budget shows a real increase of 2.7 per cent. Overall, the Budget provides direct and indirect support for science and innovation amounting to \$3.75 billion. In the context of a general program of deficit reduction, this substantial result reflects the strength of the Government's commitment to science and technology as foundations for Australia's future economic development and national welfare.

The Government has adjusted priorities within the science and technology envelope to obtain improved returns on this investment. Targeted funding for university research under the Australian Research Council will grow significantly in real terms and will be directed at remedying deficiencies in infrastructure, encouraging greater industry funding of university research, and expanding postgraduate research. CSIRO's appropriation will be maintained in real terms in the 1997-2000 triennium by virtue of restoring \$20 million per year to its baseline appropriation. Other major public sector programs, including the other research agencies and the Cooperative Research Centres Program, will in general terms be maintained at current funding levels. Subsidy arrangements for research in the primary production industries will also be maintained at present levels.

At the same time, the Government has adjusted assistance for general industry research so as to maximise incentives for commercially relevant research and to minimise the use of incentives for windfall gains by private interests. In pursuit of this, the Government had closed off the R&D syndication arrangements to new applicants prior to the Budget, and will reduce the rate of the tax concession for industry research and development to 125%. It has meanwhile introduced a new competitive grants and loans scheme which will see a threefold increase in this form of assistance to industry over the next four years.

Overall, these measures will restore the vigour and excellence of Australia's basic research while better focusing the incentives for continued strong growth in business research and development. Both objectives are critical in positioning the Australian innovation system to serve Australia's national interests in the coming century. Australia's longstanding investment in basic and strategic research will underscore the nation's capacity to sustain economic growth in the context of responsible management of the environment and improving standards of health, equity and social development. The imperative of sustaining rapid real growth in business research and development is the *sine qua non* of bringing the skills and knowledge furnished through public sector research to real effect in the national interest.

Management of science and technology

The fundamental adjustments to funding will be accompanied by more effective arrangements in the management of research. The Minister for Employment, Education and Training has circulated a discussion paper presaging the reconstitution of the Australian Research Council as more independent body with enhanced responsibilities. The restructuring of CSIRO to the sector and alliance model proposed by its Board has been implemented, and is expected to provide a more efficient and focused approach to client demands in consequence. The Prime Minister has invited the Federation of Australian Scientific and Technological Societies to join his Science and Engineering Council so as to enlist the voice of working scientists in the highest deliberations on science policy. Engineering is to be added to the title and charter of the Australian Science and Technology Council to ensure the concerns of engineering are systematically addressed in policy advice on science and technology. In more particular terms, the Government is concerned to develop appropriate strategies to deal with new and emerging sectors of research, and in the first instance will develop a National Marine Science and Technology Plan. This will identify the resource, management and program priorities for marine research in enabling Australia to realise the \$80 billion potential of its Oceans Territory. The Plan will be developed in the context of an Integrated Oceans Policy being developed in parallel.

The policy context

The Government considers the adjustments to research funding and management in this Budget are essential to keeping Australia in the global currents of economic growth and social development. Technology, or applied knowledge, now characterises over half the GDP of the OECD as a whole, and economic growth, environmental management, and advances in health and social development are driven critically by the technology based sectors. This is most dramatically demonstrated in the progress of knowledge based services, underpinned by information and communications technologies, as one of the fastest growth sectors in world trade and as one likely to feature in the early twentieth century amongst the most lucrative sectors of world trade.

The OECD trend is merely indicative of structural change across the industrialised world as a whole. In Australia's own primary market of the Western Pacific, the Republic of Korea and Taiwan have already committed proportions of GDP to research and development which exceed our own, while such countries as Singapore, Thailand and Malaysia have embarked on aggressive strategies for expanding their research investments.

The challenge for Australia has been to preserve and exploit the depth of our research system, while moving quickly to adjust its balance. The traditional strength of our public sector research has been weakened by the traditional paucity of our business research and development. While this reflects in large measure Australia's history as a resource economy, the actual structure

of the economy has long moved beyond this, and most particularly so under the influence of integration with the world economy over the last decade and a half.

The relationship of the science and technology system to the structure of an economy is necessarily iterative. Structural change towards technology based industries requires investment by existing industries in the research and development which will yield such change. Existing industries, however, can be reluctant to increase their investments in research and development beyond the minimum necessary for their continued competitiveness.

The challenge before Australia is well demonstrated by comparison with the practice for other industrial economies. It is telling, for example, that whereas industry funds 60% and performs 67% of research and development across the OECD as a whole, Australian industry funds only 36% and performs 44% of research and development undertaken in Australia. Moreover, this is only partly explained in terms of Australia's present industrial structure. While the Australian industrial structure is characterised by relatively low technology intensive industries, our industry investment in research and development is, overall, beneath OECD average levels, *even when weighted to account for our industry structure*.

Against this, there can be little doubt that the face of research in Australia has been changing dramatically in recent years. Australian business investment in research and development has, on average, sustained one of the the fastest growth rates in the OECD for over a decade, and has lifted national investment in research and development from around 1.0% to 1.60% of GDP since the early 1980s. This has been achieved in tandem with an expansion in basic research from around 0.3% to 0.45% of GDP. These achievements in funding growth have in turn been matched by one of the fastest growth rates in external patenting in the OECD, and growth rates for technology based exports comparable to those achieved by the North Asian economies and the 'catch-up' economies of Europe.

In this context, the policy imperatives for science and technology have remained largely constant since the opening of the economy in the mid-80s and must remain so for the medium term ahead. Within these, however, it has been necessary to better focus the incentives for further real growth in industrial research and development at a time when the established incentives were, by some, coming to be abused. It has also been necessary to address strains in the public research sector which have arisen in the course of rapid expansion of the university system and the introduction of external earnings to the research agencies.

In a time of unprecedented financial difficulties, the Government has been able to make these adjustments while maintaining the direct funding envelope for science and innovation at an increased level.

SECTION 2

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

This Section outlines major developments since the 1995-96 *Science and Technology Budget Statement*, released in May 1995, and reports on initiatives announced in the 1996-97 Budget on 20 August 1996 and since the election of the Coalition Government in March 1996.

Administrative arrangements following the change in Government

Following the Federal Election of 2 March 1996, a Liberal Party - National Party Coalition Government, led by the Honourable John Howard, MP, replaced the former Australian Labor Party Government which had held office since March 1983. The new Coalition Government instituted a number of administrative changes. The principal changes affecting policy and advisory arrangements for science and technology, with effect from March 1996, saw the former Department of Industry, Science and Technology become the Department of Industry, Science and Tourism and absorb administrative support functions for the Prime Minister's Science and Engineering Council, the Australian Science and Technology Council, and the Coordination Committee for Science and Technology from the Department of the Prime Minister and Cabinet.

Prime Minister's Science and Engineering Council (PMSEC)

The Prime Minister's Science and Engineering Council, which includes Ministers whose portfolios have a major science, engineering and technology interest, met in June and December 1995.

At the June 1995 meeting, the major agenda item was concerned with sustaining the agricultural resource base. Topics covered included the impacts of agriculture on water quality; sustaining the nation's soil resources; controlling the impacts of introduced weeds; managing climatic risks; integrated catchment management; and the role of community involvement and landcare in sustainable agriculture. Specific outcomes were:

- The Agriculture 2010 initiative, aimed at promoting the economic, ecological and social sustainability of agriculture, forestry and fisheries;
- The release of the Prime Minister's Land Management Task Force report on a strategy to promote sustainable property management planning;
- The establishment of the Rural Partnership Program, to coordinate access to, and delivery of, community resource management; and
- The continued efforts of the Murray-Darling Basin Commission to develop sustainability and water allocation practices which are in accord with the thrusts of the Council consideration of these issues.

The June meeting also discussed the preparation of the former Government's Statement, *Innovate Australia*.

The topic for the December 1995 meeting dwelt on the major roles for science and technology in understanding, conserving and exploiting Australia's ocean resources. Gaps, deficiencies and opportunities in our marine science, education and industry development were identified and drawn to the Council's attention. Also discussed at this meeting was the potential for plantation forestry to contribute to Australia's wood and paper needs, and the important roles being played by research and science in taking advantage of opportunities.

The Council has continued the practice of publishing the papers arising from its major sessions, and making these available to the scientific, engineering and wider communities. Two such papers, on sustainable agriculture and marine science, were published in 1995-96.

Australian Science and Technology Council (ASTEC)

ASTEC's work during the year included the completion of two studies and a review of Australia's science and engineering base for information and communications services and technologies. ASTEC also commenced a new study on science and technology in primary schools. The Government has announced its intention to change legislation so as to rename ASTEC as the Australian Science, Technology and Engineering Council.

Matching Science and Technology to Future Needs 2010

This study reviewed possible national and global changes to the year 2010, and Australia's key future needs and opportunities which rely on, or could be significantly affected by, scientific developments and the application of technology. The report highlights the growing importance of science and technology in the economy and society, its potential benefits in enhancing productivity, community well-being and environmental quality and sustainability. A focus of the report is the identification of four 'Key Forces for Change' to 2010: Global Integration, Applying Information and Communications Technology, Environmental Sustainability, and Advances in Biological Technologies.

The report examines the impacts of the forces for change on industry, government, the community and the science and technology system. ASTEC identifies fourteen 'Areas for Action', and from these suggests eight 'Priorities for Action by the Commonwealth Government', or actions that can be taken today to better position Australian science and technology in the longer term.

The Future Needs study also involved a number of Partnerships with interested organisations, which, together, examined sectoral issues into the 21st Century. Four of ASTEC's five partnerships reported during the year in the areas of: Urban Water Life Cycles, Information and Communications Technology, Health and Youth. The fifth Partnership on Australia's Shipping

sector is nearing completion with a final report expected in September 1996. Each Partnership has made a series of recommendations to government.

Australia's science and engineering base for information and communications services and technologies

This report assesses Australia's science and engineering base in information and communications services and technologies (I&CT). ASTEC found three key areas for policy development if Australia's science and engineering base is to contribute most effectively to the development of I&CT. The key areas are:

- negative views of the community/students to science and engineering careers;
- lowering of the quality of the base, there being a large number of small I&CT and engineering departments resulting in dilution of resources; and
- constraining of technology transfer because of low interaction between industry (particularly small and medium-sized enterprises) and the research and development base.

Science and technology in primary schools

A number of findings from ASTEC's most recent studies indicate that schools have a crucial role to play in improving Australia's science and technology base, and the community's general awareness of scientific and technological issues. ASTEC therefore initiated a new study to address questions about the teaching and learning of science and technology in primary schools, and to identify opportunities for enhancing science and technology in primary schools. It is expected that findings from the study will be reported to the Prime Minister's Science and Engineering Council late in 1996.

Coordination Committee on Science and Technology (CCST)

The Coordination Committee on Science and Technology met twice during 1995-96. The Committee's areas of interest included contributing to the development of the former Government's statement, *Innovate Australia*, and the selection of major national research facilities; conduct of a major seminar on science and research's contribution to ecologically sustainable development; and providing a sounding board for other agencies, such as ASTEC and the ARC, as they develop their own ideas and policies on science and technology issues.

The Committee's major role as a point for exchange of information among departments and agencies continued. Issues such as the coordination of Commonwealth use of high-performance computing facilities, CSIRO's interface with Commonwealth departments and agencies on 'public good' research, and the new Coalition Government's policies and priorities for the science and technology system, were discussed at Committee meetings.

The Minister for Science and Technology, the Hon Peter McGauran MP, attended and addressed the April 1996 meeting of the Committee.

Government support for innovation

The Government believes that future support for business R&D should encourage new or additional research and development. The Government also believes that this objective can be better achieved through greater use of targeted outlay measures which are more transparent, less open to abuse, and will not impose uncontrollable contingent liabilities on the Budget. The Government's guiding principles for all industry assistance programs are to ensure

- genuine market failures are addressed;
- net social benefits to the Australian community are achieved; and
- Australia's competitive position is upgraded.

Announcements in June and July 1996 made a number of changes in relation to the R&D Tax Concession. In particular, the R&D Syndication component of the program was closed to new applicants. In addition, changes were foreshadowed to limit claims in relation to interest on debt financing of R&D and costs associated with core technology, pilot plants, and feedstock. (See Section 5 for further details on these announcements.)

These changes were to ensure that the use of the tax concession remained consistent with the aim of encouraging new R&D and to counter opportunities for companies to receive unintended benefits.

With the 1996-97 Budget, the Government is announcing further changes.

Since the tax concession was introduced in 1986, Australia has experienced a trebling in business expenditure on research and development. The combination of the Government's clear need to achieve significant Budget savings, and Australian industry's growing commitment to research and development, leads the Government to conclude that a tax concession of 150 per cent is no longer fully warranted.

As part of its deliberations on business R&D support, the Government considered a range of options for the R&D Tax Concession to meet its twin goal of providing an incentive for business expenditure on R&D and fiscal responsibility. On balance, the Government has decided to set the rate at 125%, recognising the need to provide continuing support for industry undertaking research and development and to provide an incentive for small to medium sized firms to make research and development a normal part of their business strategy.

In addition, the Government has decided to complement its decisions to close off syndication and to reduce the rate of the R&D Tax Concession, by introducing a new outlays program as part of the Budget. The new program is to be known as the **'R&D Start' Program**. The Government will provide \$520 million over four years for this program, including \$340 million in additional outlays announced in this Budget.

The new program will encompass and build on existing R&D support measures including Competitive Grants and Concessional Loans. It will

provide a flexible package of assistance to industry for research, development and commercialisation. The new Program will:

- provide a new contestable R&D scheme, to replace the R&D Syndication Program;
- provide a mix of support measures based on large grants, loans and interest rate subsidies;
- develop additional new market-based support measures in consultation with industry; and
- complement the R&D Tax Concession scheme.

The Program will provide the opportunity to mix and match grants and loans, financing options, singularly or in combination, to support research, technology and development to better meet the needs of firms.

The new program will be administered by AusIndustry with the Industry Research and Development Board determining which applicants will be successful. It will focus on R&D that has strong support for commercialisation from the private sector. It is expected that a number of existing applicants for the R&D Syndication Program will be among the first to apply for support under the new Program.

Major statements and reports on science and innovation

For many years Australia has been a world leader in terms of the amount and quality of its analysis on socio-economic issues. The analysis of science and technology issues has been no exception, and the period since the 1995-96 *Science and Technology Budget Statement* has seen the release of an exceptional number of substantial reports and statements, including those of ASTEC already discussed above.

Innovation: A Concept to Market

In November 1995, the House of Representatives Standing Committee on Industry, Science and Technology tabled a report following an inquiry into innovation issues. The Committee had been requested to inquire into and advise on key measures and policy structures necessary for the development of an innovative national culture, and to identify options for Government activity.

The Committee's Report, *Innovation: A Concept to Market*, recognised the importance of R&D as a key factor in innovation. It considered that the solution to improving Australia's R&D situation did not require a suite of new programs, but rather the continued application of programs already in place. However, it urged a strong focus on making existing programs operate as efficiently and effectively as possible. The Committee recognised the creativity, skills and knowledge of people as the prime source of innovation - pointing to the key role of the education and training systems as drivers of innovation. It saw a need to develop a strategy that addressed the encouragement of innovation at primary, secondary and tertiary education levels, and also in skills training and managerial education courses. This

would require a long term commitment from both the Commonwealth and State Governments.

The Committee considered that a high priority should be given to educating firms about the benefits of linkages and business cooperation. It saw linkages as enhancing a nation's innovation performance in a number of important ways - through improved market knowledge, improved production processes, product development and improved quality. It also saw scope in the Australian economy for large firms to strengthen links with their local suppliers and to promote networks among those suppliers.

Innovate Australia

The former Australian Government released a major Statement on innovation, *Innovate Australia*, in December 1995. The Statement emphasised the key significance of innovation in fueling productivity growth and the creation of new industries and new employment opportunities. It emphasised the importance of major firms and their supply chains in helping to improve competitiveness and announced a range of management and training initiatives aimed at facilitating improved uptake of best practice by Australian industry. It also set out various measures to improve processes of commercialisation through better access to finance and support to enhance the transfer of technology to industry. The Statement outlined intentions to strengthen the generation of new ideas through continued support measures for industrial R&D and the establishment of new major research facilities and additional Cooperative Research Centres. Many of the specific measures and initiatives outlined in the Statement have been continued by the present Government and are described elsewhere in this Section and in Section 5.

Industry Commission review of research and development

The final Report of the Industry Commission's Inquiry into Australian R&D was publicly released in July 1995 (see *Science and Technology Budget Statement 1995-96* for earlier aspects of the Inquiry). The Commission noted that Australia's research achievements over the years had been substantial and found much to commend in current arrangements for R&D. Achievements included increased awareness of the benefits of R&D and higher growth in R&D expenditures, some firms and industries that were world leaders in research effort, a number of high quality research institutions, some innovative and effective mechanisms for supporting research, and improved policy advisory and coordination structures. The Commission also found important reasons for change in a number of areas. For example, it saw needs to enhance private R&D performance by improving the effectiveness of assistance arrangements and reducing inconsistencies of treatment among firms and industries, needs to improve the accountability, transparency and monitoring of government research agencies and funding programs, needs to raise the social and economic payoff from public sector R&D by achieving a wider external influence over the direction of research, and needs to encourage more cost-effectiveness by increasing the contestability of funding among research providers. The Commission suggested a number of broad guidelines to be taken into account in designing any policy initiatives in relation to R&D and innovation:

-
- *Diversity should be encouraged* - given uncertainties and inadequate information, a combination of interventions is desirable, as is a choice of funders and research institutions.
 - *Private incentives should be built on where possible* - R&D that users initiate themselves is best likely to meet their needs and government action to promote such user-driven research can therefore be an effective form of intervention.
 - *Assistance schemes should be simple and transparent, with well-defined criteria* - uncertainty and inadequate information on relative social benefits from alternative projects militate against administrative discretion. Vague rules can be costly to administer and serve to encourage potential recipients to 'position' themselves for support.
 - *Assistance levels should be broadly consistent* - where assistance is provided with a similar expectation of social benefits, it should be provided at comparable rates and in ways that avoid possibilities for 'double dipping'.
 - *Research should be monitored and evaluated* - benefits need to be produced to justify support for research. Evaluation (including evaluation of unsuccessful projects) helps ensure that funding goes to the right projects for the right reasons.
 - *'Contestability' should have a major role in research funding* - in many areas there is scope and potential for choice between a range of providers. Funding mechanisms should seek to target researchers and organisations that produce the best and most cost-effective research.
 - *Government's roles in sponsoring R&D should be clear and its requirements clearly articulated* - over the range of their activities, governments are involved in three aspects of R&D: in determining priorities, in choosing particular projects, and in performing and disseminating the results of research. Since each aspect involves different skills and perspectives, it can be beneficial for governmental roles in each to be clarified, and separated rather than intermingled.

The Commission made a number of detailed recommendations in relation to particular programs and agencies. The former Government responded to these in its *Innovate Australia* Statement, referred to above.

Strategic analyses of Australian innovation

In February 1996, the then Department of Industry, Science and Technology released a study of innovation in the manufacturing sector. This report, *Australian Business Innovation - A Strategic Analysis*, incorporated a discussion of much of the new research findings on innovation that have resulted from many international studies over the past decade, particularly in relation to 'national systems of innovation'. These new findings point to a growing body of evidence that innovation is *the* dominant factor in economic growth and patterns of world trade. Broadly, innovation involves the application of new ideas in any of the activities of an enterprise, or in its commercial outputs. The most consistently innovative firms possess clear business strategies, are open to the adoption of new technologies and forms of organisation, undertake continuous improvement, creative design and

R&D, and are thus better enabled to commercialise new ideas successfully. The factors that influence firms' abilities to learn are particularly important - including factors that relate to ease of communication and the effectiveness of channels of information and skills transmission between and within organisations. At the same time, there is overwhelming evidence that in-house R&D is essential for effective innovation.

The study found that Australian manufacturing firms have substantially improved their competitiveness against foreign firms, particularly in the lower R&D intensive industries. In the early 1980s, industrial R&D and manufactured exports had been very weak in *every* industry in the manufacturing sector, but Australia was now strong (with R&D intensities well above OECD average levels) in two substantial industries, *iron and steel* and *metal products*, and in two smaller industries - *shipbuilding* and the heterogenous *other manufacturing* industry. However, considerable room for improvement remained in Australia's higher R&D intensive industries - though there are some encouraging trends.

Separate work commissioned by ASTEC and CSIRO resulted in a substantial study of science, technology and economic growth in Australia by the Centre for Strategic Economic Studies at Victoria University of Technology, Melbourne. Released in December 1995, *Australia and the Knowledge Economy - an Assessment of Enhanced Economic Growth through Science and Technology*, found that an enhanced national effort in science and technology could contribute to higher economic growth and lower unemployment in Australia over the next decade. On the basis of a detailed analysis of trends in R&D, exports and economic activity in Australia, and major international trends - including the globalisation of service activities - the study concluded that continuing the rapid rate of R&D growth that Australia had experienced in recent years would by 2003-04 increase gross domestic product to a level 7 per cent higher than would otherwise be the case.

Practical advice for firms seeking to be innovative

In October 1995, the Australian Manufacturing Council released a study analysing the practices of Australian firms that had adopted product innovation as a key competitive strategy. The Council found that successful firms had adopted a wide variety of innovative practices - involving processes, marketing, and business systems - in achieving their results. The study, *The Innovation Cycle - Practical Tips from Innovative Firms*, concluded that exporting and innovativeness are closely intertwined. It identified three broad practices that competitive firms had utilised to achieve successful internal innovation:

- adopting practices that put them in the most competitive markets and in contact with the most demanding customers - thereby creating a demand for new ideas
- trawling the market for solutions - using their internal capabilities to identify, gain access to and use expertise and knowledge in the external environment
- maximising the contribution of their key resource - the skilled employees they possessed - building their organisations around that pivotal base, noting that skilled workers are also communicators and

that their technical skills were made productive through interactions with other workers.

The socio-economic benefits of basic research

The Australian Research Council commissioned a study on the connections between basic research and national socio-economic objectives by the Centre for Research Policy at the University of Wollongong. The study involved national and international data gathering and analysis together with wide consultations with the higher education sector and government, business and non-government organisations. The first part of the study, *Using Basic Research Part 1: Review of Current Theory and International Practices* (March 1995) examined international practices in direction setting while the second part, *Using Basic Research Part 2: Socio-economic Connections to Academic Research In Australia* (March 1996) explored the direct and indirect linkages between basic research and the generation of socio-economic benefits.

This work demonstrated that basic research performs an important role in supporting a wide range of Australian social and economic activities. Almost 70 per cent of about 600 Australian firms responding to a survey conducted as part of the study indicated that they relied considerably on basic research. However, it was clear that the links between basic research and socio-economic objectives followed no simple pattern of relationship. While in some cases basic research was linked quite directly to imperatives set by industry, in others the links were very indirect and reflected long personal and institutional patterns of working and the gradual development of a capacity to solve applied and complex problems in new and creative ways.

The findings of the study are assisting the Australian Research Council with the development of a strategic outlook for its funding advice on basic research, particularly in relation to the desirable balance of its funding between fields of research.

The international standing of Australian science

Three reports by the Bureau of Industry Economics sought to compare Australia's performance in science and technology with a range of other countries. The main report, *Science System: International Benchmarking*, indicated that Australia's science system is performing strongly by world standards and appears well able to support Australian firms' growing technological capabilities. The Bureau noted a strong scientific capability in the Australian workforce. Among those aged 25 to 34, Australia had the fourth highest proportion of graduates in science and engineering in the OECD and was above the OECD median in the proportion of the workforce actively engaged in R&D as research scientists and engineers (RSE). On the latter indicator, and with the single exception of Japan, Australia had higher proportions of RSE than any Asian country. However, in Australia, far fewer of these personnel were engaged in work in the business sector than in most other countries.

A Bureau report dealing with public understanding of science, *Science Awareness and Understanding: How Australia Ranks in International Surveys*, lent additional support to the finding of a strong national capability in

science. In the first major nationwide survey of basic science understanding, Australians achieved higher average scores than *all* other countries for which data were available. The third report, *Australian Science: Performance from Published Papers*, showed that Australia produced 2.1 per cent of the papers in the world's most influential scientific journals - a comparatively large output in relation to size. Moreover, Australian papers were widely cited - a measure of quality - and capabilities were broad, as measured by the shares of world research papers across all scientific fields taken at a broad level. In addition, Australian science displayed highly *consistent* quality in research papers across many fields - more so than the UK, Netherlands and France, for example.

Measuring innovation

The very serious problems in obtaining data that can be validly compared internationally, and the need to establish new kinds of international standards to solve these problems, are not generally appreciated. But increasing recognition of the significance of innovation as a concept broader than R&D alone, coupled with its emergence as a substantial item on the policy agenda in most developed countries, has led to a strong demand to develop new indicators that can provide suitable measures of innovation performance and related outputs from knowledge-based economies. This imperative for new policy diagnosis tools on innovation was first met in 1993 by the publication of the OECD's '*Oslo Manual*', a guide to standard definitions and protocols for national surveys of innovation. The aim was to establish parallel surveys of innovation across most OECD countries with an approach to standardising methodology similar to that which had been taken in the measurement of R&D in the 1960s (through the publication of the OECD's '*Frascati Manual*').

Following development of the *Oslo Manual*, the Australian Bureau of Statistics (ABS) was one of the first national statistical agencies to undertake and publish results from a comprehensive national survey of innovation. The results show that although only one third of Australian manufacturing firms are innovative, these innovative firms dominate the manufacturing sector - accounting for 70 per cent of employees, 80 per cent of sales, and 85 per cent of exports. A close association was apparent between the presence of in-house R&D and other innovation. Expenditure on R&D was found to account for one third of expenditure on all innovation activities.

Comparisons with a range of other countries should become possible by 1997, when results from a number of other national surveys should be available. With support from AusIndustry, ABS now plans a further innovation survey in 1997 - this will benefit from a new edition of the *Oslo Manual*, which is being substantially revised in the light of experience from the first round of international surveys. Australia is making a substantial contribution to the revisions.

Major National Research Facilities (MNRFs)

The Major National Research Facilities (MNRF) Program funds establishment costs of major research facilities required to keep Australia at the leading edge of key scientific and technological developments, through \$62 million provided over eight years. It will focus on facilities involving establishment costs beyond the capacity of any individual Australian institution. The facilities must be capable of offering shared use by the widest pool of users from various scientific disciplines and areas of application including industry. Such facilities will be specifically identified as being for national use and will be made available to researchers according to the merit of their proposals.

Seven new major national research facilities to be supported under the Program were announced in December 1995 in the *Innovate Australia* Statement. They are:

- Upgrade of the Australia Telescope National Facility - \$11 million
- Australian Synchrotron Research Program - \$ 12.2 million
- Australian Genome Research Facility - \$10 million
- Airborne Research Australia - \$ 8.5 million
- Australian Proteome Analysis Centre \$ 7 million
- National Plasma Fusion Research Facility - \$ 8.7 million
- Australian National Seismic Imaging Resource - \$ 5 million

Initial establishment funding for the facilities was provided under agreements made in January 1996. The final agreements are being negotiated and are expected to be in place late in 1996.

Launch of a satellite to celebrate the centenary of Australian Federation

Australia's first space satellite will be launched in 2001, to coincide with celebrations for the centenary of Federation. The space mission, known as FEDSAT, will conduct scientific experiments and develop practical applications, such as communications and earth observation. The mission will require development of a micro-satellite and funding will be provided through the Government's Cooperative Research Centre Program. The CSIRO will play a leading role, in conjunction with universities and industry. The Government will establish a Space Policy Unit within the Department of Industry, Science and Tourism to provide advice on and facilitate commercial space activities, such as space launch proposals for Australia.

CSIRO's Management and Structure

Following an evaluation by the CSIRO Board in 1994-95, CSIRO's new Chief Executive, Dr Malcolm McIntosh, announced major changes to CSIRO's management and structure in March 1996. While CSIRO's research Divisions remain the core business units of the Organisation, the Institute structure adopted in 1988 has been abolished. Research planning and prioritisation is now undertaken on a Sectoral basis with external advice channelled through Sector Advisory Committees. Each Sector represents an industry group, market or natural resource of national significance. Four Deputy Chief Executives have been appointed, each having a mix of Sectoral, Divisional and Corporate responsibilities. Each Division will contribute relevant skills to a variety of Sectors as appropriate. The changes are designed to strengthen CSIRO's capacity to assemble multidisciplinary teams to conduct world class research, and also to ensure that the Organisation's research consists of a balanced portfolio of projects directed to the short, medium and longer term needs of customers and clients in both the private and public sectors.

Enhanced support for university research and research training in the Budget

The Government has announced that additional support for research and research training in universities will be provided through the Employment, Education, Training and Youth Affairs portfolio in the form of enhancements to three key programs. Research funding will be boosted by \$129 million over three years beginning in 1997, with increased support for research infrastructure, postgraduate research training and university/industry collaborative research:

- a further \$90 million will be provided over three years to ensure the international competitiveness of Australia's higher education research infrastructure: This additional funding for infrastructure support will significantly boost the ratio of university research infrastructure relative to direct Commonwealth competitive grants;
- an additional \$9.3 million will be provided over three years to support postgraduate research training by funding 100 additional research students; and
- an additional \$30 million will be provided to enhance research collaboration between universities and industry.

A national strategy for high performance computing and communications

In recognition that high performance computing and communications (HPCC) are critical enabling technologies for international competitiveness, the Government is funding the development of a national strategy to enhance Australia's HPCC capabilities through a program administered by the Department of Employment, Education, Training and Youth Affairs

(DEETYA). The program will focus on education and training and research and development aspects of the national strategy to complement technology diffusion and industry extension activities being supported by the Department of Industry, Science and Tourism (DIST). Both DEETYA and DIST program elements will support the acquisition of additional HPCC infrastructure to supplement existing infrastructure. Such infrastructure could include high performance computers, visualisation systems, advanced software, mass data storage system, and high-speed communications networks. Development of the associated skills needed to build and develop these technologies and adapt them to industry needs is also included in this infrastructure support.

Joint Australian Research Council (ARC) and Australian National University (ANU) Review of the ANU's Institute of Advanced Studies

A comprehensive review of the Institute of Advanced Studies (IAS) and its Schools and Centres was jointly undertaken, in 1995, by the Australian National University and the Australian Research Council. The Review consisted of detailed examinations of the research and research training activities of individual Schools and Centres of the IAS and a review of the IAS as a whole by a committee chaired by Dr Keith Boardman, former Chief Executive of CSIRO. National and international comparisons were made, using agreed performance measures. In September 1995, the Institute Review Committee produced its Report on the Joint Review. The ARC/NBEET advice on the IAS, which took into account the Schools/Centres reviews, and the overall review, and completes the review process, was provided to the Government in December 1995 and tabled in Parliament in May 1996.

The overall review found that the IAS has created a social, cultural and scientific environment to act as a magnet for talent and to attract scholars of the highest calibre from all over the world. As a result, the Institute is now a world player in every field in which it has well established scholarly and research activity. The review also found that no other Australian institution, and few institutions in the world, can match the high standards of performance that were judged to have been attained by the schools and centres of the Institute. A further finding of the review is that although research at the Institute is primarily of a basic and fundamental nature, the industrial and public policy potential of much of it is apparent or being realised. The ARC found that, overall, the Institute of Advanced Studies undertakes basic research of very high quality as judged by international standards and demonstrates intellectual leadership across many disciplines.

Strategies for research disciplines

As part of a strategy for monitoring and evaluating research funded through the Employment, Education, Training and Youth Affairs portfolio, the Australian Research Council (ARC) and the Department of the Employment,

Education, Training and Youth Affairs (DEETYA) commission key peak bodies to undertake *Discipline Research Strategies* on behalf of various research communities. The strategies enable stakeholders in a discipline, including those who use research and research training graduates, to participate in developing longer term goals for the discipline and a strategy for achieving the identified goals. Seven Discipline Research Strategies have thus far been published. A further five Strategies are currently under way in the following disciplines: Language and Literacy, Humanities, Social Sciences, Management, and Information Technology.

The three *Discipline Research Strategies* published since June 1995 were:

- *Australian Astronomy: Beyond 2000* which found that:
 - despite relatively modest funding inputs to astronomy, Australia is a world leader in astronomical research and ranks highly in terms of research output and impact;
 - Australia's frontline national astronomical research facilities should be maintained at their present level of effectiveness through the timely upgrading of instrumentation as technology and astronomical imperatives evolve; and
 - Australia should strive to ensure adequate access to the next generation of international astronomical facilities.
- *Mathematical Sciences: Adding to Australia* which found that:
 - Australia's research base in the mathematical sciences is generally sound;
 - mathematical sciences make a vital contribution to many fields of research. Researchers in other disciplines make extensive use of many concepts and techniques from the mathematical sciences and much mathematical research is multi-disciplinary in nature; and
 - mathematical sciences are generic and enabling technologies and are vital to Australia's economy and quality of life. Advanced mathematical services, which are dependent on our basic research base in the mathematical sciences, are crucial to Australia's future competitiveness.
- *Psychological Science in Australia* which found that:
 - Australia is performing strongly in the psychological sciences - producing 2.8 percent of papers in the world's top journals, a figure that compares very favourably with other disciplines;
 - psychological sciences have made a significant contribution to Australia's advancement in a number of social and economic areas and the potential exists for that contribution to be enhanced - for example in the prevention of violence, reducing stress and increasing efficiency in the workplace, and preventing mental illness; and
 - the Strategy recommends various ways to ensure the continuing quality of professional training and practice.

Organisational change in ANSTO

A number of key recommendations contained in ANSTO's Mission Review have been implemented. These and other initiatives included:

- Refocusing ANSTO strategic research on priority nuclear science and technological applications following extensive consultation with stakeholders. This led to the cessation of certain areas of research and the extension of others.
- Development of a Business Plan for Radiopharmaceutical Production and Marketing
- Development and adoption of a Radioactive Waste Management Strategic Plan
- Acceptance and progressive implementation of a Communications Strategic Plan to improve existing mechanisms for interacting with the local and broader communities
- Introduction of project-based budgeting and management within Core Science Businesses

ANSTO adheres to comprehensive procedures for the safe operation of reactors. A study was initiated to determine both the remaining life of ANSTO's High Flux Australian Reactor and assess the safety of the reactor. The independence of the study is ensured through its carriage with the Department of Industry, Science and Tourism. A technical committee was established to advise the Department in an international search for a suitable consultant to carry out the study, and to monitor its progress. The consultant selected to carry out the study is PLG Incorporated, a US firm that is an international leader in the field of nuclear safety assessments and in studies of reactor components. The report from the consultant is expected in April 1997.

Review of the operation of the Bureau of Meteorology

In June 1995 the former Government announced a Review of the Operation of the Bureau of Meteorology. The review was concerned with the Bureau's efficiency and effectiveness of operation, including the appropriate level of funding for upgrading the Bureau's climate monitoring and prediction activities and for the ongoing operation of the Bureau's basic systems and services. The review, chaired by Professor Ralph Slatyer, the former Chief Scientist, found that there had been an erosion of the resources available to the Bureau of Meteorology, particularly over the past five years. This had resulted in:

- a significant deterioration in the quality and reliability of the national observational and climate monitoring networks, compared with accepted benchmark standards; and
- an inability to keep pace with the rapid and continuing increase in demand for meteorological services from an increasingly sophisticated user community.

The Review found that steady improvements in efficiency and productivity had not been sufficient to reverse these trends and recommended additional funding.

Climate Monitoring and Prediction

The Bureau of Meteorology was appropriated an additional \$1.8 million in 1995-96 to support a Climate Monitoring and Prediction Upgrade. The upgrade objective was to maintain and slightly enhance the highest priority elements of the national climate monitoring and prediction networks and services and to contribute to the establishment of essential permanent Australian benchmark networks for agrometeorological applications, drought monitoring, water resources assessment and climate change detection and monitoring. The Bureau's capabilities and performance in climate monitoring and prediction have been enhanced through specific initiatives directed at establishing reference climate stations, servicing the needs of rural industries, improving the coverage of the national rainfall network, and refurbishing the national solar radiation network. The upgrade has also aided development of improved methods for providing early warning of drought, increased understanding of the potential for seasonal to interannual climate prediction, and improved targeting of services to rural industry sectors in support of critical climate-sensitive decisions. Levels of ongoing support for the upgrade will be determined as part of the Government's response to the recommendations of a Review of the Operation of the Bureau of Meteorology, completed during the year.

National Geoscience Mapping Accord

The National Geoscience Mapping Accord (NGMA) was endorsed in August 1995 by the Australian and New Zealand Minerals and Energy Council (ANZMEC) for a further five years. The NGMA, which was originally agreed to by ANZMEC in 1990, is a joint Commonwealth-States/Territories Program designed to support Government and industry decision-making in relation to minerals and petroleum exploration and land use planning. The Accord is designed to provide a new generation of geoscience maps and datasets of agreed priority areas of Australia.

Scientific Advisory Group on the Impact of Nuclear Testing in the South Pacific

Following the announcement by the French government of the resumption of nuclear testing in the South Pacific at Mururoa and Fangataufa atolls an expert advisory group was convened to:

- provide advice on the impact of nuclear testing on the atolls,
- to propose a scientific program to monitor the effects of the testing, and

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- to prepare a paper for the South Pacific Environment Ministers' Meeting, held in Brisbane in August 1995.

The group included experts from a range of government and other organisations with expertise in relevant disciplines ranging from geophysics to meteorology. The group analysed available evidence on the structural integrity of the atolls, the possibility and timing of radioactive leakage from the atolls into the ocean, and the impact of such leakage on the surrounding environment. It proposed a monitoring program to assess the long-term impact of the testing.

The group's advice was welcomed by the South Pacific Environment Ministers, and was widely circulated in Australia and internationally.

Improving science and technology links with the Asia-Pacific region

For the first time in APEC's history, Ministers for Science and Technology gathered in Beijing, on 5-6 October 1995 to discuss how to advance science and technology cooperation amongst member economies. A Draft Action Program was endorsed at the Conference and later adopted at the Economic Leaders' Meeting in Osaka. A second APEC S&T Ministers' Conference is planned for 11-15 November 1996 in Seoul.

Representatives from fifteen member economies attended the 10th APEC Working Group Meeting on Industrial Science and Technology in Jakarta, 17-18 January 1996. The agenda included projects and new proposals on the environment, information networks, technology flow, joint research, researcher exchange, policy and regulations. Australia will host the next meeting planned for 24-26 September 1996 in Canberra.

Australia has also been participating in activities generated by the 13th Meeting of the Association for Science Cooperation in Asia (ASCA), a major regional science forum.

Stimulating international commercial relationships through science and technology

Particular attention was given to the bilateral S&T Agreement signed with Indonesia in 1994 under the newly formed and broadly based program of 'Collaboration on Science and Technology - Australia and Indonesia' (COSTAI). This culminated in the identification of a number of prospective collaborative projects at a meeting of officials from both countries held in Melbourne in June 1996.

Collaboration in science and technology with Malaysia was put on a new and firm footing through reciprocal visits of the Heads of the two respective Departments and by commitments made by both sides at the first meeting of

senior officials to be held in Australia (the last meeting having been held in Malaysia in 1992).

Efforts were made to ensure that Australian researchers took appropriate opportunities to participate in the European Commission's Fourth Framework Research and Development Program. The Commission supported ten proposals in which Australian researchers were full participants. This was double the number expected.

In August 1995, at the 4th ASEAN Science and Technology Week held in Bangkok Australia put on display some of its technology which was seen as most relevant to the interests of ASEAN member States and provided key note speakers for the associated technical conferences. The interest generated did much to draw attention to Australia as a source of solutions to pressing environmental and infrastructure problems in the region.

The French Australian Industrial Research (FAIR) program was evaluated independently in both Australia and France. Both sides found it to have been useful and to have produced tangible outcomes which amply justified the modest outlays. The Minister for Science and Technology, the Hon Peter McGauran MP, agreed in April 1996 to its extension.

Other initiatives in support of science and technology

Other measures put in place during the year to enhance Australia's science and technology effort included:

- in industry, science and technology

- The Industry Research & Development Board and AusIndustry, in partnership with Coopers & Lybrand Consultants, produced in October 1995 the first edition of a research and development (R&D) *Scoreboard* for Australian companies. The *Scoreboard* ranks Australian companies based on their total R&D expenditure (for 1993-94 or nearest equivalent), turnover and, where possible, pre tax profit, dividend and number of employees. Publication of the latest available data in the *Scoreboard* format will become an annual event and will focus attention on our top R&D performers. The *Scoreboard* aims to raise awareness of the importance and the benefits of R&D. It will assist the financial community in assessing the potential of companies and encourage leading firms to maintain their position at the forefront of developing technology.
- A Consortium of three universities, AMIRA, CSIRO and ANSTO has been established with overall responsibility to develop a comprehensive acid mine drainage R&D program.
- The ANSTO Board approved an operational plan for further research and development on Synroc during the year. Synroc has been listed as one of the immobilisation options for excess military plutonium disposition in the USA. New collaborative research projects on Synroc commenced during the year with agencies in two European countries.

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- A Consortium of Australian Universities, CSIRO and ANSTO has established a relationship under the Major National Facilities Program with the Advanced Photon Source at the Argonne National Laboratory, Chicago.
 - The Minister for Resources and Energy has invited the coal industry to provide advice on the future arrangements that might apply to coal R&D after the trial period for the Australian Coal Association Research Program (ACARP) concludes on 30 June 1998. ACARP is an industry funded and managed program introduced in 1993 to replace a government managed program that was funded by a levy on coal production.
 - In 1995 an independent Review Committee, undertook a review of the three Advanced Engineering Centres (AEC) funded by the Department of Employment, Education, Training and Youth Affairs. The Review recommended that each Centre have its funding continued for between two and three years, with further reviews to be undertaken at the end of that time. It also recommended that funding for existing and new AECs be limited to six years.
 - Through the Research Evaluation Program (REP), the Department of Employment, Education, Training and Youth Affairs (DEETYA) and the Australian Research Council (ARC) have undertaken a number of *Reviews of ARC Large Grant Outcomes*. The Reviews evaluate the effectiveness of the Large Grants Scheme in supporting research in a discipline by examining the output and impact of research carried out by individual researchers and teams. The aim is to ensure that the Scheme is supporting high quality research in the discipline, that research output is commensurate with funding input and that administrative processes are efficient and fair. The evaluations undertaken and published since June 1995 are: Computer Science, Sedimentology, Stratigraphy and Palaeontology, Experimental Physics and Astronomy and Astrophysics. Those currently under way are: Plant Physiology, Education, Marine Biology and Atmospheric and Oceanographic Science.
 - The Research Evaluation Program also conducted evaluations of three ARC/DEETYA research funding schemes:
 - **the ARC Fellowships Scheme:** The review found that the Fellowships Scheme has contributed significantly to the research success of Fellows and the institutions hosting them. It recommended various ways to improve and clarify the Schemes objectives. These are currently being considered. The report of this evaluation, *Taking the Lead: The ARC Fellowships Scheme in Australia* was published in May 1996 as the first of the Departmental Evaluations Program Report series.
 - **Australian Postgraduate Research Awards (APRA) Scheme:** This evaluation included a comparative study of the 1990 APRA cohort and a matched sample designed to identify the impact of the Scheme on its first cohort and the research training system. The final report of the evaluation is nearing completion and is expected to be published shortly.

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- **the Overseas Postgraduate Research Scholarship Scheme (OPRS):** The review found that the Scheme largely met its objective of attracting high quality research students to areas of strength in Australian universities and that it makes a valuable contribution to the internationalisation of Australia's university research system. The report recommended some changes to award conditions and improvements to the administration of the Scheme. These are currently under consideration. The report of this evaluation, *The Internationalisation of Australian Higher Education: An Evaluation of the Contribution of the Overseas Postgraduate Research Scholarships Scheme* was published in June 1996 as the second of the Departmental Evaluations Program Report series.
 - The Department of Employment, Education, Training and Youth Affairs has provided \$1.7m through the Research Infrastructure (Equipment and Facilities) Program to support greater access to high performance computing and communications facilities for universities. The grant will support four projects involving a number of universities. The projects are a National Micro-Economic Modelling Laboratory to support research at the universities of Sydney, Melbourne, New South Wales, Queensland, Southern Queensland and Western Australia, an upgrade of the Sydney Wide Area Microwave Project to link the University of Newcastle to the University of Technology, Sydney hub, a 3D dynamic modelling and analysis facility shared between the University of Ballarat and the Queensland University of Technology and a Distributed Computing Laboratory involving the University of Sydney and the University of Technology, Sydney.
 - In July 1996 the Minister for Employment, Education, Training and Youth Affairs, released a Discussion paper on the proposed restructuring of the Australian Research Council and the Higher Education Council. The paper provides the basis for consultation with the higher education sector and key stakeholders on the proposed changes.

- in science and technology awareness

- The 1996 Australia Prize was awarded in the field of pharmaceutical design to four scientists: three Australians - Dr Graeme Laver, Dr Peter Colman and Dr Mark von Itzstein - for the design and development of the world's first anti-influenza drug (see the front cover and caption; and one Belgian - Dr Paul Janssen for the development of a range of pharmacological agents for the treatment of disabling and life-threatening illnesses.
- Financial support totalling \$500 000 was provided from the Science & Technology Awareness Program to 8 ongoing and 19 new awareness raising projects. These included materials for teaching middle managers about science and technology in innovation, and a resource for teachers using S&T material on the internet.
- The 1995 Michael Daley Awards for Science, Engineering and Technology Journalism in ten categories were announced in September 1995. The overall best entry award went to Peter Hiscock and Graham Davis of the Nine Network for their Sunday program report, 'The Agent Orange Story'.

- in international science and technology collaboration

- In 1995-96, \$5.6 million was allocated under the International Science and Technology Program (ISTP), to develop and strengthen relationships between Australian and overseas researchers through a variety of funded programs under ten collaboration treaties. Assistance was provided to around 480 Australian scientists, technologists and engineers for overseas travel for research collaboration and access to major research facilities. In the same period, ISTP helped sponsor 27 major international scientific, technology and engineering conferences in Australia.
- The International Atomic Energy Agency Regional Cooperative Agreement for Asia and the Pacific is a major multilateral science and technology program involving seventeen countries in our region. The objective of the program is economic growth and social development through improving infrastructure, developing trained manpower, improving health care and advancing industrial productivity and rural development. Australia has been one of the major donors to the Agreement since 1977 and currently funds projects in industrial applications of isotopes and radiation; strengthening radiation protection infrastructures and training of nuclear medical technologists. Staff from ANSTO play a significant role in the delivery of these services.
- In late 1995 the Department of Health and Family Services and the National Health and Medical Research Council (NHMRC) supported a workshop in cancer research between Japanese and Australian researchers in this field. This continues a collaborative effort which is expected to strengthen research ties between the two countries. In 1996 NHMRC will provide support for a similar collaborative workshop on cardiovascular (Hypertension) research.
- Since June 1995, the Australian Research Council has signed Memoranda of Understanding on research collaboration with the National Research Council in Italy, the Swedish Natural Science Research Council, the Japan Society for the Promotion of Science, the Korea Science and Engineering Foundation, the Korea Research Foundation, the Swiss National Science Foundation, and Earthwatch.

-in environment

- A study into the level and nature of research relevant to ecologically sustainable development (ESD) funded under Australian Research Council (ARC) programs was published in 1995 (NBEET Commissioned Report No. 38, *Australian Research for Ecologically Sustainable Development*). This found a significant level of funding for ESD-related research under ARC programs in 1993 and 1994 and suggested a number of options for increasing the emphasis on research in this field. In its subsequent advice to Government, the Council strongly supported the national strategy for ESD and outlined a range of measures it would take to support ESD-related research.
- The first ever independent and comprehensive report on the state of Australia's environment was completed. An independent advisory council and seven expert reference groups prepared the report, drawing on the knowledge and skills of more than 200 eminent

scientists and other experts. Based on the experience gained in preparing the report, the next steps will be to develop scientifically credible environmental indicators and to improve the future state of reporting on the environment.

- At a cost of more than \$1 million, the Bureau of Meteorology has redeveloped its computer-based archive of climate data. Daily rainfall and monthly summaries of other parameters are now on-line and directly accessible through the Bureau's electronic network. The new Australian Data Archive for Meteorology (ADAM) management system will significantly improve public and industry access to and use of climate data and support improved planning and environmental management.
- Oceanographic services provided through the Bureau of Meteorology's National Meteorological Centre were enhanced through inclusion of new data types and extension of the sea-state prediction scheme. Among other uses, the scheme is used for monitoring the temperature structure of the tropical Pacific Ocean and detecting possible El Niño events.
- Enhanced versions of three operational atmospheric analysis and prediction systems, developed by the Bureau of Meteorology Research Centre, were implemented by the Bureau's National Meteorological Centre. The models provide improved performance and support forecasts over extended lead times. A major new feature is the capability to operate at higher resolution over parts of the prediction domain, allowing the finer scale structure of weather systems to be resolved.
- The Environmental Research Institute of the Supervising Scientist has joined the Northern Territory University (NTU) as a partner in establishing a Centre for Tropical Wetlands Research at the NTU. The Centre will provide a mechanism and forum for coordination of research activity on tropical wetlands management in the Northern Territory and foster linkages with other researchers in Australia and overseas.
- A national project trialed revised methodology to assess the vulnerability of coastal areas to the impacts of climate change. Nine case studies were undertaken. The results of the case studies were assessed and compared in a national workshop and a national project report completed. The project studied social, economic and cultural as well as biophysical impacts.
- Achievements in environmental information, through the Department of Environment, Sport and Territories, included: acquiring satellite imagery covering Australia's rangelands for 1980 and 1990 which will be used to analyse vegetative land cover; completion of stage two of the climate change impact study on the distribution of selected species in relation to habitat and land use; establishment of a Clearing House node, on the World Wide Web, as part of Australia's commitment under the UN Convention for Biological Diversity; development of the first stage of the National Marine Information System (NatMIS) and a prototype 'Australian Coastal Atlas'; and completion of the specifications for the National Pollutant Inventory database.

- in defence

- Work has commenced on a \$13.5m upgrade to the transonic wind tunnel at the Aeronautical and Maritime Research Laboratory, Victoria. The upgraded wind tunnel, to provide a strongly enhanced Australian capability in transonic aerodynamic testing, will be commissioned in the latter half of 1997.
- The technology of distributed interactive simulation was demonstrated for the first time, in a Defence field, in Australia. This enables the real-time interactive linking of remotely located simulations, in Australia and overseas, in a common virtual environment.
- A major analytical study has been completed into the Australian air defence system and, in particular, the potential role of airborne early warning and control (AEW&C). The results of the study identified the desired characteristics of the AEW&C platform and its on-board systems.
- Construction of the Defence Science and Technology Organisation (DSTO) Building within HMAS *Stirling* in Western Australia has been completed and initial staff accommodated. The new facility will support the *Collins* Class submarine and elements of the RAM's surface fleet based in Western Australia.
- A command and control information systems interoperability laboratory has been established in Canberra to support Defence's development of an integrated capability in command, control, communications and intelligence.
- Eight new alliances have been formed with Australian companies to facilitate communication and exchange of information. These are in such areas as command, control, communications and intelligence, Naval platforms and systems, aerospace simulation, virtual reality, signal processing, operational analysis and information systems middleware.
- The most important multi-lateral defence science forum continues to be The Technical Cooperation Program (TTCP) between the United States, United Kingdom, Canada, Australia and New Zealand. On 24 October 1995 the partners signed a memorandum of understanding formalising the arrangements under which TTCP conducts its business.
- Defence science links continue to be developed with South-East Asia. Achievements include the formation of a joint Australia-Indonesia Defence Science and Technology Working Group under formal Australia-Indonesia defence arrangements. Separate defence-related activities were conducted with other Indonesian Government science and technology organisations, covering synthetic aperture radar, the propagation of radio waves, and joint research into the development of technologies for aircraft structural integrity and repair.

- in communications and media

- A working group of national cultural institutions has been formed to consider the application of digital mass storage technologies for the preservation and delivery of cultural material.

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- An evaluation has been completed of compression systems for transmission of sound and still images over existing modem and ISDN systems.
 - Research into the decomposition of the diacetate film base is underway to determine similarities with triacetate film base decomposition, commonly known as vinegar syndrome."

- in health

Australian medical researchers have attracted substantial overseas and industry support.

- The high standing of Australia's medical researchers has been recognised by international research funding agencies and pharmaceutical companies. During 1995 several institutions, which have received significant Federal Government support for their medical research activities through NHMRC grants, capital works grants or other funding over many years, established agreements with overseas bodies to pursue specific areas of research.
- The Walter and Eliza Hall Institute of Medical Research successfully competed for a program grant of \$5 million over five years, awarded by the United States National Institutes of Health and the Juvenile Diabetes Foundation International, for research into the transplantation of foetal pig pancreas cells for the treatment of insulin dependent diabetes. The teams undertaking this research over the next five years include researchers from other major medical research institutions, including the John Curtin School of Medical Research.
- The Garvan Institute of Medical Research has entered into a collaborative agreement with Bristol Myers Squibb for research investigating the molecular mechanisms that regulate obesity, energy balance and adiposity. The Institute will receive funding of \$4.2 million over four years for this work. The research agreement builds on the successful identification by researchers at the Garvan, of the protein 'leptin' produced by an obesity gene in mice. Mice which do not produce this protein become obese but lose weight following injection of leptin.
- The Royal Adelaide Hospital and University of Adelaide will receive \$350,000 over five years from a research grant program established by Bristol Myers Squibb and Zimmer. The grant is for research into aspects of joint replacement and bone cell biology such as the mechanical and biological compatibility of materials used in orthopaedic surgery.

There have been significant research findings:

- Researchers at the Queensland University and the Queensland Institute for Medical Research have identified the gene responsible for the common skin cancer, basal cell carcinoma, a frequently occurring condition in Australians. It is hoped that this discovery will lead to the development of treatment to block the start of the cancer and to early identification of those at high risk of development of the cancer.
- An overseas fellowship awarded by the NHMRC resulted in the finding that injured blood vessels produce a protein which triggers

the growth of cells which subsequently narrow the blood vessel. This is a significant problem which often occurs following operations to unclog blocked arteries. The identification of the protein offers hope for finding a way to prevent the re-occurrence of blocking.

Support for new technologies has included:

- A co-operative program between the Commonwealth and the States provides nationally funded centres for highly specialised medical technologies. Centres provide services using the technology. Grants are awarded for three to five years and at the end of the grant period a centre is reviewed for aspects of its operation including health outcome and cost effectiveness. If it is assessed that the technology should become part of routine medical practice, the centre grant will cease and the technology becomes a superspeciality. In 1995 The Melbourne Royal Children's Hospital paediatric heart transplantation service and the Sydney Westmead Hospital pancreas transplantation service were reviewed and will continue as nationally funded centres.
- The introduction of computers into medical practice for clinical purposes is seen as having the potential to deliver better health outcomes. During 1995 the Department of Health and Family Services engaged consultants to advise on the application of information technology to pharmaceutical information. The report describes a proposed computerised system for electronic prescribing and medication management which would be a 'pathfinder' application leading to the use of computers in the patient consultation process.
- The use of digital mobile telephones can produce interference in nearby hearing aids, preventing use of these phones by the wearer and also problems when the wearer is close to a user. The National Acoustic Laboratories studied this problem and determined ways of making hearing aids less susceptible to this interference. This has resulted in appropriate modification of the design of hearing aids for the Australian Hearing Services and has attracted considerable international interest.
- The Nuclear Safety Bureau has developed two spreadsheets which can be used to calculate the consequences of nuclear accidents and to plan countermeasures and emergency responses.

- in space

- • Funding amounting to \$350,000 was provided under the National Space Program to continue and to expand the hypersonics program at the University of Queensland. This will enable the University to build on its world leadership in basic research in hypersonics, which is directed towards the development of a new generation of efficient space launch vehicles and aircraft. Agreements have been reached on research collaboration with the National Space Development Agency of Japan and the private company WBM-Stalker has obtained several export contracts for the design and supply of hypersonics research facilities.

Significant statements, reviews and reports

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SECTION 3

Science and Innovation in the Budget

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 \$6470 million in 1992-93, corresponding to 1.60% of gross domestic product (GDP). Broadly, about 44% of Australia's R&D expenditure, corresponding to 0.71% of GDP, was undertaken within business enterprises in that year. Later data show that business enterprise R&D had increased to 0.74% of GDP by 1994-95.

TABLE 1 Australia's expenditure on R&D, by sector of performance, 1990-91 to 1994-95

Sector of performance	1990-91			1991-92			1992-93			1993-94			1994-95		
	\$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	2100	0.55	0.6	2360	0.61	9.9	2855	0.71	17.4	3069	0.72	5.0	3383	0.74	9.6
- private	1896	0.50	0.5	2144	0.55	10.5	2610	0.65	18.0	2836	0.66	6.0	3051	0.67	6.8
- public	204	0.05	2.0	216	0.06	3.8	245	0.06	11.4	233	0.05	-5.8	332	0.07	43.7
Government	1704	0.45	6.6	na	na		1819	0.45	-2.7	na	na		1965	0.43	4.7
- Cwlth	1034	0.27	4.0	na	na		1151	0.28	0.6	na	na		1178	0.26	0.0
- State	670	0.18	11.0	na	na		668	0.17	-3.3	na	na		786	0.17	7.3
Higher educ.	1333	0.35	6.1	na	na		1695	0.43	10.7	na	na		*		
Priv non prof.	85	0.02	18.8	na	na		101	0.03	5.0	na	na		144	0.03	18.7
TOTAL	5222	1.38	4.5	na	na		6470	1.60	7.6	na	na		*		

Source: DIST based on ABS data.

*New data are expected by October 1996

The other principal R&D sectors include higher education, where 27% of R&D expenditure (0.43% of GDP) was undertaken, and Commonwealth agencies, which accounted for 18% of R&D expenditure and 0.28% of GDP.

At 1.60% of GDP, GERD now stands at an all time high and has increased dramatically from 1.38% in 1990-91 and 1.26% in 1988-89. The substantial increases in GERD since 1988-89 reflect substantial increases in the level of R&D in the business sector, seen to be continuous through to 1994-95, and hence in increasing GERD. The other component of the increases in GERD has been an increase in R&D expenditure in universities. This has been funded through a range of measures over the years, including increased support for postgraduate research awards and other research in the higher education sector and establishment of the Cooperative Research Centres Program. There has also been additional funding for medical R&D.

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 18% of total R&D expenditure. As a funding source, however, the Commonwealth Government provides about 44% of R&D funds directly, and has provided another 8% 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.

Commonwealth support for science and innovation through major programs

Commonwealth support for major science and innovation programs has decreased from \$3839 million in 1995-96 to an estimated \$3752 million in 1996-97, a decrease in real terms of 5.1 per cent. Broadly, support has generally increased over the period since 1985-86, with the Tax Concession Schemes providing particular stimulus from about 1985. Omitting the Concession, the rise in total Commonwealth support results from increased R&D overall in 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.

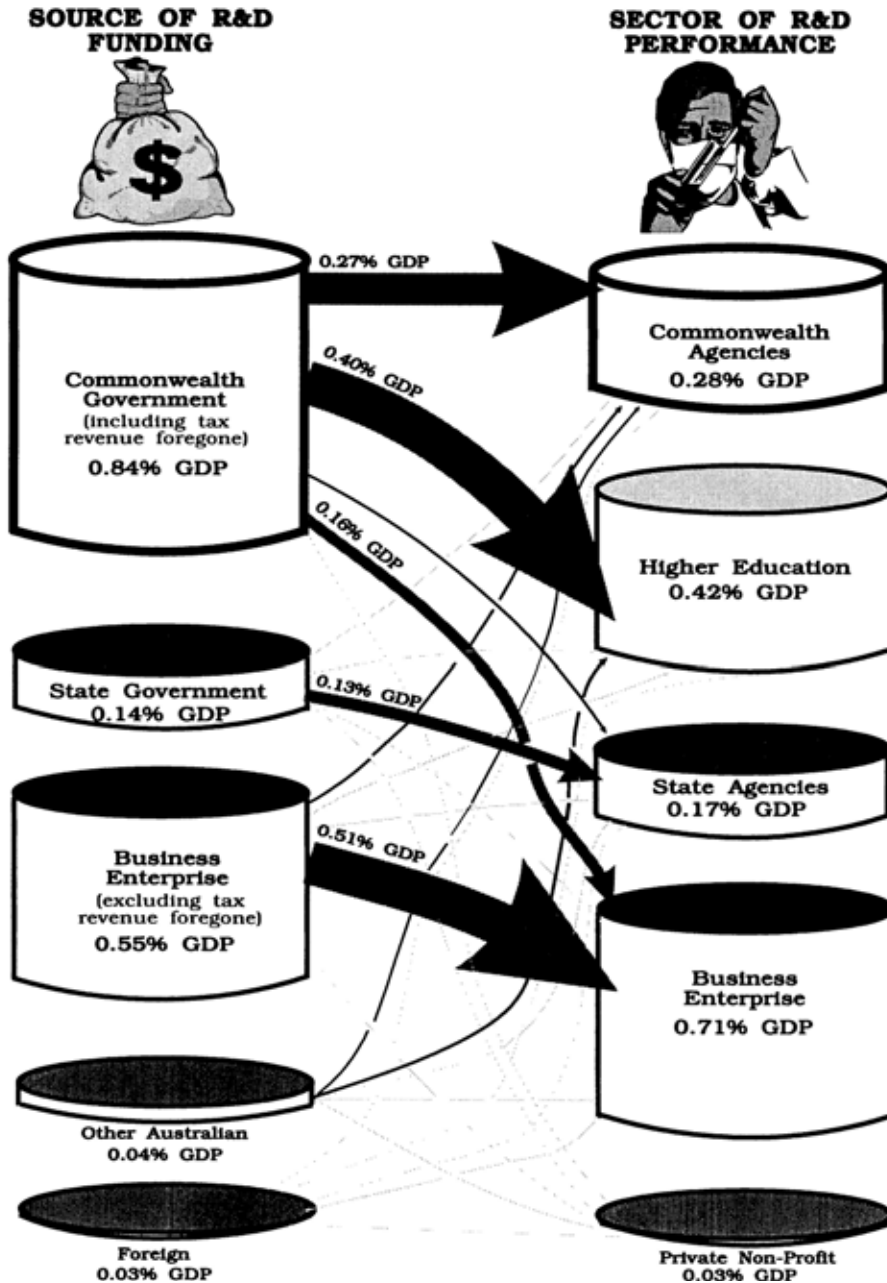
The decrease in 1996-97 is due to changed arrangements for the Tax Concession. If this indirect means of support is omitted, direct Commonwealth support for major programs of science and innovation can be seen to have increased in 1996-97 by 2.7% in real terms.

Figure 4 and Table 2 present a summary of Commonwealth support for science and innovation at constant price values. They provide a four-way breakdown of the data as follows :

- higher education research
- R&D in Commonwealth agencies
- special purpose or directed research grant schemes
- industry incentives through tax concessions.

Figure 3

COMMONWEALTH R&D SUPPORT IN A NATIONAL PERSPECTIVE



The figure illustrates major flows of funding support between sectors, based on updated 1992-93 data. It places Commonwealth funding of R&D in a national perspective.

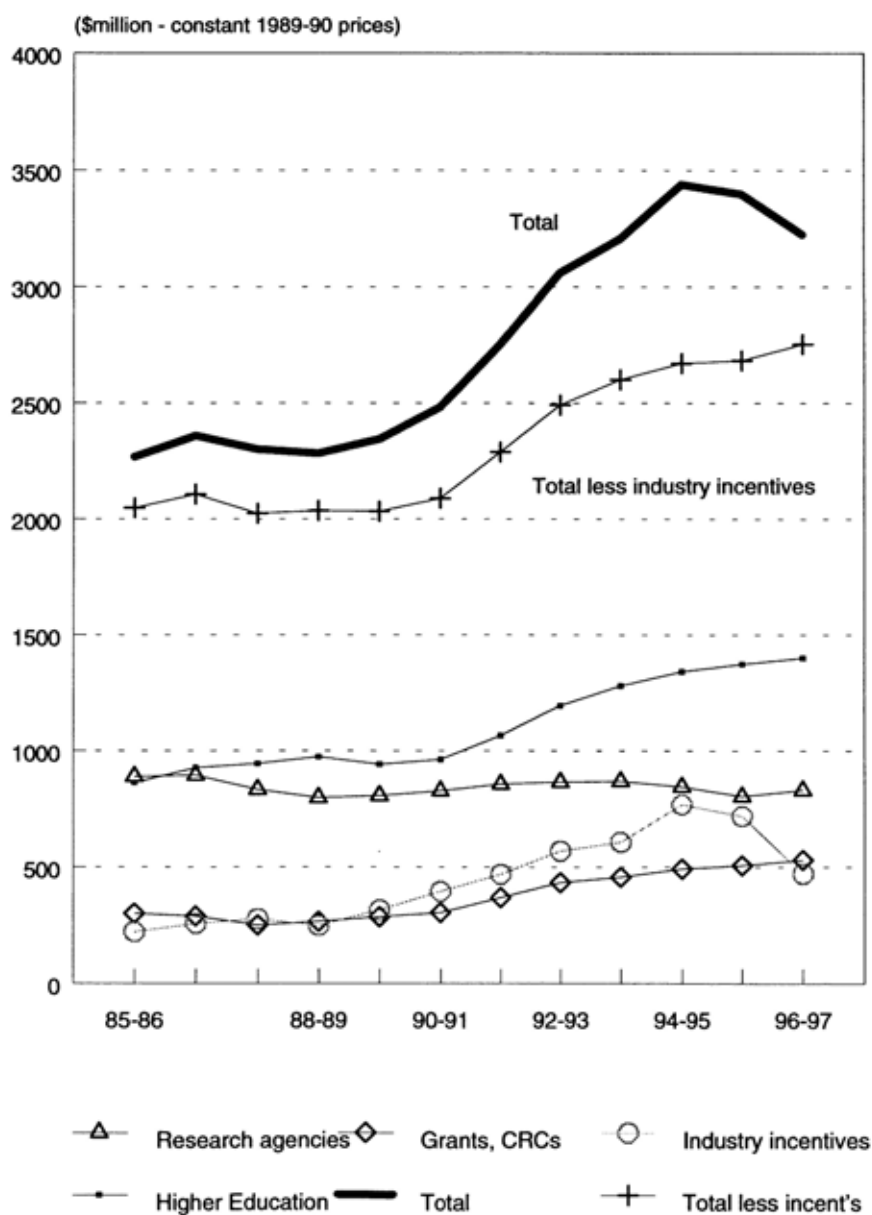
TABLE 2 Constant Price Summary of Major Commonwealth Support for Science and Innovation, through the Budget and Other Measures (\$m at constant 1989-90 prices)

	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97 (est)
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	219.2	225.9	215.9	223.2	225.2	218.1	218.9	215.5	220.9	208.2	219.7	196.6
• Civil	668.1	667.1	616.8	573.9	580.7	607.2	637.4	647.9	645.5	634.4	583.9	630.9
SUB-TOTAL	887.3	893.0	832.7	797.1	805.9	825.2	856.3	863.4	866.3	842.6	803.6	827.5
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	74.6	79.7	80.5	81.8	89.9	104.2	118.7	123.6	131.3	138.0	144.3	141.0
• Industry and space	138.4	109.5	90.6	91.4	92.8	94.2	122.1	143.3	114.2	118.8	111.1	132.1
• Cooperative Research Centres	-	-	-	-	-	-	17.2	42.2	83.6	94.3	117.5	124.6
• Rural	63.3	78.6	62.7	77.6	82.0	78.9	89.0	102.9	107.9	118.7	112.0	117.4
• Energy and environment	19.1	17.6	13.0	12.4	18.5	21.8	18.8	18.5	17.6	17.3	17.4	10.4
• Transport	3.4	2.5	2.3	2.1	2.0	2.1	2.1	2.0	2.0	2.0	1.9	1.7
SUB-TOTAL	298.8	287.9	249.1	265.4	285.2	301.3	367.9	432.5	456.7	489.1	504.1	527.2
COSTS OF IR&D & RELATED INCENTIVES	220.6	253.7	274.8	244.7	314.0	392.5	465.6	568.0	605.2	766.4	716.8	469.9
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	76.9	80.1	83.2	89.9	124.4	175.1	230.3	245.0	272.5	281.6	309.1	342.9
• Specific R&D support	155.9	155.2	154.7	170.2	165.0	163.1	172.7	187.9	198.6	208.7	209.6	207.1
• Est. general research support	627.5	689.7	704.4	712.8	650.0	623.8	659.8	761.6	806.3	849.1	854.0	848.8
SUB-TOTAL	860.3	924.9	942.3	972.9	939.4	962.1	1062.7	1194.5	1277.4	1339.4	1372.8	1398.8
TOTAL COMMONWEALTH SUPPORT												
AT ESTIMATED 89-90 PRICES	2267	2360	2299	2280	2344	2481	2752	3058	3206	3437	3397	3223
EST. REAL % INCREASE/DECREASE		4.1	-2.6	-0.8	2.8	5.8	10.9	11.1	4.8	7.2	-1.2	-5.1

SOURCE Based on data in Table 3 and using GDP non-farm deflators.

Figure 4

MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION



Source: see Table 2

– *Higher Education Research*

Support for research in the higher education sector (excluding support from special purpose grant schemes) is estimated to increase to \$1628 million in 1996-97 from \$1551 million in 1995-96, representing a real increase of 1 per cent.

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.

– *Research in Commonwealth Agencies*

The largest Commonwealth research agencies are CSIRO, DSTO, ANSTO, AGSO, Antarctic Division and AIMS. Support through Budget appropriations to these agencies, and some smaller ones, is expected to be \$963 million in 1996-97, compared with \$908 million in 1995-96 a real increase of 3 per cent due principally to the allocation of \$61 million in 1996-97 for a new AGSO building.

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 licencing 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 1996-97 are expected to amount to \$444 million (with a further \$6 million through DPIE, see Table 4), but the total income of the Organisation is expected to be in the region of \$710 million.

– *Special Purpose Research Grant Schemes*

Support for R&D through the special purpose research grant schemes is estimated to increase to \$614 million in 1996-97 from \$570 million in 1995-96, representing a real increase of 5 per cent.

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

– *Tax Incentive Scheme - Industrial R&D and Innovation*

Estimated support for R&D and innovation in the business sector through the industrial R&D tax concession is estimated be \$547 million in 1996-97 (\$810 million in 1995-96), down 34% in real terms. This is an estimated outcome from the changes to the tax concession outlined in Section 2.

The industrial component of special purpose grants will increase to \$154 million from \$126 million in 1995-96, a real increase of 19% in direct support for R&D and innovation in the business sector.

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 general university funding of R&D (GUF) which is the estimated research component of support for teaching and research.

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 since 1984-85. The slight fall after 1986-87 is due to the conclusion of some substantial capital expenditures and policy changes to shift the balance towards non-Budget competitive funding. Over the same period, the special purpose schemes have increased significantly. This increase is even more substantial if the industry incentive schemes are included. When this is done, support for industrial R&D and higher education is seen to have received the largest increases up to the mid-1990s. Support for health and medical research and for rural research also rose significantly.

The significant increases in funding in the higher education sector have been accompanied by a substantial change in arrangements so that the proportion of funds controlled by the ARC is now much higher than in the mid-1980s. Total funds have increased overall in parallel with this substantial change in the funding mechanisms.

The 1988-89 dip in total funding levels is traceable mainly to a real fall in the level of Budget funding for Commonwealth research agencies, since offset by increases in external funding. Such non-Commonwealth funding is not shown in Figures 4 and 5. The fall in 1993-94, visible in Figure 5, was due to the one-off payment in 1992-93 to initiate the Australian Technology Group Pty Ltd, and the decrease in the corporate tax rate (from 39 to 33 cents in the dollar) which reduced the tax revenue forgone from the industrial R&D tax concession. The apparent decline in 1995-96 was due to CSIRO's \$20 million borrowing from that year in 1994-95.

Detailed data

Table 3 is the current price summary corresponding to Table 2. It summarises the data from Tables 4,5 and 6.

For the most part, the data series in Tables 4 and 5 are comprised of well-defined expenditures which can be readily identified from the Budget Papers. 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 will not be available for some time in relation to the latest years shown, the effect of adding this series to others, as in Table 3, is to blur the assessment of overall trends. See the footnotes to Table 6.

A further blurring results from the inclusion of the estimated costs of Commonwealth revenue forgone through the taxation concession scheme for industrial R&D. As already indicated, the amounts shown are *estimates* only. (See footnote (5) to Table 6.) There are significant revisions to some historical data in this table. These may be subject to further revision as better estimates of claims against the concession in past years become available, and as outcomes of the very recent changes to the concession are seen.

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

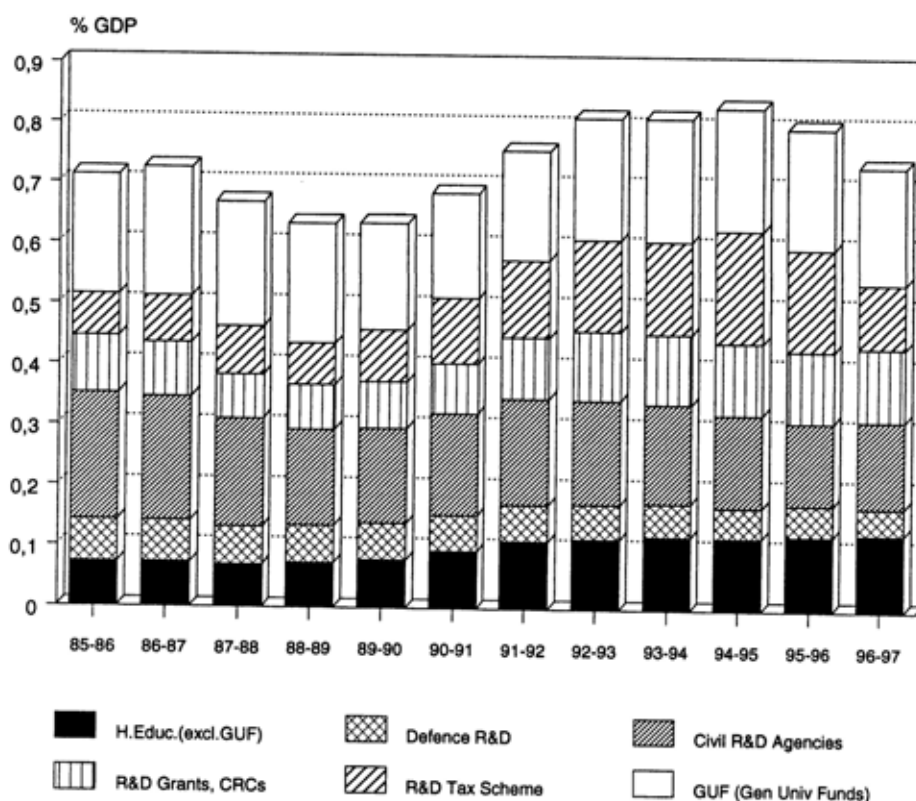
Over the past three decades there has been considerable international effort to reach agreed definitions of R&D. The resulting definitions have been applied with some rigour in periodic surveys conducted within most OECD countries. This so-called "Frascati" methodology has been applied in Australia since 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

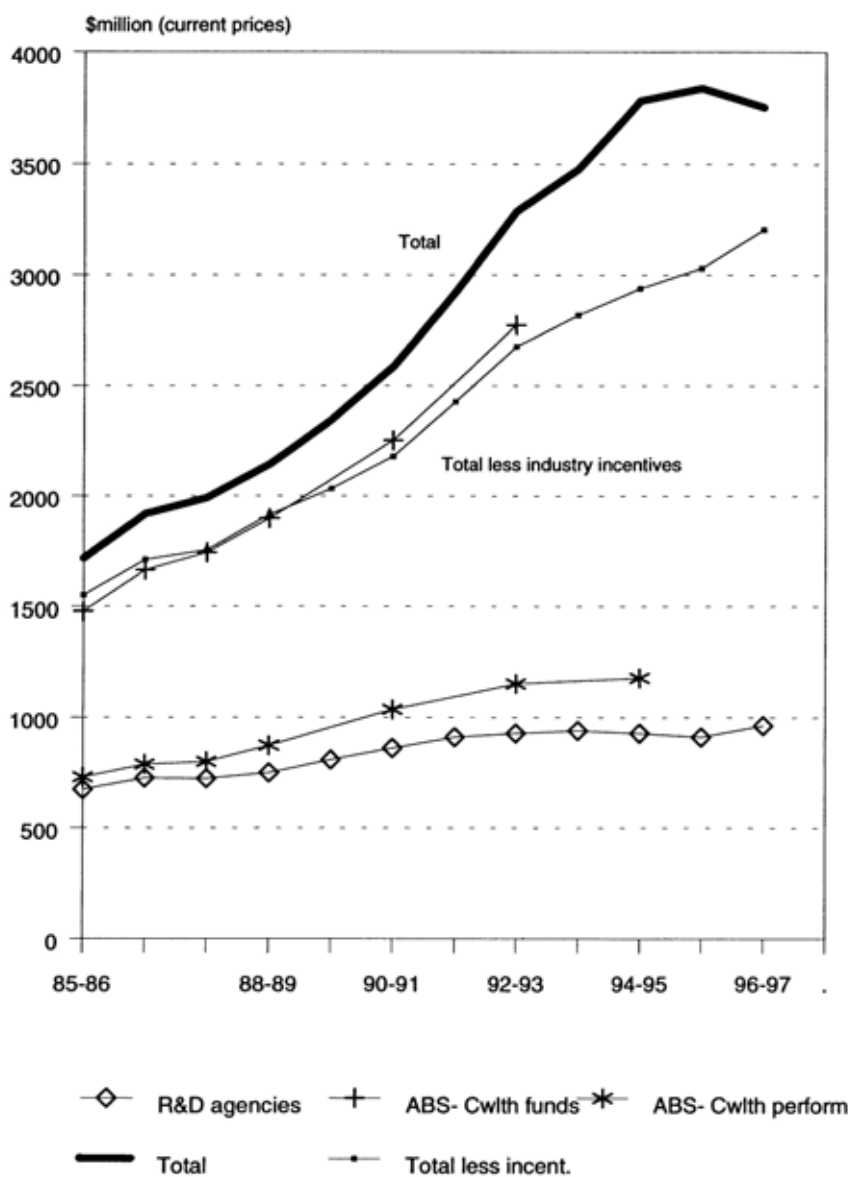


Source: See Table 2 and ABS 5206.0

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: *DIST and ABS*

TABLE 3 Summary of Major Commonwealth Support for Science and Innovation, through the Budget and Other Measures (\$m)

	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97 (est)
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	165.9	183.4	187.0	209.8	225.2	227.2	232.3	231.4	239.4	229.0	248.2	228.8
• Civil	505.8	541.7	534.1	539.5	580.7	632.7	676.2	695.9	699.7	697.9	659.8	734.3
• SUB-TOTAL	671.7	725.1	721.1	749.3	805.9	859.9	908.5	927.3	939.1	926.9	908.1	963.2
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	56.5	64.7	69.7	76.9	89.9	108.6	125.9	132.7	142.4	151.8	163.0	164.1
• Industry and space	104.7	88.9	78.4	85.9	92.8	98.2	129.6	153.9	123.8	130.7	125.5	153.8
• Cooperative Research Centres							18.2	45.3	90.6	103.7	132.7	145.1
• Rural	47.9	63.8	54.3	73.0	82.0	82.2	94.5	110.5	117.0	130.5	126.5	136.7
• Energy and environment	14.4	14.3	11.3	11.7	18.5	22.8	19.9	19.9	19.1	19.1	19.6	12.1
• Transport	2.6	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.0
SUB-TOTAL	226.2	233.8	215.7	249.4	285.2	313.9	390.3	464.6	495.0	538.0	569.7	613.7
COSTS OF IR&D & RELATED INCENTIVES	167	206	238	230	314	409	494	610	656	843	810	547
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	58.3	65.0	72.0	84.5	124.4	182.5	244.3	263.1	295.4	309.8	349.3	399.2
• Specific R&D support	118.0	126.0	134.0	160.0	165.0	170.0	175.0	201.8	215.3	229.6	236.9	241.1
• Est. general research support	475.0	560.0	610.0	670.0	650.0	650.0	700.0	818.0	874.0	934.0	965.0	988.0
SUB-TOTAL	651.3	751.0	816.0	914.5	939.4	1002.5	1127.5	1282.9	1384.7	1473.3	1551.2	1628.3
TOTAL COMMONWEALTH SUPPORT	1716	1916	1991	2143	2344	2585	2920	3285	3475	3781	3839	3752
% GDP	0.712	0.725	0.667	0.632	0.633	0.684	0.755	0.811	0.811	0.830	0.795	0.732
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 1989-90 PRICES	2267	2360	2299	2280	2344	2481	2752	3058	3206	3437	3397	3223
EST. REAL % INCREASE/DECREASE		4.1	-2.6	-0.8	2.8	5.8	10.9	11.1	4.8	7.2	-1.2	-5.1

SOURCE See Tables 4, 5 and 6

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

	1985-86	1986-87	1987-88	1988-89	1989-90	Outlays		1991-92	1992-93	1993-94	1994-95	1995-96	(est.) 1996-97
THE ENVIRONMENT, SPORT & TERRITORIES													
Antarctic Division	42.2	47.4	49.2	46.3	57.7	62.8	67.3	65.4	61.0	61.3	63.1	61.0	
Bureau of Meteorology Research Centre (BMRC)	1.8	2.3	2.5	2.2	2.4	2.8	3.3	3.3	3.6	3.6	4.0	4.3	
Supervising Scientist - including ERISS	5.5	6.1	6.0	6.6	7.6	6.7	7.5	7.6	6.6	6.5	6.0	6.0	
DEFENCE													
Defence Science and Technology Organisation ¹	165.9	183.4	187.0	209.8	225.2	227.2	232.3	231.4	239.4	229.0	248.2	228.8	
EMPLOYMENT, EDUCATION & TRAINING & YOUTH AFFAIRS													
Anglo-Aust Telescope	1.9	2.0	2.4	2.5	2.7	2.9	3.0	3.1	3.1	3.0	3.2	3.3	
HEALTH & FAMILY SERVICES													
Australian List, of Health & Welfare (excl. grants)	5.1	5.2	3.4	4.2	4.4	4.2	5.0	6.8	7.2	8.1	7.1	7.6	
CSL Ltd (Budget component)	12.8	15.8	17.3	16.6	9.4	3.0	4.2	8.2	17.0	4.3	2.8	2.9	
Nuclear Safety Bureau	-	-	-	-	-	-	-	0.8	0.8	0.8	0.9	0.9	
INDUSTRY, SCIENCE & TOURISM													
Aust Nuclear Science & Technology Organisation	45.4	45.2	50.8	54.3	57.5	62.6	64.3	68.2	64.2	66.2	65.6	63.7	
Australian Institute of Marine Science	7.6	8.2	9.5	11.0	11.4	13.6	14.2	14.2	16.9	16.5	16.6	16.4	
CSIRO	344.3	367.8	347.8	348.1	375.2	414.4	446.3	456.2	460.4	460.8	416.7	443.6	
Kraft Pulp Mill study (CSIRO)	-	-	-	-	0.5	1.4	1.9	1.9	1.9	-	-	-	
PRIMARY INDUSTRIES & ENERGY													
Contribution to CSIRO for Aust Animal Health Labs	4.1	4.4	4.7	4.7	4.9	5.3	5.5	6.0	5.9	6.2	5.8	6.0	
AGSO	35.2	37.4	40.6	42.9	47.0	52.9	52.9	54.2	50.9	60.5	68.0	118.6	
TOTAL	671.7	725.1	721.1	749.3	805.9	859.9	908.5	927.3	939.1	926.9	908.1	963.2	

(1) For comparability with earlier years in the series, DSTO expenditure estimates for 1995-96 and 1996-97 include an attributable superannuation component from other Defence appropriations.

TABLE 5 Major R&D Granting Programs and other Support for Science and Innovation through the Budget (\$m)

	1985-86	1986-87	1987-88	1988-89	1989-90	Outlays		1991-92	1992-93	1993-94	1994-95	1995-96	(est.) 1996-97
THE ENVIRONMENT, SPORT & TERRITORIES													
Aust Biological Resources Study	1.2	1.0	1.1	1.3	1.6	1.2	2.0	2.3	2.3	2.0	1.8	1.5	
Greenhouse research (NGRP)	-	-	-	0.8	5.7	5.7	6.1	6.0	5.8	6.0	6.0	4.0	
EMPLOYMENT, EDUCATION, TRAINING & YOUTH AFFAIRS													
Research evaluation and Academies	-	-	-	-	-	1.6	2.0	2.0	2.0	2.1	2.1	2.2	
ARGS & ARC grants/fellowships (including marine R&D grants) ¹	34.6	39.8	42.7	50.7	35.6	1.2	-	-	-	-	-	-	
Post-graduate Awards ¹	17.8	19.3	20.3	21.7	11.3	-	-	-	-	-	-	-	
Targeted Institutional Links Program	-	-	-	-	0.2	1.0	2.0	1.1	1.4	1.4	0.8	0.8	
HEALTH & FAMILY SERVICES													
AIDS Research	0.8	1.5	3.0	3.5	5.0	7.1	10.8	10.5	11.6	12.1	12.1	11.7	
Health and Community Services Research Grants	1.8	2.3	1.1	1.4	1.9	1.8	1.8	1.9	1.9	1.6	-	-	
NH&MRC Research Grants	51.2	59.4	65.6	72.0	83.0	94.7	103.3	110.3	118.9	125.2	141.3	150.0	
Capital Works for Medical Institutes	2.6	1.6	-	-	-	5.0	10.0	10.0	10.0	13.0	9.6	2.4	
Funds for John Curtin SMR	-	-	-	-	-	-	8.2	16.8	17.3	17.6	17.9	18.1	
INDUSTRY, SCIENCE & TOURISM													
Industry Innovation Program GRANTS	-	-	-	-	-	-	-	43.5	40.3	46.9	52.4	117.9	
Advanced Manufacturing Tech Program	-	-	-	-	-	-	0.1	-	-	-	-	-	
Technology Development Program	0.8	1.2	1.4	1.1	1.9	3.0	3.2	-	-	-	-	-	
National Procurement Development Program (NPDP)	-	-	0.7	3.9	5.6	4.2	4.4	-	-	-	-	-	
IR&D Act 1986 (GIRD)	-	10.8	25.6	31.8	32.0	29.6	32.2	-	-	-	-	-	
. Biotechnology grants	4.3	-	-	-	-	-	-	-	-	-	-	-	
IR&D Incentives Act 1976													
. Commencement grants	14.3	16.9	3.1	0.1	-	-	-	-	-	-	-	-	
. Project grants	37.7	17.9	6.4	2.8	0.3	-	-	-	-	-	-	-	
. Public interest projects	6.3	3.5	1.0	0.3	-	-	-	-	-	-	-	-	
Australian Technology Group Pty Ltd	-	-	-	-	-	-	-	30.0	-	-	-	-	
Cooperative Research Centre Grants	-	-	-	-	-	-	18.2	45.3	90.6	103.7	132.7	145.1	
National Research Facilities	-	-	-	-	-	-	-	-	-	-	6.4	17.0	

TABLE 5 Major R&D Granting Programs and other Support for Science and Innovation through the Budget (\$m) — continued

	1985-86	1986-87	1987-88	1988-89	1989-90	Outlays		1991-92	1992-93	1993-94	1994-95	1995-96	(est.) 1996-97
Malaria Vaccine Joint Venture	0.3	0.4	0.8	1.2	0.8	2.3	9.4	-	-	-	-	-	-
Research associations ²	1.9	2.0	2.0	-	-	-	-	-	-	-	-	-	-
Motor Vehicle R&D	22.9	11.6	8.4	8.3	4.7	2.3	-	-	-	-	-	-	-
Assistance under the Bounty ³ (Computers) Act 1984	13.2	19.4	25.7	31.1	45.0	51.3	74.5	75.0	78.0	74.8	64.1	56.5	
National Space Program	3.0	5.0	3.2	5.4	2.4	5.5	5.7	5.4	5.4	9.0	2.7	2.6	
PRIMARY INDUSTRIES & ENERGY⁴													
Wool Research	13.0	14.4	12.1	21.7	20.8	11.7	13.8	13.2	12.0	15.1	11.7	11.6	
Meat Research	5.5	8.4	8.6	11.9	13.8	13.6	20.8	22.9	22.1	25.1	22.6	22.3	
Fishing Industry Research	5.0	6.2	6.2	5.4	8.1	8.4	6.6	7.5	8.5	9.2	10.4	13.1	
Grains	15.2	17.9	11.2	11.1	13.3	14.4	14.8	15.7	21.2	23.3	21.3	29.1	
Horticulture Research	-	-	-	0.6	1.2	3.1	4.4	8.3	9.6	10.7	11.4	14.6	
Energy research	13.2	13.3	10.2	9.6	11.2	15.9	11.8	11.6	11.0	11.1	11.8	6.6	
Land & Water research	1.8	4.9	7.8	10.4	9.9	13.3	13.3	13.7	11.8	11.3	10.6	9.8	
Rural Industries R&D Corporation	0.4	1.5	3.0	4.0	5.0	6.0	8.4	10.5	10.5	10.5	10.5	5.5	
Other rural research	7.0	10.6	5.5	8.0	10.1	11.7	12.4	18.8	21.3	25.5	28.0	30.7	
TRANSPORT													
Payments to Australian Road Research Board	2.0	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.0	
Railway R&D Organisation	0.6	-	-	-	-	-	-	-	-	-	-	-	
TOTAL	278.5	292.8	278.1	321.9	332.2	317.7	402.6	492.5	515.7	559.1	590.5	674.9	

FOOTNOTES TO TABLE 5

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

FOOTNOTES TO TABLE 5 - *continued*

(2) Since 1988-89 the Associations have been fully funded by industry.

(3) Assistance is provided for local manufacturers of computer hardware, systems software and electronic microcircuits. It covers design and development costs.

(4) 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)

	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97 est.
Wool	11.88	15.25	18.31	14.21	19.63	17.11	14.05	12.32	12.45	19.50	10.94	11.57
Meat	5.55 ^a	7.68 ^a	8.65 ^a	11.58 ^a	13.30 ^a	15.17 ^a	25.60 ^a	25.55	24.65	23.52	22.40	23.59
Grains												
- Grain ^b	2.16	2.07	2.35	2.53	3.99	4.27 ^b	5.31 ^b	9.36	12.61	8.51	17.18	16.13
-Wheat	5.48	6.40	5.16	8.35	9.84	8.45	12.92	18.35	19.95	16.28	33.65	30.15
Coal ^c	3.28	4.82	7.07	15.02	17.05	14.95	13.88	16.10	1.48	-	-	-
Special Rural	-	-	-	-	0.20	0.30	0.15	0.99	1.03	1.32	1.57	1.89
Fish	-	-	-	-	-	0.50	1.12	1.01	2.01	2.41	2.46	4.38
Horticulture	-	-	-	0.20	1.62	3.26	4.94	7.24	3.12	3.61	4.28	9.37
Other Rural												
- Chicken Meat	0.29	0.38	0.40	0.38	0.46	0.55	0.78	0.65	0.67	0.71	0.71	0.69
- Cotton	0.89	1.04	0.86	1.55	1.87	2.66	3.87	3.89	2.57	2.13	2.90	4.11
- Dairying	0.67	1.26	1.64	1.57	2.94	4.82	5.21	5.65	6.20	6.13	5.75	8.84
- Dried Fruit	0.16	0.32	0.26	0.29	0.39	0.45	0.78	0.92	0.46	0.49	0.39	0.75
- Grape & Wine	0.52	0.67	0.82	0.94	1.28	1.25	0.96	1.60	1.70	2.08	1.91	2.51
- Honey	0.08	0.09	0.11	0.10	0.12	0.14	0.07	0.12	0.15	0.15	0.15	0.16
- Pig Industry	0.78	1.00	1.43	1.37	1.95	2.58	2.68	2.88	3.61	3.75	3.57	4.25
- Egg Industry	0.22	0.31	0.28	0.37	0.30	0.45	0.57	0.68	0.67	0.63	0.68	0.68
- Sugar	-	-	1.28	1.40	1.37	1.48	1.28	3.40	4.48	4.89	5.46	5.63
- Tobacco	0.66	0.69	0.64	0.94	0.77	0.59	0.59	0.92	0.64	0.33	0.49	0.58
- Forestry	-	-	-	-	-	-	-	-	-	0.38	1.00	1.20
Total	32.61	41.98	49.25	60.82	77.09	79.00	94.86	111.62	96.97	96.84	115.49	126.49

(a) Industry contributions for meat R&D to the Australian Meat Research Corporation.

(b) From 1990-91 barley, grain legumes, and oilseeds are covered by a single outlay to the Grains R&D Corporation.

(c) Coal research is funded entirely through industry levies. As there is no Commonwealth contribution it is omitted from Table 4.

TABLE 6 Estimated Costs of Programs and Incentives providing support for Research and Innovation outside the Budget (\$m)

	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	(est) 1996-97
EMPLOYMENT, EDUCATION, TRAINING & YOUTH AFFAIRS*												
Higher Education Funding Act: special research assistance ¹	5.9	6.0	9.0	12.1	77.3	178.7	240.3	260.0	292.0	306.3	346.4	396.2
Identifiable research support for universities ^{2,4}	118	126	134	160	165	170	175	185	198	212	219	223
Estimated research component of general university funding for both teaching and research ^{3,4}	475	560	610	670	650	650	700	818	874	934	965	988
INDUSTRY, SCIENCE & TOURISM												
Tax Concession ⁵ for industrial R&D	147	186	218	223	295	375	494	610	656	843	810	547
Tax Deduction for equity subscriptions in Management Investment Companies (MICs) ⁶	20	20	20	7	19	34	-	-	-	-	-	-
TOTAL	766	898	991	1072	1206	1408	1609	1873	2020	2295	2340	2154

* 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/DEETYA funding for research grants, fellowships, centres, postgraduate awards and infrastructure.

(2) Indicative estimates of identifiable research expenditure data from university operating grants. Later years are projections based on data collected by DEETYA from universities for the 1992 data year. Funding for John Curtin School of Medical Research of ANU was transferred to the Health portfolio IN 1992 and is therefore not included in figures for the latter years. Data for the former advanced education sector are not included in the years prior to 1989 when the unified system was established by the amalgamation of this sector with the former university sector.

(3) Indicative estimates of research expenditure from university operating grants other than those identified in the previous row. The sum of the estimates in the previous row and this row of figures is an estimate of the research component of university operating grants. It does not include funds spent on research by the former advanced education sector institutions prior to the 1989 amalgamations. Estimates for 1984-85, 1986-88, 1988-89, 1990-91 and 1992-93 are based on ABS R&D Surveys in the calendar year in which each of these financial years commences. Estimates for other years are interpolations and projections from the years for which survey data are available. The 1994-95 ABS collection was not ready in time to revise figures from 1994-95 and to inform the projection for 1996-97.

- (4) The following table provides an alternative estimate of the research component of general university funding for teaching and research. It is used to estimate DEETYA portfolio expenditure on R&D in Section 5 of this report. This estimate is based on the Relative Funding Model which was developed and applied to the university operating grant in 1990. The methodology identifies that 6.2% of the operating grant is available for research purposes unrelated to teaching and research training purposes. The balance is allocated on the basis of student load in each cell of the matrix of levels of teaching and discipline cost clusters weighted by the relative teaching costs estimated for each cell of the matrix. The estimates assume that the relative teaching costs have not changed since they were estimated in 1990 based on 1988 teaching costs data. However, the estimates take into account changes in student load relativities in the different teaching levels up to the present time. The matrix of relative teaching costs and other details of the RFM are contained in the report, *Assessment of the Relative Funding Position of Australia's Higher Education Institutions* released in August 1990 by the Hon. Peter Baldwin, M.P., the then Minister for Higher Education and Employment Services.

	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97 est
ANU Institute of Advanced Studies (estimate) ^a	93	97	100	108	122	134	133	128	129	130	132	134
Estimated research and research training component of higher education operating grants ^b	293	315	334	366	397	414	455	528	579	649	714	753

- (a) This is an estimate of funds provided for research and research training to the Institute of Advanced Studies through the operating grant of The Australian National University. Funding for the John Curtin School of Medical Research has been excluded from January 1992 when this was transferred to the Health portfolio.
- (b) Sum of Research Quantum (RQ) and Research Training Component (RTC) of the operating grant. The Relative Funding Model estimated that the RTC was 7.6% of the operating grant in 1990. Based on shifts in student load relativities in the different teaching levels (undergraduate, higher degree research and other postgraduate), the RTC proportion of the operating grant is estimated to be 7.74%, 8.68%, 9.27%, 9.22%, 9.98%, 10.69% and 10.7% in the years 1991 to 1997, respectively.
- (5) A 150% company tax deduction for eligible industrial R&D expenditure has applied from 1 July 1985. The data series comprise estimates by the Department of Industry, Science and Tourism based on information provided in registrations for the concession and from the Australian Taxation Office (ATO). They do not account for any recoupments arising from the dividend imputation system. The focus of the Table is on the effect of Government actions in the wider community. The figures in the Table 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 1985-86 to (estimated) 1996-97, as follows: nil, \$105m, \$150m, \$190m, \$220m, \$290m, \$360m, \$465m, \$560m, \$630m, \$810m and \$775m. Figures published here are significantly 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.
- (6) Licensed Management and Investment Companies invest in approved high technology/growth activities. The equity subscription in these companies attracted a 100% income tax deduction in the year that subscriptions were made. The scheme concluded in June 1991.

SECTION

4

International Context

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 7 shows the latest available GERD/GDP data for nineteen OECD and five Asian 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

TABLE 7 Gross expenditure on R&D (GERD), GERD as a proportion of GDP, and change and growth rates - international comparisons

	GERD (est. 1995 US\$m)	GERD/GDP	Period 1981 to 1988			Period 1988 to 1994		
			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 (1994)	171724	2.54	0.36	5.5	3.4	-0.25	0.6	2.0
Japan (1994)	77792	2.69	0.54	7.4	3.9	0.02	2.3	2.5
Germany (1994)	38572	2.33	0.43	4.6	2.0	-0.53	1.2	5.1
China (1994)	29666	0.50	na	na	5.4	-0.01	6.1	9.8
France (1994)	27399	2.38	0.30	4.1	2.0	0.10	2.2	1.4
United Kingdom (1994)	21238	2.19	-0.19	2.8	3.6	0.02	0.6	0.6
Italy (1994)	10829	1.19	0.34	7.9	2.4	-0.03	1.0	1.1
South Korea (1993)	10027	2.41	1.22	28.6	10.2	0.58	12.9	6.8
Canada (1994)	9338	1.57	0.14	5.3	3.8	0.19	3.6	0.9
India (1992)	7399	0.74	0.26	11.1	5.4	-0.11	-0.1	3.9
Netherlands (1993)	6018	1.87	0.37	5.1	2.2	-0.35	-1.1	2.5
AUSTRALIA (1992)	4359	1.60	0.26	7.4	3.9	0.34	6.1	2.3
Sweden (1993)	4340	3.29	0.69	7.2	2.5	0.31	1.9	-0.3
Switzerland (1992)	4255	2.68	0.57	6.8	2.1	-0.20	-1.4	0.7
Chinese Taipei (1994)	4229	1.80	0.32	13.7	8.9	0.55	13.2	6.7
Spain (1994)	4129	0.93	0.29	10.4	3.0	0.21	6.4	1.8
Belgium (1991)	3171	1.66	0.02	2.5	1.7	0.02	3.2	1.8
Austria (1994)	2476	1.53	0.18	3.8	1.9	0.18	4.9	2.6
Finland (1994)	1780	2.35	0.61	9.7	3.3	0.55	3.2	-1.5
Denmark (1993)	1752	1.80	0.40	7.5	3.0	0.31	5.1	1.5
Norway (1993)	1363	1.94	0.53	8.4	1.5	0.13	2.6	1.7
Ireland (1993)	615	1.24	0.14	6.4	2.5	0.41	13.9	4.6
Singapore (1993)	600	1.20	0.60	25.7	5.3	0.33	15.5	7.2
New Zealand (1993)	435	1.03	-0.14	-2.0	2.1	0.16	6.3	2.0
Average (24 economies)		1.89	0.36	8.6	3.5	0.13	4.5	2.5
Average (OECD only)		1.94	0.31	5.8	2.4	0.08	3.0	1.2

Source: DIST based on ABS, OECD and national sources.

dollars at constant 1995 prices). The Table also shows the change in the GERD/GDP ratio between 1981 and 1988, and between 1988 and 1994 (or nearest years), and the average annual real growth rates over each period both for GERD and GDP.

The Table shows that the scale of Australia's total R&D expenditure is about one fortieth that of the largest national effort (USA) and about ten times that of the smallest. In terms of the relative share of national wealth devoted to R&D (GERD/GDP), Australia lies in the middle range. Australia's relative R&D effort is about half that of Sweden (the highest in relative terms) and is about three times that of the lowest. 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 1988 to 1994, many economies showed slower growth in GERD than in GDP, particularly compared to the period 1981 to 1988. Australia was one of the exceptions in this case. The three "dynamic Asian economies" shown (Singapore, South Korea and Chinese Taipei) have dramatically increased their total level of R&D effort and show exceptionally high growth rates in GERD and GDP.

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 7, 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) R&D in government agencies and universities combined; and
- (ii) R&D in the business sector.

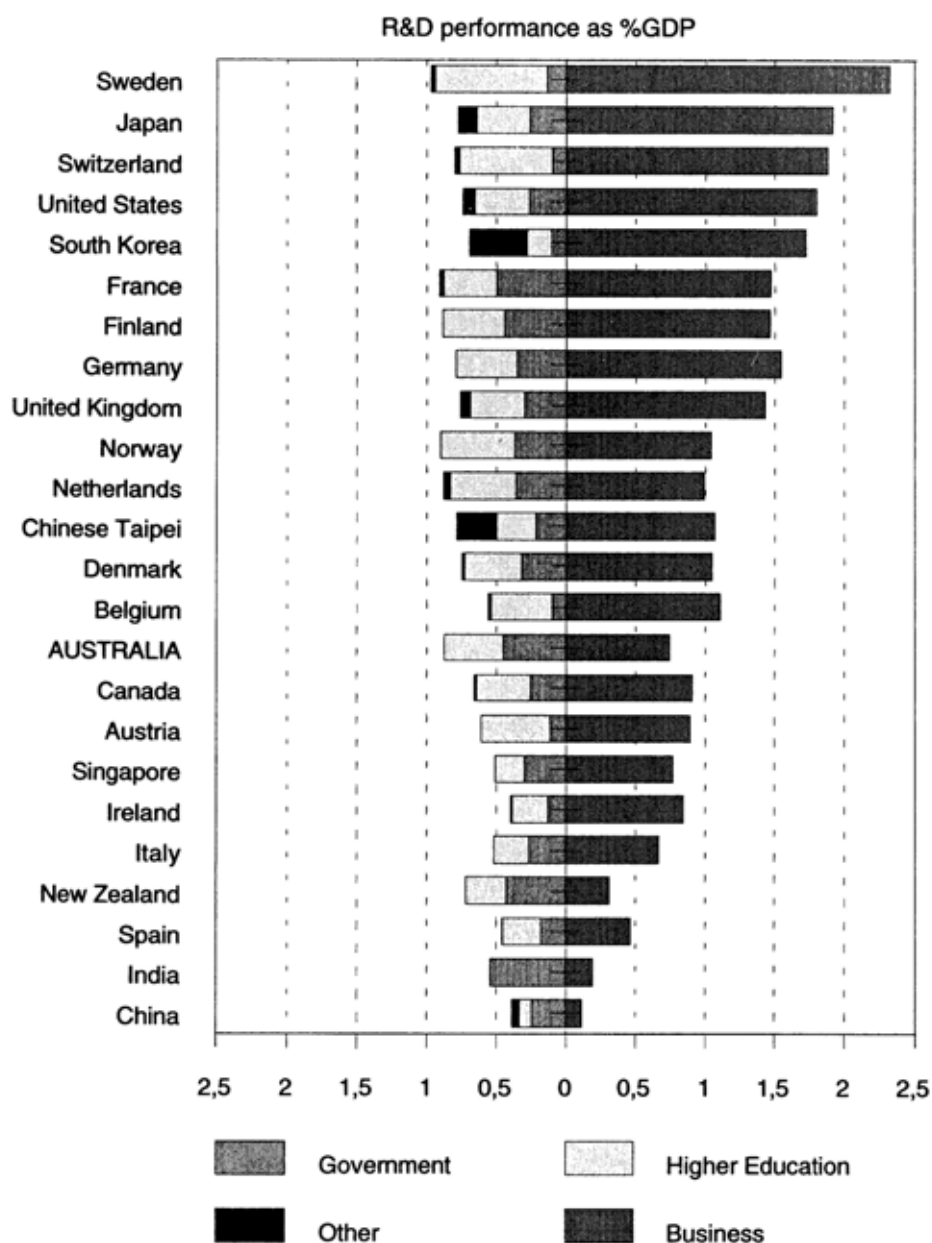
R&D expenditure in government agencies and universities

Table 8 shows comparative international data for combined R&D expenditure within government agencies and universities. In this list, 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 1981 to 1988 and 1988 to 1994, as well as the average annual real growth rates.

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 0.88% compared with an average of

Figure 7

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



Source: DIST based on ABS, OECD and national sources.

0.65% for all twentyfour economies listed. The change in this ratio for Australia was negative between 1981 and 1988, but over the period since 1988 was twice the OECD average increase. Among all countries, there was some convergence towards the mean over the whole period since 1981.

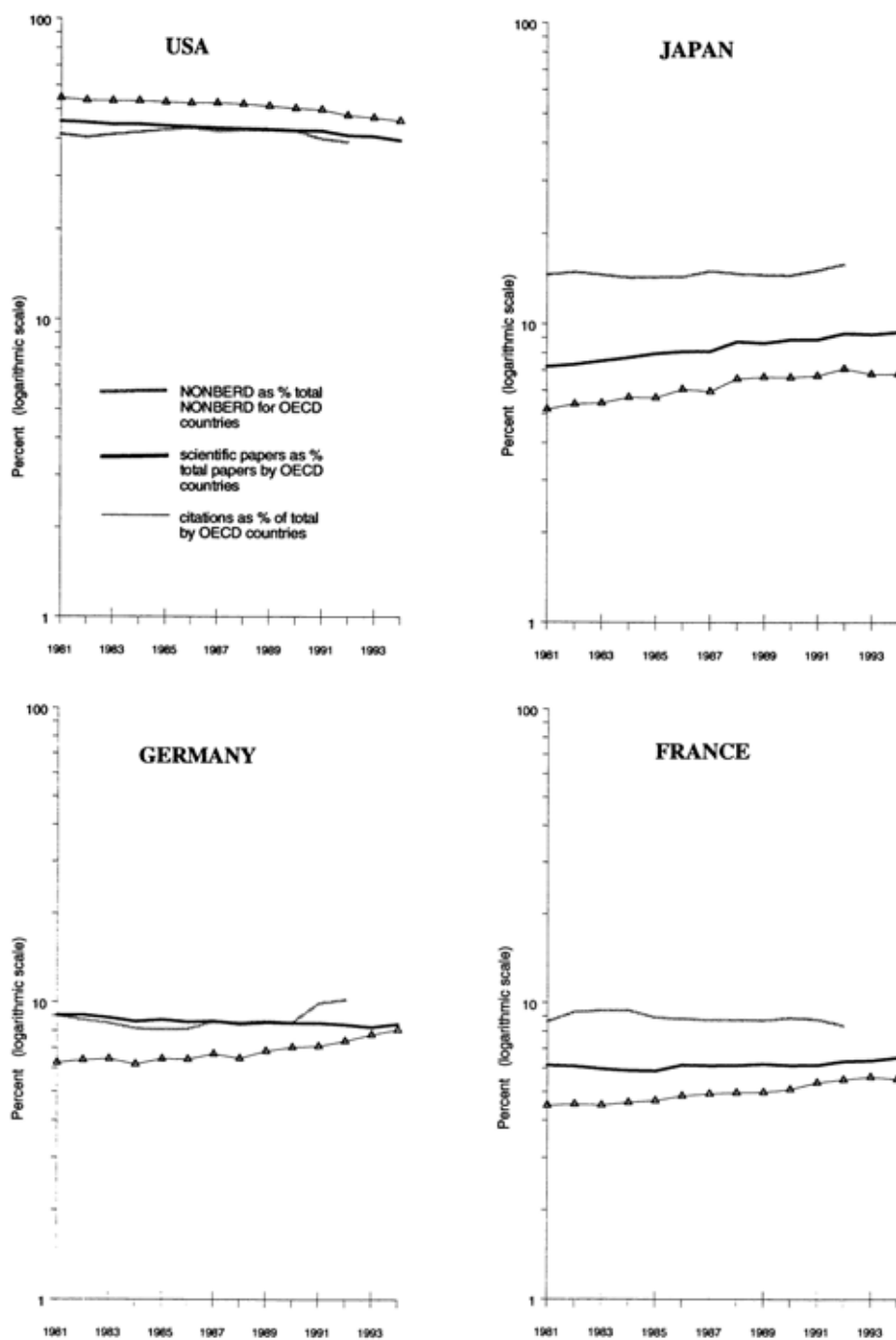
Australia's level of effort in basic research has been a matter of some interest. In fact, comparative data are available for only eleven countries. These are shown in Table 8. (The data also include small amounts of basic research conducted in the business and private non-profit sectors.) Australia has increased its level of effort in basic research from 0.33% of GDP in 1978-79, to

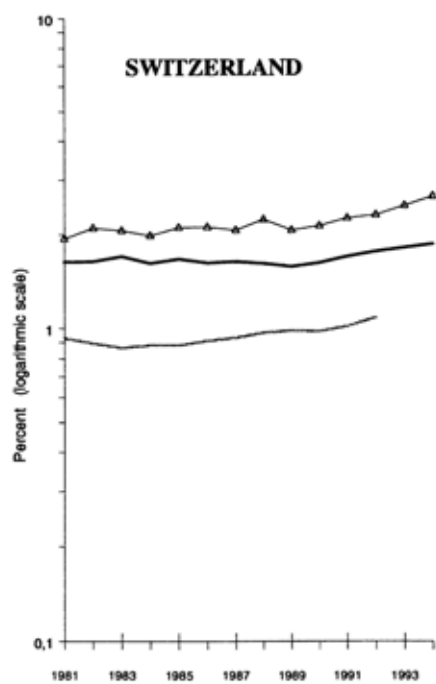
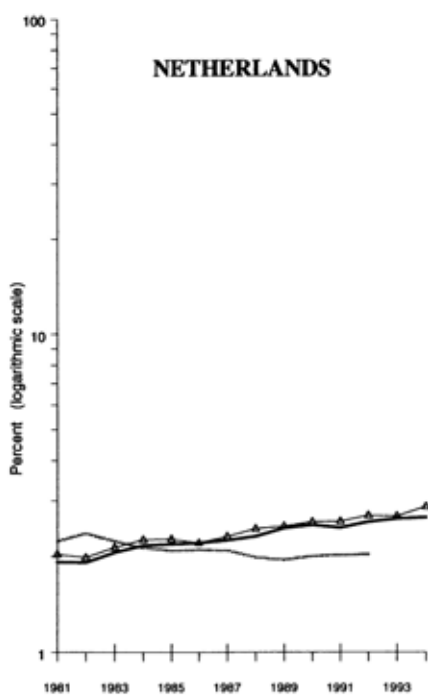
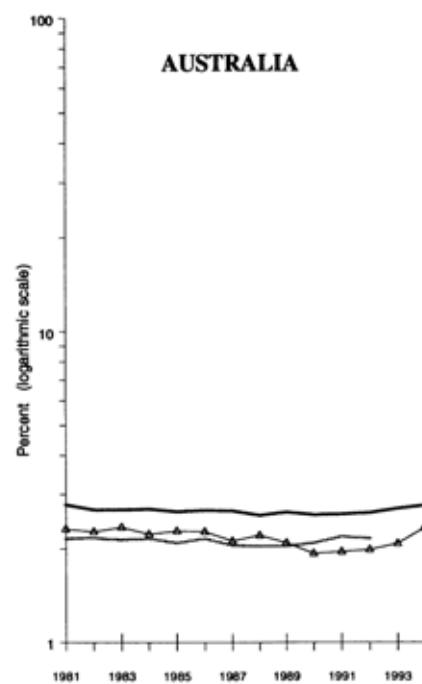
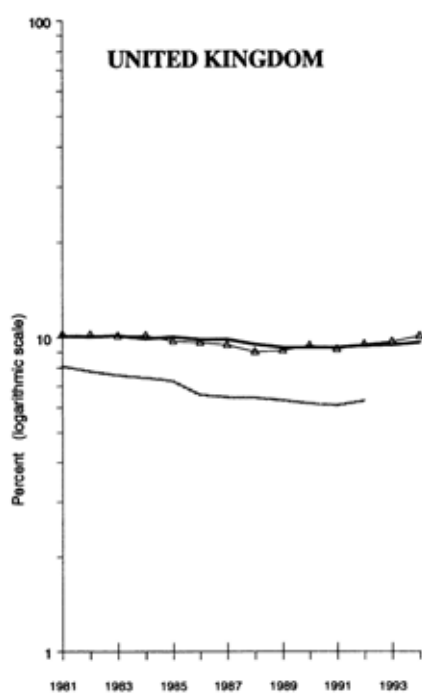
TABLE 8 Expenditure on R&D in government agencies and universities as a proportion of GDP, change and growth rates, and basic R&D as a proportion of GDP- international comparisons

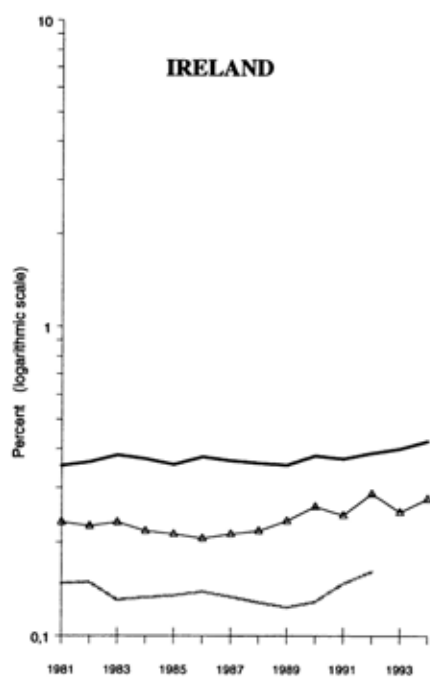
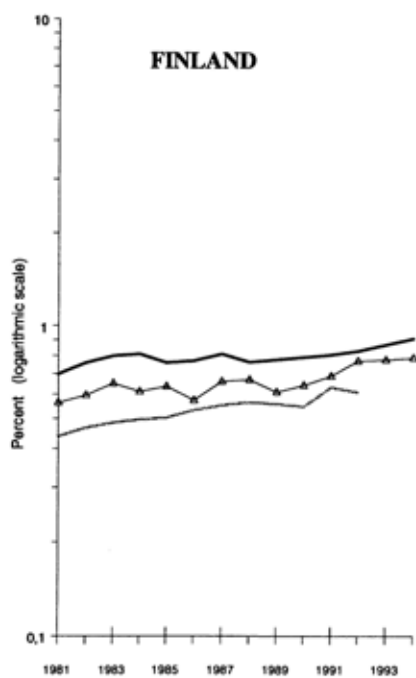
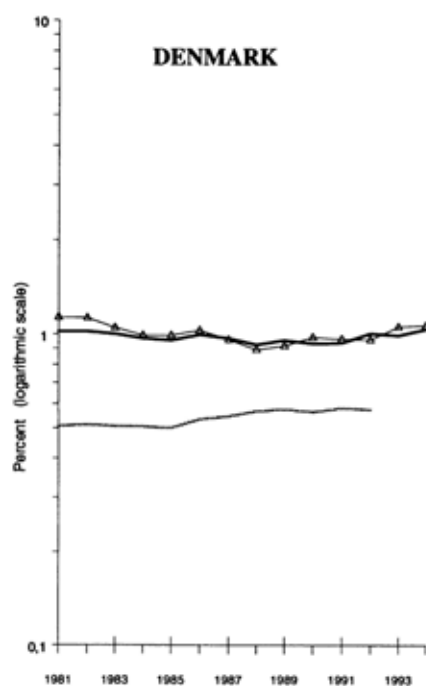
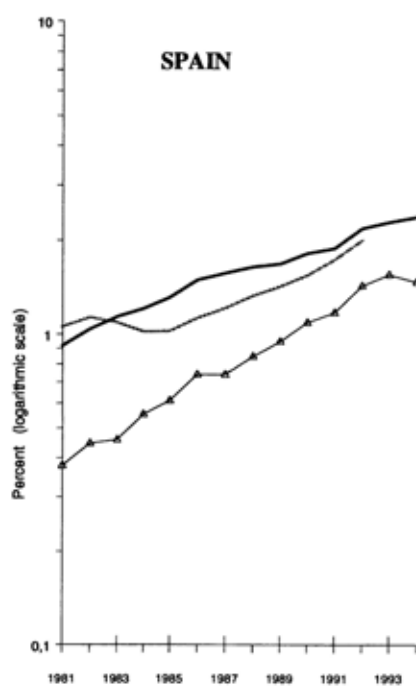
	Period 1981 to 1988			Period 1988 to 1994		
	R&D expend. in govt and universities as % GDP	Change	Average annual % real increase in R&D	Change	Average annual % real increase in R&D	Basic R& as %GDP (most recent year)
Sweden (1993)	0.94	0.16	5.3	-0.04	-2.8	0.53
Norway (1993)	0.90	0.07	3.7	0.23	4.4	0.28
Finland (1994)	0.89	0.18	7.9	0.17	3.7	na
France (1994)	0.88	0.11	3.7	-0.02	0.9	0.50
AUSTRALIA (1992)	0.88	-0.02	3.3	0.14	5.0	0.45
Netherlands (1993)	0.83	0.03	2.3	-0.01	2.7	na
Germany (1994)	0.79	0.07	3.5	0.02	5.6	0.49
Switzerland (1992)	0.77	0.10	0.7	0.22	4.3	na
Denmark (1993)	0.73	0.11	5.6	0.08	3.2	na
New Zealand (1993)	0.72	-0.18	-2.5	0.13	7.5	na
United Kingdom (1994)	0.69	-0.18	-0.4	0.06	2.3	na
United States (1994)	0.65	0.07	5.1	-0.07	0.1	0.42
Canada (1994)	0.64	-0.03	2.3	0.05	2.6	na
Japan (1994)	0.64	-0.02	3.6	0.03	4.1	na
Austria (1989)	0.55	0.06	4.9	na	na	na
India (1992)	0.54	0.23	12.4	-0.11	-1.2	na
Belgium (1991)	0.54	-0.03	0.6	0.16	14.2	na
Italy (1994)	0.52	0.13	7.3	0.01	1.7	0.24
Singapore (1992)	0.51	0.23	22.8	0.15	16.1	na
Chinese Taipei (1994)	0.48	0.16	10.6	0.06	10.8	0.29
Spain (1994)	0.45	0.07	6.4	0.15	9.9	0.15
Ireland (1993)	0.39	-0.03	2.2	0.04	7.4	0.07
China (1994)	0.34	na	na	-0.07	8.6	0.03
South Korea (1993)	0.28	0.11	17.3	0.03	8.6	na
Average (24 economies)	0.65	0.06	5.8	0.06	5.0	0.31
Average (OECD only)	0.71	0.04	3.5	0.07	4.1	0.35

Source: DIST based on ABS, OECD and national sources.

Figure 8: TRENDS IN NONBERD AND SCIENTIFIC PAPERS







0.35% in 1984-85 to the most recent level (1992-93) of 0.45%. This compares well on the limited comparisons that are available.

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 8 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 8 shows levels and trend on this basis for twelve OECD countries. For a number of reasons (caveats on publication data, particularly, have been well discussed in many recent 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 substantial improvement in Spanish shares in all three quantities are very striking.

Business expenditure on R&D

Table 9 shows comparative international data for business expenditure on R&D (BERD). The list in this case is arranged in order of BERD as a percentage of GDP. The Table also shows changes in this ratio in parallel with those of Table 8.

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 1988 to 1994 than for 1981 to 1988. As in most other economies beginning with relatively low levels of BERD, Australia achieved increases in BERD/GDP and growth rates well above OECD averages - the highest OECD rate of growth for the period up to 1988, and the second highest for the period since then. Nevertheless, growth rates in OECD nations were all much lower than for the three dynamic Asian economies in the Table - Singapore, with a real annual growth rate of about 18 per cent, Chinese Taipei on 16 per cent, and South Korea on 13 per cent - but Ireland, with the leading OECD growth rate, is now ahead of all these.

Figure 9 provides OECD comparisons for the business sectors in 12 OECD economies on a parallel basis to Figure 8. 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.

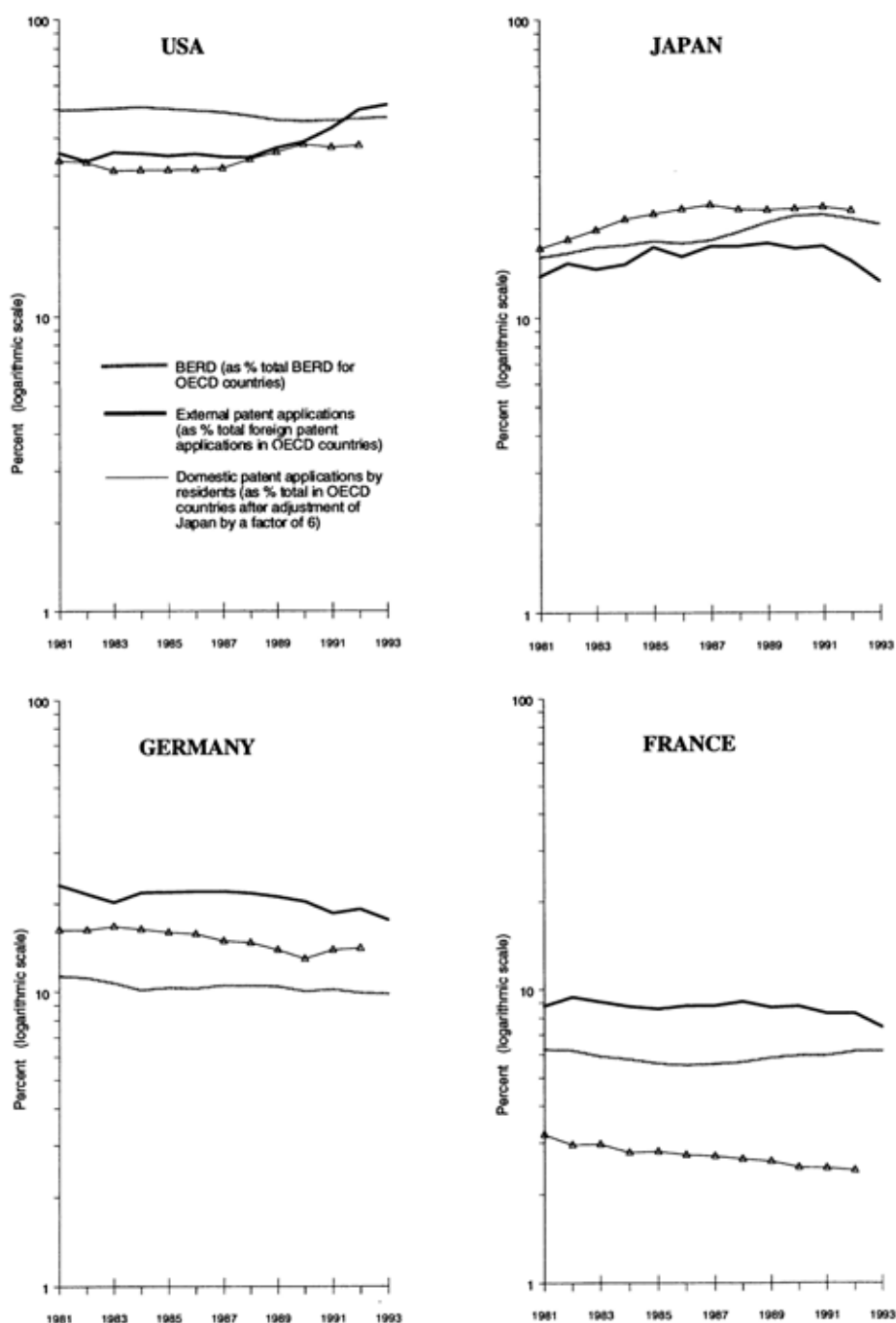
However, improvements for Spain, Finland, Denmark and Ireland should be noted. These might be regarded as indicating the dynamic European economies - to a degree, counterparts to those in Asia.

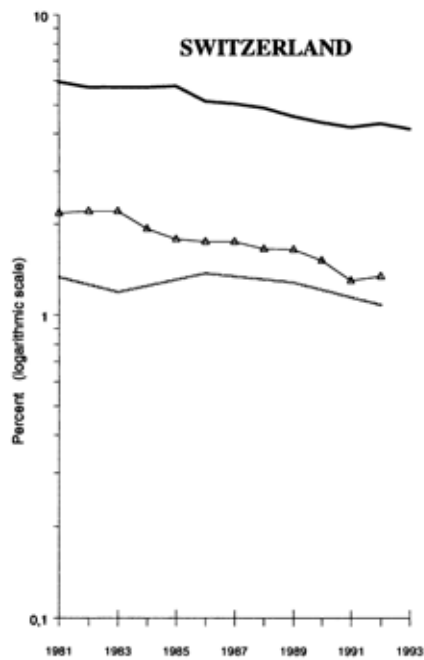
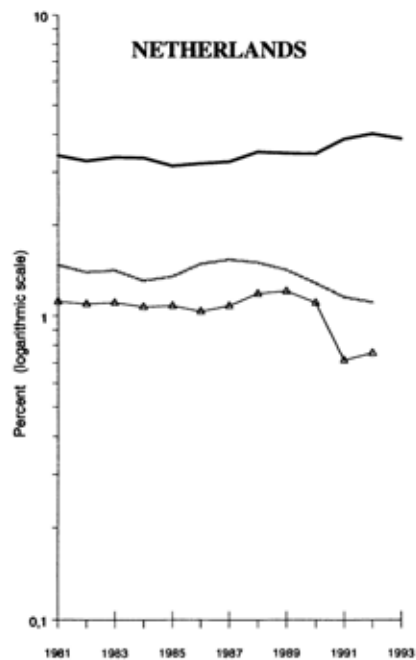
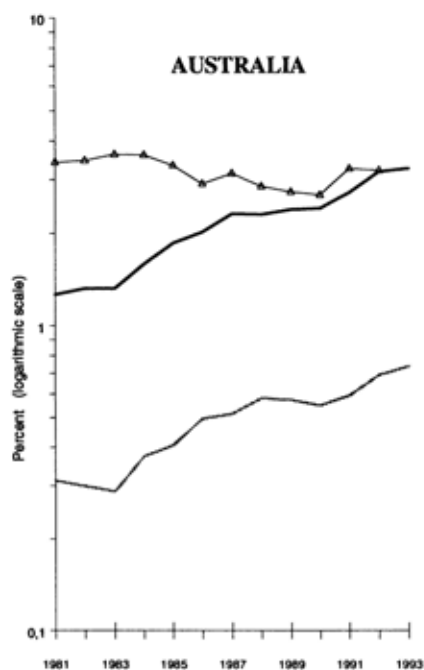
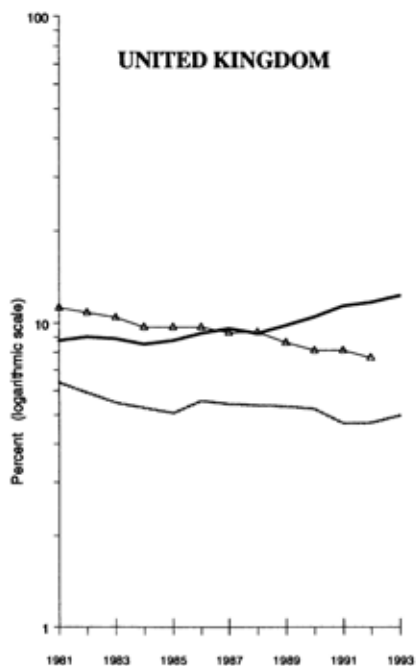
**TABLE 9 Business expenditure on R&D (BERD) as a proportion of GDP, change and growth rates in BERD
- international comparisons**

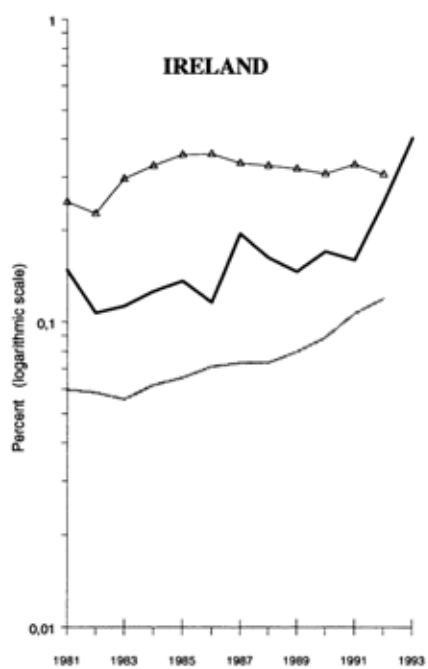
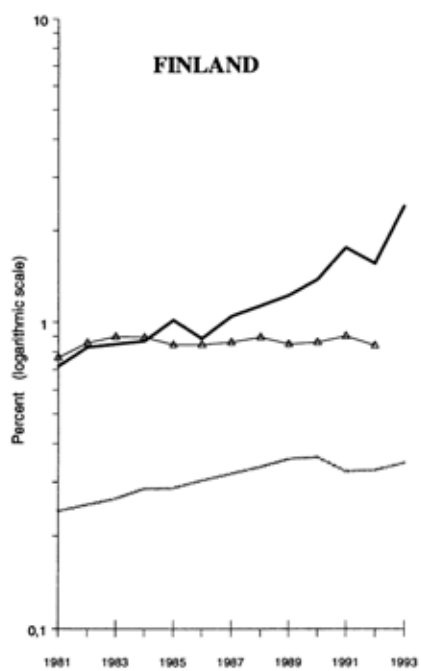
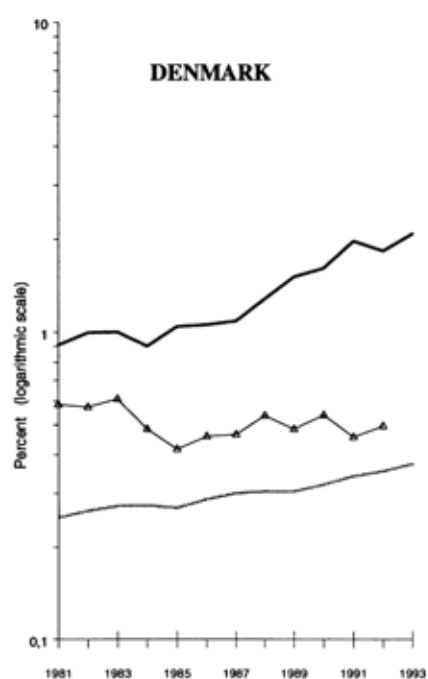
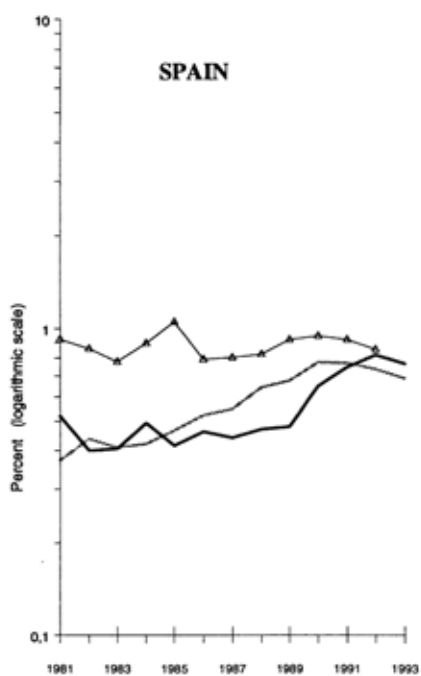
	%BERD/GDP (latest)	Period 1981 to 1988		Period 1988 to 1994	
		Change	Average annual real increase in BERD	Change	Average annual real increase in BERD
Sweden (1993)	2.32	0.54	8.3	0.33	3.8
Japan (1994)	1.91	0.54	8.8	-0.03	1.6
Switzerland (1992)	1.88	0.44	7.9	-0.26	-3.6
United States (1994)	1.80	0.29	5.7	-0.20	0.6
South Korea (1993)	1.72	1.02	37.9	0.44	12.9
Germany (1994)	1.54	0.36	5.0	-0.53	-0.5
France (1994)	1.47	0.19	4.4	0.11	2.9
Finland (1994)	1.46	0.43	11.2	0.38	2.8
United Kingdom (1994)	1.43	-0.02	4.1	-0.04	-0.2
Belgium (1991)	1.11	0.16	3.9	-0.10	0.2
Denmark (1993)	1.05	0.28	9.1	0.22	6.5
Norway (1993)	1.04	0.45	11.7	-0.09	1.2
Chinese Taipei (1994)	1.03	0.08	14.1	0.44	15.6
Netherlands (1993)	0.99	0.35	7.5	-0.34	-4.0
Canada (1994)	0.91	0.17	8.0	0.14	4.3
Ireland (1993)	0.84	0.16	10.6	0.38	18.2
Austria (1989)	0.80	0.15	3.5	na	na
Singapore (1993)	0.75	0.36	28.1	0.24	17.6
AUSTRALIA (1994)	0.74	0.28	17.7	0.21	8.0
Italy (1994)	0.67	0.21	8.2	-0.03	0.5
Spain (1994)	0.47	0.21	13.9	0.06	3.3
New Zealand (1993)	0.31	0.06	-0.6	0.03	3.6
India (1992)	0.19	0.03	7.0	0.01	3.7
China (1994)	0.11	na	na	0.11	-1.6
Average (24 economies)	1.11	0.29	10.3	0.07	4.2
Average (OECD only)	1.20	0.29	8.4	0.01	2.7

Source: DIST based on ABS, OECD and national sources.

Figure 9: TRENDS IN BERD AND PATENT PERFORMANCE







SECTION 5

Budget allocations and Portfolio achievements

Introduction

This Section presents selected information on science and technology arranged by ministerial portfolio. For each portfolio, there is a brief summary of pertinent allocations for the 1996-97 Budget compared with the expenditure outcome for 1995-96. The financial summary for the portfolio is followed by an account of recent research outcomes arranged by program or agency.

The focus of this Section is on major programs and agencies, particularly those engaged in R&D. On financial aspects, the bias is towards brevity of discussion. For additional information it may be useful to refer to Statement Number 3 of Budget Paper Number 1, which provides a discussion of financial trends for those scientific programs classified to the Budget function 'general research'.

The intention has been to complement the financial discussion 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, or steps in commercialisation which are the outcomes of the financial support received.

COMMUNICATION AND THE ARTS

Science and Innovation in the Portfolio Budget

The Government has recognised that science and technology is part of the cultural mainstream of Australian society. Through the creation of the Department of Communications and the Arts and through its cultural policy, the Government has sought to develop fully the synergies between development in communications and information technology and the creative industries sector.

The Communications and the Arts portfolio has a diverse range of science and technology responsibilities and activities which includes agencies such as the National Science and Technology Centre, the National Film and Sound Archive and the Australian Film Commission,

The National Science and Technology Centre has been allocated \$5.4 million for 1996-97 to stimulate public awareness and understanding of, and interest in, science and technology throughout Australia. The Centre achieves this by providing interactive exhibitions and education programs to audiences of about a million people each year throughout Australia and the Asia Pacific region.

The Department of Communications and the Arts:

- is a major stakeholder in the Heritage Collections Committee of the Cultural Ministers Council, which is a collaborative partnership of Commonwealth, State and Territory Governments and the museums sector;
- provided support for the Committee of Officials on Information Services (COIS) which is a high level body for coordination of the Government's overall policy strategy on information and communications services;
- played a major role in the development of the former Government's national strategy on information and communications services, which was released as part of *Innovate Australia*; and
- commissioned a Review of the National Science and Technology Centre (NSTC) which found that the NSTC is providing world class programs popularising science and technology in an effective and efficient manner. The Review reported that the NSTC is recognised in the top rank among its peers in the international science community.

MAJOR RESEARCH ACTIVITIES

National Film and Sound Archive

***Role** To increase knowledge, appreciation, use and enjoyment of Australia's screen and recorded sound heritage by acquiring, preserving and providing access to a national collection of film, television, video, radio and recorded sound materials.*

Recent Achievements

Compact Disc Preservation

Due to the increasing use of compact discs for published sound recordings, the Archive's Technology Research Unit has investigated compact disc stability and modes of failure. Following the development of a photo-micrographic technique, sampling and analysis of the disc surface was undertaken. A number of physical causes for compact disc failure have been identified and a paper presented to the 1996 conference of the Australian Sound Recordists Association.

DEFENCE

Science and Innovation in the Portfolio Budget

The Budget allocation for the Defence science and technology function will be \$229.5 million in 1996-97 (\$235.2 million in 1995-96).

MAJOR RESEARCH ACTIVITIES

Recent Achievements

Policy and command

***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.*

The Jindalee over the horizon radar in Alice Springs has been upgraded with the addition of a test-bed that includes a network of remote sounders and automated software algorithms. This facility will be used to improve the accuracy of both the Alice Springs and Jindalee Operational Radar Network radars. Collaborative trials using NASA atmospheric sounding rockets fired at Woomera, demonstrated the capability to acquire trajectory and image data and transmit in real time to a simulated battle command centre in the US.

Maritime force capabilities

A mechanism which can measure the hydrodynamic performance of underwater vehicles has been developed and transferred to the flow tank of the Australian Maritime Engineering Cooperative Research Centre in Launceston. This equipment will be used to measure hydrodynamic coefficients of the mine disposal vehicle and variable depth sonar for the new RAN Huon Class minehunters.

Land force capabilities

The development of a synthetic aperture radar concept demonstrator has laid the foundation for an effective and efficient capability in broad-area aerial surveillance of Australia's vast northern land mass.

Air force capabilities

The results of an extensive strain survey undertaken on an F-111 wing have been used to verify and calibrate a detailed computational model of fatigue-prone areas of the wing-pivot fitting. The model will provide refined estimates of the inspection intervals appropriate to a safety-by-inspection approach to fleet management. New techniques for assessing engine condition, based on engine vibration, gas path performance and oil wear debris, have been developed.

Industry and external relations

Intellectual property in the following areas has been transferred to Australian companies for Defence applications: lasers for advanced depth sounding systems, surface wave radar systems, radar target generators, software development tools, thermal imaging systems, visual displays and advanced communications systems. Arrangements have been established with Australian companies to use DSTO's laser technologies in advanced eye surgery systems and in the development of a target detection system, to manufacture a low cost infrared imager, and to develop a LADAR (Laser Radar) system. Technology for detecting faults in helicopter gearboxes has been transferred to a company internationally recognised in the aerospace field.

EMPLOYMENT, EDUCATION, TRAINING & YOUTH AFFAIRS

Science and Innovation in the Portfolio Budget

The Government, through the Employment, Education, Training and Youth Affairs portfolio, will provide about \$1284 million in 1996-97 to support research and research training in Australian universities through university operating grants and targeted research funding schemes.

Support through university operating grants

The major part of the Government's support for university research and research training, approximately \$887 million, is provided through the operating grant. This support is given in three nominal components: (a) the Research Quantum (RQ), \$276 million, (b) the Research Training Component, \$476 million and (c) approximately \$134 million of the Australian National University's operating grant which could be regarded as funding for the research schools and centres of the Institute of Advanced Studies. The estimates of (a) and (b), above, are conservative estimates, based on the 1990 Relative Funding Model methodology (see below for further discussion for estimating the research component of the operating grant).

Targeted Research Programs

A further \$396.8 million will be provided in 1996-97 directly to universities, researchers and other bodies through a range of targeted research programs: Research Grants (\$121.1 million), Postgraduate Awards (\$79.3 million), Research Fellowships (\$24.4 million), Research Centres (\$18.7 million), Research Infrastructure (\$99.7 million), Collaborative Grants (\$20.5 million), Overseas Postgraduate Research Scholarships (\$15.2 million), Learned Academies (\$1.5 million), Anglo-Australian Telescope Board (\$3.3 million), Research Evaluation Program (\$0.65 million), and other research funds (\$12.5 million).

These funds are generally allocated on a competitive basis to ensure that they go to the universities and researchers able to make the best use of them. Research grants, centres and fellowships are awarded on the advice of the Australian Research Council which conducts a competitive peer review process through its panels and committees. The primary criterion for the awards is the quality of researchers and their proposals, though some weight may be given to other criteria such as national priority areas and links to industry where appropriate.

Support for research through both university operating grants and targeted research programs is intended to promote the following Government objectives: excellence in basic and applied research, support for research training, selectivity and concentration of research resources, improved

collaboration between universities and industry, commercialisation of research outcomes, international cooperation in research and the development of infrastructure to support high quality research.

The Government has announced additional support for targeted higher education research totalling \$8.3 million in 1996-97, \$29.9 million in 1997-98, \$56.4 million in 1998-99 and \$34.8 million in 1999-2000. The additional \$8.3 million in 1996-97 increases targeted support for this financial year to \$396.8 million.

MAJOR RESEARCH ACTIVITIES

Research Funding Activities

University Operating Grants

In addition to supporting high quality undergraduate teaching, university operating grants support the research and research training capacity of universities with the aim of achieving internationally competitive basic and applied research, high quality research training, promoting research collaboration between universities and industry, promoting the commercialisation of research outcomes, promoting international links and the development and maintenance of Australia's capacity in key technological areas.

Two distinct approaches are currently used to estimate the research and research training components of the operating grant. The first is a methodology based on surveys of research expenditure of universities by source of funds. The calculation also includes an estimate of the research-component of university overhead expenditure based on the proportion of staff time spent on research activities compared with total staff time as obtained from Australian Bureau of Statistics (ABS) and DEETYA surveys. Using this method, the estimated research component of university operating grants for 1996-97 is \$1211 million (see Table 6, Section 3 *Science and Innovation in the Budget*).

The second approach is based on the 1990 analysis of the operating grant undertaken in developing the Relative Funding Model (RFM). Using this method, the estimated research component of university operating grants for 1996-97 is \$887 million, significantly less than that estimated by the ABS/DEETYA expenditure survey method. The RFM identifies three components of the operating grant as providing support for research and research training. These are:

- The Research Quantum (RQ): The RQ is identified as the component of the operating grant supporting research activities unrelated to teaching and training. In the 1993 Higher Education Budget Statement, the then Minister for Employment, Education and Training, stated that the research component of funding increases provided to universities since 1990 to sustain growth in student places would be retained by those institutions. Consequently, while the amount of the RQ reallocated in 1996 is \$218 million, for the purposes of estimating the total available for research unrelated to teaching and research training, a more appropriate estimate would be 6.2% of the current operating grant excluding capital funds. On this basis the total RQ is \$276 million including the non-reallocated \$58 million component of funding increases since 1990.
- The Research Training Component (RTC): The RTC is estimated on the basis of higher degree research student load weighted in accordance with the relative teaching costs matrix developed in 1990 in the context of the RFM. In 1990 the RTC was estimated to be 7.6% of the operating grant. Due to strong growth in postgraduate research student load since 1990, the RTC has increased and is currently estimated to be 10.7% of the operating grant, or \$476 million.
- Funding for the Schools and Centres of the Institute of Advanced Studies of the Australian National University (with the exception of the John Curtin School of Medical Research). For 1996-97 this is estimated to be \$134 million.

The ABS/DEETYA expenditure survey based methodology, as currently used, has shortcomings related to difficulties experienced in the 1992 survey. It is expected that the 1994 ABS survey of expenditure and the resulting estimates will eliminate these shortcomings when it becomes available. The RFM methodology is less appropriate with each year that passes, given that it is based on relative cost estimates from 1988 data. It is intended that a single basis for estimating research and research training components of the operating grant will be adopted based on the 1994 ABS survey. This will be described in the next *Science and Technology Budget Statement*.

Research Grants

The 1996-97 allocation for Research Grants is \$121.1 million. The Research Grants program has two components:

- Large Grants Scheme: Supports basic and applied research projects in all disciplines except clinical medicine and dentistry with grants ranging from a minimum size of \$20,000 for the social sciences, humanities, mathematics and theoretical physics, up to more than \$250,000 for Special Investigator Awards. The Australian Research Council (ARC) provides advice on the allocation of grants with proposals being selected on a competitive basis by peer review provided by the ARC's Research Grants Committee and its expert discipline panels.

- **Small 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 with the remaining funds 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.

Postgraduate Awards

Two types of award with stipend are available under this program, Australian Postgraduate Awards with stipend and Australian Postgraduate Awards (Industry). In addition, 19,900 Equivalent Full-time Student Units (EFTSU) are provided exemption from HECS. \$79.3 million is available under the Scheme in 1996-97. The stipend elements of the Scheme are:

- **Australian Postgraduate Awards:** Around 4,000 APAs provide a stipend of up to \$19,827, mainly for students undertaking postgraduate research degrees. They are tenable for up to two years in the case of a Masters student, or three and a half years in the case of a student undertaking a PhD. APAs with stipend are allocated to institutions on a formula reflecting research student load, research degree completions and comparative research strength measured by the Composite Index.
- **Australian Postgraduate Awards (Industry):** Approximately 500 APA(I) are available each year (150 new awards) and provide a stipend of \$19,827. They support higher degree research training for postgraduate students on research projects developed to meet the needs of industry. Each project is sponsored by an industry partner who is required to contribute \$5,000 in cash plus an additional \$5000 in cash or kind for each year of the higher degree training course. APA(I) are awarded on the recommendation of the ARC.

The Government has announced additional funding for postgraduate research scholarships of \$9.3 million over three years beginning in 1997.

Research Fellowships

Fellowships provide support for individuals to undertake research at postdoctoral level and above. In 1996-97, \$24.4 million will be available for Research Fellowships.

There are four types of Fellowship:

- **Australian Postdoctoral Research Fellowships (APRF):** These are normally for researchers with less than three years postdoctoral experience. Fifty-five new APRFs have been taken up in 1996.
- **Australian Research Fellowships (ARF):** These are normally for researchers with more than three years postdoctoral experience. Fifteen new ARFs have been taken up in 1996.

- Queen Elizabeth II Fellowships (QEIIF): These are for outstanding researchers who would usually have no more than six years postdoctoral experience. Fifteen new QEIIFs have been taken up in 1996.
- Senior Research Fellowships (SRF): These are for researchers with established reputations who would normally have no more than fifteen years postdoctoral experience. Fifteen new SRFs have been taken up in 1996.

Research Centres

The Research Centres Program supports centres of research concentration on the basis of excellence and their potential to contribute to the economic, social and cultural development of Australia. A total of \$18.7 million is being provided to Research Centres in 1996-97. Two types of centres are supported:

- Special Research Centres: Receive between \$0.5 million and \$1 million a year to concentrate research effort in areas of national importance. In 1996 funding is being provided to 17 Special Research Centres. A selection round for up to eight new Special Research Centres to commence in 1997 is under way.
- Key Centres of Teaching and Research: Key Centres give equal weight to teaching and research. They are based in existing university departments and aim to boost expertise in areas relevant to national development and to promote cooperation between the higher education sector and industry. Key Centres receive funding in a range of \$68,000 a year to \$411,000 a year, with most Centres obtaining additional funding from other sources. In 1996 funding is being provided to 29 Key Centres of Teaching and Research.

Research Infrastructure

The Research Infrastructure Program provides the Commonwealth Government's contribution, \$99.7 million in 1996-97, towards research infrastructure in higher education institutions in order to support high quality research by ensuring that areas of recognised research potential have access to the support necessary for their development, enhancing support for areas of research strength and remedying deficiencies in research infrastructure. The Program comprises two categories of grants:

- Research Infrastructure Block Grants (RIBG) Program: RIBG are provided to universities to assist in the development and maintenance of research infrastructure. Consistent with the program 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).
- Research Infrastructure (Equipment and Facilities) Program: 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 1997, this will include \$1.7 million to support greater access to high performance computing and communications facilities for universities (see Section 2, 'Other initiatives in support of science and technology').

The Government has announced that it will provide an additional \$90 million for research infrastructure over three years, beginning in 1997, to reduce deficiencies in the current level of support and allow Commonwealth competitive grant schemes to be more adequately supported.

Collaborative Grants

The Collaborative Research Grants Scheme supports research collaboration between universities and industry by funding high quality research which has the potential to economically and socially benefit Australia. It covers projects in basic, strategic, applied and developmental research in all fields. It is a requirement of grants that dollar for dollar matching funds from industry are available to the grantee. In 1996-97, \$20.5 million will be available to the Scheme.

The Scheme has experienced a strong growth in demand from 1995 to 1996 with more than a doubling of the number of applications. The Government has announced additional funding for collaborative research of \$30 million over three years beginning in 1997.

Overseas Postgraduate Research Scholarships

The Overseas 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 obtain a postgraduate qualification and to gain experience with leading Australian researchers. In 1996-97, \$15.2 million will be available to the Scheme. In 1996 three hundred new scholarships are available.

Advanced Engineering Centres

DEETYA provides the Government's contribution to the operation of three Advanced Engineering Centres (AEC):

- Advanced Engineering Centre for Information Technology and Telecommunications, involving Adelaide and Flinders Universities and the University of South Australia in conjunction with the SA Department of Technical and further Education;

- Advanced Engineering Centre for Manufacturing involving Melbourne University and the RMIT; and
- Australian Graduate School of Engineering Innovation, involving Sydney University and the University of Technology Sydney.

The Centres were established as a part of a wider agenda to enhance the contribution of engineering skill, research and development in the evolution of internationally competitive industries for Australia. They are designed to promote collaboration between higher education and industry to:

- improve advanced engineering education
- increase industry's capacity to apply and commercialise technology; and
- focus on teaching and short term research and consultancy projects.

Each Advanced Engineering Centre received establishment funding of \$1.4 million in 1992 and receives recurrent funding of \$0.6 million annually. University and industry partners also contribute to operating costs. \$1.6 million will be provided to AECs in 1996-97.

The Advanced Engineering Centres were reviewed in 1995. The Review recommended that funding of two of the Centres be continued for another two years whilst funding for the third Centre continue for three years. It recommended a maximum funding period of six years for existing and future AECs (see Section 2, 'Other initiatives in support of science and technology').

Recent Achievements

Research activity in universities is supported by all of the above programs 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 ARC/DEETYA program. The recent research achievements listed below have all benefited from ARC/ DEETYA research support programs and are arranged by broad field of research from 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.

Biological Sciences

Receptor binding compounds

Researchers at Deakin University have discovered novel compounds which can bind with high affinity to adenosine receptors. Adenosine regulates the balance between oxygen supply and demand in the heart. Adenosine released from heart cells increases oxygen supply through coronary dilation and decreases oxygen consumption by slowing heart rate. The protective effects of adenosine are particularly important when cardiac oxygen supply is limited, for example, in a case of coronary artery narrowing. Adenosine receptor compounds have therapeutic utility in a broad range of applications including cardiac and renal regulation. The new compounds have been licensed to a pharmaceutical company in the United States. After additional biological evaluation, the company made an application to the FDA to commence human trials. The license was granted late in 1995.

Insulin resistance

Researchers at the University of Sydney have investigated the effect on insulin resistance of long-term consumption of diets of different carbohydrate composition in rats. For up to a year, rats were feed on diets containing carbohydrate either in the simple, rapidly absorbed glucose form, or in more complex, slowly absorbed forms such as amylose or amylopectin. It was found that when carbohydrate is rapidly absorbed, insulin resistance rises.

Algae-beating bacteria

Australia's warm climate and propensity to drought makes it susceptible to algal blooms. University of Queensland researchers and CSIRO have discovered a bacterium that destroys blue-green algae toxins. The bacterium has the potential to help clean up contaminated water and make it safe to drink. The discovery of the bacterium could eventually mean relief for the hundreds of Australian country towns which have their water supplies periodically blighted by algal blooms.

New instrument

A protein sequencer instrument called GlycoSite has been developed by the Macquarie University Centre for Analytical Biotechnology. Beckman Instruments Inc, the US manufacturer of biotechnology equipment, has invested \$700,000 in the R&D. The instrument is an important tool in the newly emerging field of glycobiology. GlycoSite can determine the location and structure of the sugar coating on proteins to a level of sensitivity previously unobtainable. The instrument is of use in early cancer.

Skeleton-building gene

Researchers with the Special Research Centre for Molecular and Cellular Biology at the University of Queensland may have isolated a gene that controls the formation of the embryonic skeleton. The discovery occurred while the team was studying the gene responsible for determining the male sex of an embryo. They found a family of related genes and cloned some of them in order to determine their function. One of the genes, Sox-9, appears

to be the pivotal gene in skeletal development in vertebrates. The potential uses of the gene and further research could eventually result in the gene's practical application in medicine, for example in cartilage reconstruction.

Marine worm invasion

Researchers at Edith Cowan University, in collaboration with CSIRO, have studied the distribution of an introduced pest worm species, *Sabella spallanzanii*, in Cockburn Sound, Western Australia. The research indicates that the worm occupies over 20 Ha of the bottom of the Sound, and at least the same area on artificial vertical structures. While the presence of the worm in these areas is potentially harmful for native marine organisms, there may be some benefits. The filtration capacity of the worm beds is significant and it is estimated that they can filter the water column (5m) about four times per day. Locally, this may improve water clarity and reduce algal blooms. However, the surrounding ocean has much lower phytoplankton concentrations, which suggests that the potential for the species to spread may be limited by its low feeding efficiency.

Insect proof plants

Researchers at La Trobe University have discovered a gene in the ornamental tobacco plant, *Nicotiana glauca*, which produces a natural insecticide active against a large range of pests. They have also produced transgenic plants which secrete the insecticide and give insects the equivalent of a bad hangover. After feeding on a transgenic leaf the insect falls into a lethargic daze with both its appetite and ability to fend off predators severely curbed. If the gene is successfully commercialised, many crops will be less dependent on chemical pesticides.

Unmasking the living brain

Researchers from the University of Queensland, Vision, Touch and Hearing Special Research Centre have obtained the first optical images in Australia from the living brain. The team captured minute brain responses to visual stimuli using a modified video system. Only a few laboratories in the world have mastered the new technology, which provides rapid mapping of brain activation patterns.

Plant identification from leaf material

Traditionally, flowering or fruiting plant material is required to establish plant identity. A research team at the University of Adelaide has developed an identification system based on single leaves or leaf fragments. A new book on leaf structure and identity of Australian members of the Cinnamon family was published.

New membrane technology

The UNESCO Centre for Membrane Science and Technology at the University of New South Wales, has developed a new membrane process. It allows the selectivity of the membrane to be tuned by controlling the frequency of electric fields applied to the membrane system. The process also increases the flux and reduces fouling of the membrane during

separation processes. Patents have been applied for through Unisearch. A membrane manufacturing company has expressed interest in industrial applications.

Equine laminitis

Researchers from the Companion Animal Medicine and Surgery Department and the Physiology and Pharmacology Department of the University of Queensland believe they have identified the cause of a major horse disease, equine laminitis, and a possible preventative treatment. In the past, equine laminitis has been regarded as a mysterious and insidious disease. It is the second biggest killer of horses after colic. The team have identified an enzyme as the cause of horse hoof disintegration symptomatic of laminitis, and are now testing an enzyme-blocking drug. The enzyme's role in causing laminitis was discovered following the development of a novel experimental technique involving the first-ever growth of horse hoof fragments in tissue culture.

The eyes of the sandlance

The sandlance behaves like a marine chameleon, with independent movements of its turret-like eyes, highly effective camouflage and rapid strikes for isolated, mobile prey at close quarters. The optical system has a fixed circular pupil, a deep pit fovea and a flattened lens unlike any other telesost lens so far described. The Department of Zoology at the University of Western Australia, using ray tracing, refractive index measurements, observations of purkinje images and ultrastructural analysis, has investigated the visual system of the sandlance and found it to be very similar to that of the chameleon. The evolutionary convergence of the marine optical system of the sandlance to a terrestrial optical system of the chameleon is remarkable, given the constraints imposed by underwater optics.

Reptile kidney hormonal control

Researchers in the Department of Zoology, University of Western Australia have localised the action of the neurohypophyseal peptide, arginine vasotocin (AVT) in reptiles. AVT is thought to function as an antidiuretic hormone in reptiles, helping to limit water loss from the kidneys by reducing the rate at which blood is filtered and also by facilitating water re-absorption in the kidney tubules. The UWA team has now shown that receptors for AVT are localised primarily in the complex collecting duct system of the kidney, but they also extend to the ureter. This is the first time that the ureter of a vertebrate has been shown to function other than as a conduit of urine to the exterior and raises the real possibility that hormone action will also be detected in post-renal structures such as the cloaca and colon.

Vision in deepsea fishes

Species diversity and the biomass of fish fauna in the deepsea is extremely high. Evolution in an environment devoid of sunlight places enormous selective pressures on the visual system. Specific visual adaptations peculiar to each species' chosen ecological niche not only determine the depth range a given species will inhabit, but also on what food source it can successfully feed. The Department of Zoology at the University of Western Australia has

shown that basic neurobiological processes have undergone radical changes to overcome the lack of sunlight and adapt to the levels of bioluminescence available.

Synthetic gene

Researchers in the Department of Biochemistry at the University of Sydney have made the largest synthetic gene of its kind, encoding the protein tropoelastin. Tropoelastin is the building block for elastin, the main rubber-like substance that gives skin, lung and blood vessels their extraordinary elasticity and resilience. The laboratory synthesis of the gene involved chemical attachment of over 4000 individual molecular components. After this, the synthetic gene was inserted into a bacterial cell. In this way the cell was programmed to make large quantities of the tropoelastin protein. This could be very useful for tissue repair and the treatment of wounds.

Ecology of tropical floodplains

A study of tropical floodplains near Darwin, by researchers from the University of Sydney, is providing insights into the ways in which the harsh and unpredictable Australian climate influences the ecology. The study is focused on native rats and their predators, primarily water python, on the floodplains of the Adelaide River. Monitoring pythons using miniature radio transmitters revealed the ways populations of tropical predators are influenced by the availability of prey and thus regulated by climatic variation. This understanding will help in efforts to conserve and manage the unique ecosystems of tropical Australia.

Understanding Staphylococcus

Strains of the bacterium *Staphylococcus aureus* cause infections in hospital patients. One reason for this is that some strains of this bacterium are resistant to up to twenty different antimicrobial compounds including antibiotics, antiseptics and disinfectants. Researchers at the School of Biological Sciences at the University of Sydney have identified three genes specifying resistance to a broad range of antimicrobials. These genes appear to make transmembrane proteins which pump antimicrobial compounds out of the bacterial cell. The structure of these proteins reveals how they can recognise and export out of the cell a range of antimicrobial compounds with widely varying chemical structures. This research also has significance in the field of cancer chemotherapy, as resistance to antitumour drugs depends on an export mechanism.

Algae benefits coral

Many animals live in an intimate association with the corals. Researchers at the School of Biological Sciences, University of Sydney have sought to understand aspects of this dynamic interaction, such as how corals obtain nitrogen in the form of ammonia from the surrounding water. Using radioactive tracers to identify where ammonia was first incorporated into molecules, it was shown that the algae living in the corals are responsible for providing the corals with their nitrogen needs.

A FISH-eye view of genes

Researchers at the School of Biological Sciences, University of Sydney, in collaboration with the John Innes Research Centre in the UK, have developed a method to map genes in chromosomes. Fluorescent dyes are tagged to specified sequences of DNA which are then bound to genes in chromosomes. This is called Fluorescent In Situ Hybridisation (FISH). When the bound material is viewed with ultraviolet light, the location of the genes on chromosomes can be easily made. The technique greatly eases the task of mapping genes.

Population variation in lizards

Geographic variation in the characteristics of organisms is the basis for hypotheses about selective pressures on these organisms. Researchers at James Cook University have been examining geographic variation in morphological and reproductive characteristics of a species of viviparous lizard that ranges over the entire east coast of Australia. The results reveal that this species varies mostly in terms of offspring size and that these differences are genetically-based.

Rapid mutation screening

Researchers at Southern Cross University have developed a method for screening DNA variation. Previously, the only method available involved DNA sequencing, a lengthy, laborious and expensive process. With this new technique, it is possible for one person to screen 200 samples a week. The approach has wide applications in mutation research, human screening, and animal and plant population genetics and is already being adopted overseas.

Cooperation challenged by cheating lions

Research in the Faculty of Science at the Australian National University has challenged our understanding of the evolution of cooperative behaviour in complex bird and mammal societies. They have found that when the territorial defence mechanisms of a pride of lions are triggered by a speaker, some individuals habitually lagged behind as the defenders approached the speaker; while others were always among the first to attack. Attackers recognised the cheaters, but failed to punish them, in contrast to the expectation that cooperative interactions of this sort are usually based on altruism. This work was featured on the cover of *Science*, *Proceedings of the Royal Society*, and *Trends in Ecology and Evolution*.

Paleobotany of Central Australia

Research by scientists at the University of New South Wales has changed the accepted view of the flora and vegetation history of central Australia. Central Australia was once well forested and well watered. About 15-20 million years ago, when the climate became drier and more seasonal, the vegetation was probably a woodland/floodplain complex, where rivers running into Lake Eyre flooded annually. The vegetation became dominated by *Casurinaceae*, contrary to expectations and older hypotheses which predicted Eucalypt forests as intermediate between rainforests and the present arid vegetation. Eucalypts are not dominant in the arid zone today and this research suggests that they never were. Grasslands and shrublands developed later, about 5 million years ago.

Measuring rainfall without rain gauges

There are many parts of the world where climate stations are rare or absent, but where information on rainfall is important for water management and ecological research. Researchers from the University of Tasmania and CSIRO have developed the use of satellite remote sensing data to gain an accurate estimate of annual and seasonal rainfall. This technique was tested in South West Tasmania where it proved highly accurate, and showed that some areas received almost twice the rainfall shown on previous maps.

Earth Sciences

Assessing natural hazards

Researchers at Macquarie University are assessing the risk of natural hazards. The work is helping planning for more effective disaster reduction and may lead to the insurance industry spreading the cost of insurance more equitably. Integrated risk assessments have been completed for Fiji and Vanuatu. The data is presented as coloured maps which differentiate areas by assigning various levels of risk from a host of natural hazards. Earthquake maps of Sydney, Melbourne and Perth have been completed, with Adelaide and Brisbane under study. The work is also supported by the insurance and re-insurance industries, the Australian Geological Survey Organisation and the Australian Committee for the International Decade for Natural Disaster Reduction.

Locating mineral deposits

One of the great challenges for the Australian mining industry is the continued discovery of world-class mineral deposits in more and more difficult terrains at greater depths below the surface. Research at the University of Western Australia has developed a method for predicting the prospectivity (chance of exploration success) for gold deposits in ancient volcanic belts in the Yilgarn Block of Western Australia. The method uses software and statistical analysis together with a Geographic Information System. The enhancement factor for exploration success was over 400:1 when the method was used for prediction of the positions of known large gold deposits. Similar success is being achieved in the Kimberley regions of Western Australia for predicting exploration target areas for zirconium - lead deposits.

Mineralisation of the Olary Block

University of Melbourne earth scientists have mapped the mineralisation of the Olary Block in South Australia. The geology, geochemistry, stratigraphy, structure and metamorphism of the Lower-Middle Proterozoic Olary Block was investigated. The Olary Block has undergone five episodes of folding, metamorphism and melting each of which redistributed the mineralisation. The study has shown that some of the sea-floor precipitates are rich in gold and that a close relationship exists between the iron, copper, barium and gold mineralisation. In addition, the derivation and age of the gold deposits

within the Adelaide area have been determined. The research has been of direct benefit to the competitive mineral exploration undertaken in the Olary Block.

Biogeography

Previously it was thought that the inland aquatic faunas of south-western Australia were obliterated by long periods of isolation from south-eastern Australia and a drying climate. However, research undertaken at the Edith Cowan University has revised this view. Researchers have studied wetlands in far south-western Australia for patterns of richness in aquatic invertebrate faunas. Patterns revealed "hot spots" in the acid flats on the far southern coastline, mainly in non-flowing waters and subterranean habitats, and included discovery of a new frog genus. This suggests that the freshwater faunas of the south-west are not all species poor, and that the biota requires special management.

Bitumen paves the way for methane exploration

Researchers at the University of Queensland have found that bitumen in coal seams is a reliable indicator of the presence of significant quantities of methane gas. This discovery has safety and economic implications for the mining industry. Methane gas occurs naturally in coal seams but to date has been problematic for mining. Slow escapes of the gas into the atmosphere via mine ventilation systems contribute to the greenhouse effect, while catastrophic releases cause explosions and miner fatalities. A computer program is now being developed for use by the exploration industry. The program will predict the quantity and volatility of methane present in coal seams before mining begins.

Ground Penetration Radar (GPR)

University of Queensland researchers have developed a GPR system with the potential to earn millions of dollars for Australian mining and engineering companies. Two GPR prototypes have been constructed. A shallow and a deep version "see" to depths of around one metre and 30 metres, respectively, using microwave technology. This capability allows delineation of ore bodies such as coal beneath the surface of open-cut mines, providing more accurate exploration and planning. GPR systems are important in other industries, such as identifying the nature of earth before building foundations are installed.

Contaminated continental shelf

A comprehensive investigation of heavy metal contaminants, on the central NSW continental shelf between Jervis Bay and Seal Rocks, has been undertaken at the University of Sydney. The main objective was to determine the influence of the four large cities (Port Kembla, Wollongong, Sydney, and Newcastle) on adjacent marine sediments. Prehuman levels were established for eight heavy metals by studying deep cores, and present levels were determined for the entire region. Enrichment in most heavy metals occurs on the continental shelf adjacent to the three large metropolitan areas. The sources of these contaminants include export from contaminated estuaries, marine dumping and sewage disposal.

Origin of the Great Barrier Reef

The University of Sydney has collaborated with scientists from five countries to complete the first phase of a project to determine the origin of the Great Barrier Reef. Two drill sections have been obtained through the coastal and shelf edge zones of the Great Barrier Reef to the east of Cooktown. This, together with other drilling, gives a geological transect from the Australian coast, across the shelf, down the continental slope, and into the adjacent rift basin, a first for any continental margin. The project shows that the Great Barrier Reef is thin, varying from 52m on the inner shelf to 148m on the outer shelf, with successive reefs forming a layer cake stratigraphy.

South Tasman tectonics

Researchers from the University of Sydney were involved in mapping part of the South Tasman Rise, in the South Tasman Sea. They found a field of volcanic cones, a few kilometres in diameter, averaging 900 metres in height and between 900 to 1100 metres below sea level. The cones were most likely formed when this part of the Australian plate passed over the Balleny hotspot about 40 million years ago.

Fission track dating

Geologists from La Trobe University have used fission track dating to answer key questions about the geological evolution of south eastern Australia. The method reconstructs the thermal history of rock masses. This allows mapping of large scale movements in the earth's crust. This increases our understanding of the origin of important oil reserves around continental margins, such as those in Bass Strait.

Sediment transport in the Great Barrier Reef

Research at James Cook University of North Queensland has added to our understanding of the dispersal of sediment into the Great Barrier Reef lagoon. This is important for the management of sites of coastal-shelf erosion or siltation. Two new instruments have been developed. One measures suspended sediment concentration over periods as long as three months or more. Another important instrument is a newly patented sensor able to measure changes in the level of the sea bed. Sediment fluxes have been measured over periods of up to many weeks in mangrove swamps during both wet and dry seasons. This data has enabled an assessment of the influence of wet season flushing in the context of the longer-term evolution of coastline and distribution of sediment. A changed regime of sediment transport in mangrove swamps is one likely effect of global sea-level rise, and the dynamics of such systems are therefore of more than academic interest.

Geological history of Central Queensland

Regional geological mapping conducted by James Cook University has resulted in the discovery of a tract of fossiliferous rocks named the Sedgford Formation, near Alpha in Central Queensland. Two units comprise the formation, with the lower non-marine sandstone containing abundant plant fossils and a diverse fish assemblage. The overlying marine sequence contains a rich assemblage of corals, invertebrates and microvertebrate fossils. To the east the Sedgford Formation has been uplifted along, and truncated by, a previously recognised major crustal dislocation, the Bottle

Tree Fault. To the west, the sequence is overlain by extensive younger sediments of the Galilee Basin. The discovery has implications for petroleum gas potential in this part of Queensland.

Social Sciences and Humanities

Consumption patterns cross national boundaries

Research by the Economic Research Centre at the University of Western Australia into consumption patterns has demonstrated that consumer tastes are identical across nations. Using data from over 40 nations, the research showed that once corrections are made for the level of real income and relative prices, people are very similar in their consumption patterns irrespective of their nationality and level of development. This result may improve the ability of forecasters to project national expenditure patterns into the future. It also strengthens confidence in Engel's Law, which states that when income doubles, the food budget share declines by 10 percentage points.

Literacy

Researchers at the University of Melbourne have found there is an attitude among some school teachers that literacy is only the preserve of the primary school. The study tracked the relationship between students' patterns of speech and their written texts in three Melbourne schools. This yielded evidence about the teaching of English, especially in the case of students who cope with the literacy demands of primary school but perform poorly in secondary school. This literacy decline can be attributed predominantly to an increasing reliance on written assessment as students progress through school, and the differentiation of subjects which creates a range of different literacy demands. The researchers believe that students should continue to learn literacy throughout their schooling

Policing, citizenship and crime

The first stage of a project studying the connection between policing, citizenship and crime has been completed in the School of Humanities, University of Western Sydney-Hawkesbury. The research has identified unemployment as one of the strongest predictors of the rate of crime in a socio-geographic area. Sexual assault was not correlated in any significant way with any social indices, such as level of unemployment, and appeared to be dispersed across the socio-geographic population, albeit unevenly, with much higher rates of recorded sex offences in non-urban parts of NSW.

Intellectual property and universities

Researchers at the University of Sydney have studied the use of intellectual property deriving from publicly funded research. They have found that the public interest is considerably better served by having research output of publicly-funded universities released into the public domain rather than locked up in patents and other forms of private intellectual property which tend to be incompatible with the university mission and culture.

Violence against Filipino women

Research conducted in the Faculty of Law, University of Sydney on violence against Filipino women in Australia, has found that Filipino women are six times more likely to be victims of homicide than other Australian women. A number of factors contributed to the vulnerability of Filipino women, including conditions in the Philippines which encourage emmigration, the fact that many come to Australia as spouses or fiances of Australian residents with immigration status reliant on relationships, lack of information and service provision, and cultural myths and stereotypes.

Vocational training in industry

Collaborative research between the University of Technology, Sydney, and Charles Sturt University, has identified the main factors determining the provision of industry training. It has found that the decision to train is principally related to two factors: the nature of the enterprise, and its size. Furthermore, these factors appear to be totally independent. Seven further "drivers" of training have been identified, but at a much lower level of significance, with the next most important being workplace change. The study involved 42 case studies across five industries, and a national survey of 1760 worksites, and has led to the development of a general model of enterprise training.

Regulating driving in the road transport industry

Restricting the hours spent in driving related work has been the traditional approach to controlling fatigue in the road transport industry in most of the developed world, and in some Australian states. There has always been a concern about how effective this is since the regulations were devised many years ago before many of the causes of fatigue, such as the circadian cycle, had been identified. Researchers at Murdoch University have recently conducted a study comparing state jurisdictions with differing driving hours regulations in relation to heavy vehicle truck crashes, drivers' working hours and feelings of fatigue. The findings show that the records of fatal crashes are no worse, and working hours and feelings of fatigue are less in the unregulated state. It indicates that new approaches may be required to managing fatigue that would benefit drivers and reduce costs.

Recognising Chinese characters

Research in Chinese character recognition faces many difficulties. First, there are a large number of Chinese characters (more than 50,000, of which 6,000 are commonly used). Second, Chinese characters have a more complex structure than alphabetic characters and there are a large number of structurally similar characters. These issues become more complicated in hand-printed Chinese characters since they can appear in different fonts and sizes. Manually building a dictionary to cover all characters is both time-consuming and error prone. Researchers at the University of New South Wales have used inductive logic programming to achieve an 80% recognition rate.

Contracting and commercialisation within the Public Sector

A project at the Public Sector Research Centre, University of New South Wales, has monitored the forms and impact of contracting out and commercialisation in the public sector in Australia. It was based on a data base of over 15,000 consultancies conducted for the Commonwealth between 1983 and 1993. It found that there has been a shift from reliance on in-house staff to reliance on commercial consultants. The public sector consultancy industry has a 'comet' like structure, with a small number of high-profile firms getting a greatly disproportionate amount of work and a huge number of self-employed and small operators constituting a flexible hidden labour force. Academics still feature most prominently in program research, evaluation and planning consultancies. The major accountancy firms are doing a significant amount of work across all types of consultancies. The team also conducted a series of surveys and case studies of contracting out of service delivery. These studies called into question the methodology underpinning claims of large scale cost savings from contracting out. They also focussed attention on the extent to which cost savings had been achieved through reductions in employee numbers, wages and conditions and in dilution of service quality. Data from these case studies and surveys have been incorporated into submissions to government enquiries.

Atlas of Indonesian history

A researcher in the History Department, University of Queensland, has compiled the world's first comprehensive historical atlas of Indonesia. The atlas includes more than 200 maps as well as a 20,000 word text detailing most aspects of Indonesian life, including geographical information about the region as it was 230 million years ago, and the first human settlement 60,000 years ago.

The taste-properties of odours

Relationships between odour and flavour have implications for understanding the acceptability of various foods. The perception of odours as having properties more appropriately attributed to tastes, e.g. 'sweet' and 'sour', has been investigated in the Department of Psychology, University of Sydney, in collaboration with food scientists from CSIRO. The research has found that perceptions can be altered by arranging for a particular odour to be mixed as a flavourant in a sweet or sour solution. A particular odour will smell sweeter as a result of being paired with a sucrose solution, whether or not subjects show any awareness of the experimental conditions. The perceived sweetness of an odour has been found to be systematically related to the sweetness of a fluid to which it is added, so that both enhancement and suppression of the sweetness of a dilute sucrose solution can be obtained.

Perception of edges and objects

Humans and other animals are capable of distinguishing individual objects with no conscious effort. Researchers at the University of Sydney, in collaboration with overseas colleagues, have examined areas of the brain for responses to visual input in order to understand the processes by which individual objects are seen as distinct. The findings confirm that the distinction occurs very early in the visual cortex, analysing complex scenes

with relatively simple components. The findings imply that consciousness may in fact be a product of relatively simple cortical operations, rather than operations in the "higher" cortical areas of the brain.

Competition and performance

Researchers in the Department of Psychology, University of Sydney, have undertaken research on the optimal use of competition as a performance enhancing strategy. Results show that subjects who are highly competitive perform better during competition at all levels of task difficulty. Subjects who score low on a Competitive Index Scale (CIS) perform better under competition on easy tasks but significantly worse on difficult tasks. In addition, as the degree of competitive anxiety increases, subjects scoring low on the CIS perform increasingly poorly.

Immigrant construction professionals

Researchers at the University of Technology, Sydney have recently completed a study of the contribution of immigrant construction professionals to Australian export growth. 80% of respondents in a national survey of construction service providers perceived advantages for both domestic and overseas business from employing immigrants. In addition, 85% believe that employing immigrants is specifically advantageous to their overseas business. The most significant contributions identified are provision of cultural knowledge about overseas markets/countries, and contributions to negotiations and meetings with clients.

Visual factors in dyslexia

Research in the University of Western Australia's Psychology Department has contributed to understanding dyslexia, also known as specific reading disability. The team has been examining the sensory systems of dyslexic children for signs of specific deficits. It was recently shown under laboratory conditions that dyslexic children would perform at a higher level than other children at a particular perceptual task, known as metacontrast masking. Such a result stands in contrast to the outcome of most studies, that dyslexic children perform at a lower level than normal readers. It was also discovered that the visual systems of dyslexic children and those of normal readers respond identically to the effects of coloured light, casting some doubt on claims for the efficacy of coloured lenses in remediation of reading problems. This work was done in partnership with the Dyslexia - SPELD Foundation of Western Australia.

Egyptian religious traditions

Recent archaeological findings have challenged the belief of many historians that ancient Egyptian religious traditions died out under Greek and Roman rule. An archaeological dig involving Monash University researchers uncovered evidence that Egyptian religious and artistic culture survived and prospered virtually throughout Greek and Roman occupation. These latest discoveries, at the Egyptian oasis of Dakhleh 800 kilometres south of Cairo, may mean art historians will have to revise widely accepted dating methods for certain styles of Roman paintings. The discovery of a 'birth house' within a huge temple complex dedicated to the local god, Tutu, shows that Egyptian

religion continued to evolve with the creation of new mythology throughout the first and second centuries, and that Egyptians continued to worship their traditional gods until at least the middle of the fourth century AD.

Applied Sciences and Technologies

Light piping

Alight concentrating system has been developed to collect daylight and pipe it to the interior of buildings. Development of new materials and designs at the University of Technology, Sydney made this technology viable. Industrial scale manufacturing of key components has been carried out and prototypes built and tested.

Supersonic jet engine

Researchers from the Australian Defence Force Academy and the Australian National University have made breakthroughs in the design of a supersonic combustion ramjet. This jet engine is a proposed means of propulsion for future aerospace vehicles that are expected to revolutionise transport, with travel between Sydney and London, for example, being reduced to 2 to 3 hours. The team developed a new type of fuel injection designed to improve the efficiency of fuel-air mixing. The increased mixing efficiency should produce much faster combustion without the cost of increased drag.

Molecular wires and switches

Molecular electronics is at the forefront of miniaturisation and represents the ultimate in engineering technology. The metalloporphyrins form the basic components of chlorophyll in plants and haemoglobin in animals. They are suited to the design of new materials of use in electronics because they are chemically robust and have the properties of organic metals. Researchers at the University of Sydney have developed the first prototypes of molecular wires and switches based on metalloporphyrins linked together to form extended arrays. These conductors can be assembled in a predefined fashion into more complex systems. The ultimate aim of the research is the design of molecular-scale components for computers, molecular wires and light-harvesting devices.

Vacuum glazing

Vacuum glazing is a new form of transparent thermal insulator with potential application in the windows of energy efficient buildings. The University of Sydney is the first place to have produced highly insulating samples of vacuum glazing. Research has addressed such problems as stability of the internal vacuum, heat transfer processes through the glazing, mechanical stresses and fracture probability and production technology. Several patent applications relating to this technology have been made. The University has entered into a licensing agreement on vacuum glazing in Japan, and the first samples made on a pilot production line have been produced. It is anticipated that commercial sale of vacuum glazing will commence in 1996.

Smart electricity meters

Researchers at the University of Technology, Sydney have developed a technology which allows short messages to be exchanged between a domestic consumer's electricity meter and the local electricity substation. This will make it possible for supply authorities to read meters remotely and give consumers a greater choice of tariff options. Consumers will be able to opt for some appliances being on supplies that may be interrupted when system demand exceeds capacity in return for a lower tariff. Messages sent to the meter from the substation could also be used to switch appliances on and off and to change tariff during the course of the daily demand cycle.

Rapid mapping system

A prototype system for rapid mapping from a moving vehicle has been developed by University of Melbourne engineers. The vehicle's position at any point is determined using the Global Positioning System of satellites, gyroscopes, a tilt meter and wheel sensor. Objects are mapped using a range sensor or a stereo-vision system based on Charge Coupled Device cameras. The system is being used for road and rail centre-line and asset mapping and profiling of airport runways. Other applications include formation studies and the non-destructive biological sampling of under-water fauna.

New robot hand

Dexterous hand design has proceeded consistently along the path of anthropomorphic design for more than 20 years; an approach which has led to the dexterous robot hand remaining essentially a laboratory curiosity. Whilst previous anthropomorphic designs have coupled the grasping and manipulation functions of the hand and fingers, University of Melbourne researchers have investigated a series of alternative structures with partially or fully decoupled grasp/manipulation actions. A new three-fingered robotic hand design has resulted, from which a prototype finger has been built so far. This new robotic hand design appears much more robust and reliable than any previously built articulated hands. This is a significant step forward in flexible manufacture, because it allows automated manipulation of a variety of objects with different shapes.

Superconducting powder

The University of Queensland's technology transfer company UniQuest Limited has recently signed agreements to bring high quality, high temperature superconducting powder materials to the world marketplace. The research underpinning the agreements has been underway since 1990. The team developed processes for manufacturing very high quality powders suitable for fabrication of superconducting devices of a wide variety of shapes and applications. The ceramic powders superconduct at liquid nitrogen temperatures and without resistive losses. This may make Australia a world leader in producing state-of-the-art superconducting powders.

Slithering over snapshots

Photogrammetry is the science of making measurements from photographs. Computers can simulate stereo observations for determining heights on aerial photographs or space images in a fraction of the time taken by humans. However, the delineation of features, such as roads, in the images still

requires an operator. At the School of Geomatic Engineering, University of New South Wales, three dimensional "snakes" are being used to define details in the images, such as roads. An operator first defines the approximate position of a linear feature, and the computer snake interacts with the image details, slithering along the road, for example, and rapidly and accurately locates such a features from the image. The method can be of significant application for the automatic updating of map information, as well as databases used for Geographic Information Systems.

High technology bicycle frame

An enhanced racing bicycle frame has been developed by a team of researchers at the Royal Melbourne Institute of Technology in conjunction with the Australian Institute of Sport for the national cycling team. The design employs an aerospace style monocoque structure manufactured from graphite/epoxy materials. The frame requires 5% less propulsive power than a conventional tubular frame, while having lower weight and increased stiffness. These features have resulted in considerable advantage for cycling athletes. To date, cyclists using these frames have won gold medals at World Cup, Commonwealth Games and World Championship events. The patented processes for manufacturing the frame render it suitable for low cost production.

Car alloy

University of Queensland researchers have produced an aluminium alloy which can be used to make the engine parts of lighter, more fuel efficient cars of the future. The alloy is 40 % stronger than existing commercial aluminium alloys, allowing the replacement of a greater range of steel car parts. The use of the alloy in automobiles is considered the most significant development in the area since the 1960s, when Alcoa developed an aluminium alloy suitable for use in typewriters and photocopiers. Aluminium's lightness compared to steel means its use in automobile parts is increasing as lighter vehicles are more fuel-efficient and produce lower fuel emissions.

Microanalysis of cells

Researchers at La Trobe University have developed electron microscopy techniques that measure the concentration of salts in cells. The technology is based on a world first observation by the group that it is possible to conduct X-ray microanalysis on a frozen sample, opening up the field to closer study of cellular processes. The technology has been used in cellular salt studies ranging from the impact of pollution on the kidneys of mammals, to the way marine animals such as turtles regulate their salt intake. The group is now collaborating with world leaders in biological X-ray microanalysis at Duke University to develop a new field of chemical anatomy.

Engineering

Wind turbines

Research in the Departments of Mechanical Engineering, and Electrical and Computer Engineering at the University of Newcastle has lead to construction of a prototype wind turbine five meters in diameter for remote power generation. Commercial manufacture is being pursued in conjunction with a local company.

Cracking in masonry

Research at the University of Newcastle's Department of Civil, Surveying and Environmental Engineering is producing improved procedures for the serviceability of masonry structures. Cracking masonry is a significant problem, and is often the result of the complex interaction between external effects such as reactive soil movements, and the foundation of the structure and the masonry above. In developing the procedures, external effects and structural responses have been quantified, and placed in a statistical framework. These procedures will limit cracking to acceptable limits to ensure the satisfactory performance of future masonry structures.

Wheel bearing fault detection

Vibration sensors have long been used to detect incipient faults in bearings up to several months in advance, but for rail vehicles it would be too expensive to mount sensors on all bearings. However, sensors placed on train tracks can monitor thousands of bearings in trains each day. A collaborative project between researchers at the University of New South Wales, Hamersley Iron, and State Rail Authority of NSW has succeeded in detecting incipient bearing faults in rail vehicles using an array of vibration sensors mounted on the rails. This has the potential to prevent derailments in freight and passenger rail vehicles.

Agricultural Sciences

Controlling amylase production in wheat

Scientists at the University of Sydney's Plant Breeding Institute have discovered that cold temperatures during ripening can lead to unacceptably high levels of amylase in the grain of particular wheat varieties. This renders grain unfit for most commercial applications. A screening test has been developed to identify at an early stage wheat varieties with a genetic defect that makes them vulnerable to cool temperatures. This will assist breeders to produce new wheat varieties whose quality is less sensitive to environmental extremes.

Barramundi gene cloning

Researchers at the Queensland University of Technology have cloned insulin-like growth factors isolated from barramundi. This development will serve as a valuable tool for assessing optimal growth conditions for fish in aquaculture, including food and environmental variables which can be adjusted.

Transgenic wheat

Collaborative research between the University of Adelaide, the South Australian Research and Development Institute and the University of Hamburg, Germany, has generated transgenic wheat plants that have the potential to increase yields by up to 15%. Transgenic wheat with a chromosome arm from rye includes several disease resistance genes and can give high yields under certain conditions. However, the grain of this transgenic wheat gives flour that suffers from a quality defect character ('sticky dough') which limits its use in Australia. The 'sticky dough' defect has now been removed by inactivating the cause, namely the secalin gene.

Vaccine against salmonellosis

Researchers at the Royal Melbourne Institute of Technology (RMIT) have developed a live salmonella vaccine that is effective in protecting food animals against salmonellosis. The vaccine, trialed in chickens, turkeys and dairy cattle, protects these species against acute salmonella disease and also reduces the opportunity for shedding the organism. The vaccine thus helps to increase productivity in these animals as well as significantly reducing the opportunity for salmonella bacteria to contaminate food during meat processing. The project is a collaborative research venture between RMIT and Bioproperties (Australia) Pty. Ltd.

Growing wool fibres

Researchers at the University of Adelaide have developed methods for culturing wool follicles in the test tube, which allows wool fibre growth to be investigated under carefully controlled conditions. The development will enhance manipulation of wool quality through genetic engineering.

Identifying fruit fly larvae

In October 1995, an outbreak of papaya fruit fly caused considerable damage to fruit crops in Queensland's north and threatened around \$18 million in exports. Researchers at the University of Queensland, with assistance from the Queensland Department of Primary Industries and the CSIRO Division of Entomology, have devised a test which cuts identification time of papaya fruit fly larvae from 30 days to less than 48 hours. The test is now being refined to allow identification within one day.

Black pearl oysters

Biologists at James Cook University, with funding from the Australian Centre for International Agricultural Research, have developed new techniques for rearing pearl oysters during their more vulnerable early growth stages. Flow-through culture, developed originally for rearing giant clam larvae, has been adapted to pearl oyster larvae. A very economical hatchery has been constructed at Kiribati, a Pacific nation that is the

particular focus of this project. The hatchery has produced several batches of juveniles of the blacklip pearl oyster, from which cultured black pearls are obtained.

Algal bloom

There is disturbing evidence of a recent global increase in the incidence of harmful algae blooms, which can impact on public health, tourism and especially the shellfish aquaculture industry. Algae can contaminate shellfish with toxins that can cause paralytic shellfish poisoning, and in extreme cases death in human consumers. Prediction of algae blooms may allow farmers to harvest and relocate shellfish elsewhere. Researchers in the Department of Plant Science at the University of Tasmania have monitored the occurrence of toxic algae blooms in Southern Tasmanian waters for 11 years. They have developed a successful predictive model, based on a network of monitoring buoys; with three key environmental risk factors.

Chemical Sciences

Dimethyl sulphide and global warming

Recent research at the James Cook University of Northern Queensland suggests that the Southern Ocean produces as much dimethyl sulphide (DMS) as the rest of the globe. DMS may have a critical role in stabilising global temperatures as it is important in plant recycling of atmospheric carbon dioxide. A major source of DMS is ice algae in the marginal ice edge that surrounds Antarctica for much of the year. However which algae are the most important is still an open question. The Antarctic Convergence Zone, approximately mid-way between Tasmania and the continent, produces large amounts of DMS from phytoplankton.

Ultra tiny particles

University of Melbourne chemists have achieved a world-first by using ultrasound, ie. the passage of soundwaves through liquids, to form ultra small polymer and precious metal particles. Particles of gold, platinum or silver only one billionth of a metre in size were produced. This technique holds great potential for use in medicine, such as the treatment of tumours, as polymer particles are small enough to pass through the blood system. Tiny particles also have potential in the synthesis of new types of ceramic.

Forces between colloids

Researchers at the Australian National University have designed and built a new device for the measurement of the interaction forces between colloids (fine particles) based on an adaptation of the Atomic Force Microscope. Colloidal forces dominate many processes such as cell recognition, mineral separation, water clarification and latex paint stability. An understanding of these forces is vital for optimization in areas as diverse as mineral separation, water purification and paint film formation.

Breakthrough in fractals research

A team of chemists from the University of New South Wales, the Ecole Polytechnique in France and IBM in the US, has made a contribution to fractals research into dendritic (or tree like) forms. When a metal is grown electrochemically in a thin layer of solution the result is a tree with branches. Depending on the speed of growth, daughter branches will coexist or one will attract all the metal and cause the unsuccessful sibling to die. The team's work, recently featured in *Nature*, has provided an explanation of why tip splitting occurs. The research has applications in many fields in which dendritic forms are found, such as biology, geology and materials science.

Pollution

The early detection of pollutants in water is possible with a new biosensor developed by the University of Western Sydney. The biosensor can monitor levels of a common organic compound, formate. This allows for the early detection of trace organic components. It is sensitive, selective, portable and robust, useful for either in-field or continuous monitoring.

Electroacoustics of dairy products

Researchers at the University of Sydney have developed technology to determine the size and electrical charge of particles. The technology is based on using different ultrasound frequencies and has been incorporated into a commercial scientific instrument, the AcoustoSizer. This won a USA award as one of the top 100 innovations of the year.

Medical and Health Sciences

Early breast contact in pre-term infants

Researchers at the University of Technology, Sydney have studied weight gain and length of hospitalisation in pre-term infants who received early breast contact (EBC). The study shows that an infants' weight tended to increase at a greater rate following EBC but the total weight gained in the EBC group was not significantly different from bottle fed babies. Only gestational age was found to be a more important predictor of discharge age than age at which breast contact occurred.

Benefits of traditional Thai medicine

Researchers at the University of Sydney in collaboration with Thai universities have investigated the constituents of plants used in Thai traditional medicine. Plants of the *Schefflera* genus are widely brewed as a tea and used traditionally to ease the symptoms of asthma. These plants contain an active bronchodilatory product which is about to be trialed clinically.

Human monoclonal antibodies

University of New South Wales researchers have developed a technique for producing hybrid living cells. It includes an apparatus to manipulate individual cells, assemble a single hybrid pair of cells, and fuse the pair to make a viable hybrid cell. The apparatus can be used to construct human hybrid cells, and will enable the creation, for the first time, of useful

hybridoma cells for the production of human monoclonal antibodies. Such antibodies can be used for the treatment of viral diseases. FuCell Pty Ltd has been formed to exploit the technology commercially. The first product, a human monoclonal antibody to the Hepatitis B virus, is expected within 2 years. The commercial implications for Australia could be very significant with future annual sales possibly exceeding \$1 billion. Financial support has been from Boehringer Ingelheim (Australia), and the Australian Research Council.

Eye movements and balance disorders

The measurement of human eye movements using image processing has been developed by researchers from the University of Sydney and the Royal Prince Alfred Hospital. The system is being used for the diagnosis of balance disorders of the receptors of the inner ear. A miniature camera takes images of the eye and computers analyse the images, yielding extremely accurate measures of eye rotation. The method has now incorporated a correction for the geometrical distortion which occurs when three dimensional eye movements are imaged on a 2D camera plane. It is the first system in the world to incorporate these vital corrections.

Quinghaosu and malaria

Researchers at the University of Sydney have developed a new method to make quinghaosu, a potent pharmaceutical used to combat malaria. Qinghaosu occurs naturally in the plant *Artemisia annua* and extracts from these plants have been used in Chinese medicine to alleviate the effects of malaria for many centuries. The chemists at Sydney discovered that Qinghaosu acid, a relatively abundant component of plants, could be converted to the active Quinghaosu using a series of laboratory reactions making the drug available in large quantities. Work is in progress in collaboration with the pharmaceutical company Rhone Poulenc Rorer to make the drug more widely available.

Infant diet preferences

The University of Western Sydney (Hawkesbury) has investigated the role of food flavours in breast milk on food preferences in infants during weaning. The research showed that breast fed infants from mothers who ate garlic regularly, ate substantially more garlic flavoured food than breast fed infants whose mothers ate garlic rarely or formula fed infants. The results support the hypothesis that flavours in breast milk can facilitate acceptance of foods during weaning and provides the basis for the development of a systematic approach to introducing good dietary habits during early life.

Development of the human tongue

Research on the anatomical and physiological development of the human tongue has been conducted at the University of Western Sydney (Hawkesbury). The research has shown that the major taste receptor area of the tongue, near the tip, has fully matured anatomically by 7-8 years of age. The major growth of the tongue after this age occurs in the central region of the tongue where there are few taste receptors. This finding has allowed more accurate techniques to be developed for measuring when the physiological functions of the tongue become more mature and for

measuring sensitivity precisely in different regions of the tongue. The practical outcome of the study is a more precise understanding of young children's like and dislike for foods and the development of a clinical test for taste.

Case against an antenatal hormone treatment

Animal studies and a small human clinical trial on a hormone treatment suggested a reduced risk of neonatal lung disease in infants born pre-term. These preliminary results were followed up at the University of Adelaide by a national clinical trial. Women expecting to deliver pre-term were given antenatal thyrotrophin releasing hormone (TRH), in conjunction with corticosteroids. However, the large clinical trial found that TRH did not reduce the risk of respiratory problems. Indeed, the trial showed an increased risk of respiratory distress syndrome and need for ventilation in babies exposed to antenatal TRH.

Caffeine effective in treating apnoea in premature babies

University of Queensland researchers believe that caffeine may be an effective alternative in treating apnoea (temporary cessation of breathing) in very premature babies. This follows a two-year pilot study of the drug on 40 premature babies with apnoea at Mater Mother's Hospital in Brisbane. The researchers found that aminophylline, a drug currently used to treat apnoea, can cause side-effects such as gastro-intestinal irritation, nausea, heart damage and central nervous system damage in some babies. The study's findings mean caffeine could replace this drug for treating apnoea in premature babies.

House dust mites and asthma

Asthma is a chronic disease in children and adults, with a 5% prevalence worldwide. It is usually associated with allergy. One of the most important allergens is the house dust mite which lives in carpets and mattresses. Researchers at the University of Western Australia have shown that house dust mite faecal pellets, which we routinely inhale, contain an enzyme which breaks down structural proteins. This and other enzymes stimulate the production of cytokines from the cells lining the human respiratory system. Cytokines are potent initiators of inflammation and may be significant in disease development. This research may contribute to the development of new therapeutic drugs.

Exercise and bone density in women

Researchers in the Departments of Human Movement and Medicine at the University of Western Australia have investigated the influence of exercise on bone density in post-menopausal women. Bone density was shown to increase with a high load, low repetition regime. The greater the increase in strength, the greater was the increase in bone mass. The response of bone to maximal loading from resistance exercise was site specific. Women of all ages should be actively encouraged therefore to take up high resistance weight training. Not only are there direct, positive effects on bone mass, but also parallel improvements in muscle strength. Maintaining muscle strength brings benefits in old age, by reducing the risk of falls.

Modelling the menopause

A University of Queensland researcher has developed a statistical model to estimate the loss of eggs from human ovaries as women age. It shows there is a rapid increase in the loss of human eggs at middle age (ie around 40 years), reaching a level that is about twice the rate of loss at age 20. This accelerated loss causes the ovaries to run out of eggs earlier, resulting in menopause at around 50 years of age rather than 70 years. This study has the potential to assist in infertility studies where ability to predict the onset of the menopause may be important.

Management of chemotherapy side effects

Bone marrow transplants are used to treat many leukaemias and lymphomas. Cyclophosphamide is a drug used to prepare patients for these transplants. However, a major side effect of the drug is the development of haemorrhagic cystitis which results in urinary irritability and bleeding in the bladder. A study was conducted in Sydney teaching hospitals in collaboration with the Department of Pharmacy, University of Sydney, in which various preventative measures to limit the bladder complications of the drug were investigated. Of the methods used, both forced diuresis and treatment with the agent Mesna appear to be equally effective preventative therapy. The study findings have resulted in changes in the treatment of bone marrow transplant patients.

Variable effects in drug treatment

Variability in patients' response to drugs is a fundamental difficulty in drug treatment of disease. A study conducted by the Department of Pharmacy, University of Sydney, in conjunction with St Vincent's Hospital, Sydney, investigated the clinical use of the drug hydroxychloroquine in the treatment of rheumatoid arthritis. It was demonstrated that even when patients receive the same dose, the concentration of the drug in blood varied as much as ten fold from one patient to another, largely the result of differences in the absorption of the drug. As the clinical response in patients depends on the blood concentration it is believed that this is likely to be a major source of variability. This paves the way to therapy which tailors administration of the drug such that each patient achieves the desired blood concentration.

Predicting heart damage

Researchers at the University of Tasmania have shown that a more accurate representation of the true heart surface electrical distribution can be obtained by measuring the shape of the electrical distribution on the surface of the body. In terms of patient care, this mean that cardiologists will be able to more accurately predict areas of heart muscle damage, as well as check for electrical conduction defects in the heart muscle.

Mosquito-borne viruses

Researchers at the Australian National University have studied certain mosquito-borne viruses of Australia and south-east Asia. These include Ross River virus and Barmah Forest virus, which are associated with polyarthritis, and dengue virus and Murray Valley encephalitis virus, which cause haemorrhagic fever and encephalitis. The team has sequenced the structural protein genes of three dengue virus type 3 isolates after serial

passage in mice and cultured cells. This has provided information on the molecular events involved in dengue virus attenuation and has implications for the development of vaccines against these viruses.

Determinants of the African AIDS epidemic

More than half the HIV/AIDS cases in the world are found among 2 per cent of the world's population living in a belt of African territory stretching from southern Sudan to Botswana. This African epidemic is almost entirely heterosexual and the identification of its determinants allows an estimation of the dangers elsewhere of a heterosexual epidemic, the likelihood of a major Asian epidemic, and ways of containment. Collaborative research between the National Centre for Epidemiology and Population Health at the Australian National University and investigators in African universities have identified the conditions for the epidemic, such as low levels of health services.

Sudden infant death syndrome

Research at the University of Tasmania shows the rate of Sudden Infant Death Syndrome (SIDS) in Tasmania has decreased dramatically as the number of babies being put to sleep on their stomachs has declined. Since 1991, parents have been advised not to place babies to sleep in the prone (on the stomach) position. Before 1991 Tasmania was averaging 27 deaths per year from SIDS. In 1991 this fell to 11 and in 1992 there were 10 deaths. The study, published in the prestigious *Journal of the American Medical Association*, scientifically links the fall in the death rate with the fall in the proportion of infants sleeping prone.

Lung cancer in Tasmanian women

Researchers at the University of Tasmania have found a higher rate of lung cancer in young women than young men in Tasmania. There was an alarmingly high incidence of lung cancer in Tasmanian women aged 25-44 in the decade 1983-92. Some 7.1 per 100,000 Tasmanian women contracted lung cancer in that period, compared with 2.7 nationally. Tasmania is the only place in the world where lung cancer is more common among women than men in any age group. Tasmanian schoolgirls have a higher smoking prevalence than other Australian schoolgirls and Tasmanian women start smoking at a younger age than their mainland counterparts.

New hearing aid technology

Existing hearing aids either do not improve spatial hearing ability or make it worse. Spatial hearing ability is implicated in the ability to hear critical signals, such as speech, in competitive noise conditions. It is noticeably affected in all forms of hearing loss. As a result of collaborative research between the University of New England and the National Acoustic Laboratories new designs have been developed for the moulded component of the hearing aid which is fitted in the listener's ear-canal. The new designs have led to improvements in spatial hearing ability in certain types of hearing loss.

Moles, skin type and sunburn

A study by the Menzies Centre for Population Health Research, at the University of Tasmania, has shown for the first time that 'olive skin' may offer less protection against the development of melanoma (skin cancer) than is popularly believed. The study demonstrated that, with a small number of lifetime sunburns, children with olive skin are somewhat less likely than lighter-skinned people to form the naevi (moles) that are thought to lead to skin cancer. However, above that number of lifetime sunburns, the incidence of naevi formation is about the same in olive-skinned people as it is in people with fairer skin types. Full results of the study, which began in the late 1980s, were published in the December 1995 issue of the respected American journal, *Cancer Epidemiology Biomarkers and Prevention*.

Information, Computer and Communication Technology

Intelligent robotic systems

Collaborative research between the University of Wollongong and Fujitsu in human-robot interaction systems has led to the development of a human-machine interface based on computer vision. The interface is currently the most advanced of its type in the world. The system uses video images as input to a computer rather than the usual range of devices such as keyboard or mouse. It has a number of potential applications including providing assistance to disabled people and driver sleep detectors in motor vehicles. Discussions are currently under way regarding the commercialisation of the latter application of the technology.

Designing mobile telephone networks

Researchers at the University of Wollongong have developed, under contract to Vodafone Australia, a design for reducing the cost of transmission in wide area telephone networks. For a network, designers need to ascertain the optimum mix of inhouse and leased capacity for carrying the predicted traffic demand. The research has developed an interactive design tool enabling this optimisation in interconnecting the Mobile Switching Centres in each State. Use of the network optimisation tool will result in a significant reduction in the cost associated with running the mobile telephone network.

New speech coder/decoder

A new speech codec (coder/decoder) has been developed by researchers in The Institute of Telecommunications Research at the University of Wollongong. The new codec produces near telephone quality speech at a bit rate of only 2.4 kbit/s voice coding. Applications for the codec will initially be in the area of military communications. The technology is currently being transferred to LEO (Low Earth Orbiting) satellite cellular usage, in particular the Iridium system. This will dramatically improve the robustness of coder to background/channel noise for cellular usage. The development of the codec is particularly significant for countries like Australia which rely heavily on LEO satellites.

Implementing optimisation algorithms in parallel computers

Research carried out at the University of Western Australia has led to new techniques for the scheduling of optimisation algorithms onto networks of parallel processors. Genetic algorithms, neural networks, and simulated annealing approaches were used. These techniques are inherently parallel and naturally suited for parallel processor implementations. Several algorithms were developed. Optimisation algorithms are used in many applications including economics, process control, traffic control and manufacturing systems.

Managing global data exchange

The exponential growth of electronic data in technology-based disciplines has generated a critical need for new and flexible approaches to exchanging and storing information. The STAR File (self-defining text archive and retrieval file), designed by researchers at the Crystallography Centre and Computer Science Department of the University of Western Australia, and other laboratories in the USA and Europe, is now being widely used for global data exchange and archiving. The STAR file use a simple, general and extensible file syntax and has been adopted by a number of scientific journals for the submission of data and text, and by international chemical databases as a common interchange format

Simplifying operating systems

Researchers at the University of Sydney have produced the world's first fully persistent computer operating system. Conventional operating systems provide an interface which distinguishes between the temporary data used by executing programs and the permanent data hold in files. This dichotomy between temporary and permanent data both complicates use of the system and affects overall performance. The 'Grasshopper' persistent operating system provides a uniform interface to all data regardless of whether it is temporary or permanent. This results in significant improvements in both programmer productivity and system performance.

Data mining

Companies and other organisations are beginning to exploit a valuable resource - their own data. "Data mining" involves searching large datasets for rules or patterns that provide insights into the organisation's activities. At the University of Sydney, research has culminated in the development of a system called C4.5 that has been applied for data mining in companies in areas such as medical diagnosis, pharmaceutical development, telecommunications, manufacturing, insurance, and finance. The system has been licensed to several companies world-wide and is incorporated into commercial data mining tools.

Fair sharing of computers

Whenever two or more people use a computer, the Central Processor Unit shares out the machine's processing power between them. Researchers at the Basser Department of Computer Science, University of Sydney, have developed the 'Fair Share Scheduler'. Conventional schedulers allow some users to exploit the system and take a large part of the machine's resources. This makes it easy for a user to accidentally or intentionally create a program

that takes over large amounts of machine time. The 'Fair Share Scheduler' allows computer resources to be fairly shared between users, programs or organisations. 'Fair Share' has been commercialised in a joint venture with Softway Pty Ltd and licensed to SGI (Silicon Graphics), Cray, Convex, Pyramid and Fujitsu.

Mathematical Sciences

Environmental modelling

Modelling the atmosphere-oceans-land "system" is complex but has enormous potential. Research at the University of New South Wales has led now to accurate predictions of severe storms, floods, drought, soil erosion, the movement of tropical cyclones, storm surges, tsunamis, wind waves, and upwelling of cold sub-surface water in the near-coastal regions of Australia.

Fractal pattern formation

Researchers at the University of New South Wales and the Australian National University have developed computer models for the growth of structures under conditions far from equilibrium. Models have been developed for viscous fingering in fluids, the formation of snowflakes, and the growth of three dimensional crystals.

Modelling road safety interventions

University of Queensland mathematicians in collaboration with Queensland Transport have developed a statistical model to test the effectiveness of traffic interventions, such as increased police patrols, radar checks and audible line-marking. The model can measure savings to the community from existing traffic intervention strategies and predict the efficiency of planned interventions. Researchers found that existing traffic interventions reduced accident-related property damage (for example, cars) by 25 percent. On average, the installation of a traffic intervention saved an estimated 20 to 30 lives each year.

Mathematics of yarn balloons

Twisting yarns made from fibres such as wool or cotton is usually accomplished by rotating a loop of yarn around a fixed axis at high angular speed. The imaginary surface generated by this rotating yarn loop is called a spinning balloon in the textile industry. Knowledge of the shape and stability of these balloons, and the yarn tensions they generate, is of crucial importance for the efficient design and operation of yarn manufacturing machinery. Mathematical models of these processes developed at the University of Sydney have helped in the control of erratic behaviour of these balloons on textile yarn machinery.

Optimal control

Applied mathematicians at the University of Western Australia have developed software for computing the optimal control of dynamical systems. A model of a system is developed and using the software can be simulated to find optimal operating regimes subject to realistic operating

constraints. The software is being used world-wide in a variety of industries, including steel, defence, civil engineering and power generation. Using the software is an effective alternative to costly field trials.

Computer identification of classical groups

The classical groups are fundamental mathematical tools for classifying molecular spectra and sub-atomic particles, for example. Finding an efficient computational method to recognise whether a broader linear group contains one of the more specific classical groups has been a difficult unsolved problem and impeded the development of computer systems for identifying groups. Recent work carried out by algebraists of the University of Western Australia describes a powerful randomised algorithm to recognise classical groups.

Solving soliton equations

Partial differential equations describing solitons are important to models in fields ranging from oceanography to optics. Given a partial differential equation, a question of mathematical and physical interest is whether it is exactly solvable i.e. integrable. There is a famous conjecture, called the ARS conjecture, which asserts that integrability of a differential equation is strongly linked to the singularity structure of its solutions. This conjecture has led to hundreds of papers in which authors have attempted to formally check the possible singularities of their differential equations. Researchers at the University of New South Wales have shown that the formal expansions that appear in these papers actually represent true solutions. This forms the first step towards putting the ARS conjecture on a rigorous footing.

Physical Sciences

Semiconductor devices made from diamond

Semiconductor devices made from diamond run faster, hotter and resist radiation more than those made from silicon. Before silicon or diamond devices can be made, the material has to be modified by the insertion of extra element or dopants. Whilst this procedure is straightforward for silicon, it is difficult to achieve with diamond. To dope diamonds, University of Melbourne researchers have subjected them to a barrage of high speed atoms, which come to rest deep inside the diamonds; then laser pulses are used both to repair any damage from the bombardment and incorporate some of the dopant atoms into the diamond crystal lattice. This is the essential first step towards building diamond based microelectronic devices.

Atoms out in the cold

University of Queensland researchers have achieved the coldest atoms in Australia, opening up the possibility of the manufacture of ultra-sensitive measuring equipment. Using magnetic and laser light techniques dubbed the "temperature trap", success was achieved in lowering the temperature of an atom to one-millionth of a degree above absolute zero. Lowering the temperature of atoms to this level effectively allows them to be held still. In

this state, they can be manipulated and measured. The ability to manipulate atoms with laser beams opens up possibilities for the enhancement and creation of ultra-sensitive clocks and other high precision equipment.

Quantum optics

The field of quantum optics is moving from fundamental research to practical applications. The idea of light without quantum noise originated in New Zealand and Australia. Now the Australian National University has turned the idea into compact light sources for the design of optical sensors.

Phase noise suppression in microwave oscillators

Researchers at the University of Western Australia have reduced microwave oscillator phase noise below amplitude noise. This allowed the design of microwave oscillators with a phase noise performance 25dB better than the previous state of the art. The phase noise reduction technique was patented internationally in 1996 and has potential applications in the radar and telecommunications industries.

The Anglo-Australian Telescope Board

***Role** The Anglo-Australian Telescope Board (AATB) provides world class facilities for the Australian and British astronomical communities through its operational arm, the Anglo-Australian Observatory, to enable astronomers to undertake research for the advancement of scientific knowledge. The AATB operates under an agreement between the Governments of the United Kingdom and Australia and is equally funded by them. The Australian Government contributed \$3.2 million to the AATB in 1995-96.*

The facilities include the Anglo-Australian Telescope (AAT) and the UK Schmidt Telescope located at Siding Spring Mountain near Coonabarabran, NSW, and a laboratory in the Sydney suburb of Epping.

Recent Achievements

The 'Two-Degree Field' facility

A particular strength of the AAO is its ability to move into new research areas by developing new instrumentation for its telescopes. This is epitomised by the Two-Degree Field (2dF) facility. The 2dF is one of the most important innovations in instrument design anywhere in the world in recent years, incorporating ground breaking technologies. The 2dF has the unique ability to gather light from up to 400 objects simultaneously and direct it into a pair of spectrographs. This is achieved using a system of optical fibres which are positioned in the large two degree diameter field of view using advanced robotics technology. At the heart of the 2dF system is the lens, almost a metre

in diameter, amongst the largest precision lenses ever built. The lens focuses light from the telescope onto a flat focal plane of optical fibres, a remarkable design and engineering feat. The 2dF enables astronomers to study the large scale structure of the universe and search for distant exotic objects like quasars.

Comet Hyakutake

Using the UK Schmidt Telescope, astronomers at the AAO have photographed unique images of the recently discovered Comet Hyakutake B2, which passed within 15 million kilometres of the Earth in March 1996. It was the closest bright comet to the Earth for 450 years. The three colour images reveal a very faint multicoloured tail, which points away from the sun. The tail comprises dust and gas evaporated from the comet's nucleus by sunlight and this image shows a surprising range of subtle colours, probably the result of changes in the tail during the series of exposures.

The Milky Way and its intergalactic neighbours

Astronomers using the AAT have developed a new technique to measure the motion of galaxies neighbouring the Milky Way. These galaxies lie at such vast distances from the Earth that it is very difficult to detect their movement across the sky. However, the AAT based astronomers are using very remote and exotic objects called quasars, which lie at even vaster distances far beyond our nearer galaxies, to act as background reference points which make the measurements possible. The AAT astronomers have also been very successful at finding the elusive quasars. The observations are being used to better assess the dimensions of the Milky Way and how it interacts with its intergalactic neighbours.

Institute of Advanced Studies, The Australian National University

***Role** To be one of the world's great basic 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) has a unique place in the Australian higher education system. Approximately \$135 million of the Australian National University's operating grant can be regarded as block funding for the research schools and centres of the IAS. An additional \$17 million is provided to the John Curtin School of Medical Research from the Health and Family Services portfolio. These funds allow researchers at the IAS to undertake research and research training on a full time basis. Further, the IAS has a special responsibility to be a resource for the Australian higher education system and for Australian research as a whole. In 1994 the schools and centres of the IAS spent, on average, 9.5% of their recurrent budgets on collaborative research activities with other Australian universities.

The Institute of Advanced Studies consists of eight research schools and two research centres: the Mount Stromlo and Siding Spring Observatories, the Research School of Physical Sciences and Engineering, the Research School of Earth Sciences, the Research School of Biological Sciences, the Centre for Resource and Environmental Planning, the John Curtin School of Medical Research, the Research School of Pacific and Asian Studies, the Research School of Social Sciences, the Research School of Chemistry, the School of Mathematical Sciences, the National Centre for Epidemiology and Population Health and the Research School of Information Sciences and Engineering.

The 1995 Review of the Institute, jointly managed by The Australian National University and the Australian Research Council, found that some schools and centres were at the forefront of international research and among the leading groups in their fields and that the IAS is a world wide player in every field in which it has well established scholarly and research activity. The Review consisted of reviews of each school and centre and the IAS as a whole, conducted by panels of national and international experts in university research and administration.

Recent Achievements

Irrigation control

Researchers in the Research School of Information Sciences and Engineering and the Cooperative Research Centre for Robust and Adaptive Systems have designed a control system for a network of irrigation channels maintained by the Rural Water Corporation of Victoria. The system automatically adjusts weirs that limit the flow of water through irrigation channels, a task previously performed by hand. Benefits include robustness to fluctuations in water usage.

Technegas

Research at the John Curtin School of Medical Research led some years ago to a new radiotracer called "Technegas" for examining the airways of the lung. Recent industry supported research on new applications for the Technegas technology include a clinical trial on diagnosing gastrointestinal disorders, bone marrow imaging, and oil industry applications.

Optical thin films

Research in the Research School of Physical Sciences and Engineering has led to new plasma systems for processing optical thin films. The systems are an important tool in the microelectronics industry.

Detecting plutonium

Collaboration between the Research School of Physical Sciences and Engineering and researchers in the UK have improved the sensitivity of detecting plutonium by a factor of 100. The method is being applied to study the process of aluminium absorption from the gut. In collaboration with CSIRO, long-term erosion rates in both the Ord River catchment area and in the ACT are also being measured.

Climate change

Research on the geomorphology and biogeography of the Huon Peninsula in Papua New Guinea has provided a reassessment of historical sea levels in the region, particularly 30,000 to 70,000 years ago. It shows that some large, sudden changes of climate that occurred in the past were preceded, by several hundred years, by a change of circulation in the deep ocean. This research is relevant to questions about the earliest human migrations in Indonesia and western Oceania. The work has been conducted by researchers in the Research School of Pacific and Asian Studies, in collaboration with the Research School of Earth Sciences, the CSIRO and other Australian and overseas universities.

Fatty acids

Researchers in the Research School of Chemistry, in collaboration with scientists at Peptech (Australia) and the Adelaide Medical Centre for Women and Children, have developed a series of novel polyunsaturated fatty acids, having antimalarial, antiinfective and antiinflammatory activity. The new compounds are tailored to the treatment of specific disease states. They are currently the subject of international patent applications.

African topography and climate

The Centre for Resource and Environmental Studies has developed a continent-wide monthly mean climate database for Africa, called a Digital Elevation Model. A similar database already exists for Australia. The database, available on compact disk, contains information on topography, rainfall, mean daily minimum and maximum temperatures. It can facilitate analysis of environmental constraints on population, livestock, cropping systems, pests and pathogens, and further research planning and technology transfer.

Finding the missing matter in our galaxy

Astronomers at the Mount Stromlo and Siding Spring Observatories have made an important contribution on the nature of certain matter in our galaxy which we cannot visually observe. This 'dark matter' is believed to exist as its gravitational pull is thought to keep the sun in its orbit around the galactic centre. Astronomers are looking for the transient brightening of background stars. As part of a survey, observations of 25 million stars towards the centre of our galaxy and towards the nearest external galaxy, the Large Magellanic Cloud, have been made. Brightening of stars occurs as a result of gravitational lensing by unseen massive objects, and a number in the Large Magellanic Cloud have been detected. This supports the conclusion that at least 50% of the Galactic dark halo is made up of faint objects with masses near half a solar mass.

Soils and the missing carbon dioxide sink

Recent work in the Research School of Earth Sciences has focussed on carbon dioxide return to the atmosphere from forest soils. The research used radiolabelled carbon to demonstrate that carbon from low latitude soils is cycled back to the atmosphere within a few years of being assimilated from the atmosphere into standing vegetation. In contrast, there is a substantial time lag of several decades between the assimilation of carbon dioxide into vegetation, and its ultimate return to the atmosphere from the soil carbon reservoir. This means that any increase in carbon uptake by high latitude vegetation (from carbon dioxide or nitrogen fertilisation) will lead to the generation of a transient sink for atmospheric carbon dioxide in high latitude soils.

Fractal applications

Collaborative research between the School of Mathematical Sciences and the CSIRO has led to the development of new methods for quantifying surface roughness, using the concept of fractal dimension. This work exploits new technologies for gathering very detailed data on surfaces, typically in the form of two-dimensional digital images. Applications include development of smoother plastic food wrap offering less opportunity for micro-organisms to adhere, and analysis of water retention by soil.

Breakthrough in supercomputing

Solution of narrow banded systems of linear equations arises naturally in many applications. Effective solution on vector and parallel computers remained elusive with the exception of a divide and conquer method called cyclic reduction which could be applied only in special cases. Researchers at

the School of Mathematical Sciences have made a breakthrough using block bidiagonal matrices, a generic form capable of representing a very wide class of narrow band matrices. They have shown that a transformation technique, called wrap-around partitioning, can be used to separate out computations that can be performed independently. This permits the effective use of vector and/or parallel computation.

ENVIRONMENT, SPORT AND TERRITORIES

Science and Innovation in the Portfolio Budget

The Bureau of Meteorology, as the national meteorological service for Australia, has primary responsibility for research in support of its own operations and services, including research directed to the broad delineation of the characteristics of Australian weather and climate and for liaison with the world Meteorological Organisation, in relation to relevant research in Australia.

During 1996-97, research will be directed towards: continuation of the development of improved operational numerical weather prediction models, with particular emphasis on data assimilation and analysis methods and regional and global prediction systems; maintenance of a program of climate research directed towards improved understanding of the natural variability of Australia's climate and to reducing the uncertainties in simulating changes to climate resulting from increased concentrations of greenhouse gases; strengthening of long-term foundations of Australian meteorology through active participation in the meteorology-related Cooperative Research Centres; and building on the results of field experiments designed to elucidate tropical cyclone behaviour and severe weather occurrence, to improve operational services for tropical Australia.

The Environmental Research Institute of the Supervising Scientist, part of the Environment Protection Agency, carries out independent research on behalf of the Australian community to establish the best methods available for the protection of people and ecosystems in the Alligator Rivers Region, both during and following mining in the region. The Institute also conducts general environmental research at the request of Government and makes a special contribution to the well-being of people and the environment of the region, through research on the protection and management of wetlands.

The Institute's 1996-97 funding will support research including the development of alternative methods for the treatment of mine waters prior to discharge to the aquatic environment; assessment of alternatives for the long-term disposal of tailings at the Ranger mine; revision of the ANZECC Water Quality Guidelines for Fresh and Marine Waters; and the establishment of better methods for monitoring changes in the wetlands of Kakadu and other parts of northern Australia. The Institute's research program has established that there has, to date, been no significant impact on the people and the environment of the Alligator Rivers Region due to mining uranium in the region.

In the past a lack of easily accessible information has made it difficult for people to find out how much and what kind of pollution enters their environment. In 1992 the Commonwealth Government committed \$5.9 million to developing a National Pollutant Inventory program (NPI). During the 1995-96 financial year, the EPA supported the completion of NPI trials in Dandenong, Port Pirie, Newcastle and Launceston at a cost of one million dollars. The National Pollutant Inventory will collect information on emissions of hazardous substances from industry, motor vehicles and other day to day human activity and provide this information in an easily accessible interactive database.

The National Greenhouse Research Program has been successful in contributing to improving our knowledge of global climate change in general and, more specifically, its implications for Australia and our region; Australia has a world class scientific capacity in this field, and has made a significant contribution to the Second Assessment Report on climate change, completed in 1995 under the aegis of the Intergovernmental Panel on Climate Change (IPCC), as a major input to the Climate Change Convention. This Budget provides \$4 million in 1996-97, and a commitment of \$14 million over 4 years, to continue the Program.

The priorities for the greenhouse research program include monitoring of the coastal impacts of climate change, sea level rise and potential regional impacts.

As part of the Commonwealth Coastal Action Program, the Department is establishing a Coastal Monitoring System. This includes a national coastal monitoring directory and a coastal monitoring network. The Coastal Monitoring System focuses on ensuring availability and quality of information for coastal management and Australia's contribution to global monitoring systems.

The Department continued to provide funding to support development of the National Strategy for Rangeland Management and Action Plan, by a joint Working Group of the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). The draft strategy will be available for public comment until 13 December 1996 and when finalised, will be submitted to the Council of Australian Governments for agreement. The strategy will provide a framework for a national approach to the ecologically sustainable management of Australia's rangelands, an area approximately three-quarters of the size of the continent.

The National Strategy for the Conservation of Australia's Biological Diversity has been endorsed by the Commonwealth and all State and Territory governments and work is now under-way to implement Australia's obligations under the Strategy. The establishment of the Biological Diversity Advisory Council (BDAC), the Biodiversity Strategy Executive Group (BSEG), and the Biodiversity Strategy Network (BSN), will ensure that these obligations are met.

A clearing house of biodiversity information - Biolinks - has been set up on the World Wide Web.

Work will continue on the implementation of Australia's obligations under the National Strategy for the Conservation of Australia's Biological Diversity as well as under the Convention of Biological Diversity. For example, work on bioregional planning and incentives for conservation and sustainable use will be advanced. Work on biosafety, access to genetic resources and intellectual property rights is also underway.

The Australian Antarctic Division has a total budget allocation of \$60.6 million in 1996-97 (\$61.7 million in 1995-96). The Division directly undertakes as well as supports scientific research in the Australian Antarctic Territory, the Southern Ocean and Australia's subantarctic islands, with priority to understanding global climate change and protecting the Antarctic environment and the marine ecosystem.

The Division's 1996-97 funding will support two substantial marine science voyages during the year together with a wide range of land-based research programs on Macquarie Island and the Antarctic continent. In the early spring, the RSV Aurora Australis will undertake the final transect of a multi-year series of voyages as part of the World Ocean Circulation Experiment (WOCE) and simultaneously conduct a pelagic fish survey, the first in this area. Later in the season the Aurora will undertake an extensive geoscience coring, dredging and seismic program in two areas of the coastline in the Australian Antarctic Territory. These projects contribute to the understanding of the functioning of the modern environment of Antarctica and the way in which it has evolved.

The Forests Branch provided funding for a number of major research projects including vegetation, disturbance old growth mapping in Queensland, Victoria, NSW, and Tasmania. This work will be continuing in 1996-97 as part of the Governments commitment to the implementation of the National Forests Policy Statement (1992). In addition, funding was provided for a review of ecosystem and species assessment for Comprehensive Regional Assessment (CRA) - a: review of approaches and techniques for biodiversity assessment.

MAJOR RESEARCH ACTIVITIES

Australian Antarctic Division

Role *To contribute to knowledge of the global environment through research in the Antarctic region; to provide scientific knowledge for the effective management of the Antarctic environment; and to increase Australia's influence in Antarctic matters by participating in international scientific programs and by contributing to international scientific forums.*

Recent Achievements

Global change

Continuing analysis of data gathered in the Lambert Glacier, the world's largest ice stream, indicates that this major drainage basin is close to being in balance. The accumulation of snow is the same as the discharge of ice to the sea, and is thus making little contribution to sea level change.

Conservation of marine resources

The Commission for the Conservation of Antarctic Marine Living Resources, at its 1995 meeting, established revised precautionary catch limits for krill in the area of Prydz Bay in the western part of the Australian Antarctic Territory. The limits set are based on research by Antarctic Division scientists. A major marine science voyage has now provided the first estimates of krill abundance in the eastern part of the Australian sector and will lead the Commission to establish precautionary harvesting limits.

Research findings that the albatross population is declining by 10% per year as a result of long line fishing were reported at the first international conference on albatross biology held at the Division.

The automated penguin monitoring system developed by the Antarctic Division is used at a research site on Bechervaise Island, near Australia's Mawson station. The system also operates at the Italian Base at Terra Nova Bay under a collaborative program. Analysis of data from the Bechervaise area is showing that Adelie penguins are foraging north of the continental shelf in an area overlapping with one where commercial krill harvesting has been conducted.

Health of people in remote and isolated regions

A ten year study shows personnel at Antarctic continental stations exhibit greater suppression to their immune systems and a far greater susceptibility to illness than those on subantarctic Macquarie Island.

Human impacts

A study of soil, water and vegetable matter from current and formerly occupied sites in Antarctica shows three species of introduced plants. Successful colonisation by exotic plants may be possible as the three species collected have survived three or four Antarctic winters since the sites were last occupied.

Bureau of Meteorology

***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.*

To fulfil its research objectives, the Bureau:

- encourages high quality research inhouse 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 sector to ensure access to well-trained graduates and maintenance of the national research infrastructure for atmospheric science; and
- ensures effective coordination with the research programs of other relevant institutions both within Australia and overseas.

The main research activities are carried out by the Bureau of Meteorology Research Centre in collaboration with the various operational units of the Bureau. Major research areas are mesoscale meteorology, regional meteorology, medium-range prediction, climate and climate-change modelling. The activities involved include theoretical studies, field experiments and mathematical modelling of atmospheric and oceanographic systems. Research is also undertaken into atmospheric constituents including greenhouse gases and atmospheric ozone

Recent Achievements

Tropical thunderstorm study

The Maritime Continent Thunderstorm Experiment, conducted over the Tiwi (Bathurst and Melville) Islands, studied the physical processes involved in the life cycle of tropical island convection, and the role of this convection in the atmospheric energy and moisture balance. Data from the Tiwi Island thunderstorms will provide insight into processes which take place over the many hundreds of such islands in the tropics. This experiment also provided the first substantial field trial of the autonomous autsonde aircraft for data collection

Weather forecasting

A new Limited Area Prediction Scheme (LAPS) to support weather forecasting was developed and has led to significant improvements in forecast performance. The Australian version of LAPS, which uses data points spaced some 70 to 80km apart, will become the basic model for all Bureau forecast offices, including those in the tropics. A version of LAPS for more restricted geographical areas and with a higher resolution grid (20 to 30km) has predicted severe systems, such as cold fronts.

Climate change models

Research has reduced uncertainties associated with climate models, and will lead to improved climate prediction. Climate change modelling research includes studies on the strength and relative importance of feedback mechanisms, such as the effect of cloud layers or invisible water vapour. A feedback diagnostic tool has now been incorporated into the climate simulation model. Insights have been gained on the differing roles of water vapour and cloud, when compared to the effect of increased levels of carbon dioxide.

Environment Protection Agency

Role *The EPA works with all levels of government, business and the community to help find nationwide solutions to Australia's environment problems. The EPA manages Commonwealth environment protection responsibilities, administers Commonwealth environment protection legislation and fulfils our international environment protection obligations.*

Recent Achievements

Rehabilitating mining sites

The Environmental Research Institute of the Supervising Scientist, in conjunction with the University of Newcastle, has developed a landform evolution model to predict the long term stability of rehabilitated mine surfaces. Rainfall pattern and evolution of weathered surfaces have been examined and the findings used in the model to account for changes in erodibilities of waste rock and derived soil.

Kakadu National Park

Creek side monitoring of invertebrate populations has been conducted to detect the early effects of mining upon the aquatic ecosystems of Magela Creek. Results indicate that mining has not had an impact on the aquatic animals of Kakadu National Park. The protocols for this research are now being handed over to Energy Resources of Australia, and research on

long-term monitoring based on community structure measurements is continuing. Protocols and expertise developed under this program are being applied more widely to river management through the Monitoring River Health Initiative.

Great Barrier Reef Marine Park Authority

Role *The GBRMPA is the principal advisor to the Commonwealth Government on the care and development of the Great Barrier Reef. The Authority's research and monitoring program conducts and supports research to assist in fair and transparent decision making in the Marine Park. Its focus is on obtaining, interpreting, disseminating and applying scientific information on the Great Barrier Reef, in order to manage human use and minimise impacts to the Great Barrier Reef World Heritage Area.*

Recent Achievements:

Crown of thorns starfish

Surveys of reefs of the northern Great Barrier Reef have detected a new cycle of crown of thorns starfish outbreaks. The Authority is working with tourism operators to control the starfish in small areas of reef which are important for tourism. Sodium bisulphate is being used for locally controlling starfish. It is fully biodegradable and therefore more environmentally friendly than the previously used copper-based substances.

Endangered species

Aerial surveys of inshore areas along the Great Barrier Reef region have indicated that dugong populations are in serious decline south of Cooktown. The Authority is working with the CRC for Ecologically Sustainable Development of the Great Barrier Reef to find out why stocks are declining and to minimise human related causes of death.

Australian Heritage Commission

Role *To develop and maintain a comprehensive and accurate Register of the National Estate and to provide objective advice in all fields relating to the conservation and presentation of the National Estate.*

This role encompasses the natural and cultural environments, the latter including those of Aboriginal and Torres Strait Islanders and the historic environment. The main focus of the Commission's work in identifying the National Estate is through systematic, thematic or regional surveys. Consultation with stakeholders and establishing cooperative working relationships with state agencies are fundamental objectives of this work.

Recent Achievements

Wild rivers

A study of the naturalness of the catchments and stream flow disturbance of all Australian watercourses has been completed. A major part of this work by the consultants, the Australian National University, was the development of a continental digital elevation model. The study is now the basis for finalising the national identification of wild rivers.

Forest regional assessments

The Commission identifies and assesses the national estate values in forest areas on a regional basis. Areas within forests meeting the criteria for listing are entered in the Register of the National Estate. Following from previous regional assessment work, in 1995 the Commission entered 75 places from the Southern Forest region of Western Australia on the Interim List of the Register of the National Estate.

Australian Sports Commission

***Role** The Australian Sports Commission undertakes and funds various research projects to identify methods to improve athlete performance and the quality of participation in sport..*

Recent Activities

Atlanta Olympics secret weapons

In preparation for the Atlanta Olympics, research with the University of Sydney and James Cook University, led to improved strategies for elite athletes to perform in humid heat. A pre-competition cooling jacket was developed for use by Australian athletes. The jacket allows a coolant to be placed close to the athlete's skin before the event to reduce heat load and enhance their performance in Atlanta's hot summer climate. Research showed that in some sports played at the Olympics level, the amount of heat produced can be more than one kilowatt, or about the output of a single radiator.

Other strategies include a portable gas analysis system developed for testing athletes 'in the field'; refinement of the cycle frame for use by track cyclists at the Atlanta Olympic Games and the development of an aerodynamic set of integrated handlebars and forks .

National Greenhouse Research Program

Role *To develop Australia's ability to forecast and assess climate change and its impacts in our region. The primary objective is to conduct the research necessary to provide Australia with the capacity to predict regional climate change resulting from the enhanced greenhouse effect. Research conducted under the Program is necessary for Australia to meet its obligations under the UN Framework Convention on Climate Change and in implementing national greenhouse policy, principally the National Greenhouse Response Strategy. It is also important in developing Australia's position in international negotiations and protecting Australia's interests.*

Recent Achievements

Modelling

CSIRO and Bureau of Meteorology Research Centre, with funding from the National Greenhouse Research Program, now have the capability to complete assessments of climate change using global coupled ocean-atmosphere-sea-ice models and to embed regional models within global models for more detailed studies.

Oceanography

In oceanography, a new model of sea-level rise incorporating improved estimates of ocean thermal expansion has reduced the error margins of future sea-level rise estimates. In the Tasman Sea, the Program produced the first detection of oceanic warming in the southern hemisphere, although the cause of this warming remains unclear.

Another advance was the development of coupled atmosphere-ocean models for simulation of the El Nino Southern Oscillation and the possible impact of the enhanced greenhouse effect on this phenomenon. Greenhouse research grants to universities also identified a strong seasonal uptake of carbon dioxide in the Southern Ocean off Australia.

FINANCE

Science and Innovation in the Portfolio Budget

The Australian Government Analytical Laboratories (AGAL) operate through the DAS Business Services Trust Account on a fee-for-service basis. AGAL play an important strategic role in the protection of Australian public health and safety and agricultural trade through its quality services in analytical chemistry and microbiology. AGAL's operations now include the Scientific Services Laboratory (SSL), which offers specialist advice, industry support and export facilitation activities, particularly in the areas of building, fire safety, paint technology, and low frequency electromagnetic radiation.

The Australian Surveying and Land Information Group (AUSLIG) operates through the DAS Business Services Trust Account. AUSLIG is part of the information services industry, specialising in surveying, mapping related products and professional services. AUSLIG's geodesy, national mapping, remote sensing, offshore boundary information and co-ordination of Commonwealth geographic information activities are supported through Budget appropriation of approximately \$23 million and public interest sales of \$5 million. These represent AUSLIG's core activities, which are delivered alongside a smaller commercial program.

The DAS Centre for Environmental Management (DASCEM) is a business unit which operates along commercial lines in the DAS Business Services Trust Account. The DASCEM Halon Bank has been established to collect, store, decant and destroy halon which is found in yellow fire extinguishers and fire suppression systems. Although a very effective fire extinguisher, halon severely depletes the ozone layer.

IPS Radio and Space Services is budget-funded at \$3.6 million for 1996-97. IPS has extensive experience and expertise in analysing radio propagation and the frequency management aspects of radiocommunication systems, as well as the space environment that supports them. IPS provided the national radio propagation and space environment services.

MAJOR RESEARCH ACTIVITIES

Australian Government Analytical Laboratories (AGAL)

Role *To develop analytical methods of suitable precision, accuracy and efficiency to meet demands for emergency testing services related to the protection of public health and safety, threats to Australia's export markets for agricultural produce, and protection of the environment. Through the Scientific Services Laboratory, to provide an investigatory and advisory capability related to construction and associated activities.*

Recent Achievements

Method development projects

AGAL has completed a number of method development projects aimed at improving the capability and efficiency of the Australian analytical community. New methods involving the use of supercritical fluid extraction have been developed for the analysis of pesticide residues in wheat, fruit and vegetables, which are important for the continued demonstration of the 'clean' nature of Australian produce. These methods also avoid the use of significant volumes of environmentally harmful chlorinated solvents which are a feature of many analytical methods.

Methods critical to the protection of Australia's beef export market have also been developed. Foremost among these have been improved methods for determining hormones that promote growth and drugs using mass spectrometry.

Several new techniques have been developed for the analysis of environmental contaminants in water and seafood as well as optimised methods for determining petroleum hydrocarbon residues. AGAL has also prepared and provided a number of new analytical standards and certified reference materials for use by Australian laboratories, as well as conducting a series of interlaboratory proficiency studies in food, environment and drug analysis.

Fire safety guidelines

The Scientific Services Laboratory has led a consortium of Australian research organisations to develop guidelines for designing and assessing fire safety systems for buildings. Following publication in 1996, the guidelines have received recognition in Australia and overseas as being state-of-the-art in fire safety engineering.

IPS Radio and Space Services (IPS)

Role *To provide timely radio propagation and space environment advice that customers will rely on to perform their operations, is appropriate to the needs of the Australasian community, and uses best technical and business practices.*

Recent Achievements

Radio frequency management

A new Microsoft WindowsTM version of the Advanced Stand Alone Prediction System, an IPS PC software package for radio frequency management, was released. This incorporates a number of improvements suggested by its hundreds of users. It has been exported to many countries including Indonesia, the USA and New Zealand. Agents for sales in South Africa and in North America and Canada have been appointed.

Solar observations

The US National Solar Observatory has installed a helioseismic observatory at the IPS Solar Observatory at Learmonth, Western Australia. This site is one of six worldwide observatories in the Global Oscillations Network Group which make it possible to observe seismic oscillations on the Sun for the full twenty-four hours of the day. This is one of the forefront solar scientific experiments of the 1990s, designed to reveal information about the interior of the star that is essential to our survival on Earth. Early results suggest that the data will not only give high resolution helioseismic information, but may also support daily solar magnetic observations, which are important in forecasting disturbances in the solar-terrestrial environment.

HEALTH AND FAMILY SERVICES

Science and Innovation in the Portfolio Budget

Research activities are undertaken within the Health and Family Services Portfolio and are funded by it through major research funding programs. Research is undertaken by the Australian Radiation Laboratory, the Nuclear Safety Bureau, the National Acoustic Laboratories and the Australian Institute of Health and Welfare. Research funding is provided through the National Health and Medical Research Council (NHMRC), the Commonwealth AIDS Research Grant (CARG) Program and a number of smaller grant schemes which fund applied medical and health research relevant to the activities of the Department of Health and Family Services.

Funding for health and medical research through the NHMRC in 1996-97 will be \$150 million (\$141.4 million in 1995-96). [The Department will administer funding for the John Curtin School of Medical Research of \$18.1 million (\$17.9 million in 1995-96). Research into HIV/AIDS will be the subject of a \$11.7 million program (\$12.1 million in 1995-96).

The Australian Institute of Health and Welfare will receive \$7.6 million (\$6.9 million in 1995-96).

The budget for the National Acoustics Laboratories is allocated from the appropriation to the Australian Hearing Services. In 1995-96, it was \$1.8 million.

The Australian Radiation Laboratory will receive \$8 million in 1996-97, of which about 25% will be spent on research and development (\$1.9 million on R&D in 1995-96).

The Nuclear Safety Bureau will receive \$828,300 in 1996-97 (\$868,000 in 1995-96).

MAJOR RESEARCH ACTIVITIES

National Health and Medical Research Council (NHMRC)

Role *The objective of the National Health and Medical Research Council is to advise the Australian 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.*

In 1996, the NHMRC is providing support for 1081 research projects; 26 large research programs; 5 major research institutes; 6 special units; 376 scholarships and training fellowships; and a number of other research projects and activities in specialised areas.

Recent Achievements

Enzyme replacement therapy

Professor John Hopwood's research group at the Adelaide Women's and Children's Hospital has been studying many aspects of lysosomal function. Lysosomes are an intracellular complex important in the storage and breakdown of various molecules. Children with abnormal lysosomal function suffer from severe, progressive disabilities, often physical and intellectual and most do not survive to adulthood. The cause is the inheritance of a 'faulty' gene resulting in the inability to produce critical enzymes required for the correct storage of complex sugars. Consequently, the sugars become stored in all types of body tissues and progressive damage occurs. Professor Hopwood's group has identified important enzyme reactions and is isolating and sequencing genetic information to identify the characteristics of the particular genetic mutations. The work has already resulted in support from other organisations, such as CSL Ltd, to pursue the development of recombinant DNA produced enzymes for use in clinical trials of possible treatments. Preliminary studies have shown that enzyme replacement therapy is effective and work is continuing on the most effective methods of delivery.

Simple diagnostic test for asthma

Dr Sandra Anderson's team, at the Royal Prince Alfred Hospital's Department of Medicine, developed a simple test for the diagnosis of asthma. The test involves the inhalation of a dry powder of sodium chloride using commercially available inhalers. Once perfected, the test will be able to be used in a doctor's surgery, replacing the currently used test which requires expensive, hospital-based equipment. Applications have been

made for international patents and pharmaceutical companies have expressed interest. Research is now underway to investigate the potential therapeutic use of the powder to increase mucociliary clearance in patients with lung disease such as cystic fibrosis and bronchiectasis.

Gene for common skin cancer discovered

Many Australians suffer from skin cancers known as Basal Cell Carcinomas (BCC) and BCC incidence has been shown to be increasing. A team of researchers at Queensland University and the Queensland Institute of Medical Research, headed by Dr Brandon Wainwright, has identified the gene responsible for causing these cancers. It is hoped that this discovery will lead to the development of treatment to block the start of the cancer and to the early identification of those at high risk of development of the cancer.

Discovery of a protein which triggers blocking of arteries

While working overseas on a NHMRC post-doctoral fellowship, Dr Levon Khachigian discovered that injured blood vessels produce a protein which triggers the growth of cells which subsequently narrow the blood vessel. This is a significant problem which often occurs following an operation, known as balloon angioplasty, to unclog blocked arteries. The identification of the protein offers hope for finding a way to prevent the re-occurrence of blocking. Research is continuing at the Centre for Thrombosis and Vascular Research at the University of New South Wales.

Exposure to lead in early childhood

From the mid 1980's to early 1990's, Professor Anthony McMichael together with Professor G Vimpani conducted epidemiological studies of the effects in children of exposure to lead in the environment. The studies were conducted at the lead smelting town of Port Pirie in South Australia. The children in these studies have recently been followed up by a multidisciplinary research team which undertook intelligence testing of the children between the ages of eleven and thirteen. The recently published results demonstrate that there are significant effects from lead exposure in early childhood which continue into later life. For example, those children who had exhibited blood lead levels at relatively high levels throughout their first seven years of life had lower IQ levels than those with lower average blood lead levels during their first seven years. Earlier studies had demonstrated this effect in the children when they were much younger, but this latest study shows that the IQ deficit has persisted into later childhood.

Commonwealth Aids Research Grants (CARG) Program

Role *To foster research aimed at preventing the spread of human immunodeficiency virus (HIV) infection and minimising the personal and social impact of HIV infection.*

In 1996 CARG will be supporting 52 research grants, 47 scholarships and 11 Fellowships, as well as three national centres undertaking virology, epidemiological and clinical, and social research into HIV/AIDS.

Recent Achievements

Attenuated strain of HIV

An achievement in 1995-96 was the publication of work on an attenuated or weak strain of HIV. This was characterised in a group of blood donors and transfusion recipients identified by the NSW Blood Transfusion Service and the National Centre in HIV Epidemiology and Clinical Research. A highly attenuated HIV variant was indicated by prolonged survival and absence of AIDS-associated complications in the group members, and the extremely low viral loads found. This work was published in *Science* (10 November 1995) and was very widely reported internationally.

National Acoustics Laboratories (NAL)

Role *NAL is the research division of the Australian Hearing Services (AHS). It conducts research into hearing loss and hearing rehabilitation.*

Recent Achievements

Improved procedures

In 1995-96, NAL was successful in improving the procedure for the choice of maximum sound level of an individual's hearing aid and developed a new procedure for assessing the effectiveness of hearing rehabilitation, such as fitting an aid. The rights to the assessment procedure have been purchased by a large international hearing aid company.

Interference to hearing aids from mobile telephones

The use of a digital mobile telephone can produce interference (a "buzzing" sound) in nearby hearing aids. This prevents most hearing aid wearers from using a digital mobile telephone and they may experience problems when close to other people who are using these telephones. In conjunction with the telecommunications and hearing aid industries, consumers and relevant government bodies, NAL completed and reported an extensive investigation of the interference problem and determined ways of making hearing aids less susceptible to interference. The findings of this research have been used in designing hearing aids. They provide the basis for the Australian Standard for hearing aid immunity and have attracted considerable international interest.

Hearing loss prevention

A new test, which measures ear damage before hearing loss becomes detectable, was used in studies of orchestral musicians and people accustomed to listening through headsets. One study prompted modifications to the orchestra pit of the Sydney Opera House to reduce the risk of hearing loss to musicians. Regular users of headsets showed significant ear damage, compared with non-users and are, therefore, more likely to sustain a noticeable hearing loss with further exposure to high sound levels.

Nuclear Safety Bureau (NSB)

Role *The NSB is a statutory body which monitors and reviews the safety of nuclear plant operated by the Australian Nuclear Science and Technology Organisation (ANSTO). The bureau also provides advice to the Federal Government on nuclear safety matters, including the assessment of Australian ports for visits by nuclear powered warships, and the transport of radioactive materials.*

Recent Achievements

Planning for emergencies resulting from nuclear accidents

The type and extent of emergency response following a nuclear accident must be appropriate to the risks anticipated. The NSB has developed a computer spread sheet called 'Cloud' which would provide real-time estimates of radiation doses following an airborne release of radioactive materials, and the reductions in dose which could be expected by implementation of various emergency countermeasures. The spread sheet format makes 'Cloud' easy and quick to use as an aid in determining the optimum response during a nuclear accident. 'Cloud' is complementary to accident dose calculation programs used by ANSTO and authorities

associated with visits to Australian ports by nuclear powered warships, and has been distributed to ANSTO and State and Territory radiation protection authorities. Copies have also been provided to South-East Asian authorities following demonstration of the spread sheet at a regional course sponsored by the International Atomic Energy Agency.

A more complicated spread sheet, called 'Accident', has also been developed by the NSB, for use in emergency planning at nuclear installations. Radiation doses to individuals and populations arising from exposure to airborne radioactive materials, inhalation of contaminated air, ingestion of contaminated foodstuffs and other pathways may be calculated using 'Accident', for a large number of radioisotopes released to the environment. These doses provide an estimate of the health consequences of a hypothetical nuclear accident, as a guide to the extent of emergency actions which might be required following such an accident. The NSB has used 'Accident' to estimate radiation doses and contamination of land which might result from a very severe accident at ANSTO's High-flux Australian Research Reactor (HIFAR). The results of this study confirm the NSB's view that the existing restrictions on the use of land outside the 1.6 km exclusion zone established around HIFAR are not required.

INDUSTRY, SCIENCE AND TOURISM

Science and Innovation in the Portfolio Budget

Portfolio activities in science and innovation are aimed at developing Australia's science and technology capabilities and infrastructure, ensuring effective benefits from public sector scientific research, and building competitive firms and a competitive national environment through the enhancement of innovation in the Australian business sector.

There are three scientific research organisations in the portfolio: the Australian Institute of Marine Science (AIMS), the Australian Nuclear Science and Technology Organisation (ANSTO) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

There are also agencies and programs supporting technological development in industry through the provision of grants, concessions and services. For example, the Industry Research and Development (IR&D) Board, which includes both industry and government representatives, is concerned with promoting the development and improving the efficiency and international competitiveness of Australian industry by encouraging research and development activities.

Science and technology policy advisory arrangements

- *Advice and awareness* of key issues and developing trends in science and technology is maintained at Cabinet level through the Prime Minister's Science and Engineering Council (PMSEC), consisting of the Prime Minister and other senior Ministers, business leaders, eminent scientists and engineers, and representatives of leading professional organisations and science and engineering interest groups. Through the Minister for Science and Technology, the Council is supported by the Coordination Committee on Science and Technology (CCST), consisting of chief executives of major science agencies and Deputy Secretaries of Departments with science and technology interests. CCST provides a means for improving coordination and cooperation on science and technology issues between departments and agencies. Secretariat support for PMSEC and CCST is provided by the Science and Technology Advisory Branch of the Department's Science and Technology Division.
- *Independent policy advice* to Government is provided by the Australian Science and Technology Council (ASTEC, to be re-named as the Australian Science, Technology and Engineering Council), with secretariat support from the Science and Technology Advisory Branch.
- *Policy advice and analysis* across a broad front relating to science, innovation, research and technology is provided by the Science and Technology Policy Branch of the Department's Science and Technology Division.

AusIndustry Enterprise Improvement Program

- *The Tax Concession Scheme* has provided for registered R&D performers to claim R&D related expenses at 150%. The rate is now to be set at 125%. See Section 2.
- *Competitive Grants for R&D* are provided to assist firms to:
 - develop internationally competitive and internationally traded goods, services and systems;
 - adopt new products, materials and methods to improve manufacturing capability, productivity and quality;
 - strengthen linkages between technology developers and technology users;
 - develop technologies, including emerging and enabling technologies, that are likely to have wide application in Australian industry; and
 - foster collaboration between firms and research institutions.
- *Concessional Loans for Commercialisation of Technological Innovation* are aimed at supporting small high technology oriented firms in the early stages of commercialisation.
- The *R&D Start Program*, commencing in 1996-97 will, in future, absorb the competitive grants and concessional loans Schemes, as well as supporting activities encouraging larger scale R&D, including some that were formerly covered by R&D Syndication. See Section 2.
- The *AusIndustry Enterprise Improvement Program* is a joint Commonwealth/State program which provides extension services to firms in the traded goods and services sectors to increase internal efficiency and international competitiveness.
- The *Enterprise Networking Program* is designed to encourage small to medium sized enterprises to cooperate with other firms in strategic areas of business to exploit opportunities beyond the reach of the individual firms. Support is available to establish networks, including customer-supplier, innovation and lead firm networks.

Industry development through innovation

- The *Australian Technology Group Limited (ATG)*, a technology commercialisation company specialising in investment and management of early stage commercialisation of research outcomes from the public and private sectors.
- The *Pharmaceutical Industry Development Program*, of which the Factor (f) Scheme is a major element, contributes to the development of an internationally competitive pharmaceutical industry in Australia. Under Factor (f), companies can gain increased prices for some of their products listed on the Pharmaceutical Benefits Scheme in return for increased activity in Australia, including new investment, production, research and development.

- The *Australian Industrial Property Organisation* provides industrial property rights services for inventions, trade marks and designs. Legal protection given with the rights encourages industry to develop and exploit new technology as well as facilitating the transfer of overseas technology to Australia. The organisation operates on full cost recovery.
- The *Computer Bounty* provides assistance for the production of computer hardware, certain assemblies, electronic microcircuits, printer circuit boards, modems and multiplexors, and certain operating software (due to end on 30 June 1997).
- The *Telecommunications Industry Development Plans* encourage the licensed telecommunications carriers and key suppliers to undertake strategic investment, R&D and export activities in Australia which are internationally competitive.
- The *Partnerships for Development and Fixed Term Arrangement Programs* encourage international companies in the information technology and telecommunications industries to undertake strategic investment, R&D and export activities in Australia which are integrated into the global marketplace.
- The *Renewable Energy Industry Program* aims to facilitate the development of a viable internationally competitive Australian renewable energy industry. The program aims to improve the competitiveness of the industry by the development of critical mass and increased access to export markets. Financial assistance is available on a competitive basis for projects which are already technologically proven, yet require assistance with commercialisation and/or market development.

Science, technology and industry linkages

- The *Cooperative Research Centres (CRCs) Program* provides support for long-term collaborative ventures linking research and research users from universities, Commonwealth- and State - funded research organisations and business enterprises. It promotes high quality cooperative research and education programs through centres of research concentration, strengthening the links between research and its commercial and other applications.
- The *Major National Research Facilities 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 will create centres of capability for pursuing research with state-of-the-art equipment.
- The *Space Industry Development Centres (SIDC) Program* is directed at the development of an Australian commercial space industry. The objective of the program is to encourage industry to put R&D funds into space related activities through collaborative ventures with University-based space research centres. Three SIDCs have been established at Griffith University, Queensland University of Technology and the University of South Australia.

- The *International Science and Technology Program* aims to stimulate Australian involvement in international research collaboration and generate awareness of Australian S&T capabilities. A longer term aim is to build commercial opportunities through collaborative research.
- The *Science and Technology Awareness Program* aims to increase awareness and understanding of the central role which science and technology play in Australia's economic and social wellbeing.

Program or agency	Budget expenditure 1995-96 \$m	Budget estimate 1996-97 \$m
Factor (f) Pharmaceutical Industry		
Development Program	106.3	189.1
AIMS	16.6	16.4
ANSTO	65.6	63.7
CSIRO	417.6	444.5
Industry Innovation Program grants	52.4	117.9
CRG Program	132.7	145.1
Computer Bounty	64.1	56.5
Enterprise Development Program	28.3	25.8
Enterprise Networking Program	6.5	9.3
National Space Program	2.7	2.6
Science and Technology Awareness	1.7	2.0
International S & T Program	5.6	5.6
National Research Facilities	6.4	17.0
TOTAL	906.5	1095.4
PORTFOLIO TOTAL (Outlays)	2854.3	3160.0

Budget support for these programs is shown in the table. The Australian Industrial Property Organisation is not included in the above figures as it operates on full cost recovery.

MAJOR POLICY ACTIVITIES

Prime Minister's Science and Engineering Council (PMSEC)

Role *To provide a major national forum for consideration of issues of national significance in science and technology and to keep the Prime Minister and senior Ministers informed of key issues, thereby enhancing understanding of matters affecting Government policies.*

The Prime Minister Chairs the Council and the Minister for Science and Technology is the Deputy Chair. Membership includes Ministers with primary responsibility for science and technology matters, and has representation at the most senior level from the business and science and technology communities, and from the trade union movement.

PMSEC plays a valuable role in involving senior Ministers in discussions of current issues in science, technology and engineering. There is a particular emphasis on the application of policy research findings, giving impetus to the resolution of science and technology issues within government.

PMSEC has the following terms of reference:

- to address important issues in science, technology, engineering and relevant aspects of education and training;
- to examine the contribution of science, technology and engineering to the economic and social development of Australia;
- to enhance awareness in the community of the importance of science, technology and engineering for Australia's economic and social development;
- to examine Australia's science and engineering resources and the effectiveness of their organisation and utilisation; and
- to examine Australia's science and engineering infrastructure and the effectiveness with which it achieves the application of science and technology in the economic and social development of Australia.

Recent Achievements

The June 1995 Council discussion on sustaining the agricultural resource base contributed significantly to the development and implementation of a number of initiatives. Significant outcomes from that meeting are presented in detail in Section 2.

The December 1995 Council meeting discussed science and technology for managing Australia's ocean territory. This is expected to contribute to the development of an oceans policy, and to a marine science and technology plan.

Throughout 1995, the Council considered many issues for the former Government's statement, *Innovate Australia*, and was influential in ensuring that the Statement, released in December 1995, took into account the many views expressed by the science and technology community.

Australian Science and Technology Council (ASTEC)

Role *ASTEC is a principal source of independent advice to the Government on a wide range of policies and programs related to science and technology, and of concern to Commonwealth departments and agencies, higher education institutions and private enterprise.*

The functions of the Council are to investigate and to furnish information and advice to the Commonwealth Government in respect of issues relating to science, technology and engineering including:

- the advancement of scientific knowledge;
- the development and application of science and technology in relation to the national well-being;
- the adequacy, effectiveness and balance of scientific and technological activities in Australia;
- the identification and support of new ideas in science and technology likely to be of national importance;
- the practical development and application of scientific discoveries;
- the fostering of innovation in industry; and
- the means of improving efficiency in the use of resources by the application of science and technology.

The Government has announced its intention to legislate to change the Council's name to the Australian Science, Technology and Engineering Council.

Recent Achievements

The major study released during the year was *Matching Science and Technology to Future Needs 2010*. This study applied foresight processes to examine the forces for change into the 21st century, and to evaluate their broad implications for Australia's science and technology needs. Details of

ASTEC's reports are provided in Section 2. In November 1995, ASTEC released a report assessing Australia's science and engineering base for information and communications services and technologies. The report profiles the current science and engineering base and identifies skills requirements. Important issues identified included: community and students views on science and engineering careers; the small scale of many information and communications departments; and a low level of industry-research interaction.

ASTEC is now engaged in a study on science and technology in primary schools. The study aims to review the teaching and learning of science and technology at the primary level and identify opportunities for enhancing education.

Coordination Committee on Science and Technology (CCST)

Role *To allow departments and agencies with an interest in science and technology to share information about their programs, policies, problems and work plans. This helps ensure coherence and consistency in the implementation of Government policy for science and technology, and allows an overview by the Committee of that policy.*

The CCST's terms of reference are:

- to provide coordinated advice to the Government through the Minister for Science and Technology on national science and technology issues;
- to improve coordination of administration of government science and technology programs among departments and agencies, including cooperation among departments and agencies on specific science and technology issues and opportunities; and
- to exchange information among departments and agencies on domestic and international science and technology programs, policies, work plans, issues and opportunities.

Recent Achievements

During 1995-96 CCST:

- conducted a major seminar on R&D for ecologically sustainable development (ESD);
- advised the Government on selection of proposals to be funded under the Major National Research Facilities Program;

- assisted with the coordination of Commonwealth use of high-performance computing facilities;
- advised the Minister for Science and Technology on a proposed strategy for the preparation of the Government's Marine Science and Technology Plan;
- advised ASTEC on its work program;
- contributed to, and discussed the outcomes of, the former Government's Statement, *Innovate Australia*; and
- provided a forum for consideration of the new policies, directions and resources for Government science and technology, following the change of Government in March 1996.

Genetic Manipulation Advisory Committee (GMAC)

Role *To oversee the development and use of innovative genetic manipulation techniques in Australia so that biosafety risk factors associated with the novel genetics of manipulated organisms are identified and can be managed; and to advise the Minister about matters affecting the regulation of innovative genetic manipulation technology.*

The Genetic Manipulation Advisory Committee (GMAC) is a non-statutory body established to oversee the development and use of novel genetic manipulation techniques in Australia. GMAC's role is to identify and manage risks to the safety of workers or potential hazards to the community or environment associated with genetically manipulated organisms. GMAC is supported by a secretariat within the Department.

Recent Activities

New release proposals

During 1995-96, GMAC assessed seventeen new proposals for the planned release of genetically modified organisms into the environment and fifteen extensions to previous planned release proposals. Of the new proposals, one involved a field trial of a genetically modified microorganism and the remainder were for field trials of modified plants. GMAC also provided advice on three proposals for commercial release of genetically modified plants.

Publications

GMAC published a new edition of *the Guidelines for Small Scale Genetic Manipulation Work* and commenced work on revision of *the Guidelines for the Planned Release of Genetically Manipulated Organisms*. The Committee also

published a booklet titled *Safety Practices in PC2 Laboratories* and reprinted the *Biotechnology Information Series* produced by Iowa State University of Science and Technology.

MAJOR RESEARCH ACTIVITIES

The Australian Institute of Marine Science (AIMS)

***Role** To undertake research and development to generate new knowledge in marine science and technology, promote its application in industry, government and ecosystem management; and undertake complementary activities to disseminate knowledge, collaborate effectively, assist in the development of national marine science policy and enhance the Institute's standing as a centre of excellence.*

AIMS has reorganised its research program into a number of major projects that will provide Australia with a stronger basis for the effective management of marine resources. The new structure will enhance the already demonstrated capabilities of the Institute by focussing research activities onto high priority areas and facilitating development of linkages to users of AIMS research.

Recent Achievements

Mangroves of northwestern Australia

Research has shown that the comparatively small forests in Western Australia are just as important to coastal and shelf nutrient recycling and food chains as those forests on the east coast. The mangroves of the Pilbara coast, in the arid region of northwestern Australia, are small in size and occupy a narrow strip along the coastline. Contrary to expectations, however, the rate of nutrient cycling in mangroves of this region, including gas exchange with the atmosphere, is as high as in more productive mangroves in the wet tropics of the east coast.

Monitoring the Great Barrier Reef (GBR)

The first status report from surveys of the GBR was published in 1995. The report encompasses simultaneous assessments of benthic organisms, fish assemblages, crown-of-thorns starfish populations and water quality at 34 reefs along the length and breadth of the GBR. The report provides broadscale information on the GBR's current status and the basis for

measuring change through time. These surveys will provide a guide for assessing the impact of human activities like tourism and fishing in the GBR province, and thereby enable sustainable management of these important resources.

High technology control system

AIMS has applied for an international patent for the operating system of a general purpose underwater computer (WetPC). This new technology comprises a Human/Machine Interface for control of a conventional computer with one hand (or both) using a chordic keyboard. The technology is generic with applications in mobile computing, mobile phones, interactive television and automotive controls. The Institute is providing concept demonstrations for field trials to be undertaken next year by the Australian Army as part of Project Wundurra, *The 21st Century Soldier*. It is also working with DSTO to produce a working demonstrator for the RAN. The commercial potential of the new technology is being assessed by Stanford Research Institute Consulting (USA).

Great Barrier Reef (GBR) contaminants

Sediment cores from mangroves and mudbanks of the inner GBR lagoon contain the history of GBR contaminants over the last 100 years. Clear evidence exists in coastal embayment and mangrove sediments of contaminants from agriculture (fertilizer trace elements, phosphorous, DDT) and mining (mercury from 1870-1900 gold rush use of quicksilver in Charters Towers). These results illustrate the close linkages between land-use and the delivery of agricultural and mining waste products to coastal ecosystems. They highlight the importance of taking land-use patterns into account in conservation of the coastal environments of the GBR.

Australian Nuclear Science and Technology Organisation (ANSTO)

Role *To undertake research and development in nuclear science and associated technologies to contribute to Australia's industrial innovation and development, and environmental and health management. Maintain a core of essential nuclear expertise and nuclear facilities, and further Australia's non-proliferation, nuclear safeguards and wider nuclear technology policies.*

Recent Achievements

Epilepsy

Clinical trials at Queen Elizabeth Hospital, South Australia, show that a new radioactive iodine labelled compound localises epileptic foci in patients in the non seizure state. Accurate detection of the foci makes improved surgical treatment of the disease possible.

Radioactive copper for birth defect studies

Radioactive copper is supplied by ANSTO to the Genetics Department, University of Melbourne, for use in diagnosis of birth defects. A new process rapidly separates radioactive copper as a by-product from gallium production. It is a commercially viable process for high purity copper production.

Removal of polonium

Polonium, a decay product of uranium, has been troublesome at the Olympic Dam copper/uranium mine in South Australia. ANSTO developed a leaching process to remove polonium from Olympic Dam smelter flue dust and successfully demonstrated the process on a continuous mini-plant scale. Removal of over 90% of the copper and polonium in the dust was achieved, leaving a residue to smelt that is enriched in silver and gold.

Monitoring environmental change

First results have been obtained in the ANSTO projects on global climate change funded by the National Greenhouse Advisory Committee. Firstly, analysis of Antarctic ice cores provided measurement of the radiocarbon bomb spike produced during atmospheric nuclear testing in the 50's and 60's. This result, obtained in cooperation with the CSIRO Division of Atmospheric Research, the Antarctic CRC and the Australian National University, will allow the understanding of atmospheric signals in Antarctic ice related to global climate change effects. Secondly, high precision radiocarbon measurements for consecutive single-ring samples from a 12,700 year-old Tasmanian celery-top pine have been recently completed in collaboration with the University of Sydney, the results providing insights into possible ocean carbon dioxide releases during the last glacial transition.

The Australian Space Office

Role *The Australian Space Office is the executive arm of the Australian Space Council, and is the national government agency responsible for coordinating Australian space activities and managing the National Space Program, under objectives set by the Australian Space Council. The National Space Program aims to improve the competitive position of Australian firms to supply space-related goods and services, and to provide support for the application of space related science and technology by the Australian public and private sectors.*

Recent Achievements

Along Track Scanning Radiometer

Australia is continuing to collaborate with the UK in developing instruments for satellites, such as the Along Track Scanning Radiometer (ATSR). These instruments measure sea surface temperature with high accuracy for global climate change research. Australia provided the Digital Electronics Unit for the ATSR-1 instrument used on a satellite launched in July 1991, and both the Infrared Focal Plane Assembly and the Electrical Ground Support Equipment, for the ATSR-2 instrument used on a satellite launched in April 1995. The Advanced ATSR is currently being built and Australia is providing the Focal Plane Assembly, Fore-optics, Signal Preamplifiers, Instrument Electronics Unit and the Electrical Ground Support Equipment. The Advanced ATSR will be used on a satellite to be launched in 1999.

Atmospheric Pressure Sensor (APS)

The development of an operational prototype APS was completed in 1995. The APS is based on an Australian design that is unique by world standards. It is a space-borne instrument that will provide information for weather forecasting and climate change research, and has the potential to detect atmospheric pollutants. The APS is a leading-edge development in meteorological remote sensing designed to enhance Australia's weather forecasting capability. The APS technology has the potential to contribute to greenhouse gas monitoring and the measurement of atmospheric pollution.

Endeavour Space-Telescope

The design and construction of the ultraviolet space telescope Endeavour in Australia, its flight on the Space Shuttle in March 1995, and analysis of data during 1995-96, have contributed to the space technology capabilities of Australian industry and advanced our knowledge of the universe through the detection of new objects.

Launch facilities

Establishing light space launch services in Australia has been the subject of two feasibility studies completed with Russian companies. Australian and Russian companies now have signed a Letter of Intent on investigation of the establishment of a commercial light launch service based at Woomera. The feasibility of establishing a spaceport for large equatorial launch vehicles in northern Australia is also being studied.

Remote sensing

A demonstration model of an Australian Earth Observation Network has been developed. This is a response to industry concerns about the cost and availability of remote sensing data.

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 utilization of the results of this or any other scientific research; and*
- *to carry out services, and make available facilities, in relation to science.*

CSIRO is recognised nationally and internationally for its contributions to science and Australia's development. To ensure that the nation derives the maximum benefit from its research, the Organisation will strengthen its relationships with customers and clients, maintain its strong commitment to multi-disciplinary research, and continue active collaboration with researchers in other organisations including Cooperative Research Centres.

Recent Achievements

The following achievements are grouped on the basis of the Socio-Economic Objectives component of the Australian Standard Research Classification (published by the Australian Bureau of Statistics). This classification provides a framework for planning and describing research in terms of its anticipated economic, social and environmental benefits.

Plant Production and Primary Products

Grapevine water use

Water availability is the major constraint to Australian vineyard expansion to meet growing demand for wine exports. The Division of Horticulture, in collaboration with the University of Adelaide and with funding from the Grape and Wine Research and Development Corporation, has demonstrated that significantly reducing water requirements of grapevines is achievable. The introduction of a partial root drying regime has the benefit of reducing vine vigour to give a more open canopy with better bunch exposure. Experiments on field-grown vines showed that water usage could be reduced by as much as one third to one half, but crop yield was not reduced in comparison with normally irrigated vines. The quality of the fruit was also shown to be significantly improved, and the more open canopy resulted in better control of fungal diseases.

Animal Production and Primary Products

Southern Bluefin Tuna

Collaborative research by the Division of Fisheries and Zelcon Technic Pty Ltd has developed the archival tag for studying fish movement, physiology and behaviour. A miniature computer and data logger, the archival tag is capable of collecting and storing, for over nine years, up to one megabyte of data on a fish's depth, the temperature of its body and the surrounding water, and light levels. Using this information, the global position of individual fish can be calculated. The archival tag is being used to study the Southern Bluefin Tuna (SBT) which is the most valuable fin fishery in Australia, generating around \$100 million per year. In January 1994 and March 1995, archival tags were implanted in 300 SBT in the Great Australian Bight. Nineteen of these fish have been recaptured. The project is a key component of a program monitoring trends in the recruitment of juvenile SBT into Australian waters. The Division of Fisheries plays a central role in the assessment of SBT stocks, which are at historically low levels, and the integration of science into international management protocols.

Energy Resources

Dragline automation for open-cut coal mines

Dragline productivity is a vital factor in determining the overall economic performance of a mine. The dragline is the key component in the removal of overburden. The Divisions of Exploration and Mining, and Manufacturing Technology, have developed technology to optimise the performance of draglines in open-cut coal mines. Working within the Centre for Mining Technology and Equipment, with funding from the Australian Coal Association Research Program, a method was developed for automatically controlling the dragline during the swing and dump phases of its operating cycle. A sensor measures the swinging motion of the dragline bucket as it is suspended freely from the hoist and drag ropes. This new technology is expected to generate savings of \$3 million per year for a typical Australian open-cut mine, and potential savings of \$280 million per year for the industry as a whole. The Australian Coal Association Research Program, BHP Australia Coal Pty Ltd and CRA Ltd, has now supported a \$1million project over two years to implement the control system on a full-scale dragline.

Energy Supply

Monitoring petrol temperatures across Australia

Petrol, which is sold by volume, expands by about one per cent for every eight degree increase in its temperature. Temperature variations may be important because they cause variations in volumes. The Division of Mathematics and Statistics completed a \$2 million study for the Australian Institute of Petroleum (AIP) to determine the average national temperatures

of petrol delivered to and dispensed from petrol stations. AIP wanted values for average national petrol temperatures which accounted for variations in petrol temperatures in widely different climates. The study has provided AIP with reliable values for national average petrol temperatures. It will form part of a package which could save the petroleum industry over \$300 million.

Long life lead-acid battery

The Division of Minerals is patenting a simple change in the construction of lead-acid batteries that could significantly lengthen service life and make them a more attractive power source for electric vehicles. Initial tests by the Division's novel battery technologies group indicate that, under tough conditions which simulate use in electric cars, maintenance-free (valve regulated) batteries made to the new design have about double the endurance of standard lead-acid batteries.

Rural-Based Manufacturing

High value cheese byproduct

Bonlac Foods Ltd plans to establish a manufacturing facility to extract from whey a high value protein component, *Whey Growth Factor Extract*, a byproduct in cheese manufacture. The new manufacturing facility will use technology arising from process development and scale-up work at the Division of Food Science and Technology, based on a separation process first established at the Cooperative Research Centre for Tissue Growth and Repair. The extract is marketed under the trade name Accel gF and has uses in a number of biotechnological, biomedical and specialist food areas. These include wound healing and the prophylactic and therapeutic treatment of some gut diseases, organ culture such as the growth of skin for burn victims, and mammalian cell culture for the production of hormones, vaccines and other fine biochemicals.

Wool process goes international

Scientists at the Division of Wool Technology with support from the International Wool Secretariat (IWS) have developed Basolan AS, a chemical agent that prevents permanent setting during wool dyeing. Although permanent setting is widely used in clothing manufacture, if it occurs inadvertently when wool is being dyed, it can lead to unwanted consequences in many steps of the wool processing chain. Generally, wool dyed using the CSIRO process is stronger. It performs better in carding and spinning; it knits and weaves better; it reduces running marks which means that garment appearance is improved; and it brightens the colours obtained from the dyes with slightly better light fastness. Fabrics treated with Basolan AS also feel and handle better than untreated fabrics. Basolan AS is gaining wide acceptance in wool dyeing companies with the world's leading wool textile mills in six countries now using the CSIRO technology routinely.

Manufacturing

Conducting rubber

Rubber is one of the best insulators known, but gains the property of conducting electricity when it is doped with iodine. Scientists at the Division of Chemicals and Polymers established the reasons behind this some years ago. Recent research by the Division in this area has led to the development of microlithographic technology for the formation of conducting patterns at micron scale in thin rubber films, and the introduction of Buckminster fullerenes (bucky balls) into the structure of rubber. Both these achievements are considered key prerequisites for the successful application of the technology to electroluminescent displays, integrated circuits, microelectronics, and electronic and photonic labels.

Information and Communications

Expert systems

The Division of Information Technology has completed Phase One of the Spares Assessing Expert System (SAES) Project for Integrated Systems Solutions Corporation Australia Ltd. The SAES Project involves developing a knowledge-based support system for spare parts assessment in the Navy. SAES will reduce surplus inventory costs by encouraging a standardised approach to provisioning and spares assessment. Phase One of the project delivered a User Requirements Specification, product evaluation, and high level design for the Expert Module component of the system. Phase Two includes software implementation for the Expert Module.

Economic Framework

Frequency standard

The National Measurement Laboratory (NML) in the Division of Applied Physics has developed a new frequency standard. Frequency standards are being developed because it is recognised internationally that the stability and accuracy of many existing time and frequency standards will soon be unable to satisfy the requirements of some advanced navigation, communication, timekeeping, surveying and other applications. The short-term stability of the new 'trapped ytterbium' standard is superior by a factor of three to any passive atomic frequency standard yet demonstrated.

Health

New weapon in the fight against tuberculosis

In collaboration with industry, the Division of Animal Health developed and patented technology used for a blood test for tuberculosis in cattle, now sold by Commonwealth Serum Laboratories (CSL) to over 16 countries. With tuberculosis recently re-emerging as a significant human disease, CSIRO and CSL developed the technology to produce a blood test for tuberculosis in humans. The new test, QuantiFERON-TB, was subjected to extensive trials that demonstrated it is a rapid and sensitive test for latent tuberculosis infection.

Environmental Knowledge

Tracing the polluters of our waterways

Studies by the Division of Oceanography show that birds, wildlife and domestic animals are contributing to the contamination of Australia's waterways at previously unrecognised levels. The studies involved new techniques which use organic compounds called faecal sterol biomarkers. These chemical biomarkers provide scientists with a 'fingerprint' to trace the sources and amounts of faecal pollution in waterways. The scientists found that in Lake Tuggerah, NSW, as much as 80% of faecal pollution after rains was from sea birds. The second highest contributor was domestic animals at about 15%. Rural catchments contributed the remainder of the faecal contamination which came from sheep, cows, horses and native animals such as kangaroos. In this study, human faecal contamination was either negligible or below detection. The studies were undertaken in collaboration with the Division of Water Resources and the firm, Australian Technologies. The technique is soon to be applied to Melbourne's Yarra River in a collaborative study with the Victorian Environment Protection Authority.

Environmental Aspects of Economic Development

Control strategies for algal blooms

Scientists from CSIRO's Centre for Environmental Mechanics, and the Division of Water Resources, have developed strategies to control blooms of cyanobacteria, or blue-green algae. Strategies are based on an understanding of thermal stratification in riverine weir pools, particularly the effects of water discharge. Four strategies help prevent thermal stratification developing: manipulating the physical conditions within the weir pool by maintaining an elevated discharge through the weir; pulsing the weir discharge; releasing water over the weir wall rather than under it; and artificial destratification. Each strategy disrupted the development of thermal strata within the water column of the weir pools, potentially stopping blue-green algae blooms.

Reducing pollution problems at Port Pirie

The Division of Atmospheric Research completed a major environmental consultancy project at Port Pirie's Pasminco-BHAS lead smelter. The project required the identification of atmospheric conditions which cause elevated sulfur dioxide concentrations near the smelter. Pasminco's pollution problems typically occur during hot summer days with onshore breezes. This suggested that the plume was being brought down to ground level by a process known as shoreline fumigation, due to strong convective mixing in the lower atmosphere. To confirm this theory, CSIRO monitored meteorological conditions during pollution episodes, and gathered detailed emissions data from the smelter. Pasminco will use the results from the study to investigate technologies to reduce emission problems from its smelter. CSIRO collaborated on the Port Pirie study with Flinders University and Pasminco-BHAS.

Advancement of Knowledge - Radioastronomy

Upgrade of Parkes Telescope supports Galileo mission

In 1995, CSIRO's Parkes telescope received a major upgrade to prepare it for tracking NASA's Galileo spacecraft. Galileo, launched in 1989, is now orbiting Jupiter. From mid 1996 to November 1997, it is taking pictures of the planet and its moons. NASA will use the Parkes telescope to track Galileo for 9-10 hours a day for 13 months from November 1996. This tracking forms the largest project in the telescope's 30-year history, and the upgrade for the mission is the biggest change to the telescope since it was built. To enable both tracking of Galileo and normal astronomy research, NASA funded a replacement of the telescope's 'focus cabin'. This cabin holds the equipment that does the first processing of the signals coming into the telescope. The new cabin's design makes it possible to switch quickly between the different sets of equipment needed for tracking Galileo and normal astronomy.

The Cooperative Research Centres (CRCs) Program

The objectives of the Program are:

- to contribute to national objectives, including economic and social development, and the establishment or internationally competitive industry sectors through supporting long-term, high quality scientific and technological research;
- to stimulate 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;
- to capture the benefits of research, and to strengthen the links between research and its commercial and other applications, by the active involvement of the users of research in the work and management of the Centres; and
- to promote cooperation in research, and through it a more efficient use of resources in the national research effort by building centres of research concentration and strengthening research networks.

The Cooperative Research Centres Committee, which is appointed by the Minister, provides advice on the CRC Program. Under the CRC Program, new Government funding, rising to \$146 million annually by 1996/1997, will be provided to support the sixty two Centres currently established. The announcement of the establishment of the newest Centre, the Australian CRC for Renewable Energy, was made in December 1995.

CRCs are established under formal contracts, normally for seven years, with the Commonwealth to undertake long-term strategic research focusing primarily on the natural sciences, engineering and their application. By their very nature, CRCs do not achieve significant results in their early years. In a number of cases, the benefits of the research will not be apparent for many years. Nevertheless, some of the early Centres are now reaching the point where promising achievements are in evidence.

Recent Achievements

Automotive die casting developments

The CRC for Alloy and Solidification Technology improved a low pressure die casting process used to produce automotive cylinder heads and wheels for export. The new technology has reduced the cycle time for cylinder heads casting by 30%, freeing up production capacity for greater output with little capital outlay. The technology is currently being implemented by one Australian manufacturer and others are expected to follow.

Commercialisation of flexible modulator for radio-paging transmitters

New standards have been established for pagers in Europe, Asia and the Americas that provide many advanced features, eg standard operating frequencies will allow pagers to be used internationally. A new paging transmitter has now been developed by the CRC for Broadband Telecommunications and Networking and ERG Telecommunications Pty Ltd. The transmitter integrates the CRC's new multi-format digital modulator with ERG's paging transmitter. This allows a range of modulation formats and speeds. Paging service providers throughout the world will be able to send messages to customers.

New bacteria to enrich the diet of farmed fish at a low cost

The CRC for the Antarctic and Southern Ocean Environment developed new bacteria for enriching the diet of farmed fish. Fish farmers currently feed their larval fish on 'rotifers', a type of plankton resembling the natural diet of the fish in the ocean. They also grow micro-algae in special tanks to provide the rotifers with 'Omega-3' polyunsaturated fatty acids, which young fish require in order to grow, and their production can be labour-intensive, time-consuming and expensive. The new bacteria provide a much cheaper source of fatty acids. The bacteria, from the sea ice off Antarctica, may be grown readily in existing equipment on fish farms. Trials show the bacteria can be cultured on the waste product of fish farms.

New probes to detect petrol, chemical leaks

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 computer read-out 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 4,000 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 USA. The USA alone has over 300,000 contaminated sites with an estimated clean-up bill of US\$750 billion over the next 20-30 years. The new probes are being marketed and distributed by a wholly-owned Australian company, International Environmental Management Pty Ltd, in association with the CRC.

International collaborative research in blood growth factors

The CRC for Cellular Growth Factors' commercial partner AMRAD Corporation Ltd, has signed an agreement with the Japanese pharmaceutical company CHUGAI to pursue research and development into cytokines (blood cell growth factors). Under the agreement, CHUGAI will pay \$16m over three years to AMRAD for research into cytokines and will undertake the full commercial development of selected projects. In addition, scientists at CHUGAI's Research Institute for Molecular Medicine, AMRAD's Cytokine Research Laboratories, and the CRC for Cellular Growth Factors will collaborate in an arrangement of enormous potential value to the Australian pharmaceutical industry.

New generation bionic ear

The CRC for Cochlear Implant, Speech and Hearing Research has developed and commercialised a new generation speech processing strategy. The strategy called SPEAK has been implemented by the Centre's manufacturing partner Cochlear Ltd in the Spectra-22 cochlear implant. Children and adults using the SPEAK strategy have shown major increases in understanding of words and sentences using only their cochlear implant, particularly in situations with high levels of background noise. This will significantly increase benefits from implant use in the everyday community and in school classrooms, where noise levels are often high. The success of the SPEAK strategy has helped Cochlear Ltd to maintain its position as the leader in this high technology biomedical field, controlling over 80% of the world market.

Software packages to assess welding defects in gas pipelines

Australia is in the process of constructing a number of major new natural gas pipelines which will, when complete, form a network providing a highly competitive and environmentally attractive source of energy. These pipelines are private sector funded and are a direct outcome of deregulation of the industry. The field welding of these pipelines is a major cost component in their construction and, in the past it has also had the potential to cause major delays and additional costs. Research by the CRC for Materials Welding and Joining has led to real benefits to the industry. A software package called PIPESAFE has been developed by the CRC, BHP, ANSTO and CSIRO. The package enables engineers in the field to assess the significance of welding defects and so avoid the cost and damage caused by unnecessary repair of innocuous imperfections. Research undertaken at the University of Adelaide has provided guidelines to industry to pro actively prevent the occurrence of a potentially troublesome porosity defect called hollow bead which sometimes can occur in epidemic proportions in pipeline field welds.

Plant cell cultures producing biopolymers

The CRC for Industrial Plant Biopolymers has constructed a pilot plant for large scale culture of plant cells. This facility will be used to scale-up processes for the production of biopolymers and other plant products. The pilot plant will produce products which are used extensively by many industries, particularly the food industry, and have a world market of \$2 billion. Such products are currently fully imported into Australia. The CRC has been granted several patents covering both the production process and the commercial applications of the biopolymers produced.

New technologies for recycling of plastics

In the major waste streams plastics are often difficult to recycle because they have either undergone chemical degradation which makes them unsuitable for reprocessing or they are mixed with other different classes of plastics or contaminants. Research developments at the CRC for Polymer Blends will support the growing community call for the recycling of more of the plastics used in packaging. The Centre is currently patenting two new technologies to assist in the waste management of these plastics. One technology involves a new chemical process that reconstitutes the degraded plastic from soft

drink containers so that it may be recycled repeatedly. The second technology will allow waste plastic stretch wrap to be combined with other waste materials to form inexpensive and easily fabricated composite materials of potential use in building construction.

Industry Research and Development Board

Role *Through the operation of various programs, to facilitate wealth creation by the development of internationally competitive Australian industries; by the encouragement of successful innovation and improving Australian firms' awareness of the role of innovation in business growth.*

The Industry Research and Development Board was established on 1 July 1986 under the *Industry Research and Development Act 1986*. Under this Act the Board has responsibility for administering several innovation programs including the Tax Concession for Industrial Research and Development, Competitive Grants for Research and Development, and Concessional Loans for Commercialisation of Technological Innovation.

Innovation Programs

Program Effectiveness

According to the Australian Bureau of Statistics (ABS) survey of research and development, in 1994-95, Australia's Business Expenditure on R&D (BERD) increased by 10% in real terms to a record level of \$3.4 billion. BERD now represents 0.74% of gross domestic product (GDP) and comprises almost half of Australia's gross expenditure on R&D, which includes spending in all sectors and is currently at an all-time high of 1.60% of GDP. BERD, as a proportion of GDP, has trebled since the early 1980s, demonstrating that the Australian business sector increasingly recognises the importance of R&D as a key area for investment. This achievement is a significant measure of the success of the Board's programs and activities over many years.

Monitoring

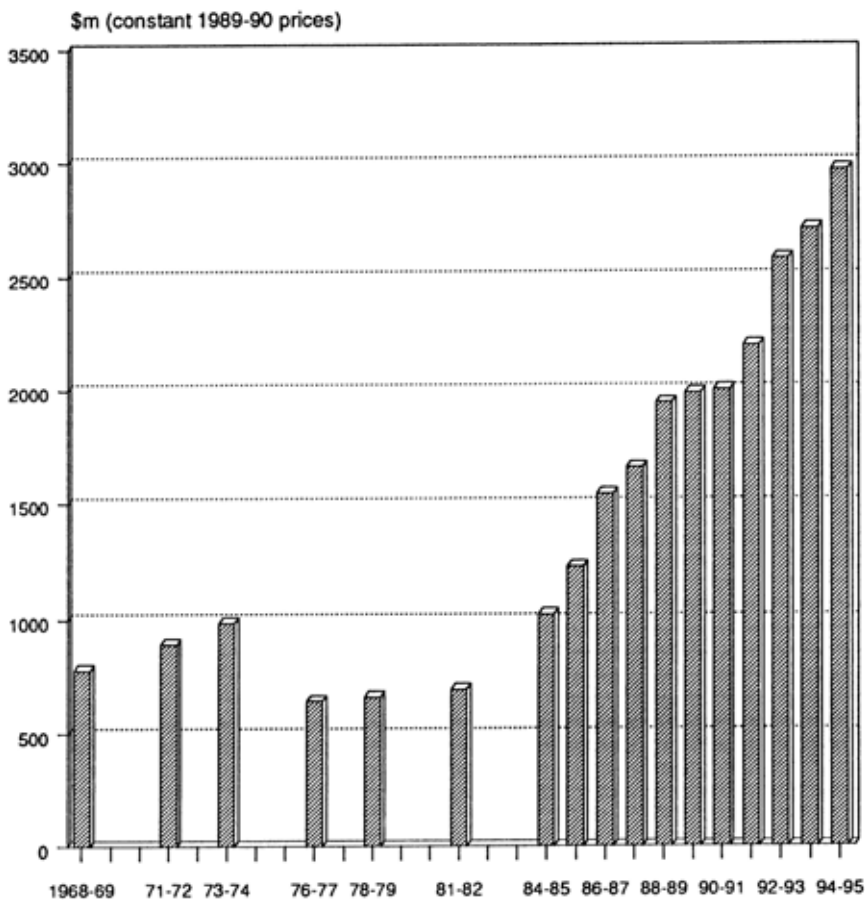
Over the past year, the Board has particularly focused on R&D syndication in the monitoring of activities under its programs. There have been improvements in investigation of applicants for R&D assistance, in promotion of changes to processes, and in adjustments to service levels and input to the process of internal review of R&D administration. In 1996-97, monitoring activity will also concentrate on applicants for the general tax concession, loans and grants. This move is aimed at increasing compliance with legislative requirements and promoting accountability. At the same time, the current level of services to clients will be maintained.

R&D Tax Concession

The tax concession for R&D is designed to encourage Australian companies to become more innovative and internationally competitive by increasing their R&D activity. The program is effectively market driven, being structured in a manner which is neither industry or product specific. This allows companies to determine both the area of innovation and the direction of their R&D activities. The tax concession will reduce from a level of 150% to 125%. See Section 2.

Figure 10

BUSINESS EXPENDITURE ON R&D



Source: DIST based on ABS data

On 3 June 1996 the Treasurer, Mr Peter Costello, and the Minister for Industry, Science and Tourism, Mr John Moore, jointly announced their intention to implement revenue protection measures foreshadowed in the former Government's *Innovate Australia* Statement of 6 December 1995, with some additional modifications to further improve the operation of the tax concession.

Further changes to the tax concession were announced in a second joint statement by the Ministers on 23 July 1996. This announcement was aimed at refining the definition of R&D to be covered by the concession and foreshadowed changes to be made in relation to interest on debt financing of R&D and costs associated with core technology, pilot plants, and feedstock.

These changes are to ensure that the use of the tax concession remains consistent with its aim of encouraging new R&D and to counter opportunities for companies to receive unintended benefits. The announcements foreshadowed the introduction of legislation to restrict registration to a period of six months after each year of income, with a one-off transitional period that required companies to lodge their 1993-94 and 1994-95 registration applications prior to 7 June 1996. These changes will also prevent applications being amended after the lodgement time for the application has expired.

As a result of the June announcement, there was a significant increase in applications for registration to over 5,600. This is double the level previously experienced. Two thousand of these applications were received in June 1996. Processing of these applications is still in progress. The tables below therefore do not include the 1994-95 figures and the figures for 1993-94, while included, understate the final number expected to be registered.

**Table 10 Registrations by number of applicants as at 24 June 1996,
by year of expenditure**

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	TOTAL
1985-86	17	961	1	247	158	38	683	194	2301
1986-87	13	753	2	192	101	26	426	123	1637
1987-88	17	894	3	241	125	27	584	142	2033
1988-89	16	891	2	261	139	34	596	147	2086
1989-90	16	958	3	308	141	36	627	172	2261
1990-91	18	1002	2	308	152	31	672	176	2361
1991-92	27	1052	3	337	157	28	719	181	2504
1992-93	24	1018	5	340	138	35	696	176	2432
1993-94p.	29	1016	3	372	137	32	737	172	2499
TOTAL	177	8545	24	2606	1248	287	5740	1483	20114

**Table 11 Registrations by \$ million of R&D expenditure as at 24 June 1996
by year of expenditure**

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	TOTAL
1985-86	0.0	60.1	0.0	16.0	0.0	0.8	18.2	0.1	95.2
1986-87	1.2	316.8	0.0	64.4	17.8	4.1	279.1	34.2	717.9
1987-88	3.0	493.8	0.1	111.3	30.9	7.5	385.3	44.7	1076.6
1988-89	3.9	532.3	0.0	121.1	33.8	11.5	497.6	64.3	1264.5
1989-90	3.8	554.2	0.0	171.4	48.4	10.6	670.4	86.2	1545.0
1990-91	4.5	642.7	0.3	270.0	66.7	8.9	966.7	107.8	2067.6
1991-92	8.0	676.5	0.5	237.3	68.2	8.8	1205.0	110.6	2314.9
1992-93	9.5	687.4	0.9	399.1	63.4	8.1	1054.0	124.5	2346.9
1993-94p.	10.1	708.9	0.4	374.3	63.3	19.0	1128.6	136.0	2440.8
TOTAL	44.0	4672.7	2.2	1764.9	392.5	79.3	6204.9	708.4	13869.4

R&D Syndication

R&D Syndication has aimed to encourage businesses to invest in R&D and innovative activity by supporting market-led innovation which, through the successful commercialisation of new products, services, processes and systems, leads to improved wealth generation.

New Finance Scheme Guidelines for R&D Syndication were introduced in 1995-96. A formal round of consultations was commenced in October 1995, with the issue of proposed draft guidelines. Over 100 submissions were received in the three week consultation period and a series of public meetings were conducted. As a result, the draft guidelines were substantially changed to accommodate most of the ideas put forward by the main

syndication promoters. The new guidelines were agreed by the IR&D Board and gazetted in November 1995. The primary objectives of the new guidelines were to provide a higher level of certainty to companies on the eligibility of their financial arrangements and to increase investor focus on the commercial potential of the R&D results, as opposed to returns through the taxation treatment. There were also specific measures to assist small and medium-sized companies.

The 1995-96 Budget had announced measures to exclude private tax exempt organisations from participating in guaranteed return syndicates. Legislation enacting this announcement was passed by the Parliament in December 1995.

Table 12 R&D registered syndicates

	Number of Syndicates	Value of Claims (\$m)
1989-90	7	192
1990-91	9	209
1991-92	22	370
1992-93	35	532
1993-94	31	346
1994-95	46	815
1995-96	62	857

On 23 July 1996, a joint statement by the Treasurer and the Minister for Industry, Science and Tourism announced the closure of Syndication to new applicants. In future, larger scale R&D - including some that formerly covered by R&D Syndication - will be supported through the new R&D Start Program. See Section 2.

Concessional Loans for Commercialisation of Technological Innovation

The Concessional Loans program is a competitive program which supports technological innovation in firms with up to 100 employees. Concessional Loans are provided for specified early stage commercialisation activities. All applications that meet the eligibility criteria are assessed on relative merit.

Recent Achievements

Cooling milk

Foley Nominees Pty Ltd received a concessional loan in February 1996 to develop and commercialise a low cost, rapid chilling system for milk. Processes used internationally normally take about 4 hours to cool milk, although it rapidly deteriorates unless it is cooled to 4 degrees Celsius. The loan has assisted Foley to complete the engineering phase of the vat production technology, move into advanced cooling systems, finalise production distribution arrangements, and promote the technology heavily in major market places. In particular, Foley is focusing on the Chinese market where a recent market push has resulted in several negotiations, including with breweries, which also require rapid chilling facilities.

Multi-folding ladders

Lofty Ladders Pty Ltd was awarded a concessional loan in April 1996 to assist in commercialisation of a multifolding ladder incorporating an innovative hinge and locking mechanism. The advantages include: its ability to lock and unlock easily, lighter weight, and a simpler manufacturing process requiring less metal usage. The loan will help Lofty Ladders to carry out trial production runs, refine its manufacturing process, meet standards requirements and conduct field trials. It is expected that the product will enter the Australian market in late 1996.

Competitive Grants for Research and Development

Grants for Research and Development provide support for a range of activities, including:

- market driven R&D in dynamic firms needing assistance but unable to use the Tax Concession for R&D;
- collaborative R&D activities, which are high risk but could provide extensive benefit to Australia;
- trial and demonstration activities between technology developers and potential customers; and
- collaborative R&D activity between industry and research institutions.

Recent Achievements

Superconductor wire

The University of Wollongong and the CSIRO Division of Applied Physics, in collaboration with Metal Manufactures Ltd, has been awarded a \$500,000 Competitive grant to develop high temperature superconductor wire. This technology can be used in existing power equipment applications such as motors, generators, cables, and transformers. It can be the enabling technology for new applications like magnetic resonance imaging in the medical industry. It can also be used for energy storage, either on a small scale for industry or a much larger scale for the supply industry. Forecasts indicate superconducting products will generate a global business of around \$150 billion within about 20 years.

Hearing aids

A grant of \$202,000 was provided to Cochlear Ltd to collaborate with a research institute on the development of a new hermetically sealed housing for the much acclaimed Cochlear ear implant which is used for those with severe to profound hearing impairment.

Bridge load capacities

Infratech is a small Brisbane company with international expertise on bridge infrastructures and proof loading. This company was awarded a grant to develop and commercialise a bridge monitoring system which tests the load capacity of bridges. Forecasts of the benefits of the development of this monitoring system are in the order of between \$10,000 and \$20,000 per ton of payload increase per vehicle per year, a potential saving of \$9 billion annually, resulting in a more efficient and cost-effective transport and road freight network.

Natural food colours

Arms International Pty Ltd was awarded a grant of \$118,000 for the development of natural pigmentation for food, ie dye products made out of 100% natural products. These products are currently used for egg yolk pigmentation and for the salmon industry. Tests are still being conducted for pearl oysters, abalone, prawns and tuna. Hoechst has joined Arms International to become the commercial side of the company. The first locally manufactured natural egg yolk pigmentor production facility has been set up in Braeside, Victoria. As a result, layer feed costs have fallen from \$14.50 to \$8.80 a tonne, enabling the replacement of imported stock feed. In another development, the Australian salmon industry has made a commitment to transfer 95% of their production of phaffia yeast to Arms International, with existing facilities to be modified. The pigmentation costs are 7.5% those of imported competitors.

PRIMARY INDUSTRIES AND ENERGY

Science and Innovation in the Portfolio Budget

The principal aim of the research and development programs operating within DPIE is to contribute to the efficiency and competitiveness of Australia's primary and energy industries and to the efficient and effective management of the resources on which they depend. Strong linkages with industry and relevant parts of Government, at both corporate and program levels, are essential to ensure that the structural and administrative arrangements for research and development facilitate these outcomes. 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 the R&D.

The two key institutional arrangements which influence the strategic and operational aspects of Portfolio research objectives and priorities are:

- three research bureaux, and
- fourteen Research and Development Corporations and five Research and Development Councils.

The institutional arrangements within the portfolio allow the key interests associated with the Portfolio's research effort including producers, scientists and Commonwealth and State Government policy and program managers an input into research priority setting. Funds from the R&D Corporations are allocated against these priorities with suitable research and development (R&D) agencies competing for the available funds.

Research Bureaux

The Department maintains three research bureaux:

- the Australian Bureau of Agricultural and Resource Economics (ABARE);
- the Australian Geological Survey Organisation (AGSO); and
- the Bureau of Resource Sciences (BRS).

The current structure of the Bureaux is aimed at ensuring that research, scientific support and resource related policy advice to Government is provided in the most efficient way and takes into account the interests of Australia's primary and energy industries and the broader community. The Department's Bureaux play a vital role in the conduct of public sector research and provide scientific and economic analysis to assist the process of Government. The research undertaken by these Bureaux is funded predominantly from consolidated revenue and totalled around

\$105.4 million in 1995-96. Research is generally directed to areas where the external benefits are high, at the more basic lines of research, in research that may have a wide social impact, and where user-pays funding is not generally cost-effective. In addition, the Bureaux undertake research on a contract basis for other agencies and industry.

R&D Corporations and Councils

R&D Corporations and Councils were established to encourage greater end user participation in research, to work with industry and research organisations to facilitate and actively pursue the commercialisation of research and the realisation of industry opportunities and to promote and become involved in technology transfer.

There are fourteen industry specific R&D Corporations and Councils:

- 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
- Meat Research Corporation
- Pig R&D Corporation
- Sugar R&D Corporation
- Wool R&D Corporation
- Dried Fruits R&D Council
- Honeybee R&D Council
- Tobacco R&D Corporation

Provision is made for Commonwealth funding of these bodies based on dollar for dollar matching of industry determined research levies up to a maximum of 0.5 percent of gross value of production (GVP) of the industry (up to 0.25 percent GVP matching and 0.5 GVP percent Government appropriation for the fishing industry). The Government's matching contribution is designed to provide an incentive for the primary sector to increase its R&D funding and to become more responsible for its own R&D priority setting.

Three other R&D Corporations in the Portfolio are predominantly funded by Government:

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

Funding of R&D by Government was judged as being appropriate for these Corporations as the private sector is likely to underinvest in R&D in these fields and substantial benefits could accrue to the community as a whole. These Corporations are, however, able to generate income from royalties and licences for successful R&D they have sponsored, to actively solicit funds to finance worthwhile research proposals, and to accept voluntary contributions from industry.

All of the Corporations and Councils report and are accountable to both industry and the Minister for Primary Industries and Energy. As a result, they are aware of, and responsive to, the needs of both industry and Government.

MAJOR RESEARCH ACTIVITIES

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

GIGABARE

GIGABARE is the next generation of a global macro-economic general equilibrium model known as MEGABARE. GIGABARE incorporates the following features: a linkage between policy changes and unemployment levels; substantially greater detail in the representation of key sectors; and an enhanced representation of the dynamics of technological change. It has a capability for projections and scenario analysis in many areas, eg. energy demand.

River environment modelling

A modelling system for analysing resource trade-offs in a multiple use river environment is being developed. The system makes use of modular optimisation and river flow networks to integrate physical and biological relationships which determine resource use options. Five models are used to

simulate the impact of alternative policy options such as environmental flow restrictions and water trading arrangements. The approach is being applied to rivers in Australia and overseas.

Bureau of Resource Sciences (BRS)

Role *To support the sustainable development of Australia's agricultural, mineral, petroleum, forestry and fisheries resources and their industries by providing high quality scientific and technical advice to government, industry and the community. BRS undertakes scientific analysis and reports on the status of the resources on which these industries depend, with special reference to trends in resource quantity, quality and distribution.*

Recent Achievements

Mineral resource assessment of Lake Eyre Basin

BRS completed a joint mineral resource assessment of the Lake Eyre Drainage Basin in South Australia with the Australian Bureau of Agricultural and Resource Economics and the Australian Geological Survey Organisation. This assessment was used in a process for selecting areas for possible 'World Heritage Listing'.

Oil and gas resources of Australia 1995

BRS published *Oil and Gas Resources of Australia 1995*. It is the definitive reference on the upstream petroleum industry in Australia, providing background information for advice to the Commonwealth Government. The information is also in demand by petroleum exploration companies, petroleum engineers and geologists, energy analysts, stockbrokers and share investors. Demand for this edition has been greater than for previous ones.

Monitoring

BRS provided regular and timely updates of maps and products of geographic information systems concerning the spread of rabbit calicivirus disease, outbreaks of papaya fruitfly, and locations of mineral and coal mines and associated facilities.

Agricultural land cover change and greenhouse issues

BRS initiated a Commonwealth-State program to monitor agricultural land cover change. It also developed a national soil carbon database to improve National Greenhouse Gas Inventory estimates of emissions due to soil carbon disturbance. BRS constructed the National Greenhouse Gas Inventory for livestock for 1987-94, and estimated the reductions in greenhouse gas emissions from Australian wheat cropping systems resulting from the use of management options such as stubble retention and zero tillage.

Food safety

The National Residue Survey monitored 22 commodities (13 meat and animal products, 1 horticulture and 8 grain commodities) in random surveys for over 50 chemicals. Two new targeted meat testing programs now meet particular monitoring needs for chemical residues that pose a potential risk to Australia's export markets. The results form the basis of advice, assurance and certification on residues to Australia's governments, industries and public, and to Australia's trading partners.

Exotic diseases of animals

BRS published the book *Exotic diseases of animals: a field guide for Australian veterinarians*. The publication provides comprehensive and concise information on the main exotic diseases of mammals and birds, and what to do in the case of a suspected outbreak. A copy was provided to every registered veterinarian and graduating veterinary student in Australia.

Australian Geological Survey Organisation (AGSO)

Role *AGSO is the national leader in geoscience mapping and information services, AGSO's primary mission is to build a vigorous, client-driven national geoscientific mapping effort to encourage economically and environmentally sustainable management of Australia's minerals, energy, soil and water resources.*

The outputs of AGSO's research underpin informed Government, industry and public decision making by satisfying client needs for high quality geoscience information and innovative research in relation to:

- developing more competitive and diversified Australian mineral and petroleum exploration industries;
- improving the management of Australia's natural resources consistent with the principles of ecologically sustainable development;
- developing effective strategies to mitigate natural geological hazards;
- achieving Australia's foreign policy and trade objectives; and
- fulfilling Australia's global and regional responsibilities in relation to geoscientific data.

Recent Achievements

New information for mineral explorers

The completion of high resolution geophysical surveys in the Broken Hill and Olary mineral provinces provided the minerals industry with new information that may assist in the discovery of new ore bodies in the Broken Hill region. This was part of the Broken Hill Exploration Initiative (BHEI), undertaken jointly with South Australia and New South Wales, with the aim of securing the future of Broken Hill, and potentially Port Pirie, beyond the life of the present mine.

Mineral potential of Georgetown region

The development of dating has enhanced perceptions of the mineral potential of the Georgetown region of North Queensland. This work established that some of the oldest rocks in the region are similar in age to the heavily mineralised sequence in the eastern part of the Mt Isa region (ie, 1650-1710 million years old).

Oils of WA report

A report on the *Oils of Western Australia* was completed and sold to seven companies, providing a significant risk-reducing product for the petroleum industry. The project which is part of the Oils of Australia project, a joint venture with GeoMark Research Inc, a US based company.

Combating salinity in the Murray-Darling Basin

The first inventory of natural lakes in the south west of the Murray-Darling Basin and their characteristics has been completed for the Murray-Darling Basin Commission. This work has enabled significant progress in combating salinity in the Basin by allowing selection of lakes suitable for disposal of excess saline waters.

Internet access to geoscience information

The Australian National Geoscience Information System was developed focusing on a set of prototype methods, using the Internet for more effective access to information. These methods include public query systems for databases and on-demand map production over the Web.

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 the dissemination, adoption and commercialisation of the results of research and development.*

The National Research Advisory Network, which comprises the Research and Environment Committee of the Australian Fisheries Management Authority and similar committees in each state and the Northern Territory, advises the FRDC on priorities for fisheries R&D and the relevance and priority of specific applications, thus minimising duplication and ensuring maximum returns on investment.

Recent Achievements

Marketing seafood

DPIE and the FRDC jointly funded a publication on names for fish and seafood in Australia. This publication has been recognised by both industry and government as a vital communication tool. It will greatly assist with market development and catch recording information in the growing \$1.7 billion Australian seafood industry.

Childhood asthma

The Institute of Respiratory Medicine at the Royal Prince Alfred Hospital conducted research into the relationship of regular fish consumption and the risk of childhood asthma. The study concluded that consumption of fresh, oily fish (such as mullet) was associated with a significantly reduced risk of asthma in children between 8-11 years old.

Improved prawn trawling equipment

Researchers at the NSW Fisheries Research Institute have designed and tested prawn trawling gear that greatly increases the environmental sustainability of trawling practices. This new gear reduces the take of unwanted fish and other marine organisms (by-catch) up to 90% for some species while increasing the catch of prawns by up to 14%. Many fishers in NSW have now adopted this new technology.

Grains Research and Development Corporation (GRDC)

***Role** The Corporation's primary goal is to invest in research, development and related activities to benefit Australian graingrowers, within a wider industry and community context.*

The GRDC is a statutory corporation funded jointly by a levy on graingrowers and matching Commonwealth contributions. There are 25 leviable crops spanning temperate and tropical cereals, oilseed and grain legumes, worth \$6 billion a year in farm production alone. The GRDC plans, develops and oversees research and development in the industries involved with these crops and their end products.

Recent Achievements

Barleys for better beer

Consumers prefer a stable foam on the top of their beer, but this is currently achieved via chemical additives. As this is seen as undesirable, GRDC-supported research is pinpointing naturally occurring barley varieties, with high levels of foam-positive proteins. Proteins important for foam stability have now been purified and it is intended that test kits will be produced in the future to enable barley breeders to measure the amount of foam-positive proteins in their breeding lines. As well, the research is contributing to a benchmarking strategy for reversing setbacks in international markets over the past decade. Australian malting barley varieties have been benchmarked against commercial barleys grown in Canada, USA, England and New Zealand. Among the Australian varieties, Arapiles and Tallon exhibited the highest quality, performing as well as, or better than, the overseas varieties. The continuation of this benchmarking study is considered a high priority by the Australian malting barley industry.

Heartening news

Promotion of the nutritional benefits of Australian oilseeds is the subject of joint research by the GRDC and Meadow Lea Foods Limited. Human subjects with canola oil rich diets showed decreased blood platelet aggregation and this may reduce the risk of heart disease. Other results with patients suffering from non-insulin diabetes indicate that a canola-based diet improves the action of insulin. This research could have implications in areas such as the manufacture of infant formula.

Russian defence

The Russian Wheat Aphid is a major problem in the wheat growing areas of North America, South Africa and West Asia. If it were to spread into Australia, it could be devastating to the wheat industry because environmental conditions in Australia are conducive to its rapid development and dispersal. International collaboration between the research centre CIMMYT in Mexico and the Plant Breeding Institute at Narrabri, NSW has been established. Through this work, resistance to the aphid is being transferred to Australian wheat cultivars and advanced lines from all major breeding programs and for all market grades. This program provides a cost-effective method of minimising losses to Australia's wheat crop should the aphid spread to Australia.

Information marketing

Grains research has, over the past five years, encouraged more than two-thirds of Australia's 60,000 graingrowers to adopt new farming practices or change their grain varieties. About half say that they have changed their practices because of research findings in the past two years. This trend in technology adoption has been verified in two successive, independent surveys of graingrowers carried out for the GRDC by TQA Research Pty Limited. Changes in farming practices occurred more in the

Western and Southern Regions. Farmers in the northern grains region (northern New South Wales and Queensland), who have been strongly influenced by drought, remained less prone to change.

The GRDC provides information to graingrowers of new developments through its research newspaper, Ground Cover. In addition, the GRDC has held seminars for several hundred professional farm advisers in the private and public sectors across the southern and western States during which researchers and marketers brought them up-to-date with the latest key research information. Through TOPCROP Australia, an integrated information marketing program, farmers were provided with access to the latest technology. In addition, farmers' needs were made more clearly known to researchers which gave farmers an opportunity to become involved in other programs such as property management planning. Backed by a national database of some 10,000 paddock records, TOPCROP Australia analyses farmer data and returns 'report cards' to growers. This enables them to compare their performance against district best practice, yields and profitability.

Grape and Wine Research and Development Corporation (GWRDC)

***Role** To improve the production efficiency, the competitiveness in domestic and international markets and the profitability of the Australian grape and wine industry, by managing and funding a research and development program to reduce production costs and improve product quality and purity.*

Recent Achievements

Grapevine identification

Following an extensive research project undertaken via CSIRO - Horticulture, a commercial service is now being offered to identify grapevines based on DNA. This is a world first, and supports industry commitment to quality assurance and validation of winegrape and wine variety. The service offered is a joint venture by CSIRO and the Australian Wine Research Institute and allows grapevine material to be accurately identified from cuttings import, through nursery propagation, vineyard planting to the end of wine fermentation.

Improved disease and pest management

The Corporation has been an important investor in the recently released publication, Grape Production Series Number 1 *Diseases and Pests*. This publication provides a complete overview of grapevine diseases and pests in Australia and New Zealand, and was compiled with input from specialists in each country.

Biological control of grape caterpillar

An Australian native insect, Light Brown Apple Moth is an important pest of the grapevine. Improved biological control against this pest is likely from research undertaken at the Institute for Horticultural Development, Knoxfield. The research has shown that the bacterium, *Bacillus thuringiensis*, produces a natural insecticide which is effective against the caterpillar precursor of the moth. However, the bacterium is less effective on grape leaves than on most other plants. Modified formulations are being supplied to the market to be used in conjunction with improved timing and application of treatments. This will result in greater grower confidence in biological control and less use of synthetic, broad spectrum insecticides

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 industry.*

Recent Achievements

Watercheck

Watercheck is the name given to an industry-wide project to increase the adoption of efficient, sustainable irrigation practices by Australian canegrowers. In the Burdekin and Mareeba districts of north Queensland, irrigation scheduling using evaporation minipans received wide acceptance, with over 130 minipans used in 1994-95. Results indicate that sugarcane yields were increased by up to 10% from improved scheduling while water use decreased by up to 47%. Water usage was also found to be reduced through management practices such as modified furrow shape, minimum tillage, and matching irrigation cut-off time to soil and field characteristics. For example, modification to furrow shape alone reduced water application by 45%.

Dried Fruits Research and Development Corporation (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*

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

Recent Achievements

Sub-surface slotted pipe irrigation system

The development of the slotted pipe irrigation system by the CSIRO Division of Horticulture enables the inexpensive conversion of flood/furrow irrigated vineyards to a controlled irrigation system utilising slotted drainage pipe buried just beneath the soil surface. The rapid uptake of the system by industry is due to the following benefits: minimal installation cost; water supply not requiring filtration or pumping; the elimination of tractor work for soil cultivating and preparing for furrow irrigation; the application of water beneath the soil surface reducing evaporation losses, weed growth, disease promoting humidity, and enabling tractor access for the application of disease and pest control sprays. In addition to viticulture, the technology is also being taken up in tree, vegetable, and perennial row crops such as cotton, and asparagus. The technology is having a significant impact on the efficient use of the nation's water resource.

Land and Water Resources Research and Development Corporation (LWRRDC)

***Role** To provide national leadership in utilising R&D to improve the long-term productive capacity, sustainable use, management and conservation of Australia's land, water and vegetation resources. The corporation will establish directed, integrated and focused research and development programs where there is clear justification for additional public funding to expand or enhance the contribution of R&D to sustainable management of natural resources.*

Recent Achievements

Land use management

A Catchment Management Support System has been developed by the CSIRO Division of Water Resources. The System is based on known levels of nutrient exports associated with different types of land use. For example, dairying, intensive horticulture, extensive grazing, and urban development. Using a map of existing land uses within a particular catchment, the System enables planners and catchment managers to predict the likely effects of changes in land use and other management actions (for example, construction or closure of sewage treatment plants) on the levels of

phosphorus and nitrogen in the catchment's river system. This information can in turn be used to predict likely impacts on water quality and the growth of blue-green algae.

Revegetating wetlands from seedbanks

Research at the University of New England showed that seed of many wetland plants is stored in soil seedbanks, sometimes for considerable periods even when adults of the species have not been present for some time. Different species have different soil moisture requirements for germination and establishment. By manipulating the water level in farm dams and ephemeral wetlands it is possible for managers to re-establish wetlands, vegetation cheaply and easily. A handbook is in production to explain in practical terms how to assess the seedload in wetland soils, identify potential weed problems, and work out how water level can be managed to optimise germination and re-establishment.

Altering property boundaries for improved sustainability

In many closely-settled areas, current property boundaries are often in neat sections of a square mile. This makes it more difficult to implement landcare initiatives because there are particular landscape components which need special management and they may be shared between several adjacent properties. Joint action through Landcare groups has gone some way to overcoming this problem. A joint project between LWRRDC and Rural Industries RDC supported the Queensland University of Technology in examining another possibility, based on the costs and benefits of realigning property boundaries to provide a better fit with the local landscape. Despite the obvious difficulties and costs in boundary realignment, the farmers involved in this research identified substantial potential benefits and there is a growing interest in examining changes to property boundaries to improve both economic and ecological sustainability.

Assessing potential for groundwater pollution

A computer model that can help assess the risk of pollution of aquifers and groundwaters from particular land uses has been developed by scientists from New South Wales, South Australia, Western Australia, and the CSIRO. The model uses groundwater salinity as a general indicator for vulnerability to pollution, and highlights the risks of using pesticides and other potential contaminants in rural and peri-urban environments. The model can predict the likely long-term impact of particular industries, especially intensive industries, within a region. It can also identify preferred sites for potential point sources of contaminants, for example, processing factories.

Improved management of pesticides by the cotton industry

A major program of research funded jointly by LWRRDC, the Cotton Research and Development Corporation and the Murray-Darling Basin Commission, is examining how the cotton industry can minimise any environmental effects. This project has attempted to track pesticides from the moment they leave the spray-nozzle until their ultimate degradation within the environment. The impact of management practices were also considered, for example, altering furrow length and shape, retention of

surface trash, use of water retention basins, and the impact of storm events. The data from this extensive program is now being brought together through the development of a best practice manual for use by the industry.

Energy Research and Development Corporation (ERDC)

Role *To stimulate and facilitate investment in effective energy innovation for Australia.*

ERDC's objectives for its investments are to increase the

- efficiency of energy use and supply;
- development of competitive Australian industries; and
- diversity of energy supply options

while reducing

- the environmental impacts of energy use and supply;
- the need for energy through proper design; and
- customers' energy costs

ERDC was established in 1990 to facilitate and stimulate effective energy innovation for the benefit of Australia. It has an annual appropriation of approximately \$12 million. At the end of 1994-95, ERDC was managing investments valued at \$50 million in 139 projects whose total cost is \$174 million.

Since its establishment in July 1990, ERDC has committed \$76 million to innovation and research projects whose total cost is around \$328 million.

Recent Achievements

Car pooling/ride sharing project

The ERDC project conducted by Melbourne company, Dynamic Transport Management has developed a low cost, convenient and flexible transport alternative. The Easy Share car pooling scheme is an innovative approach to car pooling or ride sharing, and uses the latest in technology to enable instant trip matching at any time of the day or week. This system helps to solve the low car occupancy rate, conserve energy and reduce transport costs.

Wool insulation

With assistance from the ERDC, Higgins Wool Company was able to develop a new method of manufacture of wool insulation products that met industry standards for fire retardance and insect resistance. The new product range

has been in production since February 1995. The Company has recently filled an acoustic market niche with acceptance for the Sydney airport project to insulate 4700 houses against aircraft noise.

Forest and Wood Products Research and Development Corporation (FWPRDC)

Role *The Corporation has defined its purpose as being to promote effective Research and Development which advances an internationally competitive, sustainable and environmentally responsible forest and wood products industry in Australia.*

Recent Achievements

New sawmill design

Value adding and increased profitability were the motivators for two country sawmillers to develop a new generation of sawmill design. A major feature is the flexibility of the design which can be built to suit virtually any individual sawmill's requirements, and can cut both hardwood and softwood. The mill design is compact and is easily and efficiently operated using new electronic and hydraulic control systems. The waste system, which runs beneath the entire length of the mill, incorporates a system to separate sawdust from solids.

Biodurable particleboard

It has been found that the termite and fungal resistance of particleboard can be increased significantly using a mix of white cypress and radiata in particleboard manufacture. The level of resistance is measured with various combinations of cypress and radiata. In addition, the physical properties are measured to determine if the cypress has any detrimental impact. In all cases the physical properties of the board exceed levels required for flooring grade.

Meat Research Corporation (MRC)

Role *To deliver and manage customer focused, research based initiatives and translate them into benefits for individuals and industry.*

The MRC was established in 1985 as part of a restructuring of the meat industry. The Corporation funds and manages research, development and adoption of innovation in the cattle, sheep and goat sectors of the industry. It is funded jointly by levies on livestock producers and meat processors.

These funds are matched by the Federal Government. Expenditure in 1996/97 will be approximately \$50 million. In late 1995, the Corporation commissioned three independent assessors to analyse the economic performance of the Corporation over the last five years and project any ongoing benefits to the Meat Industry and the general community. The assessors estimated that from January 1997, there will be an annual return to industry of just under \$300 million for a single five year investment of \$131 million. This represents a seventeen fold return on dollars invested. This is without including less measurable benefits, including public benefits, which the assessors considered conservatively to be another \$300 million.

Recent Achievements

Biological Control of the weed St John's wort

A network of weed officers and Landcare groups has distributed throughout South Eastern Australia a European mite that is active against the weed known as St John's wort. Results indicate the mite is reducing St John's wort vigour by up to 80% throughout the area.

Feedlot sire evaluation scheme

With the support of nine commercial feedlots throughout Eastern Australia, the MRC investigated the reasons behind the high variability that exists in the performance of steers in a feedlot. It was shown that genetic variation both within and between breeds played a major role in determining profitability. There was a difference of \$210 per head between the top and bottom 5% of sires.

Video Image Analysis

Woolworths in Queensland has adopted the MRC Video Image Analysis (VIA) to estimate saleable meat yield, meat colour and fat levels. Payments to graziers are now based on these factors rather than carcass weight. Since adopting the Meat Research Corporation retail cut version of the VIA system, QANTAS Flight Catering, which supplies meals to nearly thirty airlines nationally, has recorded a 90% reduction in customer complaints about red meat.

Pig Research and Development Corporation (PRDC)

***Role** To achieve a profitable, world competitive and environmental sustainable Australian pig industry which maximises returns on research and development funds through programs consistent with stakeholder and market priorities.*

Recent Achievements

Farrowing manual

A publication and video on farrowing was requested by pig producers and has been the Corporation's most successful module to date. The manual contains the latest knowledge on how to achieve high piglet survival, rapid piglet growth and sows in good condition at weaning in preparation for mating.

Asian smallgoods

It is predicted that within 20 years 25% of the Australian population will be of Asian origin. With this potential, PRDC believes the pig industry must capture market opportunities in Australia and also in Asia. PRDC funded research at the University of Western Sydney to provide a thorough understanding of value-added pork products preferred by Asians. The university has a well equipped pilot plant which allows production of many forms of Asian smallgoods. The final report of the project has been enthusiastically received by smallgoods processors and paves the way for further research, understanding and movement into this lucrative market.

Cotton Research and Development Corporation (CRDC)

***Role** CROC's mission is to increase the contribution that R&D makes to the well-being of the cotton industry and the community in general. Its major goals are to: develop efficient, sustainable production systems, to improve fibre quality to better meet market needs, and to develop efficient handling, transport and marketing systems and infrastructures.*

In pursuit of these goals, the Corporation has identified the following major objectives:

- Reduce chemical protection of crops against pests, diseases and weeds;
- Develop, and have adopted, environmentally sound, sustainable farming practices;
- Develop new, improved cultivars;
- Reduce post-harvest costs and better meet market requirements;
- Maintain the effectiveness of the R&D effort;
- Improve the transfer of technology; and
- Improve and support human involvement in the R&D effort.

Recent Achievements

Envirofeast - a new tool for integrated pest management

Funding of a NSW Agriculture project has led to the development of a food spray that encourages beneficial insects to enter and remain in cotton fields. An Integrated Pest Management (IPM) system has shown that chemical pesticide use can be reduced by up to 90%. This itemised system uses the food spray and lucerne strips within cotton fields as a beneficial insect refuge, combined with cotton pesticides. NSW Agriculture has entered an agreement with Rhone_Poulenc to develop the food spray, known as Envirofeast, into a commercially available product for use in cotton and other crops in Australia and overseas.

The cotton pest and beneficial guide

In response to new developments such as Envirofeast and pest resistant transgenic cotton varieties nearing commercial release, cotton growers and field consultants will need to accurately identify the pests and beneficials in their crops. The CRDC has developed a pest and beneficial guide for cotton in collaboration with the Centre for Tropical Pest management in Brisbane.

Rural Industries Research and Development Corporation (RIRDC)

***Role** To manage research and development investments on behalf of government and industry for the benefit of the people of Australia.*

The Corporation organises and funds research to support small, prospective and emerging rural industries such as honeybee, chicken meat, egg industry, rice, horses, Asian foods, spices and herbs, wildflowers, deer and animals and plants.

RIRDC also addresses broader issues which affect most, if not all, agricultural industries such as agroforestry, agribusiness, extension, sustainable agricultural systems and climate change. The Corporation provides services for the semi-independent Dried Fruits Research and Development Council.

Recent Achievements

Combating secondary salinity

Australia has approximately 32 million hectares of saltland of which approximately 1.5 million hectares is secondary salinity, caused by farm practices on productive land. A further 3 million hectares of productive land is considered to be 'at risk'. Secondary salinity makes a \$100 million annual

dent in Australian farm production. Two projects examined what farmers should plant on salt-affected land to maximise the land for grazing purposes and to help rehabilitate it. One project, conducted by the Western Australian Department of Agriculture, examined the range of plants suitable for growing on saltland where annual rainfall is below 600 millimeters. The report found that a wider range of saltland plants should be sown together with the mix of species depending on the site. The results of the project are summarised in the book *Saltland Pastures in Australia*.

A second project resulted in the publication *Trees for Saltland: A Guide for Selecting Native* species for Australia. This will help landholders, Landcare groups and others decide which native trees to plant to manage saline discharge areas.

Dairy Research and Development Corporation (DRDC)

Role *The Dairy Research and Development Corporation's mission is "to lead effective change through excellence in R&D for a profitable and sustainable Australian dairy industry".*

To realise this mission, the DRDC has identified three key objectives:

- Increase industry competitiveness and profitability;
- Improve the social and environmental sustainable dairy
- Achieve efficient use of R&D resources

Recent Achievements

Johne's Disease

Johne's disease is estimated to cost the Victorian dairy industry \$4.3 million annually. As Johne's disease is an important issue for the dairy, meat, sheep, wool and alpaca industries, a National Johne's Disease Program was established to co-ordinate activities across industries. A market assurance program was launched in 1996 to enable farmers to source livestock from herds identified as having a low risk of Johne's disease infection. This is a voluntary, user-pays scheme which allows breeders to test their animals and gain recognised herd status.

Disposable plastic bags from whey

Researchers at the University of Adelaide are using genetically engineered bacteria to convert lactose in whey into a biodegradable plastic. Commercial production of the plastic could help solve some of the problems associated with disposal of normal plastics. Tiny granules of the plastic are recovered from the bacteria.

Better tasting yoghurt

Scientists at CSIRO's Division of Food Science and Technology used milk powders to improve the texture of yoghurt. They identified strategies to improve texture using fewer milk solids and more whey solids which reduce the cost of ingredients. They are also developing ways to produce milk powders with consistent performance in sweetened condensed milk.

Creamier icecream

Reseachers are developing creamier, smoother icecream which is less likely to melt. One of the biggest problems associated with ice-cream is constantly fluctuating temperatures which can cause it to melt, then re-freeze, making the texture of the final product icy rather than creamy. Dairy ingredients and stabilisers are being tested for their ability to reduce the problems associated with ice-cream melting during storage and handling. Different combinations of ingredients such as casemate, whey protein concentrates, whey powders and skim milk blends are being used in a small scale pilot plant. The project is in its early stages, but is expected to have valuable commercial applications.

Nutritional dairy products

Researchers at the University of Melbourne found that young children given a diet rich in dairy foods may be less likely to suffer from osteoporosis in later life. Although osteoporosis is most common in older women, its severity may be reduced by building high bone density levels early in life. Calcium plays an important role in this process and this project is investigating the benefits of calcium supplementation on twin girls. It was thought that peak bone density needed to be achieved by 30 years of age but this project found that it could be as young as age sixteen.

Scientists at Monash University found that some milk and yoghurt components may help treat ulcers and other stomach complaints caused by the bacteria *Helicobacter pylori*. Laboratory studies have shown that certain milk and yoghurt components have a marked ability to act against the bacteria. *Helicobacter* is the most common bacterial infection in the world, causing peptic ulcers and having a role in gastric cancer. Milk might hold the key to a safer, cheaper and more effective treatment than is currently used with antibiotics which have undesirable side effects.

Tobacco Research and Development Corporation (TRDC)

Role *The TRDC is a national organisation responsible to its stakeholders (industry and Government) for planning, funding and managing research and development programs applicable to tobacco leaf farming. It has a strong focus on facilitating the adoption of research and development by tobacco farmers, and in fostering ecologically sustainable farm practices.*

The TRDC is guided in its R&D planning by both industry and Government stakeholder input on industry and community R&D objectives and priorities.

Recent Achievements:

Nutrition improvements

Best practice principles and farm management technologies are being adopted by the Victorian tobacco industry. Manufacturers have indicated that, in the deregulated environment, growers need to focus on improving leaf quality. This particular project aims to improve the quality of Victorian tobacco leaf. Preliminary trial work is fast tracking greenhouse technology for Victorian conditions. One objective of the work was to prove that water heating could impact on seedling germination and rate of plant growth in a greenhouse situation. The greenhouse trial work produced rapid and positive results with the successfully trialed nutrition procedure adopted by all greenhouse growers in the 1995 float season.

TRANSPORT

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 Federal Office of Road Safety, transport sector research by the Bureau of Transport and Communications Economics, the Australian Road Research Board and the Department of Transport's involvement in the introduction of Intelligent Transport Systems into Australia. Expected expenditure outcomes are \$4.4 million for 1995-96 and estimated \$4.2 million for 1996-97.

MAJOR RESEARCH ACTIVITIES

Federal Office of Road Safety(FORS)

Role *To undertake relevant and timely research and associated services to help the land transport sector in Australia provide safe, sustainable, efficient and effective transport services.*

The Federal Office of Road Safety (FORS), in its role as the Government's adviser on national road safety policy, 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

Heavy vehicle standards

FORS carried out a research program to investigate the feasibility of introducing a heavy vehicle cab strength standard in Australia, based on the standards applying in the United Nations Economic Commission for Europe or Sweden. The program included a literature search, review of crash statistics and computer simulation of a truck cab subjected to the impacts specified in these two standards.

Research was carried out on the development of deformable barrier for trucks. The program involved engaging a consultant to prepare a suitable design and a series of crash tests were carried out using a large passenger car impacting the deformable barrier at a speed of 48km / hr both in a full frontal as well as in an offset engagement of the front of the car.

Vehicle Emission Standards

Air pollution from motor vehicles is a major community concern. While emission standards introduced in recent years have resulted in a gradual improvement in urban air quality, further improvements were thought to be achievable from maintaining the emission performance of a new vehicle during its life. A major national study of In-Service Vehicle Emissions was published in May 1996 which gathered data on the car fleet and the potential for improvements to emissions from regular maintenance. Further research is being done on a pilot program with the New South Wales Government to put the findings of the study into practice.

Further research is also being done on investigating reasons for catalyst failure and for the high evaporative emissions found in the study. New emission standards for diesel vehicles have now taken effect. New emission standards for petrol vehicles will take effect between 1997 and 1999.

Australian Road Research Board (ARRB)

Role *The Australian Road Research Board (ARRB) is the principal centre for road and related transport research in Australia. It is a non-profit public company which was established in 1960.*

Its members comprise the eight State and Territory road transport and traffic authorities, the Federal Department of Transport and the Australian Local Government Association. It has an annual budget of some \$10 million of which the Federal Department of Transport currently contributes \$2.2 million annually.

Recent Achievements

Rough roads

A new instrument has been developed for collecting data on pavement roughness related to vehicle speed. The instrument is known as a 2-Laser Profiler and offers local government authorities the means to obtain information on the roughness of their road networks relative to world standards.

Bureau of Transport and Communications Economics (BTCE)

Role *To assist policy development and informed public debate on transport and communications issues through relevant, high quality and timely research.*

Recent Achievements

Greenhouse gases

The BTCE has undertaken research into greenhouse gases with funding allocated from the National Greenhouse Research Program. This research has developed long-term forecasts of greenhouse gas emissions from the Australian transport sector. Three working papers were published by the BTCE in early 1996 providing information on the costs of implementing abatement measures to the year 2015. A final report is to be published in October 1996 giving costs for about 16 separate measures.

This Statement was prepared by the Science and Technology Analysis Section, Department of Industry, Science and Tourism, 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 on (06) 276 1696.

Australia is one of the most inventive countries in the modern world.

This is illustrated by the prolific list of publicly funded scientific and technological achievements presented in this *Statement*. These achievements reflect the vision, talent and diversity of the Australian research community and profoundly affect the quality of all Australians' lives.

Our imagination has been captured with accomplishments such as CSIRO's Parkes telescope tracking NASA's Galileo spacecraft, now orbiting and observing Jupiter. This tracking forms the largest project in the telescope's 30 year history.

In health research, the gene causing skin cancers, and the trigger responsible for cells blocking arteries, have been discovered. Health researchers have also started mapping the living brain.

In resource industries, new archival tags have been developed to pinpoint fish populations anywhere in the world. These are now monitoring our very valuable stocks of the Southern Bluefish Tuna.

Our sporting prowess has benefited from innovations such as the aerospace bicycle frame developed for the national cycling team and the pre-cooling jacket for athletes.

It is important to raise Australians' awareness of the important contribution by science and technology to economic and social wellbeing. 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:

Crystals of neuraminidase from an avian influenza virus. Research on this virus aimed at developing an effective drug for the treatment of influenza, and led to the award of the 1996 Australia Prize. The colourless crystals were photographed in brightfield with coloured filters.

Photograph courtesy of the Australian National University.



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