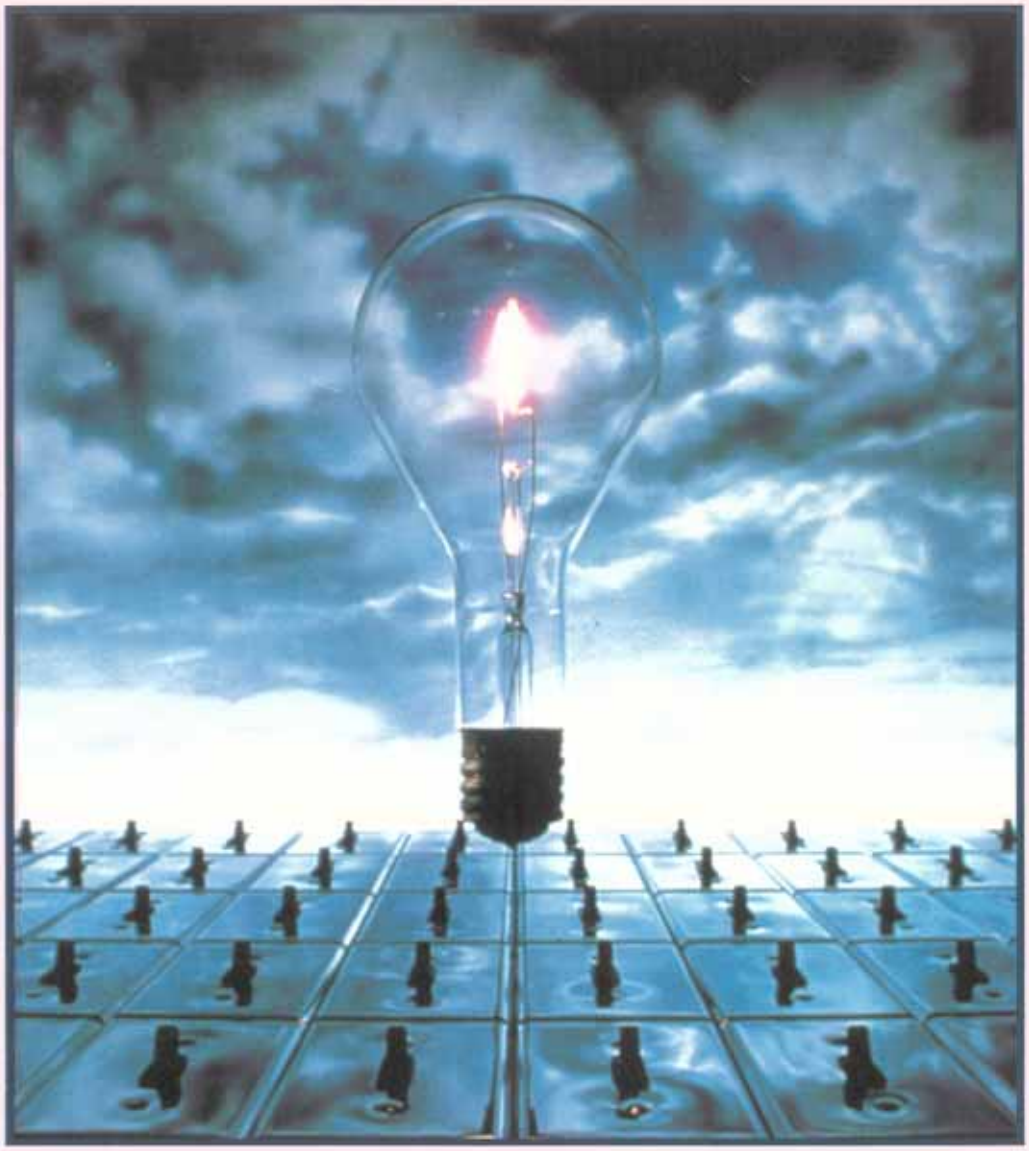
Science and Technology Budget Statement 1993-94



Senator the Honourable Chris Schacht
Minister for Science and Small Business
Minister Assisting the Prime Minister for Science

SCIENCE AND TECHNOLOGY BUDGET STATEMENT 1993-94

CIRCULATED BY
SENATOR THE HONOURABLE CHRIS SCHACHT
MINISTER FOR SCIENCE AND SMALL BUSINESS
AND MINISTER ASSISTING
THE PRIME MINISTER FOR SCIENCE

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HIGHLIGHTS

Commonwealth support for major programs of science and innovation is expected to reach over $3.1 billion in 1993-94, a rise of 1 per cent in real terms achieved in difficult economic circumstances.

Sustained Government support for these activities over the past decade is achieving a substantial cultural shift. There is much evidence that Australian business is rapidly transforming and becoming innovative and outward oriented. At the same time, Australia's excellent public sector researchers are becoming more attuned to the needs of the community, to market requirements, and to commercial possibilities.

This has been achieved through a range of Government actions. Since 1985, a generous tax incentive for industrial research and development (R&D) has provided over $2.2 billion to boost innovation in industry. Support in 1993-94 is estimated to be $368 million and will be complemented by the reduction in the corporate tax rate, which should free further business funds for productive investment in areas such as R&D.

In the public sector, improved linkages and interactions are seen as a key means to build on and extend our national research strengths. The Co-operative Research Centre (CRC) Program is a key mechanism. In 1993-94, expenditure on the CRC Program will increase by over 100 per cent in real terms, to $94 million. Over sixty Centres are expected to be operating within two years.

The discoveries, advances in understanding, improvements in technique, and steps in commercialisation from Australia's publicly-funded research are impressive:

- Researchers from the University of Technology, Sydney can pipe daylight into buildings like water. This offers the prospect or significant energy savings.
- The University of New South Wales, with funding from the Energy R&D Corporation, has achieved a world lead in high efficiency silicon solar cells. Low cost cell production technology based on this advance has been licensed through Unisearch to several major solar cell manufacturers.
- CSIRO has developed a process for extracting over 90 per cent of the cholesterol content of egg and dairy products. An Australian company has a licence for the technology and negotiations are proceeding for overseas licensing agreements.
- Other CSIRO researchers have collaborated to create a mainland sanctuary in Western Australia which will permit the re-establishment of up to six species of endangered mammals.
- Following support from the Industry Innovation Program in its initial stages, the "smartcard" ticketing system developed by ERG Australia Ltd achieved a sale worth $26 million to a Manchester (UK) public transport authority.

SUMMARY NOTES

SUPPORT FOR SCIENCE AND INNOVATION IN 1993-94

In 1993-94, Commonwealth support through major science and innovation programs is expected to rise by 1.1% in real terms to reach $3121m ($3017m in 1992-93).

Funds under the control of the Australian Research Council (ARC), directed to supporting university research, have risen to $293m ($263m in 1992-93). This represents a real increase of 9%. Total funds for university R&D are estimated to rise by about 5%.

Since the mid 1980s, substantial funds have been provided to support industrial R&D and innovation, which are key factors in improving competitiveness. Australian business R&D has been shown to be at low levels relative to other OECD nations. 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 $496m in 1993-94, a real decrease of 15%. For 1992-93, the support had been boosted by a one-off payment of $30m allocated to establish the Australian Technology Group Pty Ltd. The major component of the decrease is an estimated reduction in revenue forgone through the industrial R&D tax incentive, which decreases to $368m from $415m because of the change in the corporate tax rate. However, the improvement in the after-tax position of companies as a result of the change in the rate, should free some further funds for R&D.

There has also been concern on the level and effectiveness of interaction between industry researchers and those in government agencies and higher education. The Cooperative Research Centre (CRC) Program is addressing this problem and funding rises this year by 103% in real terms, to $94m. Over sixty CRCs will be in place within two years.

Specific purpose R&D grant schemes (support for rural R&D, the National Health and Medical Research Council grants, other health R&D and the smaller R&D grant schemes) together rise to $285m (up 6% in real terms).

Appropriations to the major research agencies will increase to $935m in 1993-94 from $921m in 1992-93. Excluding defence R&D, the increase is to $705m from $690m. These figures represent no real change for the civilian research agencies and a 1% decrease overall. Budget support for CSIRO will rise to $469m and the Organisation's external earnings will bring its total budget to the region of $685m.

While there is a natural focus on financial inputs, 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

	1992-93 $m outlays	1993-94 $m est.	Real change
AUSTRALIAN RESEARCH COUNCIL[1]	260.0	290.0	+ 9%
OTHER HIGHER EDUC. R&D	959.9	1020.3	+ 4%
CO-OPERATIVE RESEARCH CENTRES	45.3	94.2	+ 103%
INDUSTRY R&D & INCENTIVES[2]	568.9	495.6	- 15%
RURAL R&D	103.8	116.5	+ 10%
NH&MRC	110.3	118.5	+ 5%
OTHER HEALTH R&D	22.4	23.9	+ 4%
OTHER R&D GRANTS[3]	25.7	26.5	+ 1%
CSIRO[4]	464.1	468.8	- 1%
DSTO	231.4	230.7	-3%
OTHER R&D AGENCIES	225.5	235.9	+ 2%
TOTAL	**3017**	**3121**	**+ 1.1%**

NOTE: Outlays are at current prices, the real changes shown are based on constant price estimates.

1 Represents total of Budget and HEF Act funding.

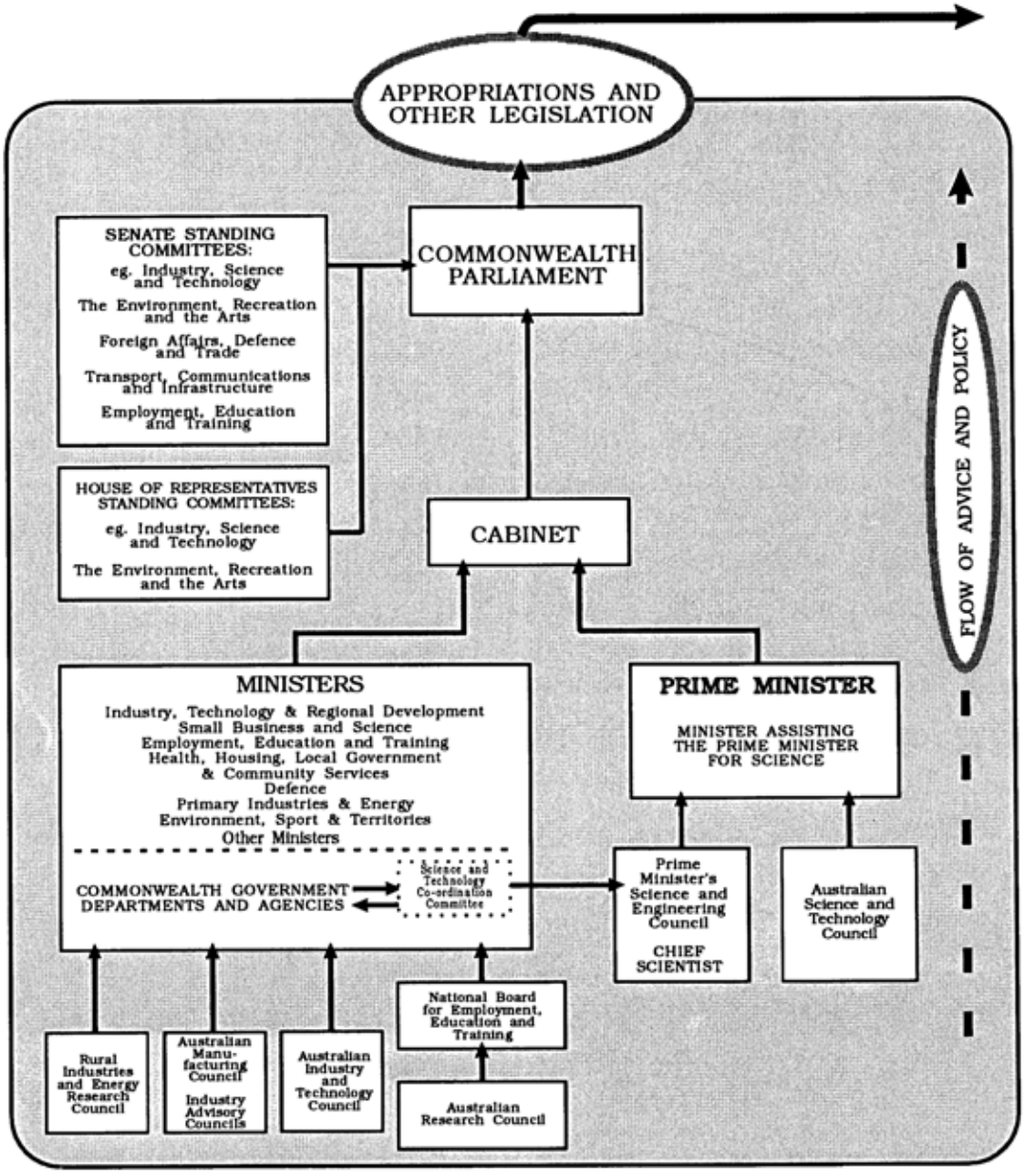
2 GIRD grants plus estimated effect of revenue foregone via the IR&D tax concession scheme

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 and through DIT&RD for the Kraft Pulp Mill study

For more detailed information see Tables 2 to 6

MAIN CHANNELS OF ADVICE
FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY

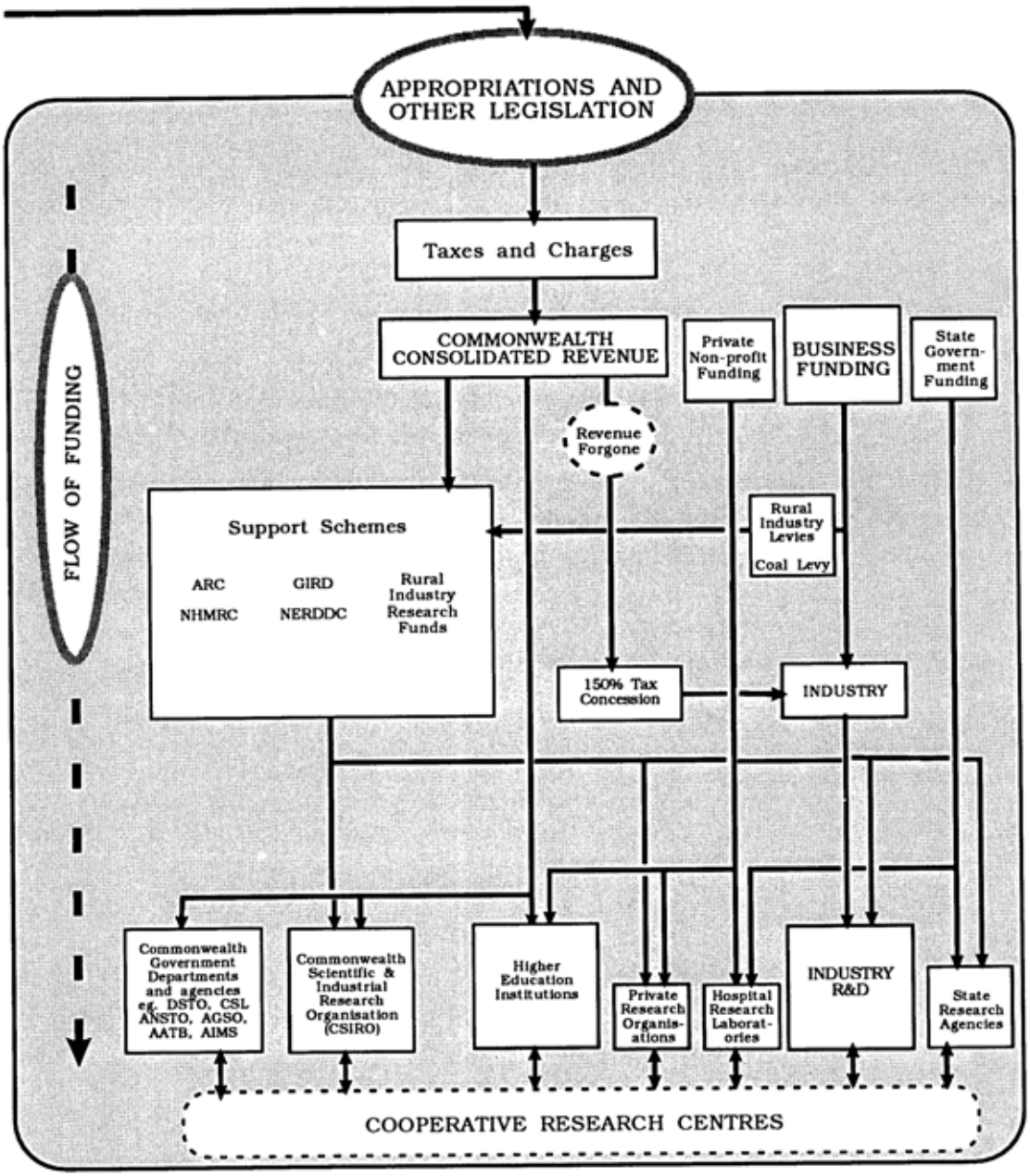


The figure is indicative of major bodies and principal channels for the flow of policy advice leading to Parliamentary and Cabinet decisions on science and technology Issues. It does not purport to be other than Illustrative.

Of course, there are a host of influential forces, Including professional organisations and other non-government groups, and there are many cross-links and productive interactions between them.

Figure 1

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.

Figure 2

Science and Technology in Context

Significance of innovation

Governments around the world have recognised that innovation is one of the keys to economic development.

Twenty or more years ago, most developed countries had a science policy. Science policies dealt mainly with issues such as levels of support and infrastructure for basic scientific research, co-ordination, and the establishment of advisory machinery. Good things were expected to flow from the science, of course, but this was seen in large measure as a natural process requiring little government attention.

A decade ago, most such policies had generally transformed to science *and technology* policies. All the original issues were still, rightly, regarded as important, but there was a greater emphasis on the further development of research. For example, it was recognised that "high technology" products, in particular, were very dependent on research *and development* (R&D). Accordingly, national science and technology policies had moved to cover issues of government support for R&D in the business sector, and issues dealing with productive interaction between industry researchers and their colleagues in the government and university sectors.

Another major change is occurring in the scope of these policies.

Increasingly, policy attention is being given to the whole *innovation* process. In its widest definition, this process includes R&D, commercial development of research results, incremental improvement and adaptation of all kinds, the diffusion and uptake of new technology, and organisational change which assists all of this. Innovation in products, processes and forms of organisation is seen as a critical factor for greater productivity, competitiveness, growth and employment. This should apply across all areas of the nation - in the private and public sectors, among small businesses and large organisations, from fisheries to education to tourism.

Major issues

Australia has an excellent scientific base, and research resource, in its government research agencies and universities. In many areas, our research strengths are well respected internationally; for example, in biology, medical sciences, environmental sciences, astronomy and earth sciences. Our excellence in agricultural research, and the innovation this has fostered, has been the foundation of high productivity levels in agriculture and our past export success in agricultural commodities - despite our possessing the poorest soil and driest climate of the continents.

In recent years, a number of concerns have been expressed on the aging state or adequacy of research equipment and other infrastructure within publicly funded research institutions. It has been recognised that a core infrastructure capacity must be maintained if the excellence of our best science is to be preserved and if new research strengths are to develop.

The other side to the excellence of our public sector research has been, over

many years, a weakness in the ability to exploit our R&D in many fields. Yet the level of our public sector R&D expenditure is one of the highest among OECD nations.

These issues apply with special relevance to Australia's industrialisation and the future directions of our economic development. High levels of industrial R&D are found to be generally associated with effective innovation processes within firms, and significant numbers of highly innovative firms are necessary for national economic health. In almost every area of manufacturing, our level of R&D expenditure has compared unfavourably with other developed countries.

Thus, to a great degree, there have been three major ideas behind much of the Government's science and technology policy in recent years. One has been to maintain and restore a research infrastructure adequate to preserve the excellence of the strong R&D effort carried out in our government agencies and universities. A second has been to look for ways which would give a better commercial return on this publicly funded research. The final thrust has been to strengthen our business R&D and generally to develop a more innovative culture within Australian business.

Government responses

Over the past decade, the Government has taken a number of measures to address these issues.

To address concerns on the science base and the adequacy of research infrastructure, the Government has, since 1989-90, provided substantial additional funding to redress deficiencies, both in universities and in government research agencies. Within the universities, concerns have been related to developing the skills base for research (tertiary science education and research training), ensuring high-level technical education, supplying satisfactorily equipped laboratories and well stocked libraries, and providing electronic information services. A Research Infrastructure Program was introduced in 1990 to address issues such as these in higher education institutions. This year, following advice from the National Board of Employment, Education and Training and based on work by the Boston Consulting Group, the Government has confirmed funding for this Program at an enhanced level.

The building and enhancement of *linkages* has been a key strategy to improve the utilisation of our public sector R&D strengths. Several mechanisms have been introduced which have aimed to bring public sector research and industry closer together, to increase industry funding for public sector or jointly undertaken R&D, and to increase industry involvement in planning and setting the agenda for public sector R&D. The Cooperative Research Centre (CRC) Program is an important example. Within two years this Program will cover over sixty Centres and provide a substantial linking effect between researchers in universities, government agencies, and industry. Another move has been to set a thirty per cent target for external earnings to be achieved by Government research agencies, so that there is

greater market and end-user influence on the projects undertaken by researchers. As a further incentive, earnings of this kind are retained by the research agencies. Similar market influence has been introduced into agricultural research in a different way, through the formation of rural industry R&D corporations with strong industry representation on their Boards.

Linkages crossing our national boundaries have been supported through an International Science and Technology Collaboration Program. This has recognised the international dimension of science and the need for a mechanism to promote better international research links, including support for international research involving industry.

In another move to improve the utilisation of public sector R&D, the Australian Technology Group Pty Ltd has been established to contribute towards greater commercialisation of publicly funded research.

Priority-setting mechanisms within mission-oriented Government research organisations have been given much greater attention - to ensure that publicly-funded research efforts are directed to areas of greatest potential benefit.

Promotion of a more innovative business culture, and continued strong growth in business R&D, has involved the introduction of a 150% tax concession for industrial R&D, together with a complementary grants scheme to cover firms not yet profitable enough to benefit from tax concessions. In other measures, key parts of programs introduced for the information technology and pharmaceutical industries have encouraged transnational companies to undertake significant R&D within Australia. In concert with these moves, the programs of the National Industry Extension Service, in raising management quality and encouraging "best practice", have underpinned the development of more innovative attitudes within industry.

Another, and broader, underpinning has been provided through the Science and Technology Awareness Program. Through a variety of initiatives, the Awareness Program has sought to increase understanding of the central role which science and technology play in Australia's economic and social wellbeing. An important concern has been to promote greater acceptance and use of modern technology in the daily life and productive activities of the workforce and the general population.

Significant progress

These Government actions are bringing success.

Over the 1980s, we had one of the highest growth rates in business R&D expenditure among OECD nations. In addition, the positive change in our level of business investment in R&D was in the upper OECD group, and close to those achieved by Taiwan and Singapore. It is no coincidence that these successes have occurred over a period which coincided with the introduction of the R&D tax concession and the range of other measures to boost

innovation in industry.

In parallel, and offering independent confirmation of the positive changes we are seeing, the rate of growth in patent applications made by Australians in foreign countries exceeded the corresponding rates of growth for other OECD countries.

Small business successes

Another sign that very positive changes are occurring came in a recent report by the consulting firm McKinsey and Company, *Emerging Exporters: Australia's High Value-Added Manufacturing Exporters*. They identified 700 small businesses which they described as "emerging exporters". It is clear from the McKinsey study that these firms have already adopted many elements of the innovative business culture which the Government has sought to promote. These 700 firms are providing more than half of Australia's manufactured exports. Almost all listed quality, technology and innovation as crucial to their export success, while more than a third ranked technology as a comprising a significant competitive advantage.

There are many more small and medium sized enterprises with the potential to join these ranks.

Links with Asia

The issue of exports raises questions on our region and Australia's trade and other relations with it.

The Government is giving a high priority to establishing Australia's place in Asia. Our strengths in science and technology are an important component of our trade and economic relations with the region.

Our emphasis in Asia is to increase the market share and improve the investment environment for Australian industry. The development of meaningful projects and programs with countries in the Asia-Pacific region, where Australia can demonstrate its own expertise in various scientific and technological fields, will complement our more traditional trade links.

International collaboration through appropriate international organisations and formal agreements is also valuable. We have been actively involved in the technology related activities of the Asia Pacific Economic Cooperation (APEC) forum. Agreements with particular countries offer opportunities for both public and private organisations to establish links through which they can demonstrate their capabilities. National benefits can then accrue to Australia in the form of investment, trade growth and access to leading edge technologies.

Specifying goals and setting policies

A clear sense of direction, planning and leadership are needed to achieve our goals.

In the past few years, there have been two major Government statements of the principles governing its science and technology policies.

A major policy statement in 1989 stressed the importance of science and technology to Australia and set out the areas where science and technology were seen to be particularly important. These were economic growth, the health of Australia's citizens, protection of the environment, our international role, national security, and human values and culture. The 1992 White Paper on science and technology extended this to a vision of Australia which had captured the benefits of a strong scientific and engineering base to provide economic prosperity, social equity, ecologically sustainable industries and a high quality, fulfilling lifestyle. As means to achieve these ends, it stressed innovation, community and business awareness, skills development, and maintaining infrastructure to sustain our strong base in public sector R&D.

Through the arrangements set in place in the 1989 science and technology policy statement, the 1992 White Paper, and those recently adopted regarding the Prime Minister's Science and Engineering Council and the Australian Science and Technology Council, effective means for providing science and technology advice to Government have evolved. The new structure also strengthens the coordination between departments and agencies involved in research.

Through the active involvement of nine senior Ministers, the Prime Minister's Science and Engineering Council has become a valuable means for integrating scientific and technological considerations into the broader national policy debate and directing the attention of Ministers to key issues. The activities of the Council are strongly supported through the work of Ministers' senior officials on the Coordination Committee on Science and Technology.

These means provide us with effective mechanisms for monitoring existing policies and assessing the need for new ones.

At the same time, Government policy deliberations are informed by many other inputs. These have included the recent inquiries into R&D by the Parliamentary Joint Committee of Public Accounts. Forthcoming inquiries include the Senate Committee on Higher Education and Training inquiry into higher education research, and the Industry Commission inquiry into R&D.

Major challenges

Many challenges remain.

From an economic standpoint, our most urgent task is to build an innovative culture in industry which is comparable with the strength and scale of our public sector research.

Although our business R&D is not as low as at the beginning of the 1980s, it still remains low by most OECD standards. Nevertheless, we have achieved significant progress over the past decade. Recently released information on Australia's business R&D expenditure for 1991-92 showed an increase of 4.6% in real terms over the previous year. This is a very encouraging result achieved in difficult economic circumstances. It is matched by many other signs that we are becoming more innovative.

The major challenge we face in the 1990s is to maintain a high growth rate in business R&D comparable to that achieved over the 1980s. If we are able to achieve that, we should come close to average OECD levels within another decade. On the present evidence, our current policies are generally the correct ones for achieving this goal. We will need to continually monitor their effects and carry out appropriate fine tuning. Above all, we need a cultural change - among business leaders, decisionmakers, and the community generally - which recognises the major significance innovation has for building national competitiveness.

Recent Major Developments

During 1992-93, science and technology has been further recognised as one of the vital components of the nation. This section outlines the major developments of the past year and the future initiatives to be taken in science and technology across all portfolios.

Prime Minister's Science and Engineering Council (PMSEC)

Two meetings of the Prime Minister's Science and Engineering Council were held during the year. The Council includes Ministers whose portfolios have a major science, engineering and technology interest. Reports presented to the Council included:

- *Australian S&T Opportunities and Strategies in the Asia-Pacific Region,* which explored ways of linking Australian science and technology (S&T) into the fast growing economies of the Asia-Pacific region, noting that Australia's S&T base is a source of comparative advantage in the region.
- *Nanotechnology,* which described the emerging technology of working at the molecular level and examined its scientific, industrial and economic promise, together with its status in Australia and overseas.
- *Microengineering,* comparing Australia's performance in developing and utilising devices with micrometre dimensions with international players and suggesting how Australia could capitalise on its existing expertise in this new technology.
- *Scheduled (Intractable) Waste*, which suggested that Australia's intractable waste problem should be solved in terms of small, specific, localised and relocatable facilities, and that the use of a high temperature incinerator did not offer significant advantages.
- *The Role of Intellectual Property in Innovation*, identifying four key areas
  - awareness and education,
  - more efficient structure and administration,
  - the maintenance of Australia's status and influence and,
  - the harmonisation of intellectual property systems in Asia,

  where the Government and the private sector could improve innovative opportunities arising from the use of intellectual property and the associated systems.

The Council also heard:

- a presentation on innovation in industry, by the Innovation Study Commission of the Business Council of Australia. The presentation covered the preliminary findings of the Study Commission's extensive investigation of the uptake and management of innovation in Australian manufacturing and service-sector firms.

- two presentations from Directors of Cooperative Research Centres (the Photonics CRC and the Eye Research and Technology CRC) on the work of those Centres, covering information on links being developed with industry and other users of the Centres' research.

The Council's consideration of major issues led to several follow-up actions.

- During the year, Ministers reported back to the Council on the Government's response to issues raised in Council discussion of the report *Australian Science and Technology Opportunities and Strategies in the Asia-Pacific Region*. Ministers emphasised the importance of science and technology in developing our trade and economic relations in the region. The Coordination Committee on Science and Technology was asked to report on options for coordination across Commonwealth agencies of science and technology links with the region.
- An inter-departmental committee has been established to consider follow-up actions based on the recommendations in the report *The Role of Intellectual Property in Innovation.*
- Ministers also reported back to the Council on the Government's response to issues raised in Council discussion of the report *The Changing Role of Manufacturing Technology*. Important Government initiatives included the Advanced Manufacturing Technology Strategy announced in the 1991 Industry Statement, and the establishment of a national system of vocational education and training, which would be overseen by the Australian National Training authority (ANTA).
- The Council noted that the White Paper on Science and Technology, which was released as part of the 1992-93 Budget, provided a consolidation of Government support for science and technology since 1983 and renewed Government commitment to this area or policy.

Review of the Australian Science and Technology Council (ASTEC)

The then Minister for Science and Technology and Minister assisting the Prime Minister, the Hon Ross Free, MP, announced a review of ASTEC in April 1992. The review committee chaired by Sir Rupert Myers, President, Australian Academy of Technological Science and Engineering, reported in October 1992. The committee examined the role and operations of ASTEC. Major findings of the review were that:

- ASTEC should continue as a separate organisation with its present functions,
- ASTEC itself needs to appreciate and come to terms with its distinctive role, and
- ASTEC's capacity to carry out that role needs to be strengthened,
- ASTEC should implement, after review, a series of measures to enhance its effectiveness.

In line with the recommendations of the review, the Government announced in June 1993 its intention to restructure science and technology advisory arrangements. To strengthen the provision of independent advice and improve co-ordination in developing and implementing policy, the Chief Scientist will become a member of ASTEC and at least two members of ASTEC will be appointed to the Prime Minister's Science and Engineering Council. Other changes will include the appointment of an increased number of industry members to ASTEC and the transfer of ASTEC staff to the Office of the Chief Scientist in the Department of Prime Minister and Cabinet. The new role for ASTEC will result in it preparing independent long and short term papers for consideration by PMSEC and the Coordination Committee on Science and Technology, as well as continuing to provide advice through reports which are tabled in Parliament.

Coordination Committee on Science and Technology

The Coordination Committee met four times during 1992-93. During the year, the Committee's work included examination of issues in research and development for ecologically sustainable development (ESD); research and training in the geosciences; methods for setting priorities for government science and technology; large national research facilities; and the state of marine science and technology.

The Committee has made major contributions to science and technology issues. It formulated a Commonwealth response to recommendations on research, development and demonstration for ecologically sustainable development. It has been asked to take this work further, including consultation with the States and Territories regarding development of priorities for ESD research. Arising from the White Paper, the Committee has also been given increased roles in assessing mechanisms for science and technology priority setting, and in advising on proposals for major national research facilities.

Research infrastructure in higher education

In July 1992, the Government asked the National Board of Employment, Education and Training (NBEET) to review the funding of research infrastructure in higher education. In response to the NBEET advice, the Government has announced the continuation of the Research Infrastructure Program beyond 1994 at an enhanced level, providing $56.4 million in 1995 and $60 million from 1996.

Changes to Postgraduate Awards

From January 1994 the Australian Postgraduate Research Award (APRA) and Australian Postgraduate Course Award (APCA) schemes and Higher Education Contribution Scheme (HECS) exemption scholarships will be integrated into a new scheme to be called the Australian Postgraduate Awards, (APA) Scheme. Holders of these Postgraduate Awards will not be liable for HECS. There will be 1375 new Awards with stipend each year, the same as under the present APRA scheme. It is expected that most Awards will be allocated to research students, but institutions will also be able to offer Awards to students undertaking postgraduate study by course work.

Australian Space Council

The Australian Space Council, with representation drawn from industry and government, was established in 1993 to develop and implement an Integrated National Space Program for Australian space-related activities over the next five years. The Council will be the reference point for national and international space policy and interaction, and will coordinate space activities within government and between the public and private sectors.

Commercialisation of research in marine science

In November 1992 the *Australian Institute of Marine Science Act* 1972 was amended to enhance the technology transfer and communication functions of the Institute and to enable it to participate in joint venture operations in order to commercialise its research results.

AIMS increased its commercialisation thrust in early 1992-93, actively seeking grants, consultancies and collaboration from mining, pharmaceutical and petroleum companies and marine management agencies. Significant results from this effort were starting to flow in late 1992-93.

The Institute is also investigating commercialisation arrangements for appropriate scientific products and services. The first significant product, marketed as a platform for linking science to industry, was OILMAP, an oil spill simulation system. This position was achieved through scientific collaboration with the University of Rhode Island.

In view of the market opportunities in South East Asia, the Institute has increased its focus on Indonesia and Vietnam with the objective of undertaking science and building strong collaborations with these countries, as a basis for developing future links with Australian and international industry.

Cooperative Research Centres Program

The Cooperative Research Centres Program completed its third selection round in December 1992 when a further eighteen centres and extensions of

two existing centres were announced. In the light of the success of the program, and the number of high quality applications in the third round, the Government announced in April 1993 a fourth round of applications, (see Section 3 for further details).

Great Barrier Reef Marine Park Authority

The Great Barrier Reef Marine Park Authority has been contracted by the Department of the Environment, Sport and Territories to prepare a comprehensive description and assessment of our marine environment, resources and the impact of human activities. The report will provide information for the national Ocean Rescue 2000 Program. The technical report will comprise over 80 different topics which are being reviewed by experts in their respective fields and will be summarised in a less technical overview report.

Review of the Australian Geological Survey Organisation

In 1992 the Government commissioned a review of the composition, structure and administrative arrangements of the Australian Geological Survey Organisation, (formerly the BMR). The review Committee reported on 13 May 1993.

The Committee's central recommendation was that AGSO's funding be increased by $100 million over five years. It saw a need for AGSO to accelerate its mapping programs so that a second generation of geoscientific maps of Australia could be completed within 20 years rather than the currently projected 40 years.

The Government has responded in the 1993-94 Budget with a carefully integrated reform package. The aggregate effect of the package gives geoscientific mapping substantially more resources, a higher profile and shares the costs of AGSO functions amongst those who benefit. The package will launch a process of organisational change that will be of lasting benefit to AGSO and its clients.

Approval has been given for the construction, in the Canberra region, of purpose built accommodation for AGSO.

Other initiatives in support of science and technology

Other measures taken to increase support for science and technology and related initiatives included:

- in industry, science and technology:

- the Government has extended the operation of the Research & Development Grants schemes by eighteen months to 31 December 1995, pending the outcome of the proposed Industry Commission inquiry into Research and Development

- guidelines for the registration of syndicates under the provisions of the R&D tax concession scheme have been revised to exclude Government tax exempt organisations where investors' funds are not fully at risk
- guidelines have been developed for syndicates to exclude financing schemes where the arrangements are primarily intended to achieve a guaranteed return for investors, as opposed to returns generated as a result of the commercialisation of the R&D results
- the Department of Industry, Technology and Regional Development, in consultation with Finance and Treasury, is investigating the desirability of cost recovery arrangements for the Industry Innovation Program.
- in March 1993, the Australian Bureau of Statistics released the *Australian Standard Research Classification* providing detailed classification guidelines which will improve the comparability of data about research projects and between different organisations undertaking or funding research
- the Government has decided to establish an Inter Departmental Committee to consider issues of effective management and the development of a nuclear science and technology in Australia, taking into account the impending interim Report of the current Research Reactor Review
- the Government will conduct a process of consultation on the establishment of a national marine institute to provide a stronger focus on marine research in Australia
- funding for the Marine Industries Development Program is to continue at the existing level for a further two years from 1994-95 to 1995-96. The Program plays a leading role in facilitating the growth of marine industries through the creation of links between marine industries and Australia s strong marine science and technology capabilities
- The Government has announced a review, to be completed by the end of 1993, to examine the effectiveness of the current arrangements of the Primary Industry Research and Development Corporation model and options for improving co-ordination with other Commonwealth programs involved in the promotion of rural industry development.

- in education and research training:

- in November 1992, the Government announced an additional $12 million for research grants (Large, Small and Collaborative) for 1994 in recognition of the significant increase in the capacity of the higher education system to undertake research of the highest quality and the considerable increase in demand for research grants in recent years.

- in environment:

- The Office of the Supervising Scientist and the Alligator Rivers Region Research Institute (ARRRI) will be incorporated into the Commonwealth Environment Protection Authority. This shift will facilitate substantial savings to the Government. At the same time the

ARRI research program will be reviewed and administrative arrangements refined

- a Centre for Plant Biodiversity Research was established as a cooperative venture between the Australian Nature Conservation Agency (ANCA) and CSIRO to consolidate Commonwealth botanical collections and plant biodiversity programs
- ANCA, through the Australian Biological Resources Study, will direct $3 million primarily into the investigation of aquatic plants and animals
- ANCA, through a cooperative venture between the Commonwealth Government and the Chicago Zoological Society, acquired a former pastoral property in South Australia which will be devoted to local community participation in developing programs for an ecologically sustainable society based on the biosphere reserve model
- funding of $17.1 million over the three years to 1995-96 was approved for research into the science and impacts of climate change
- funding of $1.6 million has been provided over four years for the establishment of a database of Australia's environment management capabilities including both soft and hard technologies, as an industry development tool
- the Eco-ReDesign Program has been set up to demonstrate to industry the economic and environmental value in redesigning products from an environmental as well as functional perspective
- funding has been provided for the demonstration in selected manufacturing companies of the economic and environmental benefits to be obtained through the implementation of cleaner productions, by rethinking processes and technologies in the production process
- the Commonwealth Environment Protection Agency is assisting the Department of Health, Housing, Local Government and Community Services to manage an $8mill ion program to demonstrate innovative water treatment technologies in Western Australia
- the National Science and Technology Centre (NSTC), opened an interactive exhibition on the environment in November 1992, which encourages the exploration of the science and technology behind environmental issues and challenges people to consider their everyday actions and the consequences or these actions. The exhibition will be at the NSTC for two years before touring to other science centres and museums throughout Australia

- in science and technology awareness:

- the S&T Awareness Program has been extended to allow increased activities through to 1995-96
- the 1993 Australia Prize was awarded in the field of sensory perception jointly to Professor Horace Barlow of Cambridge University, UK; Professor Peter Bishop of the University of Sydney, Australia; and Professor Vernon Mountcastle of the Johns Hopkins University School of Medicine, USA
- Michael Daley Awards for Science, Technology and Engineering

Journalism were expanded to include two new categories of award, with support from the Institution of Engineers, Australia. The awards were presented at the first Australian Science Festival in Canberra

- 30 new projects were supported from the Science and Technology Awareness Program, ranging from school curriculum resources developments, post-graduate scholarships for young engineers and briefing forums for the media, to surveys and publication projects. Support continued for 12 other projects, including science summer schools and national implementation of three successful State-initiated projects
- the National Science and Technology Centre organised the National Conference for Primary Teachers and Educators in January 1993 to assist with the development of understanding of science and technology
- the *Australasian Science and Technology Exhibitors Network*, a network of Australian and New Zealand science and technology centres and museums providing programs and interactive exhibitions on science and technology, chaired by the National Science and Technology Centre, was established in November 1992.
- the National Science and Technology Centre toured four major interactive science and technology exhibitions to other science and technology centres and museums in Australia (*IBM Mathematica, ICl Microcosm*, *OTC Get the Message* and *Shell Questacon Science Circus*).

- in defence:

- the Industry Support Office (ISO) was established at DSTO's Aeronautical Research Laboratory (ARL) in Melbourne in 1992 to make ARL's expertise more accessible to industry. The ISO will be expanded in 1993-94 to include the Business Development Unit of the Materials Research Laboratory.
- DSTO made a major contribution and provided technical advice to the drafting of the UN Chemical Weapons Convention signed in January 1993. DSTO also issued papers and made presentations at the April 1993 Seminar of the Chemical Weapons Regional Initiative.
- in March 1993, an Agreement was signed by the Government of Australia and the Government of the Republic of Singapore to promote collaboration in defence science and technology.

- in the arts and heritage:

- the National Film and Sound Archive is participating in an international research program into the decomposition of cellulose acetate film. This commonly used polymer decomposes to form acetic acid which will eventually destroy the film.

Significant statements, reviews and reports

The past year saw a number of statements, reviews and reports dealing with major issues relating to innovation, science and technology, both of a general and specific nature. Significant publications include :

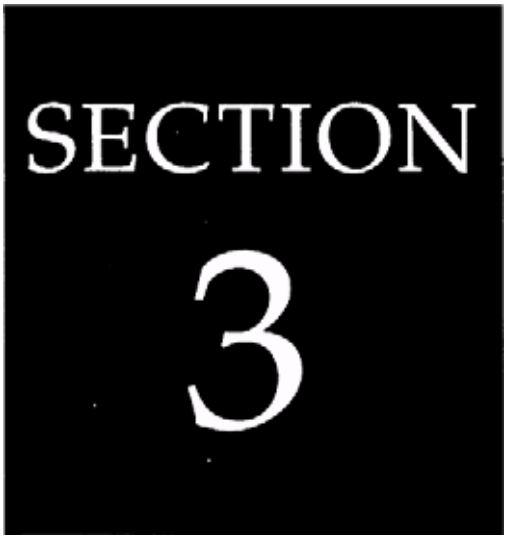
- Parliament of Australia - Joint Committee of Public Accounts
  - *Public Sector Research and Development:* Volume 1 of a Report on Research and Development
  - *Commonwealth Support for Private Sector Investment in Research and Development*: Volume 2 of a Report on Research and Development
- Prime Minister
  - *Australia's Environment: A Natural Asset*
- Minister for Science and Technology
  - *Science and Technology Statement 1992-93,* Budget Related Paper No.6
- Australian Science and Technology Council
  - *Bridging The Gap: The Social Sciences, Humanities, Science and Technology in Economic Development* (May 1993)
  - *Research and Technology in Tropical Australia*: Draft Report (May 1993)
  - Submission by ASTEC to the ASTEC Review Committee (August 1992)
  - Research and Technology in Tropical Australia: Symposia (November 1992)
  - Research and Technology in Tropical Australia: Survey (March 1993)
  - *Indonesia and Australia, Science and Technology Linkages - Case Studies of Remote Sensing, Telecommunications and Biotechnology* (December 1992)
  - *Small Things - Big Returns: The Role of Nanotechnology in Australia's Future* (May 1993)
  - Review of ASTEC: An Evaluation of the Australian Science and Technology Council
  - Nanotechnology and Australia's Future
- Australian Space Council
  - An Integrated National Space Program - Report by the Expert Panel, June 1992
  - Australia's Participation in the Space Sector of Earth Observation Systems: Technical Committee Report No.l, September 1992
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
  - *Environmental Research the pay-off,* CSIRO Occasional Paper No. 8
  - *Review of Future Direction for the CSIRO Division of Food Processing and Related Research Areas in CSIRO*
  - *CSIRO's Research for the Rural Industries- a Strategic Perspective*
  - *CSIRO and the Sustaining of Australia: CSIRO's contribution to Ecologically Sustainable Development*

- CSIRO's Contribution to the Nation
- CSIRO Division of Water Resources- Report of the Review Committee on Research Directions
- CSIRO Division of Atmospheric Research - Report of the Review Committee on Research Directions

- Department of Employment, Education and Training
  - Report on Research Funding Programs 1992
  - Status Report for the Humanities and Social Sciences
  - Higher Education Funding for the 1993-95 Triennium
  - Large Research Grants 1992, Higher Education Series Report No. 14
  - Postgraduate Mobility, Higher Education Series Report No. 15
  - Research Performance, Higher Education Series Occasional Paper No. 2.
- National Board of Employment, Education and Training
  - Research Infrastructure: Report of the Joint ARC-HEC-DEET Working Party: Advice of NBEET and ARC
  - Towards 2005: A Prospectus for Research and Research Training in the Australian Earth Sciences
  - Commercialisation of Research: Advice of NBEET and ARC
  - Educational Research in Australia
  - Expanding the Research Base in Private Industry and Improving Interaction in Research across Sectors - Developments since 1988: Advice of NBEET and ARC
  - Support for Postgraduate Research Awards in the 1993-95 Triennium: Interim Advice of NBEET and ARC
  - Internationalisation of Research and Research Training in Higher Education: Advice of NBEET and ARC
  - Research Infrastructure in Higher Education: Advice of NBEET
  - Research Performance Indicators Survey
  - Australian Research Council Comments on Discipline Research Strategies: Educational Research in Australia
  - Australian Research Council Comments on Discipline Research Strategies: Towards 2005: A Prospectus for Research and Research Training in the Australian Earth Sciences
  - *Issues in Science and Technology Education: A Survey of Factors which Lead to Underachievement*
  - *What Do They Know?: The Understanding of Science and Technology by Children in Their Last Year of Primary School in Australia*
- Department of the Environment, Sport and Territories
  - Proceedings of the Climate Change Science Forum - Canberra, 14 May 1992

— A six part series titled - Impact of Climate Change, Australia:
  - *(i) Hydrology and Water Resources*
  - *(ii) Cultural Heritage*
  - *(iii) Antarctica*
  - *(iv) Fisheries*
  - *(v) On Severe Weather Hazards*
  - *(vi) On Urban Planning Transport and Pollution*

- National Greenhouse Advisory Committee
  - *Grappling with Greenhouse - Understanding the Science of Climate Change*
  - Australian Research Requirements Regarding Exchange of Greenhouse Gases Between the Atmosphere and Agricultural and Natural Systems
- Antarctic Science Advisory Committee
  - *Antarctic Science - The Way Forward*
- Commonwealth Environment Protection Agency
  - *Development of a National State of the Environment Reporting (SER) System*
- The Department of Industry, Technology and Regional Development
  - *Review of Mineral Processing Research in Australia*, April 1993
  - *Strategic Innovation*, March 1993
  - *The Innovation Framework: Recent Findings*, April 1992
  - *Australian Water Technologies*, February 1993
  - *Joint Statement on Australian Agri-Food Industries*, July 1992
  - The Australian Petrochemicals and Polymers Industry Status and Outlook Report, December 1992
  - *Australia's Environment Industries*, May 1993
- Great Barrier Reef Marine Park Authority
  - *Ocean Rescue 2000 - State of the Marine Environment Report*
- Department of Prime Minister and Cabinet (Reports presented to the Prime Minister's Science and Engineering Council):
  - *Developing Australian Ideas - a blueprint for the 1990s* - August 1992
  - *Science and Technology Strategies and Opportunities in the Asia Pacific Region*, December 1992
  - *Micro Engineering and Micro Machines - A New Threshold for Australian Industry*, December 1992
  - *The Role of Intellectual Property in Innovation - Strategic Overview* (Vol 1), June 1993
  - *The Role of Intellectual Property in Innovation - Perspectives* (Vol 2), June 1993



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 surveys showed that Australia's gross expenditure on R&D (GERD) stood at $5109 million in 1990-91, corresponding to 1.35% of gross domestic product (GDP). Broadly, about 40% of Australia's R&D expenditure, corresponding to 0.54% of GDP, was undertaken within business enterprises in that year. Following that year, business sector R&D rose to 0.57% of GDP in 1991-92. (ABS surveys R&D in the business sector each year, but other sectors are surveyed only every second year.)

TABLE 1 Australia's expenditure on R&D, by sector of performance, 1988-89 to 1991-92

Sector of R&D performance	1988-89		1989-90			1990-91			1991-92		
	$m	%GDP	$m	%GDP	%real annual increase	$m	%GDP	% real annual increase	$m	%GDP	%real annual increase
Total business	1784	0.53	1974	0.53	2.5	2039	0.54	-1.9	2188	0.57	4.6
- private business	1635	0.48	1787	0.48	1.2	1835	0.48	-2.4	1973	0.51	4.7
- public business	149	0.04	187	0.05	17.1	204	0.05	2.2	215	0.06	3.3
Total Government	1343	0.40				1651	0.44	4.4			
- Cwlth agencies	869	0.26				1040	0.27	2.8			
- State agencies	474	0.14				611	0.16	7.3			
Higher education	1073	0.34				1351	0.36	7.0			
Private non profit	52	0.02				68	0.02	6.5			
TOTAL	4253	1.25				5109	1.35	3.4			

The other principal R&D sectors include higher education, where 26% of R&D expenditure (0.36% of GDP) was undertaken, and Commonwealth agencies, which accounted for 20% of R&D expenditure and 0.27% of GDP.

At 1.35% of GDP, GERD now stands at an all time high and has risen substantially from 1.25% in 1988-89. However, the sharp increase in the GERD/GDP ratio is due more to the sluggishness of increase in GDP (which showed a real increase of only 2.3% over the two year period) than the size of the increase in GERD. (Over the previous two year period, from 1986-87 to 1988-89, GERD had shown a real increase of 12.8%, but GERD/GDP had dropped from 1.27% to 1.25%.) The increase in GERD since 1988-89 largely reflects increases in Commonwealth funding for public sector R&D, which had passed through a trough in 1988-89, but was subsequently increased following the initiatives announced in the May 1989 policy statement on science and technology.

Commonwealth support for R&D in a national perspective

As is seen in Table 1, Commonwealth agencies are significant performers of R&D, but undertake only 20% of total R&D expenditure. As a funding source, however, the Commonwealth Government provides about 45% of R&D funds directly, and another 7% 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

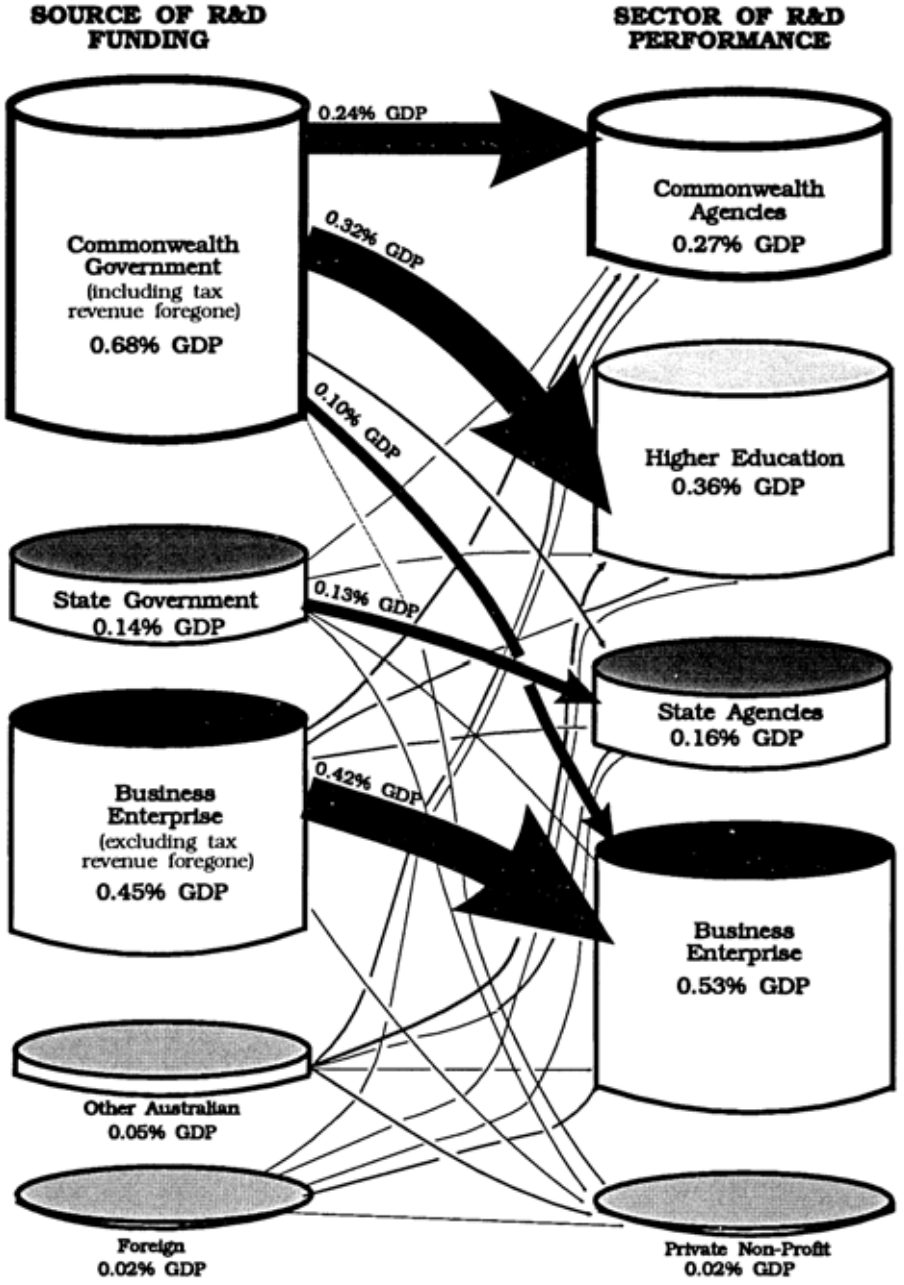
Commonwealth support for major science and innovation programs has risen from $3017 million in 1992-93 to an estimated $3121 million in 1993-94, a real increase of 1.1 per cent. Broadly, there have been significant increases over the whole period since 1982-83, with the tax concession schemes providing particular stimulus from about 1985. Omitting those concessions, 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.

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
- industrial 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 199O-91 data. It places Commonwealth funding of R&D In a national perspective.

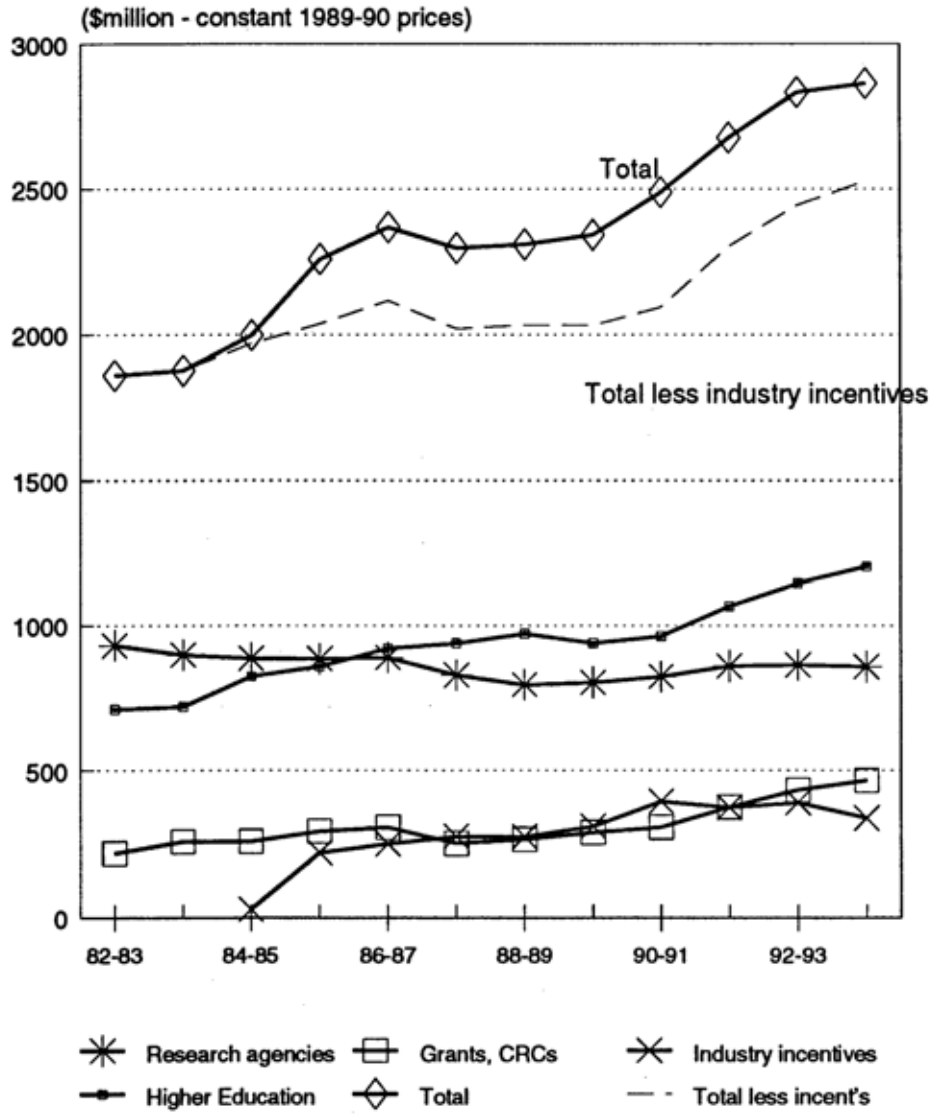
TABLE 2 Constant Price Summary of Major Commonwealth Support for Science and Innovation, Through the Budget and Other Measures ($m at constant 1989-90 prices)

	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94 (est)
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	222.1	219.8	224.4	218.9	225.0	215.2	223.0	225.2	218.3	219.7	217.3	211.7
• Civil	709.4	679.4	662.0	667.2	664.7	614.6	573.3	579.0	606.2	640.8	647.5	646.5
SUB-TOTAL	931.5	899.2	886.3	886.1	889.7	829.8	796.2	804.2	824.5	860.5	864.8	858.2
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	55.5	67.9	73.8	74.5	79.4	80.2	81.7	89.9	104.3	119.1	124.6	130.6
• Industry and space	90.5	106.3	98.1	132.4	128.1	94.0	91.4	96.4	96.6	124.8	144.5	117.1
• Cooperative Research Centres	-	-	-	-	-	-	-	-	-	17.3	42.6	86.4
• Rural	44.0	52.3	58.6	63.2	78.3	62.5	77.6	82.0	78.9	89.3	97.5	106.9
• Energy and environment	24.0	26.3	23.7	19.0	17.6	13.0	12.5	18.5	24.7	22.2	22.1	22.3
• Transport	4.0	5.1	4.0	3.4	2.5	2.3	2.1	2.0	2.1	2.1	2.1	2.0
SUB-TOTAL	218.1	257.8	258.1	292.6	305.9	252.0	265.3	288.8	306.6	374.7	433.3	465.3
COSTS OF IR&D & RELATED INCENTIVES	-	-	28.3	220.3	250.3	275.0	275.2	309.0	393.9	373.7	389.7	337.6
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	64.5	69.4	74.7	76.8	79.8	82.9	89.8	124.4	175.4	231.2	247.1	268.9
• Specific R&D support	150.4	155.9	158.6	155.7	154.6	154.2	170.0	165.0	163.3	173.3	184.8	185.5
• Est. general research support	496.0	494.8	592.1	626.6	687.1	702.0	712.0	650.0	624.4	662.3	713.6	747.7
SUB-TOTAL	710.9	720.1	825.4	859.2	921.5	939.0	971.9	939.4	963.1	1066.7	1145.5	1202.2
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 84-85 PRICES	**1860**	**1877**	**1998**	**2258**	**2367**	**2296**	**2309**	**2341**	**2488**	**2676**	**2833**	**2863**
EST. REAL % INCREASE/DECREASE		0.9	6.5	13.0	4.8	-3.0	0.6	1.4	6.3	7.5	5.9	1.1

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 $1310 million in 1993-94 from $1220 million in 1992-93, representing a real increase of 5 per cent.

The higher education sector receives support through general or nondirected research funds (actually 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).

- *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 $935 million in 1993-94, compared with $921 million in 1992-93 (a real decrease of 1 per cent).

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 1993-94 are expected to amount to $461 million (with a further $8 million through DPIE and DIT&RD, see Table 4), but the total budget of the Organisation is expected to be in the region of $685 million.

- *Special Purpose Research Grant Schemes*

Support for R&D through the special purpose research grant schemes is estimated to increase to $506 million in 1993-94 from $461 million in 1992-93, representing a real increase of 7 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 new 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 will be $368 million in 1993-94 ($415 million in 1992-93), down 13% in real terms because of the decrease in the corporate tax rate (from 39 to 33 cents in the dollar).

If the tax concession scheme is included with the industrial component of the special purpose grants, total support for industrial R&D and innovation is expected to be $496 million in 1993-94, down from $569 million in 1992-93, a decrease of 15 per cent. In addition to the lower corporate tax rate, the one-off payment in 1992-93 to initiate the Australian Technology Group Pty Ltd has also contributed to this decrease.

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 1982-83. The slight fall is due to the conclusion of some substantial capital expenditures and recent 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 is seen to have received the largest increases. Support for health and medical research and for rural research has also risen significantly.

The increases in funding for industrial R&D have followed policy changes which recognise its important role in innovation and competitiveness. Australian business R&D has been shown to be at comparatively low levels in relation to other OECD nations (see Section 5) and there has been little effective interaction between industry researchers and those in government agencies and universities.

In the higher education sector there has also been a significant increase in funding since 1982-83. Within the sector, there has been a substantial shift so that the proportion of funds controlled by the ARC is now much higher. Total funds have increased overall and there has been a 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.

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 foregone through the taxation concession scheme for industrial R&D. As already indicated, the amounts shown are estimates. (See footnote (4) to Table 6.) There are significant revisions to some historical data in this table.

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

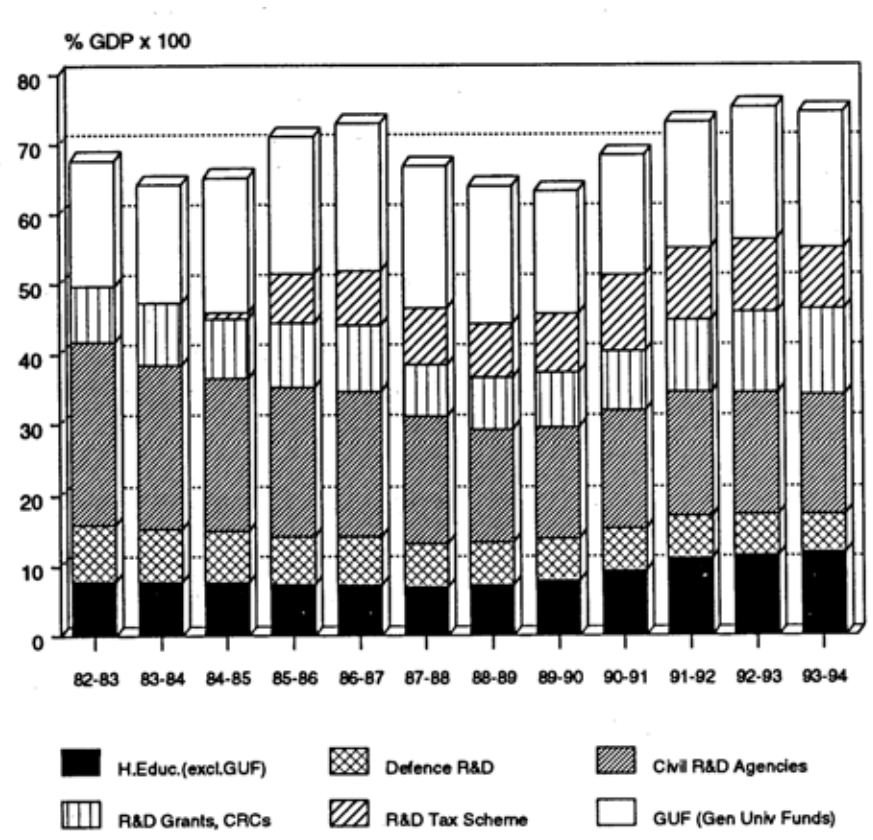
Over the past three decades there has been considerable international effort to reach agreed definitions of R&D . The resulting definitions have been applied with some rigour in periodic surveys conducted within most OECD countries. This so-called "Frascati" methodology has been applied in Australia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

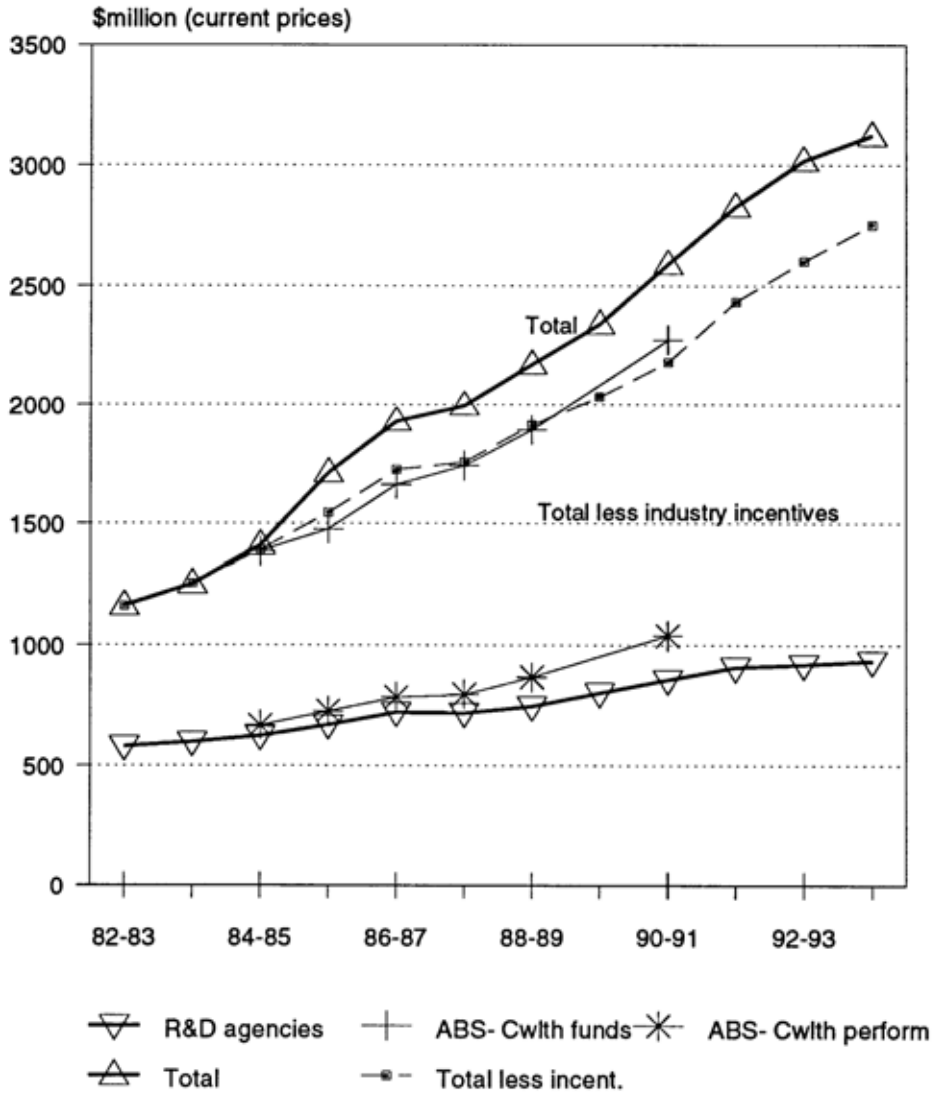


Source: *See Table 2 and ABS 5206.0*

Figure *6* shows the comparison between the "science and innovation" series presented in this Section and ABS (Frascati) R&D. The total budgets of the research agencies show little deviation from ABS R&D performance data. The discrepancy which does occur 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 here shows only directly appropriated Commonwealth funding.)

Figure 6

BUDGET-BASED DATA AND ABS R&D



Source: DIT&RD and ABS

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

	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94 (est)
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	138.8	146.6	158.4	165.9	183.4	187.0	209.8	225.2	227.2	232.3	231.4	230.7
• Civil	443.3	453.2	467.3	505.8	541.7	534.1	539.5	579.0	631.1	677.3	689.6	704.7
• SUB-TOTAL	582.2	599.8	625.7	671.7	725.1	721.1	749.3	804.2	858.3	909.6	921.0	935.4
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	34.7	45.3	52.1	56.5	64.7	69.7	76.9	89.9	108.6	125.9	132.7	142.3
• Industry and space	56.6	70.9	69.2	100.3	104.4	81.7	86.0	96.4	100.5	131.9	153.9	127.6
• Cooperative Research Centres	-	-	-	-	-	-	-	-	-	18.2	45.3	94.2
• Rural	27.5	34.9	41.4	47.9	63.8	54.3	73.0	82.0	82.1	94.4	103.8	116.5
• Energy and environment	15.0	17.5	16.7	14.4	14.3	11.3	11.7	18.5	25.8	23.5	23.5	24.3
• Transport	2.5	3.4	2.8	2.6	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2
SUB-TOTAL	136.3	171.9	182.2	221.8	249.3	219.0	249.6	288.8	319.2	396.1	461.4	507.2
COSTS OF IR&D & RELATED INCENTIVES	-	-	20	167	204	239	259	309	410	395	415	368
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	40.3	46.3	52.8	58.3	65.0	72.0	84.5	124.4	182.5	244.3	263.1	293.1
• Specific R&D support	94.0	104.0	112.0	118.0	126.0	134.0	160.0	165.0	170.0	183.2	196.8	202.2
• Est. general research support	310.0	330.0	418.0	475.0	560.0	610.0	670.0	650.0	650.0	700.0	760.0	815.0
SUB-TOTAL	444.3	480.3	582.8	651.3	751.0	816.0	914.5	939.4	1002.5	1127.5	1219.9	1310.3
TOTAL COMMONWEALTH SUPPORT	**1163**	**1252**	**1411**	**1712**	**1929**	**1995**	**2172**	**2341**	**2590**	**2828**	**3017**	**3121**
% GDP	0.677	0.642	0.652	0.711	0.730	0.669	0.640	0.632	0.683	0.731	0.752	0.745
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 1989-90 PRICES	**1860**	**1877**	**1998**	**2258**	**2367**	**2296**	**2309**	**2341**	**2488**	**2676**	**2833**	2863
EST. REAL % INCREASE/DECREASE		0.9	6.5	13.0	4.8	-3.0	0.6	1.4	6.3	7.5	5.9	1.1

SOURCE See Tables 4, 5 and 6

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

	Outlays											(est.)
	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
THE ENVIRONMENT, SPORT & TERRITORIES												
Antarctic Division	32.0	35.2	37.4	42.2	47.4	49.2	46.3	57.7	62.8	67.3	65.4	64.1
Bureau of Meteorology Research Centre (BMRC)[1]	1.7	1.7	1.8	1.8	2.3	2.5	2.2	2.4	2.8	3.3	3.1	3.4
Supervising Scientist Alligator Rivers Research Inst	6.0	4.5	4.7	5.5	6.1	5.9	6.6	5.9	5.1	5.6	5.1	5.3
DEFENCE												
Defence Science and Technology Organisation[2]	138.8	146.6	158.4	165.9	183.4	187.0	209.8	225.2	227.2	232.3	231.4	230.7
Anglo-Aust Telescope	1.9	1.8	1.8	1.9	2.0	2.4	2.5	2.7	2.9	3.0	3.1	3.1
HEALTH, HOUSING, LOCAL GOVERNMENT & COMMUNITY SERVICES												
Australian Inst. of Health (excl. grants)	3.4	4.0	4.6	5.1	5.2	3.4	4.2	4.4	4.2	5.0	6.8	7.2
CSL Ltd (Budget component)	6.3	6.6	8.8	12.8	15.8	17.3	16.6	9.4	3.0	5.9	8.2	17.0
INDUSTRY, TECHNOLOGY & REGIONAL DEVELOPMENT												
Aust Nuclear Science & Technology Organisation[3]	36.4	38.8	41.9	45.4	45.2	50.8	54.3	57.5	62.6	65.1	69.0	65.0
Australian Institute of Marine Science	6.4	6.9	7.4	7.6	8.2	9.5	11.0	11.4	13.6	14.2	14.2	16.9
CSIRO[2]	328.2	331.6	324.9	344.3	367.8	347.8	348.1	375.2	414.4	446.3	456.2	460.9
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	-	-	3.9	4.1	4.4	4.7	4.7	4.9	5.3	5.5	6.0	5.9
AGSO[4]	21.1	22.0	30.1	35.2	37.4	40.6	42.9	47.0	52.9	54.2	50.7	54.0
TOTAL	**582.2**	**599.8**	**625.7**	**671.7**	**725.1**	**721.1**	**749.3**	**804.2**	**858.3**	**909.6**	**921.0**	**935.4**

(1) BMRC was established on 1 January 1985. Prior data are estimated R&D expenditures by the Bureau of Meteorology.
(2) DSTO estimated expenditure for 1993-94 includes additional components of computer services, SES salaries, and 3% employer super to maintain historical integrity.
(3) CSIRO and ANSTO figures for 1980-81 were adjusted to include superannuation on the same basis as in subsequent years.
(4) From 1989-90, property operating expenses (principally rent) of about $3m per annum are deducted to reflect expenditure on the same basis over the series.

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

	Outlays											(est.)
	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
THE ENVIRONMENT, SPORT & TERRITORIES												
Aust Biological Resources Study	1.0	1.1	1.2	1.2	1.0	1.1	1.3	1.6	1.2	2.0	2.3	2.0
Greenhouse research	-	-	-	-	-	-	0.8	5.7	8.7	9.6	9.6	10.5
EMPLOYMENT, EDUCATION & TRAINING												
Research evaluation and Academies	-	-	-	-	-	-	-	-	1.6	2.0	2.0	2.0
ARGS & ARC grants/fellowships (including marine R&D grants)[1]	22.7	25.5	30.8	34.6	39.8	42.7	50.7	35.6	1.2	-	-	-
Post-graduate Awards[1]	11.5	15.1	16.3	17.8	19.3	20.3	21.7	11.3	-	-	-	-
Education R&D Grants	0.2	-	-	-	-	-	-	-	-	-	-	-
Targetted Institutional Links Program	-	-	-	-	-	-	-	0.2	1.0	2.0	1.1	1.1
HEALTH, HOUSING, LOCAL GOVERNMENT & COMMUNITY SERVICES												
AIDS Research	-	-	-	0.8	1.5	3.0	3.5	5.0	7.1	10.8	10.5	12.0
Health and Community Services Research Grants	1.5	3.2	1.6	1.6	2.3	1.1	1.4	1.9	1.8	1.8	1.9	1.9
NH&MRC Research Grants	30.0	38.5	44.2	51.2	59.4	65.6	72.0	83.0	94.7	103.3	110.3	118.5
Capital Works for Medical Institutes	3.2	3.5	6.3	2.6	1.6	-	-	-	5.0	10.0	10.0	10.0
Funds for John Curtin SMR	-	-	-	-	-	-	-	-	-	8.2	16.8	16.2
INDUSTRY, TECHNOLOGY & REGIONAL DEVELOPMENT												
IR&D Incentives Act 1976												
. Commencement grants	13.1	14.6	16.3	14.3	16.9	3.1	0.1	-	-	-	-	-
. Project grants	34.8	43.2	38.1	37.7	17.9	6.4	2.8	0.3	-	-	-	-
. Public interest projects	4.9	8.1	9.8	6.3	3.5	1.0	0.3	-	-	-	-	-
IR&D Act 1986 (GIRD)	-	-	-	-	10.8	25.6	31.8	32.0	29.6	32.2	-	-
. Biotechnology grants	-	0.7	2.2	4.3	-	-	-	-	-	-	-	-
Advanced Manufacturing Tech Program	-	-	-	-	-	-	-	-	-	0.1	-	-
National Procurement Development Program (NPDP)	-	-	-	-	-	0.7	3.9	5.6	4.2	4.4	-	-
Technology Development Program	0.2	0.7	0.9	0.8	1.2	1.4	1.1	1.9	3.0	3.2	-	-
Industry Innovation Programs	-	-	-	-	-	-	-	-	-	-	43.5	42.0

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

	Outlays											(est.)
	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
InterScan support	2.2	2.5	-	-	-	-	-	-	-	-	-	-
National Space Program	-	-	-	3.0	5.0	3.2	5.4	2.4	5.5	5.7	5.4	7.7
Malaria Vaccine Joint Venture	-	-	-	0.3	0.4	0.8	1.2	0.8	2.3	9.4	-	-
Research associations[2]	1.3	1.7	1.9	1.9	2.0	2.0	-	-	-	-	-	-
Motor Vehicle R&D	-	-	20.6	22.9	11.6	8.4	8.3	4.7	2.3	-	-	-
Assistance under the Bounty[3] (Computers) Act 1984	-	-	1.5	13.2	19.4	25.7	31.1	45.0	51.3	74.5	75.0	78.0
Australia Technology Group Pty Ltd	-	-	-	-	-	-	-	-	-	-	30.0	-
PRIMARY INDUSTRIES & ENERGY[4]												
Wool Research	8.6	10.0	11.7	13.0	14.4	12.1	21.7	20.8	11.7	13.8	12.0	12.7
Meat Research	4.6	5.4	4.0	5.5	8.4	8.6	11.9	13.8	13.6	20.8	23.7	23.0
Fishing Industry Research	2.5	3.1	4.3	5.0	6.2	6.2	5.4	8.1	8.4	6.6	6.9	8.3
Grains	6.8	10.8	14.1	15.2	17.9	11.2	11.1	13.3	14.4	14.8	14.7	20.4
Horticulture Research	-	-	-	-	-	-	0.6	1.2	3.1	4.4	5.8	8.6
Energy research	14.0	16.4	15.5	13.2	13.3	10.2	9.6	11.2	15.9	11.8	11.6	11.8
Land & Water research	1.2	0.7	1.5	1.8	4.9	7.8	10.4	9.9	13.3	13.3	11.0	11.1
Rural Industries R&D Corporation	0.2	0.1	0.3	0.4	1.5	3.0	4.0	5.0	6.0	8.4	11.3	11.5
Other rural research	3.6	4.6	5.4	7.0	10.6	5.5	8.0	10.1	11.7	12.3	18.4	20.9
PRIME MINISTER & CABINET												
Cooperative Research Centre Grants	-	-	-	-	-	-	-	-	-	18.2	45.3	94.2
TRANSPORT & COMMUNICATIONS												
Payments to Australian Road Research Board	2.0	3.0	2.3	2.0	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2
Railway R&D Organisation	0.5	0.4	0.5	0.6	-	-	-	-	-	-	-	-
TOTAL	**170.9**	**212.5**	**229.4**	**274.1**	**308.4**	**282.0**	**322.1**	**335.8**	**323.1**	**408.3**	**481.3**	**527.5**

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. ARC funding now includes post-graduate awards and the grants and fellowships formerly administered under the Australian Research Grants Scheme (ARGS)

FOOTNOTES TO TABLE 5 - *continued*

(2) Prior to 1981-82, Commonwealth support for Research Associations was provided through CSIRO. Since 1988-89 the Associations are 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)

	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94 est
Wool	8.83	9.30	12.32	11.88	15.25	18.31	14.21	19.63	17.11	14.05	12.00	12.50
Meat	4.16	3.61	4.61	5.55[a]	7.68[a]	8.65[a]	11.58[a]	13.30[a]	15.17[a]	25.60[a]	23.74[a]	22.99
Grains												
- Grain[b]	0.52	1.33	1.30	2.16	2.07	2.35	2.53	3.99	4.27[b]	5.31[b]	8.75[b]	7.63
-Wheat	4.65	4.65	5.40	5.48	6.40	5.16	8.35	9.84	8.45	12.92	18.24	16.06
Coal[c]	4.28	2.14	4.17	3.28	4.82	7.07	15.02	17.05	14.95	13.88	16.10	1.08
Special Rural	-	-	-	-	-	-	-	0.20	0.30	0.15	0.85	1.00
Fish	-	-	-	-	-	-	-	-	0.50	1.12	1.06	2.10
Horticulture	-	-	-	-	-	-	0.20	1.62	3.26	4.94	7.31	9.23
Other Rural												
- Chicken Meat	0.24	0.23	0.24	0.29	0.38	0.40	0.38	0.46	0.55	0.78	0.55	0.62
- Cotton	0.25	0.67	1.00	0.89	1.04	0.86	1.55	1.87	2.66	3.87	3.74	2.15
- Dairying	0.54	0.57	0.60	0.67	1.26	1.64	1.57	2.94	4.82	5.21	5.65	5.77
- Dried Fruit	0.12	0.09	0.12	0.16	0.32	0.26	0.29	0.39	0.45	0.78	0.86	0.47
- Grape & Wine	0.37	0.38	0.49	0.52	0.67	0.82	0.94	1.28	1.25	0.96	1.60	1.61
- Honey	0.05	0.05	0.05	0.08	0.09	0.11	0.10	0.12	0.14	0.07	0.11	0.13
- Pig Industry	0.40	0.42	0.60	0.78	1.00	1.43	1.37	1.95	2.58	2.68	2.75	3.47
- Egg Industry	0.15	0.15	0.16	0.22	0.31	0.28	0.37	0.30	0.45	0.57	0.59	0.64
- Sugar	-	-	-	-	-	1.28	1.40	1.37	1.48	1.28	3.40	5.26
- Tobacco	0.47	0.55	0.67	0.66	0.69	0.64	0.94	0.77	0.59	0.59	0.92	0.57
- Forestry		--	-	-	-	-	-	-	-	-	-	2.00
Total	22.29	23.71	30.61	32.61	41.98	49.25	60.82	77.09	79.00	94.86	108.22	95.27

(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)

	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94 (est)
EMPLOYMENT, EDUCATION & TRAINING*												
Higher Education Funding Act: special research assistance [1]	5.9	5.7	5.6	5.9	6.0	9.0	12.1	77.3	178.7	240.3	260.0	290.0
Identifiable research support for universities[2,4]	94.0	104.0	112.0	118.0	126.0	134.0	160.0	165.0	170.0	175	180	185
Estimated research component of general university funding for both teaching and research[3,4]	310	330	418	475	560	610	670	650	650	700	760	815
INDUSTRY, TECHNOLOGY & COMMERCE												
Tax Concession[5] for industrial R&D	-	-	-	147	184	219	252	290	376	395	415	368
Tax Deduction for equity subscriptions in Management Investment Companies (MICs)[6]	-	-	20	20	20	20	7	19	34	-	-	-
TOTAL	**410**	**440**	**556**	**766**	**896**	**992**	**1101**	**1201**	**1409**	**1510**	**1615**	**1658**

* 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 funding for ARC Research Grants, Postgraduate Awards, Fellowships, Overseas Postgraduate Research Scholarships, Special Centres and Infrastructure but excludes funding through Budget sources.

(2) Indicative estimates. The three most recent items are projections based on 1987 identifiable research expenditure data collected by DEET from pre-1986 universities and include funds earmarked for research purposes. They do not include funds spent on research from the operating grants of former advanced education institutions nor do they include funding of the John Curtin School of Medical Research which is now funded through DHHLGCS.

(3) The data since 1988-89 are projections based on the 1988 ABS R&D Survey. They should be regarded as indicative only, especially given the magnitude of changes in the higher education sector over recent years, including amalgamations and the redirection of funds from university operating grants to the ARC. They include an estimate of the research component of teaching and research expenditure from the operating grants of the pre-1986 universities. They do not include funds spent on research from the operating grants of former advanced education institutions. Estimates for 1978-79, 1981-82, 1984-85, 1986-88, 1988-89 and 1990-91 are based on ABS R&D Survey data. Estimates for other years are indicative only.

(4) As far as possible, the estimates provided are on a basis consistent with the regular ABS surveys of R&D. The following data, of interest for other purposes, are derived using the Relative Funding Model (see last year's Statement).

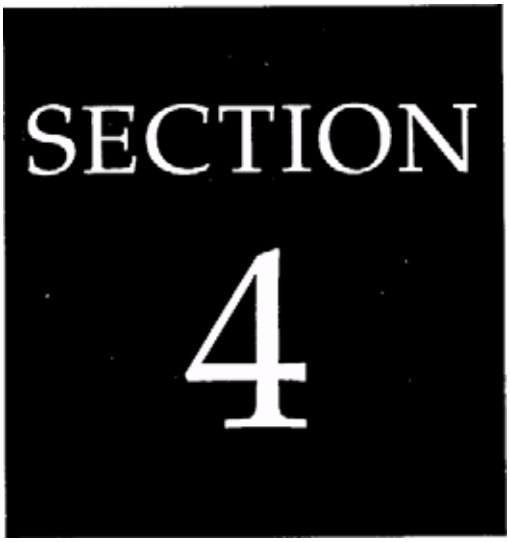
	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94 est
ANU Institute of Advanced Studies (estimate) [a]	76	81	87	93	97	100	108	122	134	133	128	129
Estimated research and research training component of higher education operating grants [b]	229	252	271	293	315	334	366	397	390	440	475	510

(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. From 1992 excludes John Curtin School of Medical Research which is now funded through DHHLGCS.

(b) This is an estimate of the research and research training funds within the operating grants of all higher education institutions. The relevant methodology, developed for the Relative Funding Model applied to the operating grants of institutions in 1990, estimates a component of the operating grant associated with research training and another associated with non-training research.

(5) A 150% company tax deduction for eligible industrial R&D expenditure has applied from 1 July 1985. The data series comprise estimates based both on information provided in registrations for the concession and analysis by 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. Hence the series given shows the estimated cost to revenue attributable to business R&D activity in particular years. Because the payment of tax is lagged behind the concessional R&D activity, a separate series estimates the revenue foregone in each year. From 1985-86 to 1992-93 this series is nil, $105m, $145m, $190m, $250m, $290m, $370m, $385m and $405m.

(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.



International Context

Broad international comparison of R&D levels

R&D levels in different nations 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 comparison between different countries. The major advantage of this ratio is that it removes any need for consideration of exchange rates or inflation.

TABLE 7 Gross expenditure on R&D (GERD), GERD as a proportion of GDP, and change and growth rates since 1981 - nineteen OECD and five Asian nations

	GERD (1985 US$m)	GERD/GDP	Change since 1981	Average annual real increase in GERD	Average annual real increase in GDP
United States (1991)	126722	2.78	+0.33	4.2%	3.3%
Japan (1991)	54175	2.85	+0.72	7.4%	4.3%
Germany (1991)	27932	2.58	+0.15	4.2%	2.9%
France (1991)	20044	2.42	+0.45	4.3%	2.4%
China (1990)	19945	0.72	na	na	13.8%
United Kingdom (1990)	16765	2.22	-0.20	2.5%	3.0%
Italy (1991)	10751	1.38	+0.50	7.3%	2.6%
Canada (1991)	6053	1.46	+0.23	4.1%	3.1%
India (1990)	5667	0.79	+0.20	9.4%	5.7%
South Korea (1990)	4790	1.86	+1.24	24.2%	9.9%
Netherlands (1991)	3935	2.00	+0.12	3.3%	2.3%
Spain (1991)	3412	0.87	+0.45	11.3%	3.5%
Switzerland (1989)	3317	2.86	+0.57	5.8%	2.3%
AUSTRALIA (1990)	3190	1.35	+035	6.6%	3.2%
Sweden (1991)	3004	2.54	+0.24	3.3%	2.1%
Belgium (1990)	2293	1.69	+0.07	3.1%	2.3%
Taiwan (1990)	2241	1.69	+0.77	15.8%	8.5%
Austria (1991)	1629	1.48	+0.32	4.6%	2.5%
Finland (1990)	1286	1.87	+0.68	8.8%	3.0%
Denmark (1991)	1143	1.59	+0.49	6.6%	2.3%
Norway (1991)	953	1.83	+0.54	5.3%	1.2%
New Zealand (1990)	333	0.87	-0.14	-0.2%	1.2%
Singapore (1990)	307	0.90	+0.62	22.3%	6.6%
Ireland (1990)	281	0.90	+0.17	6.2%	3.7%
Average (24 countries)		**1.73**	**+0.39**	**7.4%**	**4.0%**
Average (OECD only)		**1.87**	**+0.32**	**5.2%**	**2.7%**

Source: D1T&RD based on ABS, OECD and US National Science Foundation data.

Table 7 shows the latest available GERD/GDP data for nineteen OECD and five Asian countries. Since it is also useful to know the relative scale of national R&D effort in different countries, the countries are ranked by the total R&D expenditure level (in US dollars at constant 1985 prices). The Table also shows the change in the GERD/GDP ratio since 1981, and the average annual real growth rates over the decade 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 of countries. Australia's relative R&D effort is less than half those of Switzerland and Japan (the highest) and is just under double that of the lowest. In almost all countries, the real growth rate in GERD over the past decade was significantly higher than the corresponding growth in GDP. The three "dynamic Asian economies" shown (Singapore, South Korea and Taiwan) 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). Different countries vary widely 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 each of the countries in Table 7, and shows countries in order of GERD/GDP.

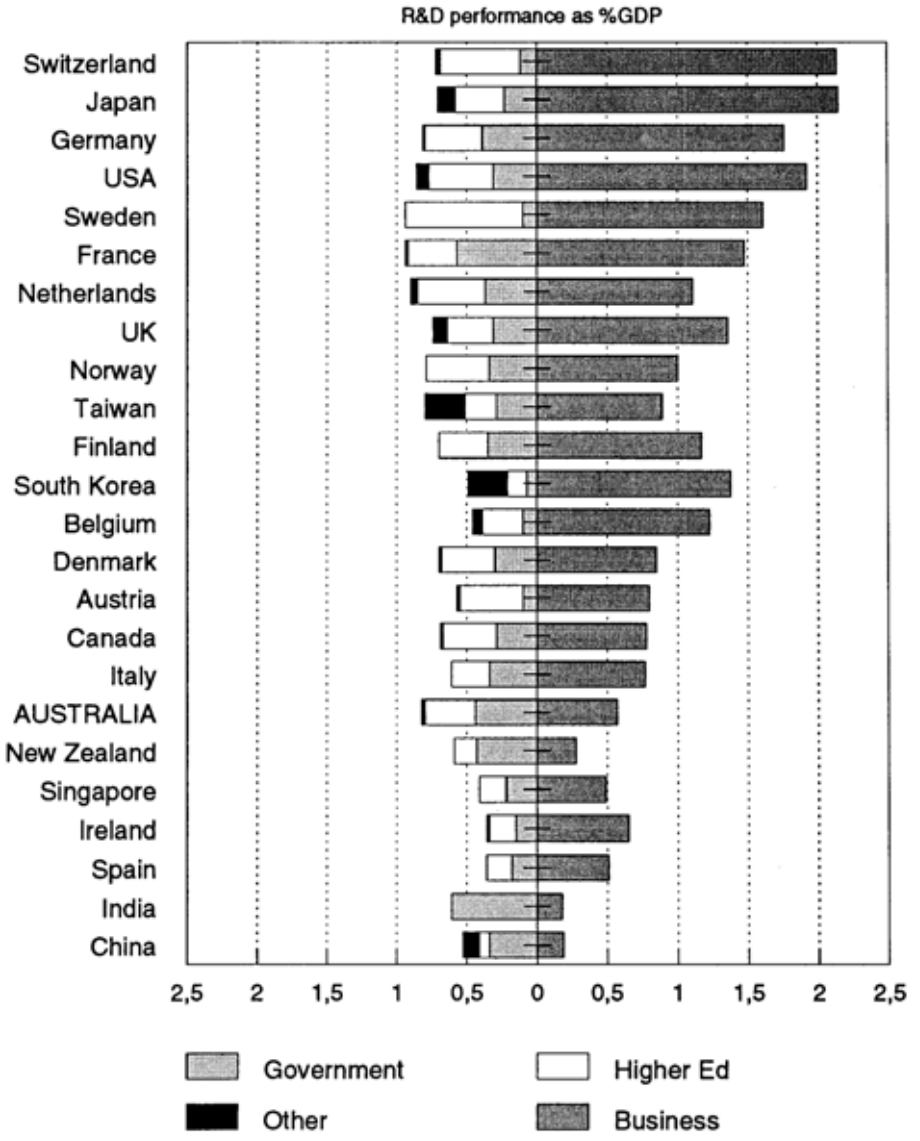
There is much advantage in comparing the sectors separately. A complication, however, is that institutional structures in the government and academic sectors vary widely between countries. The type of research or function typically undertaken in government agencies in one country may be undertaken in universities in another. The reverse also applies. Thus, international comparisons are best based, not on GERD, 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. The countries are arranged in order of R&D expenditure as a percentage of GDP. The Table also shows shows changes in this ratio since 1981 and the average annual real growth rate since that time.

Figure 7

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



Source: DIT&RD based on ABS, OECD and US National Science Foundation data.

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 0.79% compared with an average of 0.62% for all twentyfour countries shown. Our change since 1981 has been +0.04, below the average change of +0.08. However, there was some degree of convergence towards the mean among countries over the period. The eleven countries which were highest ranking in 1981 increased by an average of only +0.03, compared with an average increase of +0.13 for the lowest ranking eleven.

TABLE 8 Expenditure on R&D in government agencies and universities as a proportion of GDP, change and growth rates since 1981- nineteen OECD and five Asian nations

	R&D expend. in govt and universities as % GDP	Change since 1981	Average annual % real increase in R&D expend.
Sweden (1991)	0.93	+0.10	3.5%
France (1991)	0.92	+0.13	3.5%
Netherlands (1990)	0.85	+0.03	2.0%
Norway (1991)	0.83	+0.23	4.9%
Germany (1991)	0.80	+0.09	4.4%
AUSTRALIA (1990)	**0.79**	**+0.04**	**3.5%**
United States (1991)	0.76	+0.11	4.8%
Finland (1990)	0.70	+0.17	6.8%
Switzerland (1989)	0.69	+0.10	4.6%
Denmark (1989)	0.68	+0.14	5.7%
Canada (1991)	0.67	+0.05	2.5%
United Kingdom (1990)	0.64	-0.22	-0.5%
Italy (1991)	0.61	+0.23	7.1%
India (1990)	0.61	+0.18	10.1%
New Zealand (1990)	0.59	-0.17	-1.6%
Japan (1991)	0.58	-0.05	3.4%
Austria (1989).	0.55	+0.06	3.7%
Taiwan (1990)	0.51	+0.25	12.7%
Singapore (1990)	0.41	+0.29	20.6%
China (1990)	0.41	na	na
Belgium (1990)	0.40	+0.00	2.2%
Spain (1991)	0.36	+0.13	8.4%
Ireland (1990)	0.34	-0.06	1.6%
South Korea (1990)	0.21	+0.06	14.1%
Average (24 countries)	**0.62**	**+0.08**	**5.6%**
Average (OECD only)	**0.67**	**+0.06**	**3.7%**

Source: DIT&RD based on ABS, OECD and US National Science Foundation data.

Business expenditure on R&D

Table 9 shows comparative international data for business expenditure on R&D (BERD). The countries are arranged in order of BERD as a percentage of GDP. The Table also shows changes in this ratio since 1981, the average annual real growth rate since that time, and the average annual increase in patent applications made by nationals of each country to all other countries ("external" patent applications).

TABLE 9 Business expenditure *on* R&D (BERD) as a proportion of GDP, change since 1981 and growth rates in BERD and patents applied for in foreign countries - nineteen OECD and five Asian nations

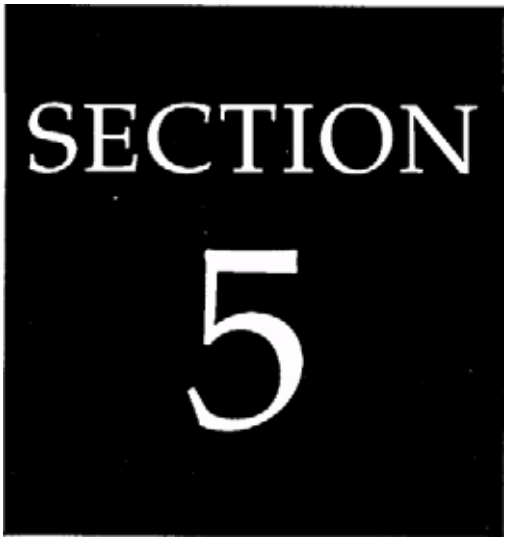
	%BERD/GDP	Change since 1981	Average annual real increase in BERD	Average annual increase in ext. patents
Japan (1991)	2.15	+0.74	8.8%	11.4%
Switzerland (1989)	2.14	+0.44	6.0%	5.0%
United States (1991)	1.92	+0.20	4.0%	9.4%
Germany (1991)	1.76	+0.06	4.1%	8.2%
Sweden (1991)	1.61	+0.14	3.1%	8.4%
France (1991)	1.48	+0.32	4.9%	8.2%
South Korea (1990)	1.38	+1.12	31.6%	na
United Kingdom (1991)	1.36	-0.14	2.8%	10.5%
Belgium (1990)	1.23	+0.18	3.9%	8.7%
Finland (1990)	1.17	+0.52	10.4%	15.1%
Netherlands (1991)	1.11	+0.11	4.3%	9.1%
Norway (1991)	1.00	+0.32	5.7%	13.6%
Taiwan (1990)	0.89	+0.37	16.5%	na
Denmark (1989)	0.85	+0.31	8.5%	13.5%
Austria (1989)	0.80	+0.15	4.9%	8.8%
Canada (1991)	0.78	+0.18	5.6%	8.8%
Italy (1991)	0.77	+0.28	7.5%	10.1%
Ireland (1991)	0.65	+0.34	11.2%	12.5%
AUSTRALIA (1991)	**0.57**	**+0.32**	**13.1%**	**16.9%**
Spain (1991)	0.51	+0.32	14.0%	10.7%
Singapore (1990)	0.49	+0.34	23.8%	na
New Zealand (1990)	0.28	+0.06	4.8%	0.5%
China (1990)	0.19	na	na	na
India (1990)	0.18	+0.02	7.2%	na
Average (24 countries)	**1.05**	**+0.29**	**9.0%**	**na**
Average (OECD only)	**1.16**	**+0.25**	**6.7%**	**10.0%**

Source: DIT&RD based on ABS, OECD and US National Science Foundation data.

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. There was little sign of any convergence. As with most other countries beginning with low levels of BERD in 1981, Australia achieved increases in BERD/GDP and growth rates well above OECD averages. In fact, over the period 1981 to 1991, Australia's real growth rate in BERD was the second highest in the OECD. Nevertheless, growth rates in OECD nations were all much lower than for the three dynamic Asian economies in the Table. South Korea, with a real annual growth rate of about 32 per cent, Singapore on 24 per cent, and Taiwan on 17 per cent, were all well ahead of the OECD leaders, Spain and Australia, with corresponding growth rates of 14 and 13 per cent, respectively.

While comparative R&D data for the business sector are often used as an indicator or proxy for innovation in the wider sense, national data on external patent applications provide an alternative indicator. These data, at present available only for OECD countries, show Australia with substantially the highest growth rate. The ranking of countries by growth in external patent applications correlates well with their ranking by growth in business expenditure on R&D. Since this information is statistically quite separate from the business R&D expenditure, it provides valuable confirmation of the substantial growth achieved in Australia's business sector R&D.

The data in Table 9 confirm the picture of very significant increases in Australian business innovation over the 1980s, over a period in which an extensive range of Commonwealth programs were instigated with the aim of stimulating innovation. Nevertheless, in view of Australia's continued low ranking in BERD/GDP, which is also shown in Table 9 - and the remarkable BERD growth rates being achieved in Asia - there is no room for complacency. If, over the next decade, Australia is able to continue the R&D growth rates achieved since 1981, a significant improvement in our ranking is likely.



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 1993-94 Budget compared with the expenditure outcome for 1992-93. 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 and scientific research n.e.c.*

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.

ARTS AND ADMINISTRATIVE SERVICES

Science and Technology in the Portfolio Budget

The Arts and Administrative Services portfolio provides science and technology services through a number of organisations.

The Australian Government Analytical Laboratories operate through the Department of the Arts and Administrative Services (DAS) Trust Account on a fee for service basis. The Laboratories' projected 1993-94 turnover is $20 million, of which $5.9 million is provided through appropriation for public interest activities.

The Ionospheric Prediction Service is budget funded at $2.8 million in 1993-94.

The Scientific Services Laboratory is part of DAS Australian Construction Services, which operates through the DAS Trust Account on a fee for service basis.

The DAS Centre for Environmental Management is a business unit which operates along commercial lines within the DAS Business Services Trust Account. The Halon Bank has been established on a commercial basis with major users meeting the cost of collection, storage and destruction of halons. These are a class of ozone-depleting substances in common commercial use. The community service component of the project will be subsidised by Government ($4.6 million over four years).

The following agencies and authorities administered by the Australian Cultural Development Office have a diverse range of science and technology responsibility and activities: the National Science and Technology Centre, the National Film and Sound Archive and the Australian Film Commission. The Cultural Development Office believes that science and technology are essential components of culture. The Minister for the Arts and Administrative Services is developing a Cultural Policy which will view science and technology as part of the cultural mainstream of Australian society and as a driving force in the development of an Australian identity.

MAJOR RESEARCH ACTIVITIES

Australian Government Analytical Laboratories (AGAL)

Role: *To develop analytical methods of suitable precision, accuracy and efficiency to meet demands from the Australian Government for emergency testing services involving the health or safety of the community or threatening Australia's export market for agricultural produce.*

Recent Achievements

Analytical advances for public health and the environment
AGAL has applied its expertise in general analytical chemistry techniques to the development of solutions for national problems. In particular, AGAL now has methodologies available to assist regulatory authorities to identify polluters of the marine environment so that appropriate action can be taken.

AGAL has developed a capability for the analysis of nitrosamines, known carcinogens, commonly found in many processed foods and rubber based products. These compounds have been of concern to public health authorities but until now facilities to enable their routine identification have not been widely available.

In the environmental area, AGAL has extended existing methodologies to develop a multi-residue screening method which can be applied to a wide variety of soil types. Previously identification of the soil type was required in order to select the appropriate analytical method. This development will be useful in assessing land sites for contamination.

Ionospheric Prediction Service (IPS)

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

Recent Achievements

Advanced Stand Alone Prediction System (ASAPS)
A new version of an IPS PC software package for radio frequency management, was released. This incorporates a number of improvements suggested by its users. It has been exported to many countries including Indonesia, USA and NZ. An agent for North America and Canada has been appointed. Also a software licence was negotiated with the Australian Defence Science and Technology Organisation for ASAPS enhancement of their own software, which is being marketed by Australian industry.

Autoscaling
IPS, like similar international organisations, has been developing computer software to analyse ionospheric records. The main objectives for the software, called autoscale software, are to reduce the amount of tedious manual processing currently required to process records, to allow more data to be collected and to speed up the data processing so estimates of ionospheric conditions can be obtained in near real time. This capability has attractive commercial applications and the present system has been licensed to a private enterprise group.

Ray tracing
IPS High Frequency (HP) predictions are based on an empirical model that simulates the radio wave path through the ionosphere. This path can be calculated more precisely using numerical ray path tracing techniques, but the associated methods are usually too slow for practical application. Recently, there has been a revival of interest in faster analytic ray tracing techniques that could be used to enhance the IPS empirical model and reduce the need for approximations. A number of analytic ray tracing programs have been developed for IPS by a visiting French scientist for this purpose.

Culgoora radiospectrograph
The upgrading of the Culgoora radiospectrograph, which monitors radio storms on the sun, has enabled IPS to provide a standard against which the United States' global solar radio network measured its capability. IPS was invited by the United States Air Force to evaluate the development of its own smaller spectrograph. Japan has also sought information about the IPS spectrograph.

Scientific Services Laboratory (SSL)

Role: *To provide the Department of the Arts and Administrative Services with a research and investigation capability in relation to its design and construction and maintenance operations, and to provide a commercial scientific service to external clients in the construction and related industries.*

Recent Achievements

National fire safety
SSL has been a major contributor to the development of a new Fire Safety Code. Research targets to complete the Code have been identified and a new Fire Code Reform Centre has been formed to coordinate and facilitate this research to establish more cost effective fire protection for Australian buildings.

SSL has also published research relating to standards of fire protection products particularly in the telephone and computer industry in this past year.

Appraisal and accreditation
SSL has extended its national accreditation service to domestic smoke alarms, advising to councils, building control authorities and fire brigades with major input to new Australian Standards. SSL's role in appraisal and accreditation has been recognised by South East Asia by acceptance of SSL's listing by Hong Kong Fire Brigade and through the international agreement with Factory Mutual Research Corporation (USA) that is influential in supporting Australian fire equipment exports to that region.

Magnetic field interference
SSL has conducted research into problems of magnetic fields associated with 50Hz power distribution cables in buildings. SSL has conducted extensive field surveys identified limits for equipment interference and developed methods for investigation of the effects of these fields. In addition, SSL has conducted research for and with a major occupational health consultant on the OHS aspects of magnetic fields.

Fluorescent lights and exit signs
SSL has undertaken significant research into failures of fluorescent light starters and exit signs that have led to fires in Commonwealth properties. The work has been undertaken at the request of the Commonwealth Fire Board within DAS and has resulted in identification of a failure mechanism for fluorescent starters and the development of new test requirements for input to an Australian Standard.

Government Paint Committee (GPC)
The GPC has taken the initiative in progressing the Government's policy in Occupational Health and the Environment to reduce the toxicity of paints by making Material Safety Data Sheets more widely available, by withdrawing approval of paints containing known toxic ingredients and encouraging the industry to offer non toxic alternatives. By its input to Standards Australia, it has ensured the redrafting of National Standards to exclude toxic ingredients.

DAS Centre for Environmental Management (DASCEM)

Role: *DASCEM provides its customers with a range of environmental management services. DASCEM's market segments are contaminated land assessment and remediation, energy management services, and halon management and recovery.*

Recent Achievements

The halon bank
In recent years the international scientific community has expressed concern over the depletion of the ozone layer in the Earth's upper atmosphere. Amongst other factors, this depletion has been attributed to the human released gases chloroflurocarbons (CFCs) and halons. Halon is a volatile liquid used in some fire extinguishers and for explosion suppression.

To support Australia's international obligations a 'halon bank' has been established with operations having commenced in May 1993, its purpose is to collect, store, decant and eventually destroy most of the existing quantities of halon.

National Film and Sound Archive

Role: *To increase knowledge, appreciation, use and enjoyment of Australia's moving image 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

Management database system
During 1991-92 the National Film and Sound Archive developed and implemented a new, custom designed, integrated database collection management system called AIMS (Archive Information Management System). AIMS has replaced incompatible computer and manual systems, and gives the Archive greater control over its collection of moving image and recorded sound material. AIMS is at the forefront of computerised collection management system in archives throughout the world. The Archive is currently examining the feasibility of commercialising AIMS and marketing

it as a product with, a particular focus on the Asia Pacific market.

Restoration of acetate colour film

On 30 June 1993, the National Film and Sound Archive completed a three year Colour Film Restoration Program. During the project a total of 22 million feet of acetate film was examined to identify damage sustained in conditions of high humidity. An estimated 7.7 million feet of colour film was given restorative treatment for film suffering from emulsion lifting, mould infestation and interlayer adhesion which causes the reel of film to become a solid block. The treatment was based upon research studies of gelatin polymers with extensive use of artifical ageing techniques by the Archive's Conservation Laboratory. As a result the Archive is now among the world leaders in colour film repair technology.

DEFENCE

Science and Technology in the Portfolio Budget

The Budget allocation for the Defence science and technology function will be $231.4 million in 1993-94 ($218.1 million actual outcome in 1992-93).

MAJOR RESEARCH ACTIVITIES

Defence Science and Technology Organisation (DSTO)

Role: *To enhance the security of Australia through the application of science and technology.*

Recent Achievements

Surveillance technology

The evaluation of an Infrared Intrusion Sensor (IRIS) for use in perimeter surveillance and vital asset protection has been completed. IRIS was successfully trialled with the Australian Army at Puckapunyal and Darwin and demonstrated to other Australian Defence Force (ADF) units, the NT Police Drugs Squad and the Australian Customs Service. Two units have been lent to the Swedish defence R&D, procurement and testing organisations. AWA Defence Industries Ltd has taken out a licence to develop and market IRIS.

Currently the Navy does not have fleet-wide forward looking infrared (FLIR) in its Seahawk helicopters to assist passive identification of surface vessels. A FLIR concept demonstrator system designed by DSTO and developed by British Aerospace Australia with Defence Industry Development funding has been delivered to the Department of Defence and trialled. The concept demonstrator was compared with various in-service and experimental infrared surveillance equipments furnished by companies from around the world. The performance of the concept demonstrator confirmed the predictions of the modelling studies and will assist the ADF to specify its Sea Hawk FLIR requirements.

Command, control, and communications
Research into command and control systems progressed with DSTO scientists working with key Department of Defence clients to explore advances in this technology. Key achievements were the demonstration of a prototype distributed situational awareness display and a movement planning system.

Collaborative research with Telecom resulted in the completion of a developmental communications network which is capable of supporting complex command and control applications over long distances. This network is one of the first in the world to be deployed in either the civil or military communications arenas and is now operational.

Electronics countermeasures
Through transfer of technology to Australian industry, development of an improved radar warning receiver for the ADF's F-lll aircraft was completed and a concept demonstrator provided to the Air Force, which has decided to proceed with full scale engineering development based on its performance. The benefits include a state-of-the-art radar warning receiver for the F-111 and the establishment in Australian industry of the capability to design, build and maintain advanced electronics support systems.

Life extension and repair of aircraft structures
A collaborative test program has been established to provide base-line data on the fatigue performance of the Australian F/A-18 and similar Canadian fleets. The Canadians are testing the centre fuselage and wing structure while Australia is testing the aft fuselage and empennage structure. Full-scale fatigue test of the aft fuselage of the F/A-18 will commence in 1993-94. Other achievements included: completion of research on detection and assessment of cracks in load-bearing structures in the F/A-18; on repair and preventive reinforcement schemes, and on improved surface treatment of airframes and specialist advice was provided to the F-111 Avionics Update Project Office regarding aircraft dynamic manoeuvres and store separation characteristics.

Transfer of technology
An Industry Support Office (ISO) was established to assist the transfer of DSTO developed technology to industry and make DSTO expertise and facilities more readily available. Specific assistance was given in composite bonded repair technology, vibration and defect prediction in helicopter gearboxes, corrosion protection and automatic hydraulic test facilities. Active participation in Cooperative Research Centres was undertaken.

International initiatives
DSTO made a major contribution and provided technical advice to the drafting of the UN Chemical Weapons Convention which was signed in Paris on 13 January 1993. Since then, the implementation phase has progressed with a strong Australian input to the establishment of the Preparatory Commission of the Organisation for the Prohibition of Chemical Weapons (OPCW) and more specifically for DSTO to the Provisional Technical Secretariat in the Hague. Additionally, DSTO issued papers and made

presentations at the April 1993 Seminar of the Chemical Weapons Regional Initiative.

On 24 March 1993, an Agreement was signed by the Government of Australia and the Government of the Republic of Singapore to promote collaboration in defence science and technology. This will allow DSTO and the Singaporean Defence Technology Group to cooperate and collaborate in areas of mutual interest. Collaboration has already commenced and at the time the Agreement was signed, two Subsidiary Arrangements were also signed to cover cooperation in communications technologies. Further cooperation is planned in the areas of aircraft engine performance modelling and in mine countermeasures.

EMPLOYMENT, EDUCATION AND TRAINING

Science and Technology in the Portfolio Budget

The Department of Employment, Education and Training will provide over $900 million in 1993-94 to support research and research training at higher education institutions, both through higher education operating grants and through a range of targeted research support programs.

Support for Universities

A major part of the Department's support for the research activities of higher education institutions is provided through operating grants which cover the cost of training postgraduate research students, research infrastructure costs, and internal research funding. In 1993 institutions have been notionally allocated $285million for research training and $207million as the research component for staff research activity unrelated to research training. These funds are provided to institutions as part of their one-line operating grants with the institutions themselves deciding on how these funds are allocated.

In addition, direct research funding of about $129 million in 1993 is provided by the Department as operating grant funding for the Institute of Advanced Studies at the Australian National University. (The John Curtin School of Medical Research is now funded through the Department of Health, Housing Local Government and Community Services.)

The Department funds the research activities of higher education institutions directly under a range of targeted research support programs. Most of these programs allocate funds on a competitive basis in line with Government policy that research funds should go to those researchers that are most able to make the most effective use of them.

ARC Research Funds

Research grants and fellowships are awarded competitively on the advice of the Australian Research Council (ARC) using the primary criterion of excellence as determined by the peer review process, and support research in all fields other than medicine and dentistry. Other research support programs promote Government objectives of selectivity and concentration of research resources, support for research training, improved research collaboration between higher education institutions and industry, international cooperation in research, and the development of infrastructure to support high quality research.

In 1993-94 around $296 million (over and above the operating grants components) will be allocated under the Department's research support programs, as follows: $113.7 million for Research Grants (including Large, Small and Collaborative Research Grants); $20.4 million for Research Fellowships; $67.2 million for Postgraduate Awards; $12.7 million in Overseas Postgraduate Research Scholarships; $20.7 million for Research Centres; $55.7 million for Research Infrastructure; $3.1 million for the Anglo-Australian Telescope Board; $1.4 million for grants to the learned academies and ANZAAS; and $0.6million for research evaluation.

The Department administers the Targeted Institutional Links Program which aims at stimulating academic and research cooperation between Australian higher education institutions and their counterparts in Asia. The program provides seed funding to Australian institutions to support collaborative research links which foster internationally competitive research in Australia's national priority areas. Postgraduate scholarships are also awarded to scholars from Korea and Taiwan, whose field of study directly complements the research links between institutions. In 1993-94, $1.4 million will be allocated under this program.

Advanced Engineering Centres

The Department contributes to the cost for the establishment and operation of three Advanced Engineering Centres within universities:

- the Advanced Engineering Centre for Manufacturing (Proponents: The University of Melbourne and the Royal Melbourne Institute of Technology);
- the Australian Graduate School of Engineering Innovation (Proponents: the University of Technology, Sydney and the University of Sydney); and
- the Advanced Engineering Centre for Information Technology and Telecommunications (Proponents: The University of Adelaide, The University of South Australia, The Flinders University of South Australia and the South Australian Government Department of Technical and Further Education).

The Advanced Engineering Centres increase the higher education contribution to industry design and engineering capability thereby helping in the development of competitive value-added industries. They also increase higher education's contribution to developing and applying commercial uses of technology. Industry partners will be directly involved in the planning and management of the Centres, as well as in program design and delivery. In 1993, each Centre received a Commonwealth contribution of $0.7 million for establishment costs and $0.5 million for operating costs. Operating costs will continue to be funded at $0.5 million each in 1994 and 1995. The higher education and industry partners also contribute to establishment and operating costs.

MAJOR RESEARCH ACTIVITIES

Higher Education Operating Grants

Role: *To maintain and enhance the range and quality of education provided by higher education institutions and to maintain the capacity for research across a broad spectrum of fields in higher education institutions.*

Recent Achievements

The use of fabrics in sun protection
Funds distributed through the Special Research Grants Program of the University of New South Wales have provided an opportunity to expand work relating to the use of fabrics in sun protection. The University's contribution to this work has led to the promotion of a measure of the effectiveness of fabrics in reducing radiation incidence on the skin, known as the sun protection factor (SPF). Further work has shown that certain chemical agents applied to textiles can substantially alter the protection indices of fabric, and patent applications have been made for certain chemical agents. Licensing agreements between the University's Unisearch, chemical manufacturers and the textile processing industry support commercialisation.

Getting sunlight into buildings
Researchers at the University of Technology, Sydney have developed technology to illuminate dark areas inside buildings with 'captured' sunlight. They have found that light absorbed by molecules on plastic sheets or tubes can be channelled in the same way as water runs through a pipe. Ways of mass-producing this 'molecular light bulb' are being explored with a local company. An appliance using the principles tested by the researchers is manufactured by Skydome Industries in Sydney. The clue to its high efficiency is a silver metal coating inside the pipe which reflects 94 per cent of incoming light. Using this technology, a pleasant yellowish illumination can be provided several metres into a building from the inlet. The technology has potential to deliver major savings in electricity consumption for daylighting commercial buildings.

Early detection of breast cancer
Researchers at the University of Technology, Sydney have been working on a biophysics project to improve the follow up process of assessing mammograms. The method they have proposed is non-invasive and safe. Results can be obtained quickly compared with several days delay and the high cost of a pathological test after initial clinical diagnosis.

Research Grants

Role: *The Research Grants program supports high quality research by individuals or research teams throughout Australia. Research grants are allocated for specific research projects on a competitive basis on the advice of the Australian Research Council. The program includes the Large Grants Scheme, the Small Grants Scheme and the Collaborative Grants Scheme.*

The Large Grants Scheme provides research grants on a competitive basis for high quality research by individuals or research teams throughout Australia. Applications are invited each year for grants for the following year in support of pure and applied research in the physical, chemical, biological, earth, engineering, applied and social sciences, the humanities and designated priority areas. Applications are assessed by the Australian Research Council's Research Grants Committee and its expert discipline panels with the aid of external assessors.

The Small Grants Scheme provides block grants to higher education institutions to fund research grants for less than the minimum for which large grants are provided. In 1994 these limits will be $20 000 in the social sciences, humanities, mathematics and theoretical physics, and $30 000 in other disciplines. All institutions in the Scheme will receive a base grant of $50 000 and the remaining funds will be distributed according to a formula which takes account of the success each institution has in obtaining Large Grants in each of the main discipline groupings and the distribution of Small Grants across those groupings in the previous year.

The Collaborative Research Grants Program aims to support high quality research with the potential for economic and social benefit to Australia, and to encourage research collaboration between higher education institutions and industry. Grants are available for work in all areas of the natural sciences and engineering, as well as the social sciences and humanities. Funding is provided on a dollar for dollar matching basis with industry. Applications are assessed by the Collaborative Research Grants Panel of the Australian Research Council.

Recent Achievements

Advanced semiconductor structures

The National Pulsed Magnet Laboratory for condensed matter research has been established at the University of New South Wales and produces the highest non-destructive magnetic fields available in the world. Experiments have concentrated on the optical detection of the formation of an electron solid in specialised semiconductor structures. This is a new state of matter and represents the study of fundamental physics of semiconductors which

will form the basis for the next generation of electronic devices. The research group is actively pursuing extremely small structures down to the atomic scale and represents the first stage of nanotechnology in Australia.

Regulation of gene expression in yeast

Research being undertaken at the University of New South Wales into the regulation of gene expression in the yeast *Saccharomyces cerevisiae* has produced major outcomes with significance for basic medical research as well as potential for commercial application. The first major outcome is the identification of elements within the protein coding sequence that controls the way genes are expressed which has major implications for the biotechnological use of yeast for producing valuable proteins by recombinant technology. A second outcome has been the identification of elements that control the timing of the flow of genetic information during cell development. This work will contribute to an understanding of how cells normally differentiate and how aberrant changes can occur in pathological states. The third major outcome has been the identification of inducible response systems protecting yeast cells from stress caused by oxidants and free radicals.

Studies of the fossil animals of Riversleigh and Murgon

Researchers at the University of New South Wales have achieved spectacular results from studies into the diversity, distribution and significance of fossil animals from Murgon, south eastern Queensland, and Riversleigh, North Western Queensland. From the 55 million-year-old clays at Murgon, which accumulated at a time before Australia split from Gondwana, have come a plethora of strange marsupials as well as some of Australia's earliest known frogs, birds, crocodiles and snakes and perhaps the earliest known bat in the world. However, the most surprising result has been the discovery of the first and only known terrestrial 'primitive' placental mammal from Australia, which indicates that our marsupials dominated this continent not because they had a refuge from more 'superior' mammals but because here they out-competed the placental groups that subsequently dominated the mammal faunas of other countries.

From Riversleigh, 200 new kinds of Tertiary mammals have been found, trebling the previous count for the whole continent. These, along with the rich record of birds, snakes, lizards and invertebrate groups are contributing to a massive overhaul of knowledge about the diversity, evolutionary history, biogeography and biostratigraphy of Australia's Cainozoic animals. The accumulating data in conjunction with modern ecology is being used to assess the conservation status of Australia's living animals to develop an understanding of which of Australia's animals are really secure and which are endangered.

Industrial catalysis by supported metals and metal oxides

Researchers at the University of New South Wales and Macquarie University have succeeded in achieving improvements to industrial heterogeneous catalysts that are made and used in Australia. The researchers developed a method for replacing expensive imported alumina used in the manufacture

of car exhaust catalysts by cheap Australian sourced raw material.

Research into supported nickel catalysts used in Australia to promote steam reforming en route to ammonia production was also undertaken. To avoid the formation of carbon on the catalysts requires operation at high temperatures. The researchers have identified a family of dopants that, when added in small amounts to the catalysts, lead to significant reduction in the propensity to form carbon. This invention, currently being pilot tested in America, is expected to significantly reduce operating costs of steam reforming.

Ecophysiology of rainforest regeneration

Researchers at the University of Queensland have shown that the maintenance of diverse rainforest communities is essential to their conservation and for commercial production. A project in the rainforests of southern Queensland has shown the importance of both the quantity and quality of light in the forest on time scales from a few minutes to a whole year. Physiological characteristics of a number of ecologically important forest species have been determined and their abilities to grow in different environments have been predicted successfully. This work will enable forest and conservation managers to design regeneration strategies for valuable species under conditions where changing climate or other environmental conditions may be important.

Plasma fluidized bed reactor

Researchers at the University of Queensland are undertaking research into a new kind of reactor in which materials are ionised in a high temperature plasma (at about 30,000 degrees) and then condensed into a fluidized bed. The reactor was initially aimed at direct reduction of refractory metal ores to metal in a single step. The experiments showed that a variety of metal oxides and ores can be directly reduced to metal in this reactor. The size of the product material was found under some conditions to be in the superfine range (less than 100 nanometres). Superfine particles, and the materials made from them, display uniquely useful properties of major industrial importance, and command very high values.

Viral diseases in cultured prawns

Researchers at the University of Queensland have developed a rapid tissue-imprint method to detect *Monodon Baculovirus* (MBV), the commonest virus infection in prawn hatcheries in Australia. The virus was shown to be transmitted to mysis and early postlarval stages through water contaminated with virions. It became abundant in the digestive gland for 2-4 weeks after which time it became undetectable if the prawns were kept under good conditions. Drying the tanks or exposing them to high levels of chlorine eliminated the disease.

Sapphire clock

Research into gravitational wave detection at the University of Western Australia has resulted in valuable technological spin offs including the invention of the sapphire clock. This device provides the extremely pure microwave signal which allows the supersensitive measurement of vibration needed to detect gravitational waves. Sapphire clock technology has also

been developed for both time standards and radar systems. Radar versions are now being sold commercially by Poseidon Scientific Instruments. Recently the research group demonstrated a new generation of clocks with even better accuracy. By working closely with the manufacturer of the artificial sapphire, researchers have been able to demonstrate the purest sapphire yet created. Researchers demonstrated the lowest loss ever measured in a crystal resonator, resulting in improved clock technology capable of measuring to an accuracy of almost one millionth of one billionth of a second.

Research Fellowships.

Role: *Fellowships provide support for individuals to undertake research at postdoctoral level and above.*

There are four types of Fellowship: Australian Postdoctoral Research Fellowships (for researchers normally with less than three years postdoctoral experience); Australian Research Fellowships (for researchers normally with more than three years postdoctoral experience); Queen Elizabeth II Fellowships (for outstanding researchers who would normally have no more than six years postdoctoral experience); and Senior Research Fellowships (for researchers with established reputations who would normally have no more than fifteen years postdoctoral research experience).

Recent Achievements

Classification of Australian isolates of Blackleg Fungus
Blackleg Fungus threatens the survival of the canola industry in Australia. A Fellow at the University of Melbourne is using molecular approaches to classify new isolates of the fungus, which will allow for the design of more effective plant breeding programs for blackleg resistance in Australia. The researcher and her team have discovered that major changes in chromosome size occur during meiosis, which may be responsible for the ability of the fungus to adapt rapidly in the field and become virulent.

Fibre-reinforced composites
This project, being undertaken at the University of Sydney, aims to develop high fracture resistance in fibre-reinforced composites, providing a foundation for various types of engineering constructions in the aerospace, automotive, marine, building and sporting goods industries. In experimental study, the Fellow and his colleagues have proved that the fibre bundling technique can improve the fracture toughness of carbon fibre-epoxy matrix composites by 100 per cent.

Analysis of stable isotope ratios by ion microprobe
A Fellow at the Australian National University is applying isotopic microanalysis to ore deposit science. Results to date include several

important microanalytical studies of Australian and other ore deposits which allow a better tracing of source materials and understanding of localisation processes for base metal, precious metal and precious stone concentrations. The research has provided evidence which addresses and answers long-standing questions concerning the origins of these deposits.

Research Centres

Role: *To support research concentrations on the basis of excellence and their potential to contribute to the economic, social and cultural development of Australia.*

The Research Centres Program supports two types of Centres: the Special Research Centres, and the Key Centres of Teaching and Research. Special Research Centres are currently funded at a rate of between $0.4 million and $0.9 million per annum, depending on the Centre and represent concentrations of research effort in areas of national importance.

The Key Centres of Teaching and Research are designed to give equal weight to teaching and research in institutions. They are based on existing departments in higher education institutions and aim at boosting expertise in areas relevant to national development and promoting cooperation between higher education and industry. Key Centres are funded at a rate of around $0.2 million per year. Though this level of funding may be considered modest, a large proportion of the Key Centres obtain considerable additional funding from other sources, such as industry.

Recent Achievements

Advanced control systems
The Centre for Industrial Control Science at the University of Newcastle has made significant advances in the development of Advanced Control Systems. The Centre has developed an adaptive controller, called UNAC, which translates the theoretical aspects or simulations of control theory in software into command applications in hardware to work industrial machinery. UNAC is much more user friendly than other adaptive controllers, UNAC requires fewer functions to operate. A number of units have been sold to BHP for testing.

Solar cells
The issue of how to meet rapidly growing energy requirements sustainably and without pollution is being tackled by the Centre for Photovoltaic Devices and Systems, at the University of New South Wales. The Centre has maintained its international lead in the high efficiency cell area and has now developed the first 19% efficient flat plate photovoltaic module. Low cost, high-efficiency cell technology based on these developments has been

licensed through Unisearch to several major solar cell manufacturers, with technology transfers to two new licensees completed during 1992.

Australian Postgraduate Awards and Overseas Postgraduate Research Scholarships

Role: *Australian Postgraduate Awards provide competitive awards for Australian students undertaking higher degree studies at Australian higher education institutions. Australian Postgraduate Awards (Industry) promote joint industry-higher education research opportunities. Overseas Postgraduate Research Scholarships aim to assist overseas students to undertake research degrees at Australian universities.*

Recent Achievements

Discoveries with IRIS Infrared Imager-Spectrometer
An Australian Postgraduate Research Award holder of the University of Sydney has applied the IRIS Infrared Imager-Spectrometer at the Anglo-Australian Observatory to a wide range of important astronomical projects. She has been involved in projects that have detected the solid surface of Venus beneath its cloud layers, revealed new aspects of the behaviour of oxygen in the atmosphere of Venus and discovered new evidence of starburst and nuclear activity in the radio galaxy CentaurusA.

High Phosphorus content rare-earth doped fibres
An Australian Postgraduate Research Award holder at the University of Sydney has developed an optical fibre fabrication technique based on a high-temperature flash-condensation reaction of a phosphoric acid within a porous silica frit. This technique has enabled production of a novel form of rare-earth doped fibre with a high concentration of phosphorous in the fibre core. This fibre may be incorporated in optical fibre amplifiers, for use in telecommunications. The student's work has resulted in a series of publications and two provisional patents.

Movement of floating blue-green algae
In a collaborative project between ANU and CSIRO's Centre for Environmental Mechanics, an Australian Postgraduate Research Award holder is investigating the mechanisms by which floating blue-green algae are moved around by the wind. This research involves a model "lake" installed in a wind tunnel at the CSIRO. The experiments show that during light winds the algae will be found on the water surface and on downwind beaches, but at moderate winds the algae is removed from the surface by breaking waves and turbulence. A detailed description of the wave breaking

is revealed by state of the art laser illumination and image analysis techniques. The information gathered during this project is to be used in the future to design strategies for the management of blue-green algae in our lakes and rivers.

Spatial variation of sea level change
Although the last deglaciation was practically finished by 6000 years ago, the Earth continues to deform because of the delayed response of its deep interior to the transfer of water from ice caps to oceans. An Australian Postgraduate Research Award holder at ANU has developed numerical models for the spatial variation of sea-level change resulting from the formation and melting of the Earth's vast Pleistocene ice sheets. Accurate models must take account of nonlinear effects such as changes in ocean shape resulting from movement of the coastline and proper redistribution of meltwater. The student has performed the first calculations to include these effects for comparison with the relatively well documented history of coastline movement in the North Sea region. His calculations open up new opportunities for interpreting detailed coastline evolution measurements around the world in terms of the Earth's response to ice age cycles.

Research Infrastructure

Role: *This program provides direct support to higher education institutions to develop and maintain their research infrastructure.*

The three components of the program are: Research Infrastructure Block Grants (Mechanism A) allocated to all members of the Unified National System on the basis of a competitive grants index which measures institutional success in obtaining competitively awarded research funding; Research Infrastructure Development Grants (Mechanism B) provided to institutions with advanced education components in specific areas of identified research strength or potential; and Cooperative Research Infrastructure Development Grants (Mechanism C) for equipment and facilities shared jointly by at least two higher education institutions. From 1994 Mechanism C will also include grants for large equipment items requested by single institutions which previously would have been handled under the former Large Equipment Program.

Recent Achievements

Mechanism A

Robotics and intelligent machines group
A Robotics and Intelligent Machines Group has been established within the Faculty of Engineering at the University of New South Wales to develop integrated robotics research facilities. One local firm has sponsored a

research project aimed at increasing the efficiency of their Plant. The Plant makes chlorine by electrolysis and each of several hundred anodes have to be adjusted manually to keep the efficiency of production at its peak. Members of the Robotics and Intelligent Machines group have designed and built a robot which can be programmed to automatically adjust the anodes. Pre-production trials have shown the robot to be fully capable of all the required functions.

Controlled Environment facility
The central controlled environment facility of the Biomedical and Tropical Veterinary Sciences Department of James Cook University of North Queensland has enabled the breeding of increased numbers of balb-C mice which are used to produce monoclonal antibodies. The monoclonal antibodies are used as vital components in the development of improved diagnostic assays for a range of animal diseases.

Saltwater aquarium
Saltwater aquarium facilities have been developed at James Cook University of North Queensland for use by aquaculture projects, including the development of micro-encapsulated artificial diets for larval bivalves, including clams, oysters and scallops. This work has been very successful and has the potential to substantially reduce the costs of rearing the early stages of these organisms, which at present depends on labour-intensive algal culture. The process is now being adapted to the culture of juvenile fish including barramundi.

Mechanism B

Aerospace design technology
The Sir Lawrence Wackett Centre for Aerospace Design Technology at the Royal Melbourne Institute of Technology is the only design-based aerospace research facility in Australia. Some of the Centre's research achievements over the past year include major developments in 3-D reinforced composite structures for aerospace applications, eg stitched and woven preforms for aircraft structural components, the solution of control problems in non-linear spacecraft and robotic type structures, and the commissioning of a robotics six degree of freedom probe for a wind tunnel - the only one of its type in Australia, and possibly the only one in the world.

Music technology
The Sydney Conservatorium of Music at the University of Sydney is achieving recognised success in Music Technology. This is a growing field of study with the second International Computer Music Conference being held last year in Greece. The Conservatorium's major achievements to date has been the composition of the computer music work Balibo for flute and tape and the live performance MIDI piano piece *A Visit From the Queen* by Dr Martin Wesley-Smith.

Digital communications
The Digital Communications Group at the University of South Australia has

had particular success in developing new remote sensing satellite receiver systems and designing a new wideband 155 Mbit/s satellite transmission standard which is now designated by NASA as the international standard for other Research and Development groups to follow.

Mechanism C

Australia's book heritage resources (early imprints project)
This project aims to provide Australian scholars with precise and detailed information about all books printed before 1801 held in the country's libraries. This information is now contained on the Australian Bibliographic Network and is accessible through over 1,000 libraries. The availability of this unique and important Australian resource is becoming more widely known in the scholarly community. The participating institutions are Monash University, Australian National University, University of Sydney, Australian Academy of Humanities, National Library, State Library of New South Wales and the Bibliographical Society of Australia and New Zealand.

Regional research facility for microscopy and microanalysis
This Facility provides support not only to the participating universities (University of Sydney and University of Technology, Sydney), but also to industry and other research organisations, such as CSIRO and ANSTO. Research achievements include studies of thin film surfaces, elucidation of high critical temperature superconductors and the development of techniques for thin film analysis and energy filtered imaging of biological tissues. The Facility is now studying surfaces at close to atomic level and its electron energy loss microscopy is being applied to several major biological programs.

The Institute of Advanced Studies, Australian National University

Role: *The Institute carries out research and postgraduate training in the physical, biological and social sciences.*

Its budget of approximately $130 million ($114 million of which is provided through the Department of Employment, Education and Training) and the full-time commitment of its staff to research, permit it to concentrate on fields of research and large scale endeavours which take advantage of its particular range of facilities and expertise. It has a special responsibility to carry out research of national importance and to combine a search for fundamental understanding with a concern for the use of the research results. It aims at being a research resource for other Australian universities and also maintains strong contacts with universities and research institutions in other countries.

Recent Achievements

Biological detoxification of arsenic
The work of the Research School of Chemistry Inorganic Stereochemistry Group on the complexities and functions of 'left-handed' and right-handed' molecules, including arsines, has led to the world's first observation that micro-organisms preferentially synthesise right-handed arsines. The micro-organisms convert toxic inorganic arsenic into much less toxic organic arsenic. For example, lobster flesh contains about 30 mg of non-toxic organic arsenicals whereas ingestion of the same amount of inorganic arsenic would be poisonous. This work raises the possibility that arsenic compounds may be of hitherto unrecognised importance to animal and plant life. It is forming the basis of a much greater understanding of the role of arsenic in the biological environment and perhaps will lead to an effective method for removing arsenic from polluted water and soil, by using micro-organisms as detoxifying and accumulating agents.

Treatment of cancers
The Molecular Genetics Group at the John Curtain School of Medical Research is investigating glutathione S-transferases (GST), enzymes which appear to have a major role to play in genetic susceptibility to certain kinds of cancer. Deficiencies or variations in the expression of GSTs in tissue may alter an individual's capacity to respond to certain environmental carcinogens. On the other hand, overproduction of GST by tumour cells appears to explain one of the pitfalls with chemotherapy of how tumours may become resistant to anti-cancer compounds. The Group is involved in finding ways to inhibit GST production in tumours and they have worked out the molecular structure of one of the GST enzymes. This information now opens the way for scientists to design very specific inhibitors that could be useful in potentiating the effects of some anti-cancer drugs and reducing resistance to them.

The Anglo-Australian Telescope Board (AATB)

Role: *Operating under an agreement between the Governments of the United Kingdom and Australia, the Anglo-Australian Telescope Board maintains facilities which enable British and Australian astronomers to undertake research for the advancement of scientific knowledge.*

These facilities include the Anglo-Australian Telescope and the UK Schmidt Telescope at Siding Spring Mountain outside Coonabarabran, and a laboratory in the Sydney suburb of Epping.

Recent Achievements

The jets in Orion

Using the new infra-red camera/spectrometer on the Anglo-Australian Telescope, IRIS, astronomers of the Anglo-Australian Observatory took spectacular images of the explosive birth of a star that occurred about 1000 years ago. This was the first time astronomers have observed such an explosion. IRIS allowed the astronomers to penetrate the dense clouds of dust and gas of Orion which obscure all but its outer regions to visible light. The image made of the explosion shows the shock waves left by bullet-like blobs of gas surging into space from the explosion's source. Each is about the mass of a planet, but as it is gaseous it is far more tenuous and larger. The energy of the explosion was equivalent to the Sun's radiation over 1000 to 3000 years. Investigations for other similar explosions continue, in an endeavour to increase astronomers' understanding of the birth of stars.

ENVIRONMENT, SPORT, AND TERRITORIES

Science and Technology in the Portfolio Budget

The Australian Antarctic Division has been given a total budget allocation of $64 million in 1993-94 ($65 million in 1992-93). The Division's activities include the undertaking of and provision of support for scientific research in the Australian Antarctic Territory, the Southern Ocean and subantarctic islands. The Division's research priorities in 1993-94 will include programs contributing to the study of global climatic change and monitoring of Antarctic ecosystems. The overall science program supported by the Division in 1993-94 will include marine biology, oceanography and sea-ice studies using the RSV Aurora Australis in the Prydz Bay region and in the Southern Ocean between Tasmania and Antarctica. Other research will include a major glaciology traverse from Mawson station, around the south of the Lambert Glacier Basin to the Larsemann Hills, and a diverse program in many disciplines at each station. Analysis work will continue in Australia.

The Commonwealth Bureau of Meteorology has been given a total budget allocation of $119.2 million in 1993-94 ($114 million in 1992-93). The Bureau's activities include meteorological research. The Bureau's research priorities to be pursued in 1993-94 include particular emphasis on climate research including greenhouse studies, numerical weather prediction modelling, tropical meteorology, background air pollution monitoring, remote sensing and marine meteorology.

The Australian Heritage Commission has been given a total budget allocation (including the state and territory components of the National Estate Grants Program [NEGP]) of $13.3 million in 1993-94 ($14 million in 1992-93). Australia-wide 241 projects received funding under the 1992-93 program of which more than fifty were related to ecological, biological and geomorphological survey.

The central office of the Department co-ordinates research into the greenhouse effect. The Government has allocated $5.7 million to this activity for each of the next three years $0.5 million of which in each year is included in the Bureau of Meteorology's budget allocations identified below. The priorities for the greenhouse research program are the development of the capacity for regional predictions of climate change, climate modelling, monitoring of sea level rise and the assessment of potential regional impacts.

The scientific results of research supported by this program, and closely related work, have given authority to Australia's participation in international discussions leading to signing and ratification of the UN

uncertainties about climate change and to exchange of relevant scientific and other information. Australian research is making a unique contribution to the better understanding of climate change in the southern hemisphere.

Within the Biodiversity component of the Environment program a number of projects are being undertaken to support the development of the National Strategy for the Conservation of Australia's Biological Diversity and the early entry into force and implementation of the Convention on Biological Diversity. These projects are primarily aimed at filling critical gaps in knowledge and methodologies.

These projects include pilot testing rapid biodiversity assessment techniques, development of national approach for biodiversity monitoring, the application of remote sensing techniques for nation-wide monitoring, the development of a bioregional resource information and accounting system, and the development of guidelines incorporating biodiversity into planning and management at local government and sectoral levels.

The Office of the Supervising Scientist (OSS) has been given a total budget of $6.5 million in 1993-94 ($7.4 million in 1992-93). The Supervising Scientist has a supervisory, coordination and research role in the protection of the environment (which includes traditional Aboriginal owners, mineworkers and the public) from the effects of uranium mining operations in the Alligator Rivers Region in the Northern Territory.

During 1993-94, research at the Research Institute, Jabiru, will continue on suitable methods for detecting short and long term effects of mining on aquatic animals; the long term radiological consequences of land application, particularly dust resuspension, and its relevance to radiation exposure following rehabilitation; the biology of native plants, and their suitability for use in revegetation of mine soils; soil science and symbiotic micro-organisms; also the preliminary model for assessing radiation exposure to traditional owners near Ranger from unattached radon gases.

Since 1992, GBRMPA has been co-ordinating the collation of diverse research information to prepare the State of the Marine Environment Report (SOMER) for Australia as a baseline for the Ocean Rescue 2000 program. Progress reports, including initial statements of emerging findings, have been published in Ocean Rescue 2000 Update and Reef Research. The final report should be available in 1994.

The Ocean Rescue 2000 Program, initiated by the central office in conjunction with ANCA, GBRMPA, the states and the territories is a decade long marine conservation and sustainable use program. It includes a national marine education program, a marine information system being developed by the Environmental Resources Information Network, a marine and coastal community network, an Australian marine conservation strategy and surveys of marine and estuarine habitats to select areas for inclusion in a national representative system of marine protected areas.

In December 1992 the Department of the Prime Minister and Cabinet announced the success of a proposal for a Cooperative Research Centre for Ecologically Sustainable Development of the Great Barrier Reef. This resulted from a joint submission by the Great Barrier Reef Marine Park Authority, the Australian Institute of Marine Science, James Cook University of North Queensland, the Queensland Department of Primary Industries and the tourism industry represented by the Association of Marine Park Tourism Operators. The Agreement for the establishment of the Centre was finalised in early June 1993 and operations commenced on 1 July 1993.

A primary objective of the Centre is to work with industry and environmental managers in addressing strategic and tactical issues to maximise opportunities for use of the Great Barrier Reef Region consistent with ecologically sustainable development.

The Centre will receive approximately $6 million over seven years from Marine Park charging fees and $13 million from the Commonwealth Government for its research, monitoring, education and extension activities.

The International Tropical Marine Resource Centre (INTROMARC) located in Townsville (a consortium of AIMS, GBRMPA and JCU), established recently, is currently providing training in the management of tropical marine ecosystems for sustainable use to a number of countries in the South East Asian Region (including Vietnam, Malaysia, Indonesia, Philippines and PNG).

The World Heritage Unit of the central office will be continuing research at the Murgon Fossil Site in South-east Queensland. This site is to be included in the 1993 Australian Fossil Sites World heritage nomination. The Commonwealth and South Australian governments will commence a joint survey of the environmental values in the Lake Eyre Region of South Australia.

The Commonwealth Environment Protection Agency (CEPA) is implementing the Monitoring River Health Initiative announced in the PM's Statement on the Environment of December 1992. This will fund selected R & D on scientific water quality monitoring, with an emphasis on biological indicators of the health of our waters.

Over three years, CEPA will provide $0.5 million to the UNSW CRC on Waste Management and Pollution Control to develop a computerised database of waste generation and recycling statistics to ensure a reliable base for decision makers.

As part of the Government's initiative in ozone protection, $0.4 million is being provided by CEPA over four years to the CSIRO Division of Entomology for research into acclimatisation and containment measures for methyl bromide, an ozone depleting substance, in quarantine fumigation.

The current budget for the Environment Resources Information Network (ERIN) Program is $2.4 million per annum. The ERIN Program aims to

to gain access.

The Australian Sports Commission has various research projects to identify methods to assist in improving the performance of elite athletes in several sports. In 1993-94 major research projects will be undertaken into the effect of training at altitude on performance at sea level and the development of technology for immediate performance feedback by telemetry.

MAJOR RESEARCH ACTIVITIES

Australian Antarctic Division

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

Recent Achievements

Deep ice drilling at Law Dome

The Glaciology Program in the 1992-93 summer completed a continuously cored 1200 metre hole to bedrock on the summit of Law Dome near Casey Station. The hole had been drilled to 552 metres in 1991-92. This core holds a very high resolution record of the many climate variables for the area over approximately the last 15,000 years. These include precipitation, atmospheric composition, and volcanic activity. In addition, variation of the structure of the ice with depth was logged through routine thin sectioning as drilling progressed. Law Dome is a small, almost separate icecap and the data gained can be used in modelling studies of icecaps in general. The climate data will contribute to global climate models which are evolving at present.

Southern Ocean environmental studies

The RSV *Aurora Australis* was used for the first time as a sediment coring platform for the Antarctic Cooperative Research Centre. The object is to understand and interpret changes in the marine environment over a series of time scales leading to the present.

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.*

Most research within the Bureau is conducted by the Bureau of Meteorology Research Centre (BMRC) in the general areas of short and medium range weather prediction, climate, mesoscale meteorology, satellite meteorology and climate change modelling.

Some research into atmospheric constituents (eg carbon dioxide, methane, chlorofluorocarbons) is also conducted using data from the Bureau's Baseline Air Pollution Station at Cape Grim in northwestern Tasmania. Research into stratospheric ozone is also performed using data from the Bureau's Ozone Network.

Recent Achievements

Tropical meteorology
The BMRC tropical weather prediction model is now used for operational weather forecasting in the Bureau. It makes special use of satellite data to estimate the distribution of moisture and rainfall over the tropical oceans, where there has been sparse conventional observations. It was also used to support the international Coupled Ocean-Atmosphere Response Experiment (COARE) which took place in the western Pacific region from November 1992 through to February 1993. The Bureau played a significant role in the planning and execution of COARE, which aims to elucidate the physical processes that are important for the development of systems to predict seasonal climate fluctuations.

Climate change
The BMRC global climate model has been used in the International Atmospheric Model Intercomparison Project (AMIP) in which about 30 models are simulating the atmospheric behaviour over the decade of the 1980s. The project, which is sponsored by the US Department of Energy under the auspices of the World Climate Research Programme (WCRP), is helping to identify the sources of uncertainty in models used for climate change studies.

Great Barrier Reef Marine Park Authority (GBRMPA)

Role: *The GBRMPA is the principal advisor to the Commonwealth Government on the care and development of the Great Barrier Reef Marine Park. The Authority's research monitoring program aims to achieve competence and fairness in the care and development of the Marine Park through the conduct of research, and the deliberate acquisition, use and dissemination of relevant information from research and other sources.*

Recent Achievements

Crown-of-thorns starfish
The causes and effects of population outbreaks of the crown-of-thorns starfish on the Great Barrier Reef have been controversial issues for more than 30 years. A research program to monitor starfish numbers and the recovery of affected reefs and to determine possible causes of the outbreaks is continuing. The research program involves 24 projects. Recent research is suggesting that connection between water quality and outbreaks are likely. While the current outbreak cycle (which started in 1979) is nearly over, there are indications that another cycle may develop over the next few years.

Torres Strait Study
The report on the pilot Torres Strait Baseline Study was published in February 1993. A final report of the four year study is expected in December 1993. A major samples collection program was completed in 1992-93 and results are being compiled for publication.

Reef health
A program was initiated to co-ordinate and conduct long-term monitoring of the key biological communities which are indicative of reef health.

The threatened dugong populations of the GBR were re-surveyed in 1991-92 and 1992-93 for the first time in six years. Preliminary results indicate that dugong populations have undergone a dramatic reduction between Cooktown and the southern boundary of the Marine Park. This reduction is most likely to be a result of natural fluctuations. Populations between Cooktown and the northern boundary of the Marine Park appear to be stable. The agencies involved include AIMS, QDEH, GBRMPA and CSIRO.

Office of the Supervising Scientist for the Alligator River Region

Role: *To provide a scientific basis for developing standards and measures for the protection and restoration of the environment and for assessing the actual and potential short and long term effects of mining operations on people and the ecosystem of the Alligator Rivers Region of the Northern Territory.*

Recent Achievements

Radiation dose from radon daughters
Uranium mining inevitably leads to the release of radon gas from the disturbed orebody, stockpiled ore, and tailings residues. Both workers and members of the public are at risk of radiation exposure from radon and its long-lived daughters, Po-210 and Pb-210. Recent OSS research has indicated that radon daughters do not attach themselves to aerosols as effectively in the Alligator Rivers Region as occurs in other uranium mining localities. The unattached fraction is able to lodge at a lower level in the lungs and hence has a lower probability of exhalation than those that do attach to atmospheric particulates. Thus the atmospheric conditions prevalent in the Alligator Rivers Region result in a higher-than-expected radiological dose being sustained when radon (and its daughters) are inhaled. The effect is likely to be most important for some Aboriginal groups.

Erosion modelling
Tailings residues from uranium mining contains most of the radionuclides of the original orebody and since the decay chain is supported by Th-230 with a half-life of 80,000 years, the tailings pile will remain a low-level radiological hazard for several hundred thousand years. Australian legislation requires that rehabilitation includes a long-term (>1000 years) containment strategy for tailings. In the wet-dry tropics, the erosion response to high intensity rainfall is considered to be the most critical factor in maintaining a protective cover on a tailings containment. In collaboration with the University of Newcastle, OSS has devised and calibrated a computer model to simulate the erosion performance of man-made structures in this type of environment. The model represents a low-cost approach for uranium miners to test different options for tailings disposal.

Revegetation
Revegetation of Nabarlek and Ranger minesites is to be restricted to native plant species. A quantitative study of vegetation in the region has been undertaken in order to determine the species dominance in the herb, shrub and tree layers on lowland and schist sites in the vicinity of the mines. This information will be used to establish targets for revegetation at the minesites. The targets will thus provide the basis for judging whether the

agreed goals for revegetation have been achieved. Phenological investigations have been carried out to determine the availability of seed of the target plant species. OSS has established a seed collection of 280 species of trees, shrubs, forbs, grasses, sedges and palms that will form the basis of further growth and establishment experiments. It has also documented storage requirements and species-specific germination requirements for 68 native species in the Region.

Aquatic toxicology
OSS has developed biological tests that can be used to assess the toxicity of mine waste water before it is released into local surface water. From these tests, four tests using *Moinodaphnia macleayi* (water flea), *Hydra spp* (a coelenterate), and *Mogurnda mogurnda* (a fish, the purple spotted gudgeon), were developed to a stage where they were able to be registered with the National Association of Testing Authorities (NATA) for testing mine waste effluents, the first, (and still the only) such registration in Australia. Although toxicity tests are widely used overseas, the application of these tests in Australia is still in a rudimentary stage; OSS has played a pioneering role in introducing the concept for regulation of uranium mining. The technology is available to mining companies by the publication of detailed test protocols.

Australian Nature Conservation Agency (ANCA)

Role: *The ANCA administers a number of programs which contract, sponsor and award grants for scientific research and technological developments, including that related to monitoring, surveys and management, as part of the Agency's role as the principle nature conservation agency of the Commonwealth. Government.*

This role encompasses the flora, fauna and all areas of Australia, including designated protected areas, areas outside such designation and the External Territories. The ANCA also has an active role in the publication of the results of scientific research. Through these avenues, as well as the research of individual staff, ANCA contributes to the national research effort.

The agency is responsible for a number of programs which include the following. The Feral Pests Program (FPP) aims to reduce the impact of feral animal pests on native species and/or the natural environment, particularly in areas important for the recovery of endangered species. The program develops and implements projects in cooperation with State, Territory and other Commonwealth agencies. During 1992-93 the FPP funded 39 projects for a total of $1.8 million.

The States Cooperative Assistance Program (SCAP) involves ANCA in

cooperative nature conservation programs of national or international significance related to wildlife and parks and reserves in the States and Territories. In 1992-93, 33 projects were funded by SCAP to a total of $0.8 million.

The objective of the Research and Surveys Program (RSP) is to gather and maintain scientific, socio-economic and cultural information required by the ANCA to meet its obligations as the principal adviser to the Commonwealth Government on national and international conservation issues. During 1992-93 over 50 projects were funded under the RSP for a budget of $1.07 million.

The objective of the Save the Bush Program (STB) is to encourage, facilitate and support programs and activities associated with protection, management and investigation of remnant native vegetation, particularly outside national parks and other reserves, which directly or indirectly assist with the maintenance of biological diversity in Australia. The STB research component funded 11 projects in 1992-93 from a budget of $0.25 million.

The Endangered Species Program (ESP) aims to prevent the extinction of native species, to prevent further species from becoming endangered and to return endangered species to a secure status in the wild. The program funds research and management projects aimed at species recovery and threat abatement and education programs to increase public awareness of endangered species issues.

Recent Achievements

Australian Biological Resources Study (ABRS)
The ABRS documents what plants and animals there are in Australia and where they occur by co-ordinating work aimed at collecting, describing, classifying and determining the distribution of Australia's biodiversity. In so doing, the ABRS is a national and international resources centre for information on biogeographic and taxonomic research and documentation. A participatory program provides grants for research. During 1992-93, an additional 32 projects were funded. A publications program produces high quality flora and fauna reference series. Two major volumes were published during 1992-93:

- Zoological Catalogue of Australia Hymenoptera: Apoidea
- Flora of Australia Brunoniaceae, Goodeniaceae and Lichens - Introduction, Lecanorales 1.

Australian National Botanic Gardens (ANBG)
The ANBG aims to grow, study and promote Australian flora. It is involved in research into the classification and distribution of Australia's native flora, in developing and implementing recovery plans for endangered plant species and in developing techniques and standards for exchange of botanical information. A major achievement during 1992-93 was the development of a system to make the botanical database information at the ANBG accessible to researchers through the international electronic

network. The ANBG is the first botanic garden in the world to do so. The herbarium at the ANBG and the CSIRO herbarium have formed a cooperative venture as the Centre for Plant Biodiversity Research.

Environment Resources Information Network (ERIN)
Two awards have been presented to ERIN during 1992-93. ERIN was presented the Gold Government Technology Productivity Award in recognition of the environmental Resources Information System (ERIS) developed by ERIN. ERIS provides users with access to geographically related information through an easy to use interface. ERIN was awarded the prestigious Computerworld-Smithsonian Award in the 'Environment, Energy and Agriculture' category for a creative use of information technology that benefits society.

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.*

Recent Achievements

The National Wilderness Inventory (NWI)
The NWI maps wilderness quality (remoteness and naturalness) for natural areas across Australia. The completed NWI will provide a very flexible computer based tool to assist identification and resolve management issues for Australia's wilderness areas.

Achievements during 1992-93 included the completion of baseline surveys in South Australia and the Northern Territory and the completion of the primary database for Queensland. Bringing the completed coverage of the inventory to well over half of the Australian continent. A NWI Handbook, outlining the principles, procedures and usage of the Inventory was produced, as was the first in a series of NWI Bulletins that document the progress and use of the Inventory.

HEALTH, HOUSING, LOCAL GOVERNMENT AND COMMUNITY SERVICES

Science and Technology in the Portfolio Budget

This portfolio includes several agencies dealing with research and scientific services. These are the National Health and Medical Research Council (NHMRC), the Australian Institute of Health and Welfare (AIHW), the Australian Radiation Laboratory (ARL), the Chemicals Safety Unit (CSU) and CSL Limited. AIDS research and health research programs are also funded through the portfolio.

Medical and public health funding through the NHMRC will increase to $118.5 million in 1993-94 ($110million in 1992-93). The AIDS research program will increase to $12 million in 1993-94 ($10.5 million in 1992-93). AIDS research may also be funded through the NHMRC. Health, housing and community services research funding through Health, Housing and Community Services Research and Development Grants (RADGAC) increases to $1.9 million in 1993-94 ($1.8 million in 1992-93).

ARL spends approximately 50% of its total budget of $5.2 million on research to support its service activities and to improve its knowledge in radiation protection. Funding for ARL in 1993-94 is expected to be $5.4 million.

In 1992-93 CSL Limited received $1.23 million as a World Health Organisation Reference Centre, and grants totalling $0.3 million from Austrade.

The Chemicals Safety Unit had a budget of $2.29 million for 1992-93 to cover its current activities in the public health assessment of agricultural, veterinary, industrial and other chemicals. In 1993-94, the CSU will receive $3 million.

The appropriation to the Australian Institute of Health and Welfare for 1992-93 was $7.4 million ($6.5 million in 1992-93). The increase reflects the expansion of the role of the Institute from 4 May 1992 to encompass the collation, analysis and publication of national data in the areas of welfare services and housing assistance.

Capital works for medical research institutes for 1992-93 totals $10 million and is continued at the same level in 1993-94. In addition, in 1992-93 the portfolio provided $16.8 million to the John Curtin School of Medical Research at the Australian National University, increasing to $17.2 million in 1993-94.

MAJOR RESEARCH ACTIVITIES

National Health and Medical Research Council (NH&MRC)

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.*

The Council is currently providing support to 1,517 research projects, as well as providing block funding for five major research centres and institutions.

Recent Achievements

Treatment for brain cancer
Approximately 600 people die in Australia each year from cerebal glioma, the most common adult brain tumour. Researchers at the Royal Melbourne Hospital have studied a promising therapy involving destruction of tumours by getting them to take up a photosensitive compound which is then activated by light treatment. Their work has studied the uptake and localisation of photosensitisers and is being used to optimise the therapy for the treatment of patients with brain cancer.

Rheumatic disease
Autoimmune rheumatic diseases are a significant cause of illness among younger people. Researchers at Flinders Medical Centre have used molecular cloning technology to study how disease-specific circulating antibodies arise and have developed improved diagnostic tests for autoimmune inflammatory diseases such as systemic lupus erythematosis. These tests are being developed for clinical use in collaboration with the AMR AD Corporation in Victoria.

Parkinson's Disease
Parkinson's disease is attributable to the loss of a neurochemical messenger, dopamine, in the brain. A research team at the Austin Hospital has shown that the distribution of dopamine loss is more marked in a specific part of the brain, which will be useful in targeting new transplantation techniques for the treatment of the disease. They have also shown that in a proportion of

patients the failure to respond to dopamine replacement is due to defective receptors in a certain part of the brain. This knowledge will enable researchers to develop other therapies which by-pass these receptors.

Injury
Data collected on children presenting with injury to hospitals in a particular region of NSW showed an excess of children from areas characterised by high youth unemployment, high unemployment overall, single parent families, a high proportion of State housing and low incomes. Researchers are testing the hypothesis that in such communities a lasting reduction in the frequency and severity of injuries can be achieved by taking an area approach of community information on the nature of the problem and community participation in finding solutions.

Commonwealth Aids Research Grants Program (CARG)

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.*

CARG is currently supporting 132 research projects and three National Centres: in HIV Virology Research; in HIV Epidemiology and Clinical Research; and in HIV Social Research.

Recent Achievements

Drug design and development
Researchers at CSIRO in Melbourne continued work on aspects of anti-HIV drugs that they have developed and which are currently in comparison studies at the USA National Cancer Institutes AIDS Drugs Program. This project has also led to the patenting of a series of compounds which has attracted the support of a commercial syndicate for further development.

A research team at the Centre for Drug Design and Development has developed a number of inhibitors of an enzyme that plays a vital part in the life cycle of HIV. These inhibitors were developed using three dimensional modelling techniques of the structure of the enzyme. Funding for later stage research and commercial development has been attracted in syndicated research funds and from Wellcome Australia Ltd.

Detection of virus
Standard HIV tests detect the presence of antibodies to HIV rather than the virus itself. At the Howard Florey Institute, researchers have developed methods for the preparation of non-radioactive reagents to be used in the

detection of HIV genetic material by both polymerase chain reaction (PCR) and direct hybridisation methods.

Australian Institute of Health and Welfare (AIHW)

Role: *To inform community discussion and to support public policy making on health and welfare issues by co-ordinating, developing, analysing and disseminating national statistics on the health of Australians and their health and welfare services, and by undertaking and supporting related research and analysis.*

Recent Achievements

Health and welfare agreements
In February 1993 an Agreement was signed between the Commonwealth, and all States and Territories on the transfer of welfare services data to the Institute. The Agreement provides a basis for the Institute to gain access to welfare data for the enhancement and maintenance of State-based child welfare data.

AIHW has also had a lead role in the development of the National Health Information Agreement, which was endorsed by the Australian Health Ministers' Advisory Council in April 1993. AIHW, under the Agreement, will co-ordinate the development of future work programs, develop and maintain statistical standards, and act as the repository for most national collections.

Information services
The Institute has collated the 1990-91 State/Territory child welfare data on adoptions and child abuse and neglect and in June 1993 published two reports: *Adoptions Australia 1990-91* and *Child abuse and neglect Australia 1990-91*.

The AIHW publication *Australia's Health 1992* describes the health of Australians. Aspects of health care funding, resources and utilisation were covered, while it directed special attention to differentials in health status and health risk factors between various sub-groups of the population.

This latter feature of health differentials was a major project. It identified links between socio-economic status and health. The results were published in the National Health Strategy Report, *Enough to make you sick*, and in *Australia's Health 1992.*

Aboriginal health
The Institute completed a major consultancy for the Royal Commission on Aboriginal Deaths in Custody on Aboriginal health aspects of the

Commission's work relating to Aboriginal health, and published a series of reports profiling Aboriginal health in various States and the Northern Territory.

CSL Limited

Role: *To be a leading manufacturer of biological pharmaceuticals for local and international health care markets.*

Recent Initiative

Co-operative Research Centres
CSL is a partner in two consortiums which have successfully established Co-operative Research Centres under the program initiated by the Australian Government. The first of these, the Biopharmaceutical Research Centre will focus on the development of new biopharmaceuticals for use in human medicine. The second, a Research Centre for Vaccine Technology will enter into strategic research to address issues of fundamental importance in the development of new and improved vaccines for both human and animal diseases. It is intended that CSL will have a major role in the Australian development and commercialisation of the intellectual property generated by these two research centres.

Australian Radiation Laboratory (ARL)

Role: *ARL is concerned with all aspects of radiation which have implications for public or occupational health. It provides advice and services on many different forms of radiation and undertakes research to support these activities and enhance its fundamental knowledge.*

Recent Achievements

Sizing airborne radioactivity
The risk to health from inhalation of the radioactive gas radon and its decay products during the mining of uranium is dependent upon the radiation dose to particular parts of the lung. The International Commission on Radiological Protection (ICRP) has accepted a new model of respiratory tract dosimetry in which the magnitude of the dose to the lung is a sensitive function of size of the airborne radioactivity, particularly those particles less than 20 nanometers. Supported in part by a grant from the Mining and Quarrying Occupational Health and Safety Committee, ARL has carried out

an extensive set of particle size measurements in the underground uranium mine operated by Olympic Dam Operations at Roxby Downs, South Australia. The data collected has been combined with the ICRP Lung Model to derive a measure or radiation risk for different locations and activities within the mine.

Solar ultraviolet radiation (UVR) studies

Exposure to solar UVR is a major cause of skin cancer and there is growing evidence that the pattern of exposure is an important parameter. In collaboration with the Victorian Anti-Cancer Council the personal exposure of indoor, outdoor and retired workers resident in Maryborough (Vic) was studied. It was found that the potential exposure of outdoor workers approached a third of the ambient levels. Knowledge gained in these studies permits the accurate design and targeting of educational campaigns to reduce UVR exposure.

ARL is increasingly involved in UVR protection activities the recently developed UPF (ultraviolet protection factor) rating scheme for fabrics The distinctive UPF swingtag, which includes a message on protection, will be found on many garments this summer.

Chemical Safety Unit

Recent Initiatives

Role: *To ensure the protection of public health by assessing potential hazards of chemicals in the environment and by developing and implementing strategies to minimise associated risks.*

Since its creation in February 1992, the Chemical Safety Unit has been involved in the assessment of public health aspects of agricultural, veterinary, industrial and other environmental chemicals. The Unit undertakes the toxicological assessment of chemicals as well as the assessment of the implications of residues in food commodities. It provides advice to national regulatory authorities under the National Registration Scheme for Agricultural and Veterinary Chemicals and the National Industrial Chemicals Notification and Assessment Scheme. The scope of the advice includes public health implications of the registration of chemicals, relevant maximum residue limits, label warning statements, first aid and safety directions. The unit has also developed the public health policy for a program to review existing agricultural and veterinary chemicals (adopted by the Australian Agricultural and Veterinary Chemicals Council, December 1992). The Unit also provides on-going technical support for expert committees of the National Health and Medical Research Council.

INDUSTRY, TECHNOLOGY AND REGIONAL DEVELOPMENT

Science and Technology in the Portfolio Budget

There are three major 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 is also a number of agencies and programs supporting technological development in industry through the provision of grants, concessions and services. 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. The Board operates through its Tax Concession Committee, and five Industry Sector Committees which consider grant applications.

Grants or incentives to industry include the following:

- *Industry Innovation Program,* administered by the IR&D Board, supports market-led innovation and includes:
  - *Tax Concession Scheme* which provides for registered R&D performers to claim R&D related expenses at 150%.
  - *Discretionary Grants* provide support for market driven research and development in companies with high growth potential that cannot take advantage of the tax concession scheme.
  - *Generic Technology Grants* provide support for collaborative research and development in strategic technologies that are important to the international competitiveness of Australian business. These technologies are:

    Biotechnology

    Communications Technology

    Environmental Technology

    Information Technology

    Manufacturing and Materials Technology
  - *Advanced Manufacturing Technology Development Grants* provide support for joint projects between technology developers and end users that research, develop, trial and/or design advanced manufacturing technology products, services or systems.

  - *National Procurement Development Grants* provide support for the collaborative development of internationally competitive goods, services or systems with government departments or agencies.
  - *National Teaching Company Grants* encourage links between companies and public sector research institutions to employ high calibre graduates on projects that are designed to improve company performance.

- *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.
- *The Factor (f) Pharmaceutical Industry Development Program* provides higher prices for some products, in return for a commitment by individual manufacturers to undertake increased activity in Australia, including new investment, production, research and development.
- *Australian Building Research Grants Scheme (ABRGS)* provides funds to encourage building and construction research of long term benefit to the building industry.

Services to industry and community include:

- *The National Industry Extension Service (NIES)* 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.
- *Policy advice* for the establishment and delivery of Government services in science and technology is provided through the Science and Technology Policy Branch (Innovation Division), the Policy and Projects Division, the Bureau of Industry Economics and other Divisions of the Department of Industry, Technology and Regional Development.
- The *Vendor Qualification Scheme (VQS)* provides assistance to export oriented firms in the Information Technology sector seeking accreditation to internationally recognised quality and regulatory standards.
- The *National Space Program* promotes the growth of commercially viable industries based on space technologies and encourages greater involvement by industry in space R&D.
- *Australian Industrial Property Organisation* provides industrial property rights services in 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 Australian Technology Group (ATG),* a small commercially focused company, evaluates research with commercial potential, particularly but not limited to, research from the public sector.

Program or agency	Budget expenditure 1992-93 $m	Budget estimate 1993-94 $m
Factor (f) Pharmaceutical Industry Development Program	51.9	129.5
AIMS	15.3	16.9
ANSTO	68.2	64.2
Nuclear Safety Bureau	0.8	0.8
CSIRO	456.3	461.3
Kraft Pulp Mill Study	1.9	1.9
Industry Innovation Program	43.5	42.0
Australian Technology Group	30.0	0.0
Computer Bounty	74.9	78.0
ABRGS	0.3	0.0
NIES -Commonwealth	5.3	9.9
-States	11.2	11.5
VQS	1.3	1.5
National Space Program	5.4	7.6
Science and Technology Awareness	1.6	1.7
International S & T Program	5.3	5.4
TOTAL	773.1	832.2
PORTFOLIO TOTAL	1466.2	1462.0

- *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.
- *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.
- *Marine Science and Technology Program* aims to align marine R&D more closely with industry requirements and to play a key role in international cooperation in marine science and technology. Closer links between the marine industry, government and research agencies are being developed through the Consultative Group on Marine Industries Science and Technology (C-MIST) and the Oceans Australia conference series.
- *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.

- *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.

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

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 marine environmental 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.*

The Institute is receiving additional funds of $1.323 million over the three year period from 1991 to 1994 to extend its crown-of-thorns starfish monitoring program to a detailed investigation of factors affecting the health of the Great Barrier Reef. This includes monitoring nutrients, trace elements, fish stocks and hydrodynamics.

In line with the Government's intention that marine science be conducted in a national manner, the Institute, with additional federal funding ($0.15 million to 1992-93 and $4.73 million to 1994-95), has taken the first steps in building up a marine science presence in the northwest of Western Australia. During this early period the focus will be on establishing the plan for long term strategic research studies. This will provide the basis for targeted tactical research and monitoring to aid sustainable use of the marine environment and resources of the northwest.

Recent Achievements

Monitoring the Great Barrier Reef
The primary objective of the Institute's longterm monitoring program is to detect and quantify major changes in the status of the reef ecosystem through surveys of the distribution and abundance of corals, fishes, nutrients and crown-of-thorns starfish. The surveys are primarily being conducted on a suite of reefs located across the continental shelf in 6 regions (Cooktown/Lizard Island, Cairns, Townsville, Whitsunday, Swain and CapricornBunker).

Field work associated with the monitoring program has been underway for approximately a year. In that time, three sites have been established on each of 25 reefs between Cairns and the Capricorn Bunker Complex. A total of five 50 m permanent transects have been established and surveyed for corals and fishes at each site. Water samples for nutrients have also been collected at stations near these reefs and at a further 30 stations closer to the coast. Fifty-seven reefs were surveyed during the year to obtain more broadscale information on reef status.

Prawn farming
The mariculture group at the Institute has developed techniques to successfully rear large numbers of prawn family lines on a pilot scale. This technology is an essential first step in the development of selective breeding programs for the prawn farming industry. The mitochondrial genome of the leader or giant tiger prawn has been cloned. DNA technologies achieved will provide a more rapid means of documenting the genetic resources available in wild stocks of prawns in Australia, for selective breeding. Significant advances that allow the genetic analysis of pearl oysters, without killing the valuable animal concerned, have also been achieved.

Fisheries in the Gulf of Papua and Fly River Delta
During 1992-93 extensive field studies were undertaken to assess the fate of material such as nutrients and other terrestrial matter, debouching from the Fly and adjacent rivers into the Gulf of Papua and northern Coral Sea. Results to date indicate that most of this riverine matter, which fuels coastal fisheries production, deposits in the inner Gulf of Papua with some material reaching the adjacent deep sea. The areas of maximum seabed production and rates of nutrient regeneration from the seabed coincide with the areas of maximum prawn trawling. This suggests a close coupling between fisheries production and the outflow of nutrients from the great Papuan rivers. The study is also relevant to fishing industries in the Torres Strait and has an impact on environmental management of the PNG mining industry.

A major international workshop, cosponsored by DIT&RD, AIMS and the US Natural Science Foundation, held at AIMS during June 1993, dealt with the influence of wet tropical rivers on coastal oceanographic processes. At this conference a review was drafted and plans made for a largescale international collaborative project on wet tropical coastal regions.

Climate records in coral
AIMS has been working towards an understanding of how coral density bands are formed. Amajor breakthrough has provided new insights towards the recovery of proxy information from both density bands and from organic and inorganic materials taken from the environment and included in the skeleton during growth.

The Australian Nuclear Science and Technology Organisation (ANSTO)

Role *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

Radiopharmaceutical achievements
The radio-labeled 3B6 monoclonal antibody, developed jointly by Biomedicine and Health and Agen Biomedical Ltd, Qld, demonstrated detection of blood clots in the legs and blood clots in the lung. Clinical trials were conducted in NSW and the UK. An exclusive worldwide license agreement was reached with Hybritech, a subsidiary of the Eli Lilly multinational health care company, for further commercialisation of the technology.

Biomedicine and Health completed a trial of ^{165}Dy-HMA which showed its effectiveness in the treatment of rheumatoid arthritis. Subsequently, ARI has forwarded a general marketing application to the Australian Therapeutic Goods Administration. This radiopharmaceutical has the advantage that treatment can be administered on a day patient basis, resulting in lower health care costs amounting to approximately $0.3 million per annum.

Sewage treatment
Isotope tracer techniques are being used to evaluate the performance of the Sydney Water Board's deep ocean outfalls off Malabar. The technology has been developed to the extent that the labeled plume can be traced in three dimensions for up to 30 hours. A unique data set is being collected to validate the mathematical models developed by the Australian Water and Coastal Service (AWACS). By collecting simultaneous samples for isotope and bacterial analysis, the rate of die-off of the bacteria, normalised for dilution effects, can be measured with considerable precision. The techniques are

now being extended to allow tracing of sewage grease independent of the other components.

Light weight sediment corer
The radiotracer group has developed a light weight corer which can operate from a small vessel and collect undisturbed 1 metre cores in about 30 metres of water. The data will assist quantitative measurement of sediment movement. Anumber of units have been sold into the South East Asia region through the IAEA.

Mine rehabilitation

Powerful computer modeling techniques in concert with in-situ measurement techniques developed by ANSTO allow the mechanism which determines the generation rate of pollutants from pyritic mine wastes to be quantified and cost-effective methods to reduce pollutant generation developed. This expertise is the basis for collaborative work to mitigate pollutant generation at mine sites in Sweden and Canada as well as in Australia.

ANSTO has been awarded two scientific consultancy contacts (total value $0.5 million) concerned with the rehabilitation of former uranium mining sites in Germany. The projects involve the assessment of options to treat water arising from the flooding of an in-situ leaching operation at Konigstein and a conventional underground mine at Ronneburg. In both cases, the treated water must comply with strict discharge limits and a plan for the management of solids residues must be developed.

Global transport of air pollutants
A major problem in defining pollutant concentrations in air at the global level is eliminating the effects of local sources of air pollution. Radon concentrations in air samples have become a useful criterion since radon concentrations decrease the longer such air is away from a land mass. ANSTO has developed very sensitive radon detectors which have been successfully deployed at a number of baseline monitoring stations in the Pacific and Southern Oceans.

Synroc
Discussions have been held with the Radioactive Waste Management Centre of Japan for ANSTO to join with a Japanese company in a study to evaluate the feasibility of the use of Synroc in Japan. Significant progress has been achieved in the accelerated damage tests of Synroc conducted at JAERI, Japan under the joint cooperative R&D program with ANSTO. The results of these accelerated tests confirm the long term stability of Synroc deduced from the observations on natural minerals.

Remaining life of coal fired electricity generation plant
Pacific Power has agreed to fund an $0.8 million three year collaborative project with ANSTO to assess the remaining life of large critical boiler components in coal fired electricity stations. Work carried out under the previous project in collaboration with engineers from Pacific Power demonstrated that the life of two boiler headers (cost of about $2 million)

could be extended safely for at least 12 years. The current program will enable power plant maintenance inspection periods to be based on the actual condition of the components rather than on arbitrary time intervals. The aim of the joint development program is to reduce the cost of electricity generation in NSW.

ANSTO passes US FAA test

Scientists at ANSTO have been assisting Hawker de Havilland for more than a year in carrying out a rigorous mechanical tests program. The program is linked to the design and production of the fuselage of an eight seater twin engine helicopter being developed by the McDonnel Douglas Helicopter Company, U.S.A. in association with other international companies. The test program includes sophisticated tests of elements of the fuselage including adhesive bonds and riveted joints linking aluminium and carbon fibre components. Prior to commencing the tests for Hawker de Havilland, ANSTO was required to demonstrate a quality management program to gain approved supplier status and to pass rigorous conformity tests dictated by the U.S. Federal Aviation Authority.

Pollution monitor

A network of 25 aerosol sampling monitors have been established throughout NSW to determine elemental pollution levels in airborne particulate matter throughout the State. The samples produced at the sites are analysed using Ion Beam Analysis techniques. A comprehensive database of elemental concentrations of all elements from carbon to uranium plus hydrogen concentrations and their dependence on factors such as weather, industrial activities, power generation, and traffic conditions, etc has been obtained. More recently these techniques have been applied to specific problem areas such as lead contamination in Broken Hill.

The Australian Space Office

Role *The role of the Australian Space Office is to implement the National Space Program in support of the activities of the Australia Space Council. This includes the promotion and development of commercially viable industries based on space technology and the encouragement of local industry participation in space R&D.*

The National Space Program promotes the growth of commercially viable industries based on space technologies and encourages greater involvement by industry in space R&D.

Recent Achievements

Atmospheric Pressure Sensor

The Atmospheric Pressure Sensor (APS) is a passive remote sensing instrument for measuring atmospheric pressure at the Earth's surface from an orbiting satellite. This technology is expected to improve significantly the accuracy and range of meteorological forecasting. Following the success of the laboratory model, developed by CSIRO, the Office subsequently awarded a contract to Vipac Engineers and Scientists Ltd to carry out a phase A concept study on the scientific and engineering feasibility of a spaceborne APS. The new model being developed for further ground testing has improvements in: detector electronics, data resolution through vibration reduction measures; pointing accuracy through better fore optics and scanning subsystem redesign; thermal and vacuum subsystem stability; uniform brightness distribution on each detector pixel; and replacement of the Reticon detector.

Australian Fast Delivery Processor

The Australian Fast Delivery Processor was installed at the Australian Centre for Remote Sensing in October 1992, where it produces radar images of the Earth's surface. The processor uses radar data from the European Space Agency's remote sensing satellite ERS-1. This processor is a specialised computer which was designed and developed by British Aerospace Australia Ltd in a five-year development project funded under the National Space Program. It will be commercialised world-wide under a licensing agreement between the Commonwealth and that company.

Along Track Scanning Radiometer - 2

The Along Track Scanning Radiometer - 2 is an instrument which will make highly accurate measurements of sea surface temperature. Under a collaborative agreement with the United Kingdom, Australia has provided the Infrared Focal Plane Assembly and the Electrical Ground Support Equipment for the instrument. These subsystems were built by Auspace Ltd and British Aerospace Australia Ltd respectively. It will be flown on the European Space Agency's remote sensing satellite ERS-2 to be launched in 1994. Under a further agreement with the United Kingdom, Australia will also be providing subsystems for the Advanced Along Track Scanning Radiometer to be flown on the European Space Agency's ENVISAT-1 satellite to be launched in 1998.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Role *CSIRO's mission is to give Australians a better future. Its main role is the conduct of strategic research to:*

- *improve the competitiveness of Australia's primary and manufacturing industries;*
- *develop ecologically sound management principles and practices for the use and conservation of Australia's natural resources;*
- *achieve sustainable development in production systems and develop technologies to protect the environment;*
- *improve the competitiveness of the information and communication industries; and*
- *enhance productivity and effectiveness in provision of infrastructure and services.*

CSIRO is recognised nationally and internationally for its contributions to science and Australia's development. We will build on this reputation through close collaboration with industry, government, and other research institutions to ensure the nation derives the greatest benefit from our research.

Structure and Organisation

CSIRO is governed by a Board comprising up to ten members, one of whom is the Organisation's Chief Executive. The research carried out by CSIRO's 7400 staff is undertaken in six research institutes which have the following objectives:

- *Institute of Animal Production and Processing*
  To enhance the global competitiveness of Australia's animal based and food industries, the health and well-being of its people and the wise long term use of its natural resources for these purposes.
- *Institute of Industrial Technologies*
  To increase the international competitiveness, efficiency and scope of Australia's manufacturing industries and be a leader in strategic research for those industries.
- *Institute of Information Science and Engineering*
  To be a leader in strategic research on information and communications technologies and the integration of systems based on these technologies for the benefit of Australia.

  To help increase the international competitiveness and export orientation of the Australian information and telecommunications industries.

To assist other industry sectors to improve their competitiveness through process improvements and the use of advanced computer and communications systems.

- *Institute of Minerals, Energy and Construction*
  To play a contributing role in the development of sustainable and competitive minerals, energy and construction industries in Australia and in the creation of a better living and working environment for all Australians.

- *Institute of Natural Resources and Environment*
  To provide the scientific knowledge required for the effective management and conservation of Australia's natural resources and environment, particularly in relation to the conservation and protection of national heritage and sustainable use of natural resources.

- *Institute of Plant Production and Processing*
  To enhance sustainability, competitiveness and growth of Australia's field crop, horticultural, forestry and pasture-based industries, and to improve the extent of knowledge of Australia's indigenous plants, insects and soils leading to the development of technology for the better management of its natural resources.

While CSIRO is funded primarily by direct appropriations from the Commonwealth, an increasing proportion of the its funds come from external sources. These included collaborative ventures with industry, granting schemes funded by both industry and government, and earned revenue. In 1993-94, it is estimated that $214.4 million of CSIRO's $682.1 million estimated expenditure will come from these external sources.

Commercialisation Task Force

CSIRO has established a Task Force to carry out a fundamental examination of its commercialisation policies and practices. The increasing interaction by CSIRO with sponsors and collaborators in companies, industry and other community areas over the past five years has led to a much higher level of activity which must be dealt with on a commercial basis. In addition, the widespread adoption among this client group of management systems based on international quality standards provides the opportunity for CSIRO to examine these standards as the basis for commercial interactions.

Planning and Reporting

CSIRO has adopted the Socio-economic objectives classification of the Australian Bureau of Statistics' (ABS) Australian Standard Research Classification as the basis for strategic planning and reporting outcomes of the CSIRO's research. This classification provides a framework for describing the purpose for undertaking research in terms of economic and social benefits. The following achievements are reported on this basis.

Plant Production and Primary Products

Recent Achievements

Reducing losses from root diseases
The fungal disease *take-all* cost wheat growers in South Australia around $60 million in 1991-92. Research by the CSIRO Division of Soils has shown that timely elimination of grasses in the crop rotation is essential for controlling the disease and that, in the Mallee, the accepted procedure of spraying herbicides in mid-July is far less effective than spraying in June. The Division is developing a predictive model based on rainfall and soil type to enable farmers to assess the risk of *take-all* before it strikes. In looking for a means of controlling root diseases in regenerating medic pastures, the Division has found that application of phosphorous acid is a potential treatment. Also, soil disturbance prior to seedling emergence is beneficial where the disease Rhizoctonia is a problem.

Progress with transgenic plants
In collaboration with Monsanto, CSIRO's Division of Plant Industry has produced genetically engineered cotton plants that produce a toxin that kills the bollworm pest within 24 hours. Initial field trials at the CSIRO Cotton Research Unit Narrabri have recently been harvested. Preliminary indications are that good insect defence was achieved.

Using the same principle, CSIRO succeeded in producing potatoes genetically engineered to resist potato leaf roll virus. Also with sub clover, CSIRO succeeded in improving, genetically, the quality of leaf protein in pasture legumes giving better feed value for sheep.

The first successful transfer of an eucalypt, cleared the way for inserting genes for such economically important traits as insect resistance and wood density. The gene transfer from a bacterium into a river red gum was achieved by scientists collaborating in the CSIRO Divisions of Forestry and Plant Industry.

A recent discovery by CSIRO's Division of Plant Industry provides an important breakthrough in the search for a gene for tolerance to aluminium, a major cause of poor plant growth in Australia's increasingly widespread acid soils.

New grain storage method
In collaboration with GrainCorp, CSIRO's Stored Grain Research Laboratory has completed a successful trial using nitrogen as a controlled atmosphere for storage of grain. This provides a new alternative to fumigants such as phosphine or the ozone-depleting gas, methyl bromide.

Improving the quality of horticultural produce
CSIRO's Division of Horticulture has been investigating alternative post-harvest and handling treatments to ensure that produce reaches the market in top condition free from unwanted chemical residues from disinfestation treatments. Semi-commercial trials with carbon dioxide

fumigation of dried fruit achieved 100 per cent insect kill, indicating that this could be a viable alternative to methyl bromide. In another project, heat treatment was shown to be an effective non-residue-producing method of disinfesting export quality navel and Valencia oranges and Lisbon lemons.

The Division also tested a trial shipment of flowers to Japan with a prototype new active packaging system incorporating condensation/humidity controls. The shipment arrived in good condition. A pilot-scale trial demonstration of the HiHume system for controlling conditions in export containers was also very successful.

Pest control in cotton
The CSIRO Divisions of Entomology and Plant Industry have collaborated in developing decision-support systems aimed at achieving effective pest control in cotton with minimum use of sprays. The latest software developed for this purpose is entomoLOGIC, and an IBM version was released at a cotton conference in August 1992. The software was then widely distributed to growers and consultants at a series of workshops, and a user manual was produced to accompany it. Further improvements have now been made to the software in response to suggestions by users.

Effects of grazing management
Looking into the sustainability of livestock production in savannah woodlands, CSIRO's Division of Soils found that microbial biomass in the soil was reduced by 40 per cent under heavy grazing. It was also found that the mounds of two species of termites in the area were high in nitrogen and that 16 per cent of the inorganic nitrogen available to plants in these ecosystems was being recycled annually by the termite mounds.

Animal Production and Primary Products

Recent Achievements

Production of insect-resistant animals
CSIRO's Division of Animal Production has made a significant step towards the production of genetically-engineered animals resistant to insect ectoparasites such as blowfly larvae and lice. A chitinase gene isolated from tobacco has been modified for expression in animals and has recently been transferred to laboratory mice where the new gene has been shown to operate to produce the insecticidal chitinase enzyme. Current testing of these animals for insect resistance will determine whether transgenic sheep will be produced over the next year.

Meatseal
During abattoir processing, animal carcasses are stored in chillers and freezers prior to boning and/or dispatch. The atmosphere in these storage facilities effectively causes the carcasses to lose moisture - typically about 3% for pigs and 2.5% for beef. The surfaces dry out causing darkening of the

lean surface and yellowing of the fat which require subsequent trimming and loss of saleable produce. MEATSEAL, developed by CSIRO's Meat Research Laboratory, is an edible surface coating made from animal extracts which is sprayed onto the carcass as it enters the chiller. The savings by MEATSEAL is estimated at $60 million per annum (based on 1990 meat production figures of 2 million tonnes). It is being commercialised by ICI Australia Pty Ltd.

'Rumentek' - new specialised feeds for beef cattle.

CSIRO's Division of Animal Production has successfully negotiated a new R&D syndication agreement worth $20 million with the newly formed Rumentek Syndicate which provides $5 million for R&D over the next 18 months. Prototype plants will be constructed to manufacture specialised feed supplements for ruminants from oil seeds and proteins to be marketed under the name Rumentek. Field trials will also be conducted to optimise the amount of Rumentek in the diets of cattle for specific markets such as the Japanese, Korean or domestic markets. Preliminary results indicate a 10-15% improvement in feed conversion, a 3-4% increase in dressing percentage and enhanced marbling of the meat. It provides Australia with an opportunity to produce high quality value-added beef.

Combating sheep disease

Internal parasites of sheep cost the industry more than $300 million annually in lost production and control costs using chemical drenches. CSIRO's Division of Animal Health is working to develop alternative parasite control measures using recombinant sub-unit vaccines. Strategic work in that area has focused on a class of antibodies, IgE, which appear to play a role in expelling worms from the gut. We have now successfully cloned and expressed the gene coding for ovine IgE and developed monoclonal antibodies which will greatly enhance our capacity to determine the role of IgE in protecting sheep against a number of important diseases including both internal and external parasites. These reagents are being made available to a number of research groups in CSIRO and Australian universities and will speed the development of vaccines to supplement or replace chemical use.

'Think the worst first - and call a vet'

An outbreak of a foreign livestock disease could do great damage to Australia's livestock industries - and our balance of trade. Rapid detection and control of an outbreak will minimise the impact. CSIRO can quickly detect all major foreign disease viruses only if a farmer reports unusual signs in an animal. The Australian Animal Health Laboratory has now completed the production and distribution of a complete portfolio of exotic disease training and awareness resources. Five videos for farmers have been broadcast on the ABC and widely shown to producers by State and Territory animal health officers. Ten recognition kits comprising videos, slides and notes, are being used in training vets and other animal health professionals. Five videos on disease control are held at 50 regional centres ready to train control workers in the event of a disease outbreak.

Fisheries resources of Torres Strait
CSIRO has completed a major three year study for the Australian Fisheries Management Authority (AFMA) and the Torres Strait Protected Zone Joint Authority (TSPZJA) of the fisheries resources of the Torres Strait. The main outcomes of the study include the development of the capacity to predict rock lobster stock levels one to two years ahead; the discovery of important deepwater breeding populations of rock lobster off the Great Barrier Reef; the development of a cost effective technique for monitoring traditional fisheries and the development of the first operational marine geographic information system in Australia. Information contained in this database include demographic information, all fisheries statistics, and environment and habitat information. This study has greatly enhanced the capability of AFMA and the TSPZJA to effectively manage the fisheries resources of the Torres Strait on a day-by-day and predictive basis.

Minerals Industry

Recent Achievements

Laterite geochemistry finds gold in Western Australia
Industry sponsored research in CSIRO's Division of Exploration Geoscience has shown that concealed gold deposits could be detected very efficiently by establishing the distribution of various trace elements in laterite. Furthermore, geochemical haloes preserved in laterite were shown to be up to 500 times larger in area than the concealed ore deposits themselves. The greatly enlarged target size can result in reductions in exploration costs in appropriate terrain by more than 95%. Laterite geochemistry has now contributed to the discovery of a number of concealed gold deposits and there is strong industry support for this continuing research.

Airborne remote sensing for mineral deposits
A unique airborne remote sensing instrument has been tested over the mineral rich country surrounding Broken Hill. The carbon dioxide laser spectrometer designed by CSIRO's Division of Exploration Geoscience illuminates a two meter footprint on the earth's surface with a beam of mid-infrared light and measures the signals reflected by minerals and rocks at the surface. The test flights showed for the first time that silicate minerals and the many different rocks they constitute can be mapped from the air using mid-infrared wavelengths from an active two-way remote sensing system.

Mine safety
A computer package called SAFEX has been developed as a result of research and continuing interaction between the CSIRO Division of Geomechanics' Rock Reinforcement Group and the mining industry through a series of AMIRA funded projects. The SAFEX package consists of a number of modules that are used in an integrated approach for processing geological data, prediction of rock mass conditions, stability assessment of excavations

and the design and analysis of reinforced rock. The SAFEX package is installed at over 50 mine sites throughout Australia. It has also been purchased by a number of overseas organisations in Papua New Guinea, Canada, USA, Brazil, Chile and South Africa. It is currently being incorporated into a number of teaching courses at universities throughout the world.

Flotation separations in complex ores

Many of the sulphide ores now being developed by Australia's mining companies present major processing challenges. The particles in the ores are often of a very fine size and the ores themselves are both mineralogically and chemically complex and difficult to process by froth flotation. The research from CSIRO's Division of Mineral and Process Engineering has shown that sulphide minerals in complex ores interact with each other in complicated ways. For example, metal hydroxides, which are oxidation products of the minerals can be transferred from one sulphide mineral to another sulphide mineral and this can suppress or promote floatability. The transfer of sulphur in particular was unexpected and this is the first time such behaviour has been seen. The results have also pointed the way to some possible solutions to current failures in flotation sparation of complex ores, which the Division is now working on in collaboration with industry.

***QEM*SEM* technology**

The *QEM*SEM* system provides an automatic off-line size-by-size and particle-by-particle mineralogical analysis of metallurgical flow stream and products. Current applications of the system range from exploration and ore assessment, through flow sheet development to plant operation and control. CSIRO's Division of Mineral and Process Engineering has recently finalised negotiations with Wirsam Scientific Precision Instruments Pty Ltd., Johnannesburg for a Distributorship Agreement for the *QEM*SEM* technology which provides for that company to have exclusive distribution rights in Africa and non-exclusive distribution rights in the rest of the world.

Production of rare earth alloys

Australia is a large producer of rare earth minerals as a byproduct of its mineral sands industries. The value of these rare earth products is substantially increased when they are processed and refined for use in high technology materials. Research in CSIRO's Division of Mineral Products has provided a novel way of producing rare earth alloys by direct reduction during cold milling. Various alloys have been produced that have been shown to possess the highest coercivity known. Furthermore, a technique has been developed to produce mixes of magnetic alloys with an inert filler that gives stability and excellent magnetic properties.

Absorption and precipitation of metals on MgO

There is a continuing need to remove heavy metal and organic pollutants from natural waters, domestic and industrial effluents and from mineral processing streams. Research in CSIRO's Division of Mineral Products is focused on the determination and understanding of the relationship between the physical properties of calcined magnesia (MgO) and its reactivity and utilisation rate during neutralisation of acids and

precipitation of heavy metals from solution. Large scale laboratory and field trials have produced outstanding results and work has now moved onto the marketing of commercial-scale quantities in a number of applications areas.

Energy Resources and Supply Industries

Recent Achievements

Wellbore stability in the NW Shelf
New technology is helping operators manage wellbore stability problems in the NW Shelf. Instability in vertical wellbores has been the major cause of drilling delays in some fields in this region. Improvements in stability can normally be made by altering the density of the drilling mud and orienting deviated and horizontal drill holes to take advantage of low differential stresses acting on the borehold wall. Both of these parameters can be determined using an analytical procedure based on data that is normally collected during drilling. The technology is based on analytical procedures that assess the risk of failure in a borehole and allow quantitative comparisons to be made between alternative drilling strategies. It has recently been used successfully in developing a drilling strategy for new wells in a previously difficult field.

On-line analysis of low rank coals
Moisture and ash are the two most significant quality parameters in the combustion of low rank coals. These parameters are related to the energy content and burning properties of the coal. CSIRO's Division of Mineral and Process Engineering has recently concluded the development of prototype gauges based on prompt neutron gamma-ray activation and microwave transmission for the one-line measurement to determine the quality of low rank coals. The technique was licensed to MCI Ltd in October 1992 and the first commercial gauge is to be installed at Loy Yang power station in mid 1993.

Pulse combustion for domestic applications
CSIRO's Division of Building, Construction and Engineering is developing an improved gas burner that can favourably compete with imported versions in both quality and price. The new process based on pulse combustion, offers heating efficiencies as high as 97% and promises substantial reductions in household and commercial heating bills. Although pulse combustion burners have been used in the USA and Japan, the work of the Division has introduced significant improvements in noise levels and nitrous oxide emissions. The new pulse combustion technology has particular application in domestic water and space heating.

Manufacturing Industries

Recent Achievements

Gene Shears
CSIRO is building Australia's international competitiveness through the application of molecular biology to the pharmaceutical and agricultural industries. The gene shears breakthrough, expertise in plant and animal gene transfer and superior molecular biology skills provide a solid base for future advancement. $9.2 million has been allocated over four years to boost the general strategic R&D base and prove the feasibility of a gene shears approach to these economically important industries. Commercial links have already been gained for four projects. These include: the application of 'minizymes' to pharmaceutical products to enable efficacious, precisely-delivered drugs including anti-viral drugs; a new method of sex control in domestic animals through regulation of genes in transgenic animals, a major objective of the cattle and dairy industries; and the application of molecular biology to rabbit control which has received $0.35 million to isolate specific proteins allowing sterilisation with the potential to save $70 million annually in lost production.

Gas metering technology
CSIRO and its commercial partner, AGL Ltd, launched a new gas metering technology recently. The new ultrasonics based technology supersedes traditional means of measuring gas flow. The meter is a battery operated unit, about the size of a videotape, with improved accuracy over a wide range of temperatures and flow rates and the capacity to be read electronically. Commercialisation of the technology is under way with a view to full scale production by industry licensees.

Effluent monitoring meter
A RACOD meter, which measures the amount of organic material in sewage has been developed by CSIRO. The meter which is compact and portable, enables low cost monitoring of effluent flow of optimal oxygen treatment. The device is now in further commercial development.

Walking robot
A walking robot was launched during CSIRO's Manufacturing Month. The robot, "Mister Plod", weighing 50kg, with a payload of 15kg, can walk over horizontal, curved, vertical and overhead surfaces was designed to do jobs not possible for 'conventional' robots. It is designed to walk on surfaces, especially on big structures such as buildings, tanks or ships. It can be instructed to track a feature, such as a join, and perform a task related to the feature, such as monitoring, welding or maintenance tasks.

Rural Based Manufacturing

Recent Achievements

Timber treatments reap commercial benefits
An oil-extended preservative developed by CSIRO's Division of Forest Products in collaboration with Koppers-Hickson Timber Protection Pty Ltd, for improving the stability and durability of softwoods has been commercialised as "Tanalith Gold". Seven treatment plants are now using this preservative and agreement has been reached with a UK company for a pilot scale trial to evaluate it under UK and European conditions. A second preservative developed by the Division, PEC (pigment emulsified creosote), is providing a steady stream of royalties from Australian usage. A successful plant trial in the UK has now led a German manufacturer to request a licence to build the first European PEC plant.

Improved resins for timber products
In its search for faster curing resins for fibreboard, laminated veneers and plywood, CSIRO's Division of Forest Products has shown that catalysed resins out-perform commercial products in the manufacture of medium density fibreboard. Also, the Division has completed laminated veneer tests for the Japanese market and is awaiting commercial response.

Whey protein fractionation process commercialised
In conjunction with United Milk Tasmania Ltd and the Dairy Research and Development Corporation, CSIRO's Division of Food Science and Technology has developed the Thermal Whey Protein Fractionation technology. This has allowed the production of new whey protein products enriched in the two major whey proteins respectively to varying degrees of purity as required. The variation in purity permits the intrinsic physical properties of the individual proteins to be exploited as food ingredients. Ingredients for specific applications are derived from these fractions and are currently being produced at substantial pilot-scale by the licensee (United Milk Tasmania Ltd) and should be available to the Australian food industry for commercial food formulation and evaluation trials in a few months.

Cholesterol-reduced foods
There is potential to reduce the dietary intake of cholesterol in the Australian community substantially to achieve the daily intake of 300mg that the National Heart Foundation recommends. CSIRO's SIDOAK process for extracting around 90% of the cholesterol content of egg and dairy products has been demonstrated on a pilot plant scale. An Australian egg processing company has a licence agreement for the technology, and negotiations are proceeding for overseas licensing agreements.

Commercial success for SIROSCOUR
The CSIRO medal winning, wool washing process SIROSCOUR, is now beginning to have commercial as well as critical success overseas. In Korea the Hanil Company is installing SIROSCOUR to wash Australian wool in Masam. And in China the Nam Kwong International Trading Company of

Macao will install a 2.4 metres wide, six bowl SIROSCOUR to handle a wide variety of Australian wool from the finest lambs wool to bellies.

Information and Communications Industries

Recent Achievements

A new generation cellular telephone system
CSIRO and Exicom Pty Ltd agreed in 1992 to conduct a design study for the development of a 38HGz radio link that could be used for radio transmission between base stations in the rapidly growing market for cellular mobile telephones. The aim of the study was to develop a system that would maintain the quality of cellular radio transmission at a much lower cost than those currently being used. This would be done by using microwave links rather than fibre optics. The study was a success, and CSIRO will produce four prototypes of the new radio link for evaluation and trials by the end of 1993. CSIRO's involvement includes work in systems design, microwave and gallium arsenide technology and antenna design.

Commercial Services

Recent Achievements

Ground probing radar
CSIRO and BHP, in a collaborative project involving BHP Engineering and the CSIRO Divisions of Geomechanics and Applied Physics have produced an Advanced Ground Probing Radar System for general engineering applications. The system is capable of imaging structures to a depth of 3m below the surface, and has been used to reveal buried pipes, pavement layering beneath a road, wash-out channels beneath a weir and delamination zones in the far surface of a concrete wall. System features incorporate a new radar antenna design, high performance electronics and advanced data capture and image processing/presentation modules. The system is now being trialed by BHP in applications throughout their business units, with the ultimate aim of national and international commercialisation.

Environmental Aspects of Economic Development

Recent Achievements

Biological control of environment-threatening weeds
CSIRO's Division of Entomology is involved in several projects aimed at introducing and testing natural enemies of important weed species. The Division has significant success during the year in the control of *Mimosa pigra*, a thorny plant which threatens Kakadu and has already engulfed large areas in the Northern Territory. A moth released in 1989 is reducing the plant's prolific seed production by up to 60 per cent and a number of new control agents have now also been released. Under attack by another moth introduced by the Division is bitou bush, a South African shrub that has taken over large tracts of the southeastern coastal belt. The bitou tip moth has reduced the weed's fruit and flower production by 70% and 50% respectively.

Bushfire control
From its research on bushfires, CSIRO's Division of Forestry has developed a decision-support system which, by predicting fire behaviour under specific conditions, helps managers take appropriate action to reduce the immense damage caused to forests and the rural environment by wildfires. The "National Bushfire Model" has now been released as a PC-based training version and distributed to fire management officers around Australia. Models have also been used in developing a prescribed burning guide for young regrowth forests of *Eucalyptus sieberi*, the major commercial species in coastal SE Australia. The guide describes conditions under which prescribed burning can be conducted without causing excessive damage to tree crowns and boles.

Water quality instrumentation
A total dissolved organic carbon analyser developed by CSIRO's Division of Coal & Energy Technology has now been commercially released. The new instrument, ANATOC, will be manufactured by SGE International Pty Ltd who expect significant export sales. The instrument will enable industry to detect organic carbon at levels of between 0.1 and 20,000 parts per million in process, waste and natural waters. The secret of the new instrument is the use of a titanium dioxide photocatalyst which accelerates the oxidation of organics when waters are irradiated with low level ultraviolet light.

Sewage treatment
The SIROFLOC process developed by CSIRO is currently employed in a number of plants in Australia and overseas for purification of drinking water. The technology is now being developed for treatment of sewage. The process involves use of magnetite (magnetically charged iron oxide) to separate suspended solids, oils and grease from urban effluent streams. A $4.5m prototype plant developed in CSIRO with the Sydney Water Board and Davy John Brown was opened at Malabar recently. This prototype plant is

capable of cleaning 5 million litres of sewage per day, the equivalent of a town of 20,000 people.

Environmental Knowledge

Recent Achievements

Major contributions to National Environmental Policy
CSIRO has prepared a major discussion paper for CEPA entitled *Development of a National State of the Environment Reporting (SER) System* which is now in wide circulation for comment. The concept of SER is well established overseas, especially in OECD countries. In Australia, the establishment of State and Federal Environment Protection Agencies and the public's desire to know 'what is happening to our environment' heralds a new beginning for SER here.

CSIRO prepared two further discussion papers for CEPA, *Towards Healthier Rivers and Urban Stormwater - a resource too valuable to waste*. Both were launched by the Minister for the Environment as major policy contributions, and both received wide national coverage.

Reintroduction of endangered mammals
Australian fauna is at considerable risk - 18 species of our mammals have become extinct in the last 200 years, which represents half of all mammal extinctions world-wide over this period. Our record would have been worse had not some species survived as remnant populations on off-shore islands. The burrowing bettongs are among one of many desert mammals that were forced from the mainland by feral animals. CSIRO has succeeded in reintroducing the burrowing bettong to mainland Australia after an absence of 50 years. The bettongs are breeding successfully and after nine months, their population has doubled.

In collaboration with a local community group and with support from a Perth company, CSIRO has created a mainland sanctuary in Western Australia free of predators and stock to allow the re-establishment of up to 6 species of endangered mammals.

Chewing the cud and greenhouse gases
Methane is a major component of greenhouse gases and emissions from animals, and their waste products are estimated to make up between 7% and 20% of total methane emissions into the atmosphere. Cattle are estimated to emit between 100 and 500 litres of methane per day. Until recently, these measurements could only be taken in chambers, in unfamiliar conditions likely to lead to stress on the animals and, consequently providing unrepresentative results.

CSIRO scientists have now devised a technique that tests methane emissions in natural conditions. This has produced results that exceed the previous estimated maximum. The experiment has also shown that methane

emissions are significantly affected by diet. When cattle were fed a high quality diet of lucerne and oats, the methane emissions dropped to between one third and one half the figures when they were on a grass diet.

Impacts of climate change
Based on its research in climate change, CSIRO is developing scenarios about the impacts of alterations in our climate in different regions in Australia. It provides specific and regional scenarios of plausible changes in various parts of the country for use by groups who wish to assess sensitivity to climate change. One likely change that has been identified is an increase in the frequency of heavy rain events. CSIRO general circulation models suggest that, in future, the time between heavy rainfalls may decrease significantly in Australia and many parts of the world. If such changes were to occur, the frequency of flooding would increase, which would have major implications for the design of drains, dams and bridges.

Construction

Recent Achievements

Metal framed houses
Metal frames for housing have been used for thirty years, but have always had strong competition from traditional timber frames. Metal framing for houses is gaining popularity with project builders, as well as being used in kit homes. CSIRO collaborated with BHP to develop a design manual and a performance standard for metal house frames. The standard aims to maintain the quality of metal framed houses, while encouraging innovation in design. The Standard is unique in that it contains mandatory servicability criteria which are purely advisory in other codes. In the United States, the National Science Foundation has only just begun a research program into the development of steel-framed systems for domestic construction, and there are expressions of interest from other countries such as New Zealand and Italy.

International user of SIROWET
Billed as one of the world's most intelligent buildings, the prestigious UOB Bank Building in Singapore boasts some of the latest in construction technology. The Australian company, Permasteel-isa, supplied and installed the curtain walling, thick natural granite cladding and special 26mm thick double glazed vision and spandrel units in an aluminium framework custom designed for the Bank. CSIRO's Division of Building, Construction and Engineering was selected in the face of tough world wide competition to conduct stringent performance tests on the curtain walling. The engineers used a modified version of the CSIRO-developed SIROWET method to test for deflection of the structure, and air infiltration and water penetration on full scale prototypes. Other tests included the strength of the panels, the abrasion resistance of the facade to movement of the building

maintenance unit which runs up and down the building, and the continuity of electrical connection.

Fire safety at airports
The Federal Airports Corporation is adapting fire safety engineering designs proposed by CSIRO through the application of "Firecalc", a computer program that models how fire grows. The FAC saved several million dollars in more effective planning of its fire protection facilities at the international and domestic terminals in Melbourne and Sydney. In the extensions to the Sydney international terminal, 3000 less sprinklers were required when "Firecalc" was used to design the system. A direct saving of about one million dollars was made in that terminal alone, while maintaining the same level of safety.

BCAider - expert system for building code use
BCAider, a $1.5 million collaborative project between CSIRO, the Australian Building Regulations Coordinating Council, Jennings Housing and Butterworths, allows users to quickly and accurately check compliance of building designs with the regulations in the Building Code of Australia. It is the world's first commercial expert system for building codes and is attracting wide interest from overseas including Europe, North America and SE Asia. BCAider provides a printed certification of code compliance. It also provides electronic access to associated Australian Standards and compendia of accredited building products. In just over 18 months the product has achieved substantial acceptance in spite of severe recession in the building industry, and has had a number of sales overseas.

Health

Recent Achievements

Australian health food program
CSIRO's Division of Human Nutrition commenced an applied research project in collaboration with the then Commonwealth Department of Health, Housing and Community Services, and Woolworths Pty Ltd in October 1992. The main aims of this two-year project are to develop, implement and evaluate a variety of nutrition information materials which will facilitate shoppers' selection of healthy foods. The project, part of the Australian Food and Nutrition policy, is based on the recently revised Australian Dietary Guideline. Materials from the project will be made available to all retailers at its conclusion.

Advancement of Knowledge

Recent Achievements

The longest jets in the universe
Astronomers using the Australia Telescope have discovered a pair of radio jet - streams of particles that emit radio waves emerging from a giant galaxy, 319-453. Radio jets are not uncommon, but these are the largest ones ever found. Each is about 2 million light years long (about twenty times the diameter of our own galaxy).

Industry Research and Development Board

Role *Through the operation of various programs, to facilitate wealth creation by the development of internationally competitive Australian industries through 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 programs which are the Tax Concession for Research and Development, the Discretionary Grants Scheme, the Generic Technology Grants Scheme, the National Procurement Development Program (NPDP), the Advanced Manufacturing Technology Development Program (AMTDP) and the National Teaching Company Scheme.

Industry Innovation Program (IIP)

- Tax Concession for Industrial R&D
The tax concession for industrial research and development is a major program in the Government's package of measures to encourage the performance of R&D in industry. The objective of the tax concession for industrial research and development is to encourage Australian companies to be more innovative and internationally competitive through improving innovative skills in Australian industry by:

- increasing companies' investment in R&D;
- encouraging better use of Australia's existing research infrastructure;

- improving conditions for the commercialisation of new process and product technologies developed by Australian companies; and
- developing a capacity for adoption of foreign technology.

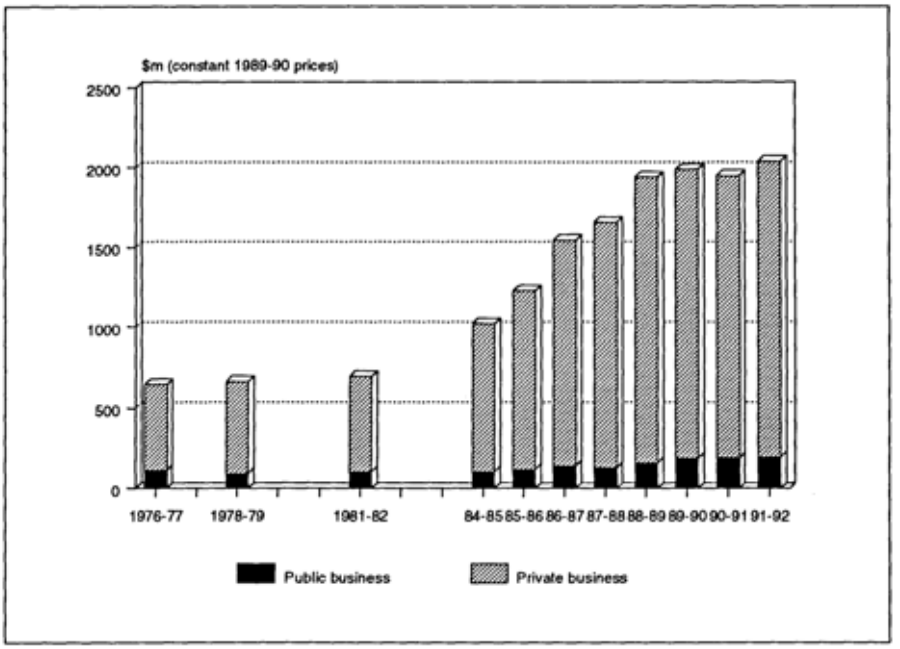
Recent Achievements

Effectiveness

The Australian Bureau of Statistics R&D data show that the level of private business expenditure on R&D has increased substantially in real terms over the period since the introduction of the concession (see Figure 8). Much of the growth may be attributed to the concession. It provides a considerable incentive to industry, with an estimated $386 million of company tax revenue foregone in 1992-93. It is available to all tax-paying companies conducting eligible R&D in Australia and was used by about 1800 companies in the last financial year.

Figure 8

BUSINESS EXPENDITURE ON R&D



Source: DIT&RD based on ABS data

Electrical appliances and telecommunications equipment
Melbourne based company, Kambrook Distributing Pty Ltd, has established itself as a market leader, exporting Australian technology to 28 countries. It has a diverse product range including a number of Australian and world firsts, such as the smokeless grill, cordless iron and cordless electronic kettle. Recently the company launched a new range of telecommunications products which it is anticipated will earn in excess of $22 million in sales in the first few years of production. The assistance of the tax concession has enabled Kambrook to substantially reduce the cost of many developments within the company, keeping products price competitive and allowing ongoing reinvestment in R&D.

- Grants

Recent Achievements

Grants to provide support for market driven industrial research and development in companies with high growth potential that cannot take full advantage of the tax concession.

Using recycled plastic in pipes
Rib Loc Australia Pty Ltd were awarded a grant of over $400,000 to develop a process that incorporated the use of recycled polyethylene, in place of less environmentally friendly polyvinyl chloride, into the manufacture of their range of drainage pipes and related products. This project involved breaking new ground in plastic processing, materials handling and production engineering. Rib Loc have successfully completed the project and developed a process which has the potential to use 25,000 tonnes of recycled plastic each year.

A voice/data switch for telecommunications
With the assistance of a grant of more than $1,100,000, Hypercom Pty Ltd has developed a voice/data switch capable of processing, routing, concentrating and terminating digital and analogue data and voice streams. The switch allows a company to have one telephone number across a country which will route a call to the closest or most appropriate store or service. The MegaSWITCH is currently being marketed in Australia, the USA, Brazil, Mexico, Colombia, Singapore, Hong Kong and New Zealand and has achieved contract sales worth $12 million.

Award-winning safety helmets
In 1989 Matich (Aust) Pty Ltd commenced a project to design and manufacture a performance oriented safety helmet, under the Headway brand, using new generation materials and technology. With discretionary grant support of more than $0.4 million for the project the company has developed a range of helmets that meet world recognised and Australian safety standards and include ten different sizes, aerodynamically designed ventilation and a unique buckle. In Australia the company, with its Australian Design Award winning helmets, holds a large share of the

lightweight bicycle helmet market and dominates the middle and premium bicycle helmet market.

Grants to provide support for collaborative research and development in strategic technologies that are important for the international competitiveness of Australian business.

Photocatalytic total organic carbon analyser
Supported by a generic technology grant of $103,000, SGE International Pty Ltd has developed a photocatalytic total organic carbon analyser that uses photocatalysis, a unique method of oxidation. As a result of this method the analyser has several advantages over other similar machines including, no high temperature furnaces are required, the oxidant is atmospheric oxygen, no unstable oxidising solutions need be added during the process and no special gases in cylinders are required.

Source technology for remote sensing
Researchers from the Centre for Lasers and Applications, Macquarie University, with assistance from the Defence Science and Technology Organisation, and in partnership with BHP Research and AWA Defence Industries Pty Ltd, have developed very compact and rugged infra-red lasers utilising all solid state components that have very low power requirements and long operating life between servicing. The components are a part of generic laser technology which is a key source technology for various remote sensing systems, particularly for minerals processing and exploration, medical instrumentation and defence industries.

Extending shelf life
As part of a project to develop active packaging for horticulture, researchers from the CSIRO have developed an innovative adhesive closure system that allows sealed holes to be opened by increasing the surrounding temperature. The system uses an adhesive formulation and a temperature sensitive device that can be made so that it is not sensitive to temperature until it has been exposed to the storage environment. This technology has been developed in response to the need to address international quarantine requirements.

Grants to support the collaborative development of new, internationally competitive goods, services or systems with government departments or agencies.

Continuing success for smartcard
ERG Australia Ltd designed, developed and trialed a smartcard ticket issuing system with the support of a NPDP grant. The project was conducted from 1988 to 1990 and involved support of more than $200,000. The resulting system has been successfully marketed, particularly over the past year. In August 1992 a $26 million sale of a smartcard system to the Greater Manchester Passenger Transport Executive was announced. Total sales for the system are now more than $45 million.

Reducing the size of timber waste

Unable to purchase a mill capable of meeting its needs, the Brisbane City Council joined with Van Gelder Crushers Pty Ltd and Stubbeng Materials Handling Pty Ltd in a project to develop a heavy duty mill and associated feeders needed to reduce the size of timber for land fill. Such a mill would allow the timber waste to be turned into re-useable products such as mulch. Supported by over $95,000 from a NPDP grant, the project developed a mill capable of handling both vegetation and demolition waste. Total sales for the mill are now over $1 million.

International success for InterScan

InterScan, now a wholly owned subsidiary of AWA Defence Industries, has secured a $5 million contract to provide three Microwave Landing Systems to Taiwan. This sale represents the first significant sale of Australian high-technology equipment to Taiwan. Previous sales of the system, which was developed with the assistance of a NPDP grant of over $1 million, have been made to Spain, the Peoples Republic of China and the USA.

Grants to encourage links between companies and public sector research institutions to employ high calibre graduates on projects that are designed to improve company performance.

Integrated manufacturing system

With support from a National Teaching Company Scheme grant, Computer Systems Development Pty Ltd commenced a project that would integrate job costing and quotation functions for jobbing and service shops into the company's Quisine Commercial System. The project was completed in November 1992 and the final system caters for at least four types of Job Costing businesses. The company has earned additional income of more than $250,000 as a result of the enhancements made through the project.

Increasing contact lens production

Eycon Lens Laboratories Pty Ltd, in conjunction with the University of Sydney, completed a successful NTCS project to optimise the machining parameters for high-water lens materials and to automate the process of machining. As a direct result of the project production efficiency has doubled per person hour per day and with fewer rejects. The project also allows the company to test the machinability of new materials in-house and to offer the service to the industry.

PRIMARY INDUSTRIES AND ENERGY

Science and Technology in the Portfolio Budget

The principal aim of the research and development programs operating within Department of Primary Industries and Energy is to contribute to the efficiency and competitiveness of Australia's primary and energy industries and the management of the resources on which they depend. Strong linkages with industry and relevant parts of Government, at both corporate and program levels, are therefore essential to ensure that the structural and administrative arrangements for research and development meet this purpose, that industry and Government needs and objectives are taken into account in the development of research programs, and that the technology arising from the research is channelled back into industry.

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

- three research bureaux, the Australian Geological Survey Organisation (AGSO), the Bureau of Resource Sciences (BRS) and the Australian Bureau of Agricultural and Resource Economics (ABARE); and
- thirteen Research and Development Corporations and five Research and Development Councils.

The institutional arrangements within the Portfolio allow all the 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. Monies 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) formerly the Bureau of Mineral Resources, Geology and Geophysics; and
- The Bureau of Resource Sciences (BRS).

The current structure of the Bureaux reflects changes implemented by the Government to ensure that scientific support for resource decisions are provided in the most efficient way. The refocussing of the DPIE research Bureaux will provide an improved mechanism for the provision of research,

science and resource related policy advice to Government. The resources allocated to petroleum and minerals resource assessment within Bureau of Mineral Resources (BMR) were merged on 19 October 1992 with the Bureau of Rural Resources (BRR) to become the Bureau of Resource Sciences (BRS). BRS includes the National Resource Information Centre (NRIC) which was previously operated jointly by AGSO and BRR.

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. Expenditure by these three Bureaux in 1993-94 is expected to be $103 million. Their research output is mostly in areas where the external benefits are high, in the more basic lines of research, in research that has 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.

R&D Corporations and Councils

Eighteen R&D Corporations and Councils have been established to encourage greater end-user participation in research and to ensure industry research organisations are more active in the commercialisation of research and the realisation of industry opportunities and more involved in technology transfer. Research expenditure through these bodies in 1993-94 is expected to be $260 million, of which approximately 38 percent will be collected from industry levies and 50% from direct Commonwealth contributions, the balance of expenditure comprising reserves and other income.

The fifteen industry based R&D Corporations and Councils are:

- Cotton R&D Corporation
- Dairy R&D Corporation
- Fisheries 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
- Chicken Meat R&D Council
- Dried Fruits R&D Council
- Egg Industry R&D Council
- Honeybee R&D Council
- Tobacco R&D Council

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 generally. 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.

Direct funding of R&D by Government was judged as being appropriate for these Corporations, particularly as the private sector is likely to under-invest 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. During the course of 1993-94 the Government intends to establish the Forest and Wood Products R&D Corporation, to commence from 1 January 1994.

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

Bioeconomic models for fisheries
Bioeconomic models were developed for the northern prawn and Torres Strait prawn fisheries. These models were used to assess proposed management options for these fisheries.

Energy demand and supply data
A detailed assessment of current and projected energy demand and supply for Australia was undertaken including projections of greenhouse gas emissions. Such information has become a necessary input into the analysis of Australian energy sector trends by government and industry. It also allows Australia to fulfil its international reporting responsibilities with respect to energy data.

Model of the world uranium market
A model of the world uranium market was developed to allow a better understanding of the implications of developments in this market and to help industry analysts project the impacts of changing supply and demand conditions.

Econometric model of Australian broadacre agriculture
The Econometric Model of Australian Broadacre Agriculture was further developed for use in meat industry analysis, trade policy simulations and in fulfilling regular outlook analysis.

New steel-making technologies
A number of studies were undertaken to assess the impact of changes in steel making technology on the future structure of the Asian steel industries and on Australian export oriented steel production and iron ore and coking coal markets.

Bureau of Resource Sciences (BRS)

Role *BRS's role is to provide a more informed scientific and technical basis for decisions by governments and managers and thereby assist them to improve the economic and environmental sustainability of Australia's primary industries.*

In undertaking its role, BRS:

- provides short term advice and carries out strategic analysis and research to provide timely, authoritative scientific advice as input to primary industry policy and management
- facilitates and coordinates primary-industry related scientific activities including collaborative programs with other agencies, and participates in international scientific and other fora with direct relevance to the Bureau's objectives
- informs the community and stimulates public debate on primary industry issues of a scientific and technical nature.

Recent achievements

Drought and risk management
BRS published a number of reports on drought monitoring and drought and risk management. Collaborative studies with the Queensland Department of Primary Industries, have substantially increased the accuracy of estimating the local and quantity of rainfall. BRS also collaborated with the Bureau of Meteorology on the effects of climate variability on agriculture and responses to lessen land degradation during drought.

Information resources
In January 1993 BRS released *Australia's Identified Mineral Resources, 1992* which contained estimates of the nation's identified mineral resources, trends in these resources over the past 27 years, and mineral exploration expenditure for various minerals over the past three years.

In April 1993, BRS released the second edition of a report on the oil and gas resources of Australia, showing the current state of reserves, future potential for production, existing developments and unconventional resources. The report indicated that production of oil was likely to continue near current levels until the year 2000.

Albacore tuna opportunity identified

Completed in August 1992, the BRS survey of albacore tuna resources off south eastern Australia demonstrated, through collaboration with the fishing industry, that an albacore fishery exists in our fishing zone provided sufficient new markets are developed, and that small-scale fishermen can generate income from other sources in the off-season. In addition, BRS also produced 4 new fishery status reports on South East Fishery Quota Species, Southern Shark, Northern Fish Trawl and Great Australian Bight Trawl.

Australian Geological Survey Organisation (AGSO)

Role *AGSO's role is to improve the quality, utility and accessibility of the geoscience knowledge base to underpin: the development of a more competitive and diversified Australian mineral and petroleum exploration industry; the improved management of Australia's natural resources consistent with the principles of ecologically sustainable development; and the development of effective strategies to mitigate natural geological hazards.*

Recent Achievements

New mapping influences exploration industry investment decisions

Under the National Geoscience Mapping Accord, a joint Commonwealth-State initiative, a new generation of geoscience maps and data sets will be provided of strategically important areas of Australia. AGSO's research results have changed the fundamental understanding of the nature of mineral and petroleum accumulations in project areas. This has attracted exploration investment and had a significant impact on industry perceptions of the prospectivity of, and exploration strategies to be applied in, these project areas.

Petroleum and minerals exploration

As part of the Eastern Goldfields National Geoscience Mapping Accord project (with the Geological Survey of Western Australia), AGSO's seismic reflection survey which was reported last year continues to have a major impact on models used in both the minerals and petroleum industries to frame exploration strategies. This work has established very strong correlations between regional geological movement and the migration of mineralising fluids from deep in the crust.

Mapping in south eastern Australia attracts exploration interest

As part of the Lachlan D Kanmantoo National Geoscience Mapping Accord project (with the New South Wales Geological Survey and the Geological Survey of Victoria), mapping in the Bathurst region showed a particular rock type to be prospective for gold, copper and platinum group elements. The study showed prospects more extensive than previously believed, and outlined volcanic complexes with copper and gold potential. Early results from mapping around Ballarat have also indicated extensions of prospective rock units into areas where they were not previously known.

Offshore exploration potential
The Continental Margins Program (CMP) continues as a central element in the Government's strategy to encourage the exploration for, and responsible development of, Australia's offshore petroleum resources. CMP work on the north west margin of Australia has had a significant impact on the development of industry exploration concepts by releasing deep crustal data sets which change industry interpretations of margin history, structural development and petroleum potential.

A benchmark for changes in groundwater quality
Groundwater is a major contributing factor to the processes of land degradation in Australia. AGSO has compiled a draft Status *of Groundwater, 1992* report for the Murray Darling Basin Commission which provides a benchmark against which changes in the quality of groundwater in the Murray Darling Basin and the impact of mitigation strategies can be compared for resource management and policy decision making. The draft has already been used by the New South Wales Environmental Protection Agency as a model for their State of the Environment reporting; ultimately, these reports may come out biennially.

Better building codes for urban Australia
During 1992-93, AGSO upgraded Australia's national earthquake monitoring facilities by developing a prototype satellite telemetry station and acquiring 12 digital accelerographs for installation in Adelaide, Brisbane, Melbourne, Newcastle, Perth and Sydney. This will allow AGSO to obtain good estimates of expected ground motion in Australia's main urban areas and provide input into the development of better building codes.

Seabed boundary between Australia and New Zealand
Under the Continental Margins Program, AGSO recently completed a survey across the Lord Howe Rise and Norfolk Ridge to help define Australia's seabed boundary and Australia's legal continental shelf in the context of future negotiations on the unresolved boundary between New Zealand and Australia. This Program also provides invaluable information on the identification of Australia's maximum legal continental shelf under the United Nations Convention on the Law of the Sea.

Cotton R&D Corporation (CRDC)

Role *The CRDC is responsible for the allocation and administration of just under 40% of all funding for Australian cotton research.*

The Cotton R&D Corporation is based in Narrabri, in north western NSW, and is run by a Board of Directors and a small, but dedicated staff. It currently contributes to more than 90 research projects covering a range of problems associated with cotton production.

The Corporation's mission is to: "increase the contribution that R&D makes to the well-being of the cotton industry and the community in general."

The Corporation's main goals are to:

- develop efficient, sustainable production systems
- improve fibre quality to better meet market needs, and
- develop efficient handling, transport and marketing systems and infrastructure.

Recent Achievements

Genetically modified cotton
For the first time, 'genetically' engineered cotton plants were tested in the field. These plants carried a gene for the expression of *Bacillus thuringiensis* (a naturally occurring bacterial 'insecticide'). See CSIRO pl03 for details.

Identification kit
As a result of research specifically commissioned by CRDC, an 'identification kit', to differentiate between pest species of *Heliothis,* will be commercialised for the coming season. The kit was developed by CSIRO's Division of Entomology and will be marketed through Abbott Laboratories in the coming season.

Sugar Research & 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:

Induction of flowering in sugarcane
A significant breakthrough in induction of flowering in sugarcane has provided the means of obtaining substantial improvement in sugarcane breeding programs. Unreliability of flowering response in parent clones previously circumvented the use of many chosen hybrid combinations.

Control of the flowering response in parent clones has opened the way for a targeted crossing program and significantly improved genetic strain.

Integrated pest management of rats
A study of rat biology has led to the introduction of a more efficient and effective rat control program in sugarcane in the Herbert River district in North Queensland. It was found that control of weeds, whose seeds provide rats with a source of protein, leads to lower rat reproductive rates. When combined with a monitoring program which gives accurate predictions of potentially damaging rat populations, and subsequent strategic application of baits, rat infestations have been successfully controlled over a number of years. The program has application in other districts where rats cause economic damage.

Dairy Research and Development Corporation (DRDC)

Role *To lead effective change through excellence in R&D, for a profitable and sustainable dairy industry.*

Recent Achievements

Grazing management in the sub-tropics
Research at Wollongbar Agricultural Institute found that feed production could be increased when grazing intervals were extended. Grazing ryegrass 'when ready' instead of every two weeks, produced 36% more feed. 'When ready' was before lodging, rust or leaf death occurred (about 16 days in spring and more than 40 days in winter).

Combining this approach with good management to utilise the extra feed can substantially boost milk production. Extending the grazing interval also increased ryegrass survival.

Turnips boost summer food production
Trials in Victoria with improved varieties of turnips and better cultural practices have shown turnips to provide lowcost high quality summer feed. There has been rapid uptake and use of this technology in Victoria in association with pasture renovation programs.

New products
Six new milk-derived products resulting from the Corporation's funded R&D program either entered or completed commercialisation during the year. These products ranged from milk powders with improved functional specifications to new protein products. In addition a technology transfer

program by licence agreement in milkfat fractionation technology to a company was completed.

Fisheries Research & Development Corporation (FRDC)

Role *The FRDC is a national organisation responsible to its stakeholders (the fishing industry, and the Government and the people of Australia) for: planning, funding and managing research and development programs; and facilitating the dissemination, adoption and commercialisation of the results of research and development.*

Its mission is to increase economic and social benefits for the fishing industry and the people of Australia, through planned investment in research and development in an ecologically sustainable framework.

The National Seafood Centre was established on 26 October 1992. Its role is to advance post harvest seafood technology through: investment on short term market focused projects with the potential for high return; and networking in the industry to disseminate information on opportunities and developments in seafood technology.

Recent Achievements

Transportation and storage of live penaeid prawns
The successful method of handling live prawns from capture, through packing, to distribution. Commercial trials with kuruma prawns *Penaeus japonicus* achieved a survival rate of more than 95% at auction in Tokyo.

Improved diagnosis of infections
The development of a rapid, cheap and accurate test for the epizootic haematopoietic necrosis (EHN) viral infection in salmonids in Australia has been achieved. The research has resulted in the development of an enzyme-linked immunosorbent assay (ELISA) test for routine EHN diagnosis. ELISA will now be used as a certification test.

Honeybee Research and Development Council

Role: *To direct, administer, examine and evaluate research and development needs and to fund projects aimed at improving the productivity and profitability of the honeybee industry.*

Recent Achievements

The effect of farming practices on honeybee foraging behaviour
The pollination biology of cucurbits (eg cucumbers and rockmelons) and the pollination efficiency of honeybees following the application of a range of pesticides to these crops has been investigated in a series of glasshouse and field trials in the Lockyer Valley in Queensland. The research has confirmed the vital contribution of bees to successful pollination and fruit set and resultant high yields. It has also demonstrated the importance of adherence to recommended spraying practices which minimise bee deaths.

Code of practice for assuring the quality of Australian honey
The world's first Code of Practice for assuring the quality of honey has been developed in Australia through a joint venture between the Australian Honey Bureau and the Honeybee Research and Development Council. As quality standards become increasingly more stringent the honey industry needs to have the procedures available to ensure that Australian honey not only conforms to these standards, but can produce a product which is well inside the tolerances permitted.

The Meat Research Corporation (MRC)

Role: *The Meat Research Corporation, is one of three agencies consequently established to help develop the Australian red meat industry (beef, sheep, buffalo and goats). The other two are: the Australian Meat and Livestock Corporation (AMLC), which is responsible for marketing and promotion; and the Australian Meat and Livestock Industry Policy Council (AMLIPC), which deals with broad policy issues.*

The Corporation is funded by levies on livestock producers and meat processors, matched with contributions from the Commonwealth Government.

Recent Achievements

Reduction of meat processing costs
Prototype equipment capable of a 30% reduction in the cost of current boning methods for beef has been developed. The first commercial prototype nears completion at Kilcoy, north of Brisbane.

Increase in efficiency in Northern beef herds
This project aimed to increase by 1994, the carcase weight turnoff per breeding cow by at least 20%. Already early weaning, better supplementary feeding and reduced breeder mortality have been achieved through the North Australian Beef Research Program.

Reduction of sheep flock costs
Significant reduction in sheep flock costs have been achieved. Homozygous Border Leicester rams and ewes homozygous for the Booroola gene will be available for sale by the end of 1993. In addition, practical, cost effective methods for halving the mortality of twin lambs to weaning in the prime lamb industry have been developed. Twin lambs born 46 weeks later onto green pasture halved mortality.

Japan/Korea markets
The requirements of both customers and meat eaters were investigated and the Japanese were found to like both grain fed and high quality grass fed Australian beef. This has now led to the development of production systems to economically supply these products.

Tobacco Research and Development Council

Role: *To support a research and development program to reduce significantly the cost of producing tobacco leaf and improve overall leaf quality.*

Recent Achievements

Biological control of bacterial wilt of tobacco
Bacterial wilt caused by *Pseudomonas solanacearum* is a major disease of tobacco and other crops in Queensland. Disease control systems for this disease are being developed at the Queensland Department of Primary Industries, Mareeba. The system involves the use of avirulent mutant strains of *P. solanacearum*, in conjunction with plant resistance and crop rotation. Several genetically altered avirulent mutants of *P. solanacearum* are being tested as potential biological control agents. Some of these mutants retain the ability to colonise the roots of the host plant, and multiply in and around

the root system, preventing the entry of virulent bacteria, and significantly reducing the severity of bacterial wilt.

Egg Industry Research and Development Council

Role: *To develop and implement a plan for research and development for the Australian egg industry. The Council aims to improve the economic, environmental and social conditions facing producers and those involved in the processing and marketing of eggs and egg products.*

Recent Achievements

Cholesterol research program
Research supported by the Council over several years in relation to cholesterol in eggs has been completed to the satisfaction of the Council. Research conducted has shown that fat in a diet is a more significant factor in high blood cholesterol levels than is cholesterol in eggs. This outcome now allows the Council to prepare information for the medical profession and the community about the place of eggs in a diet.

Grape & Wine Research & Development Corporation (GWRDC)

Role: *To improve competitiveness and returns in domestic and international markets, and to ensure sustainable, commercial, environmental, marketing and social outcomes for the long term welfare of the Australian wine industry.*

The Corporation's objectives are:

- improved efficiency of grape and wine production
- improved capacity to manage grape and wine style
- development and adoption of sustainable, environmentally acceptable production techniques
- balanced production of grapes in relation to size and nature of market demands, and

– high level of communication and accountability to the Australian wine industry.

Recent Achievements

Revised management program for grapevine blackspot
Grapevine blackspot is a particular problem on susceptible varieties, such as Sultana, and in seasons with extended wet springs. In work jointly supported by the Grape and Wine Research and Development Corporation and the Dried Fruits Research and Development Council, researchers at Sunraysia Horticultural Centre have defined: four candidate alternative chemical sprays to the standard chemical treatment; the manner in which black spot is established and how it spreads; and a management program based on a weather driven computer based disease prediction system. As a consequence, it is now possible to determine the need for intervention sprays and establish the risk of incurring damage if chemical treatments are eliminated in some years.

DNA Fingerprinting for grapevine identification
The concept of DNA typing or fingerprinting for grapevine variety identification has been clearly demonstrated as feasible in work undertaken at CSIRO-Horticulture, Adelaide. Supported jointly by the Grape and Wine Research and Development Corporation and the Dried Fruits Research and Development Council, this work is of international significance as it offers the prospect of independent, objective identification of grapevine material, whether in the nursery, vineyard or even grapes about to be crushed. This will enable development of a varietal quality assurance process to support development of our international and domestic markets. The process is being developed in conjunction with the Australian Vine Improvement Association and OIV (Office International de la Vigne et du Vin).

A PCT (international patent) application is being undertaken for both the concept of DNA typing in plants, and the specific technology.

Pig Research and Development Corporation (PRDC)

Role: *To facilitate the development and adoption of research and technology appropriate to the improved performance of the entire Australian pig industry.*

In seeking to achieve its mission, the Corporation has adopted a Research and Development Plan for the period 1991 to 1996 with the following major objectives:

- improve the productivity of Australian pig production
- improve the efficiency of processing and marketing of Australian pigs and pig meat products
- improve the design, construction and operation of pig production units in Australia
- provide the information and communication necessary for the efficient operation of the pig industry
- develop the human resources of the pig industry, and
- efficiently manage the Corporation's responsibilities relative to the enabling legislation.

Recent Achievements:

PIGBLUP
PIGBLUP is a computer program developed by the Animal Genetics and Breeding Unit at the University of New England with PRDC support. PIGBLUP produces estimated breeding values for pigs which can be combined into an economic selection index. The computer program is supported by an extension group, the PIGBLUP Foundation Club, which comprises the breeders who are expected to make most use of the technology and apply it at a national level.

Horticultural Research & Development Corporation (HRDC)

Role: *The Horticultural Research and Development Corporation is responsible for the coordination and funding of horticultural research and development at a national level and aims to improve the efficiency and competitiveness of Australian horticulture and ensure accountability for expenditure on R&D.*

The Horticultural Research and Development Corporation is the research arm of the Australian horticultural industries, which includes fruits, vegetables, nuts, nursery products and cut flowers and foliage. Production, post harvest and processing research and development all fall within the ambit of the Corporation. Funding of research and development by the Corporation is on the basis of equal costsharing by industry and the Commonwealth Government.

From its inception in 1988 the Corporation has played a fundamental role in developing industry involvement in the planning, funding and commercialisation of research. Through the Corporation, direct industry financial support for R&D has grown from approximately $1.25 million in 1989, to $8.5 million in 1993.

Recent achievements

Development of partial processing technology for vegetables
Processing, packaging and storage procedures have been developed, which enables the extension of shelflife of shredded lettuce, mixed lettuce, broccoli florets, and cauliflower florets. The adoption of the procedures developed in this project will facilitate the marketing of convenient, premium quality, premium price, "fresh" prepared vegetables in the domestic market and greatly enhance Australian access to, and competitiveness in, overseas markets.

Commercialisation of modified atmosphere packaging for horticultural products
In joint venture with ANL Ltd and CSIRO, the Corporation has previously developed various modified atmosphere packaging films suitable for use on a broad range of export horticultural produce. In 1992-93 trial commercial shipments of blueberries, broccoli and cauliflower have been undertaken and protocols developed for successful introduction into the export market. This will allow wider use of sea freight without the current loss of quality and shelf life, resulting in a cheaper, more competitive Australian product in lucrative overseas markets.

Reduced pesticide use in citrus crops using biological control
With the reduction of pesticide use in citrus production, what were minor pests have now become significant problems. One such insect, the spined citrus bug, is now being controlled using synthetic attractant pheromones. Researchers supported by the Corporation have successfully synthesised the pheromones of this bug and its predator, the assassin bug. Such synthetic blends of pheromones are now being used to significantly reduce the use of insecticide to control this pest.

Identification of Western Flower Thrips
HRDC funded research has been responsible for the rapid detection and containment of Western flower thrips in Western Australia. The thrip is an important part of a number of plant viruses, including tomato spotted wilt virus, which are responsible for serious economic damage to nursery, cut flower, potato and tomato crops overseas. It had not previously been present in Australia and its detection, while disappointing, will allow rapid implementation of appropriate quarantine and control measures to prevent its spread and minimise crop losses.

Wool Research and Development Corporation (WRDC)

Role: *To plan and implement a research and development program to increase the net returns to Australian woolgrowers and the economy in an environmentally and economically sustainable way.*

The objectives of the Corporation are:

- wool value enhancement
- the adoption of quality management systems
- increased efficiency of production and processing
- environmental sustainability
- improved information flow and technology transfer

Recent Achievements

Sirolan-Laserscan
Answering the challenge for an automated, standardised, reliable and accurate method of measuring the mean diameter and diameter distribution of wool, the CSIRO Division of Wool Technology has developed the Sirolan-Laserscan instrument. Prepared fibre snippets are automatically dispersed in a carrier liquid that transports them through a measurement cell. In the cell, fibres intercept a laser beam and changes in the beam's intensity are converted into diameter readings by the instruments computer. Sirolan-Laserscan has recently been approved by the International Wool Textile Organisation Standardisation Committee as meeting all the technical requirements necessary for progression to a full Test Method.

New soil test for sulfur
Anew soil test for sulfur has been developed in cooperation with Incitec, the Australian Centre for International Agricultural Research and the University of New England. The test takes into account the organic fraction of sulfur which can become available for plants and gives a more reliable indication of the need for sulfur. The new test, together with the existing phosphorous test will enable farmers to more accurately predict the amount of sulfur fertilisers needed for their pastures and select the most appropriate fertiliser for their situation.

Energy Research and Development Corporation (ERDC)

Role: *To stimulate and facilitate investment in effective energy research for Australia in order to: increase the efficiency of energy use; increase the development of competitive Australian industries in all sectors; increase the diversity of energy supply; reduce adverse environmental impacts; reduce energy requirements, and reduce energy costs.*

The Energy Research and Development Corporation has carried on the following activities:

- Endorsement by the Australian Gas Association of the R&D Strategy developed by the Gas Industry in consultation with ERDC.
- Endorsement by the Australian Petroleum Exploration Association Council of the R&D Strategy. Membership of the Committee is made up of representatives from the Australian Petroleum Exploration Association, ERDC, the Australian Petroleum Industry Research Association, the Australian Institute of Petroleum and the Australian Petroleum Cooperative Research Centre.
- Draft of a Renewable Energy Strategy document out for public comment. ERDC and the Australian and New Zealand Solar Energy Society worked together to develop a simple ranking to prioritise renewable energy and related technologies in the Australian context. The ranking is based on three major criteria for weighting each technology.

  (1) potential R&D impact

  (2) commercialisation prospects, and

  (3) potential pollution benefit.

  Implementation is anticipated later in 1993.

Recent Achievements

ERDC and the Electricity Supply Association of Australia working together to jointly fund projects.

Project outcomes have included:

- the highest efficient polycrystalline silicon solar cell in the world
- the highest efficient silicon solar cell module in the world
- the licensing of the Vanadium Redox battery to Thailand and Japan

– the first 150 kW wind turbine operating in Australia which operates close to economic viability.

Land and Water Resources Research and Development Corporation (LWRRDC)

Role: *To improve the long term productive capacity, sustainable use, management and conservation of Australia's land, water and vegetation resources through a directed, integrated and focused research and development effort.*

Recent Initiatives

Dryland salinity
Dryland salinity is considered a major threat to the resource base of many rural industries around Australia. For many years, however, government and community activities aimed at managing the problem have been fragmented and uncoordinated. In recognition of this, the Corporation, in partnership with the Murray-Darling Basin Commission and National Landcare Program, initiated a national dryland salinity research, development and extension program. The major achievement in 1992-93 was to get State and Commonwealth agency agreement to work closely with community groups to maximise the coordination of salinity management activities within five focus catchments located around Australia.

Drought
The devastating impact of drought on rural productivity and farmers' livelihoods was highlighted in 1992-93. In response, the government implemented activities under a National Drought Policy initiative which were aimed at improving the self sufficiency of farmers during times of drought. The Corporation was successful in including under the initiative a commitment to fund research and development activities which will provide the information and skills farmers require to adopt practices which will enhance their self sufficiency, productivity and sustainability. The Corporation subsequently developed a national Climate Variability R&D Program which will commence research funding from 1993-94.

Grains Research and Development Corporation (GRDC)

Role *Investing in R&D into grain products for markets, improving grain production efficiency, making better and longer term use of the natural resource base, and securing the adoption of grains technologies.*

Recent Achievements

Canola
Canola production more than doubled from 58,000 tonnes in 1989 to an estimated 140,000 tonnes, in 1992. Much of this success can be attributed to joint action between growers, oilseed crushers and margarine and edible oil manufacturers, resulting from their involvement in a popular technology adoption project called "Canola Check", one of the Corporation's 900 industrywide research projects.

More than 80 per cent of NSW canola growers and a growing number in Victoria have taken part in "Canola Check", a decision support package which aims to increase grower confidence in crop management and marketing.

Rural Industries Research and Development Corporation (RIRDC)

Role *To enhance the sustained economic contribution of agricultural industries to the national economy.*

To achieve this, it organises and funds research and development to support small, emerging and new rural industries. RIRDC also addresses broader issues of interest to those in the agricultural sector such as agroforestry, climate change and pest and disease control. The Corporation also provides services for the semi-independent research and development councils.

Recent Achievements

Australian cashew nuts
The Corporation has been working closely with Australia's major cashew growers and researchers to improve the quality and yield of cashew trees in order to develop a viable industry. This year, for the first time, Australia exported its first commercial shipment of homegrown cashews. The 16 tonne consignment was coordinated by Cashews Australia Limited on behalf of the major growers. The crop was processed and packed under contract in China for sale to the United States.

Venison products
The Corporation commissioned AUSMEAT to develop a venison trading language and product specifications for the deer industry. Deer farmers now have a means of accurately describing venison cuts and a system which enables them to receive objective feedback about the acceptability of their deer for the venison market.

Agribusiness opportunities in South East Asia
INSTATE Pty Ltd was commissioned by the Corporation to study agribusiness and processed food development in South East Asia. A publication outlining the findings of that study has just been released, and is a valuable reference document for strategic planning by Australian agribusiness and food industry operators and policy makers. It will help them take more advantage of the opportunities of the South East Asian food market -potentially worth $150 billion by the year 2000.

Low rainfall agroforestry
RIRDC, together with the Land and Water Resources R&D Corporation, developed a joint program on agroforestry. As part of that program, a national workshop on 'Low Rainfall Agroforestry' was held, culminating in a useful reference publication. A national program was also developed on windbreaks, which is being supported by a number of other R&D Corporations.

Vegetation growth forecasting
'Vegetation Watch' a significant remote sensing project by the WA Department of Land Administration and CSIRO, was established with RIRDC support. The project monitors the growth of vegetation across the state and is helping land managers maximise benefits and minimise losses of their crops and livestock through better forecasting of the effects of seasons, cyclones, storms, droughts, fires, etc. on vegetation.

Cost of health and safety on the farm

RIRDC sponsored research into the hidden costs of farm health and safety. One report analysed the cost of farm accidents including hospitalisation compensation payments and time away from work and found that the average cost of farm accidents was just over $1,000 p. a., with one in every four farms experiencing this loss every year.

PRIME MINISTER AND CABINET

Science and Technology in the Portfolio Budget

Expenditure on science and technology policy and programs through the Office of the Chief Scientist is expected to rise to $95.6 million in 1993-94 ($46.6 million in 1992-93). This amount incorporates $94.23 million for the Cooperative Research Centres Program (of which $9.18 million is a carry over from 1992-93).

Expenditure on science and technology policy through ASTEC is expected to be $1.9 million in 1993-94 ($2.0 million in 1992-93).

MAJOR POLICY ACTIVITIES

Prime Minister's Science and Engineering Council

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's Science and Engineering Council (PMSEC) was created (as the Prime Minister's Science Council) as part of the advisory and coordination arrangements announced in May 1989 in the Statement *Science and Technology for Australia.*

The Prime Minister chairs the Council and the Minister Assisting the Prime Minister for Science is the Deputy Chair. The Chief Scientist is a member of the Council and is also Executive Officer. Membership includes Ministers with primary responsibility for science and technology matters, and representation at the most senior level from the business and science and technology communities and from the trade union movement.

In August 1992, as part of the White Paper on Science and Technology, *Developing Australian Ideas - A Blueprint for the 1990s*, the membership of the Council was expanded and its name was changed to reflect the strong role played by engineering in capturing the full benefits of our scientific knowledge. Notable additions to the membership included the Treasurer and the Presidents of the Academy of Science and the Academy of Technological Sciences and Engineering.

The Council meets twice a year, with each meeting addressing a number of matters, including at least one major presentation based on a report prepared by an independent working group. These reports are generally published and released at the time of the PMSEC meeting.

PMSEC has played a valuable role in involving senior Ministers in discussion of current issues in science and technology, with a particular emphasis on the application of research to economic and social objectives. PMSEC has assisted greatly in the development of policy, with many of its discussions giving new impetus to the resolution of 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
- 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 Council held meetings in December 1992 and June 1993. Among the topics discussed were Australian science and technology opportunities and strategies in the Asia-Pacific region, intellectual property and innovation.

As reported in Section 2, developments in several policy areas were assisted by the Council's consideration of reports by independent working groups. Important initiatives related to issues raised in the report *The Changing Role of Manufacturing Technology*, included the Advanced Manufacturing Technology Strategy, announced in the 1991 Industry Statement, and the establishment of a national system of vocational education and training, to be overseen by the Australian National Training Authority (ANTA). Issues raised in Council discussion of the report *Information Technology and Telecommunications: Looking to the Year 2000* form part of current Government activity in supporting and developing the telecommunications and the

information technology industries was in line with the recommendations in the subsequent *ad hoc* committee report.

The Council discussion of the report *Science and Technology Strategies and Opportunities in the Asia Pacific Region*, contributed to new actions relating to science and technology in the Asia Pacific region. Coordination issues raised in the report will be addressed by the Coordination Committee on Science and Technology.

In addition to these major presentations and reports on actions taken as a result of discussion at earlier meetings, the Council was informed of current activities and research outcomes at two Cooperative Research Centres.

Coordination Committee on Science and Technology

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.*

During 1992-93, the Government's White Paper on Science and Technology provided further roles for the Committee, in reporting to government on mechanisms used to set science and technology priorities; addressing the adequacy of those priorities; and keeping a watching brief on the development of proposals for national research facilities.

Recent Achievements

The Coordination Committee has, during 1992-93 taken a major part in:

- surveying mechanisms used by departments and agencies for science and technology priority setting; this will lead to the publication of a comprehensive paper summarising the range of mechanisms, and setting out conclusions;
- setting guidelines for the evaluation of proposals for large national research facilities, in order to be able to advise the Government on any proposals which may arise; these will be circulated to departments and agencies who may be developing such proposals;
- resolving issues concerning coordination of responsibility for the nation's major biological collections; and
- investigating the exploitation of Australian biological resources.

The Minister Assisting the Prime Minister for Science plans to attend all meetings of the Committee.

Office of the Chief Scientist

Role *The Office of the Chief Scientist provides policy advice, briefing and support directly and through the Chief Scientist to the Prime Minister and the Minister Assisting for Science. It also provides advice, information and administrative support for specific programs in order to maintain and enhance a world class Australian science and technology infrastructure, and to achieve the effective application of science and technology for the economic and social development of Australia.*

The Office of the Chief Scientist:

- provides secretariat services to the Prime Minister's Science and Engineering Council and to the Coordination Committee on Science and Technology, including coordination of the preparation of papers for consideration by the Prime Minister's Science and Engineering Council;
- provides support for the Cooperative Research Centres Committee in developing recommendations to the Minister Assisting for Science on the selection of Centres;
- implements and administers the Cooperative Research Centres Program;
- provides advice on issues in science and technology, directly and through the Chief Scientist, to the Prime Minister and the Minister Assisting for Science;
- obtains information about current and emerging developments and issues in science and technology policy;
- maintains close liaison with the Prime Minister's Office and consults with other departments and agencies in order to keep informed of significant developments and to facilitate cross-portfolio coordination;
- consults broadly with people outside Government, including the research, business and academic communities and the trade union movement, in order to bring a wide range of views and experience to bear on the development of policy advice;
- advises on the work of the Structural Adjustment and Trade Committee of Cabinet and other Committees, as appropriate;

- initiates and develops new policy proposals, where appropriate, in consultation with other departments.

Recent developments and achievements

In September 1992, Professor Michael Pitman, OBE, FAA was appointed Chief Scientist, succeeding Professor Ralph Slatyer, AC, FRS, FAA, FTS in that position.

During the year, the Office of the Chief Scientist coordinated the preparation of the Government's White Paper on Science and Technology, *Developing Australian Ideas - A Blueprint for the 1990s* and provided substantial support for the development of that part of the National Strategy for Ecologically Sustainable Development dealing with research and development.

The Office organised two meetings of the Prime Minister's Science and Engineering Council and four meetings of the Coordination Committee on Science and Technology. Support was provided for several sub-committees and working parties of the Coordination Committee.

The Office played a central role in arranging for the selection and establishment of additional Cooperative Research Centres and in the administration of the Program. Details of this activity are given below.

The Cooperative Research Centres Program
The Cooperative Research Centres Program was launched in May 1990. Under the Program, new Government funding, rising to $130 million dollars (1990) annually by 1996-97, will be provided to support up to sixty two Centres.

The objectives of the Program are:

- to support long-term high-quality scientific and technological research which contributes to national objectives, including economic and social development, the maintenance of a strong capability in research and the development of internationally competitive industry sectors;
- 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;
- to build centres of research concentration by promoting cooperative research, and through it a more efficient use of resources in the national research effort;
- to stimulate education and training, particularly in graduate programs, through the active involvement of researchers from outside the higher education system in educational activities, and graduate students in major research programs.

The Cooperative Research Centres Committee, which is appointed by the Minister Assisting the Prime Minister for Science, provides advice on the Program.

Selection of Centres

The third round of the selection process for the Program was completed in December 1992, with the selection of a further eighteen centres and extensions of two existing centres. The following fifty two Cooperative Research Centres (CRCs) are now established:

- CRC for Intelligent Manufacturing Systems and Technologies
- CRC for Alloy and Solidification Technology
- CRC for Aerospace Structu res
- Australian Maritime Engineering CRC
- CRC for Materials Welding and Joining
- CRC for Polymer Blends
- CRC for Molecular Engineering and Technology: Sensing and Diagnostic Technologies
- CRC for Industrial Plant Biopolymers
- CRC for Broadband Telecommunications and Networking
- CRC for Advanced Computational Systems (ACSys)
- Research Data Network CRC
- CRC for Intelligent Decision Systems
- CRC for Robust and Adaptive Systems
- CRC for Distributed Systems Technology
- Australian Photonics CRC
- CRC for Sensor Signal and Information Processing
- CRC for New Technologies for Power Generation from Low-rank Coal
- Australian Geodynamics CRC
- CRC for Mining Technology and Equipment
- G K Williams CRC for Extractive Metallurgy
- A J Parker CRC for Hydrometallurgy
- Australian Petroleum CRC
- CRC for Australian Mineral Exploration Technologies
- CRC for Premium Quality Wool
- CRC for the Cattle and Beef Industry (Meat Quality)
- CRC for Aquaculture
- CRC for Sustainable Cotton Production
- CRC for International Floriculture

- CRC for Food Industry Innovation
- CRC for Legumes in Mediterranean Agriculture
- CRC for Plant Science
- CRC for Tropical Plant Pathology
- CRC for Tropical Pest Management
- CRC for Temperate Hardwood Forestry
- CRC for Hardwood Fibre and Paper Science
- CRC for Viticulture
- CRC for Ecologically Sustainable Development of the Great Barrier Reef
- CRC for Freshwater Ecology
- CRC for Southern Hemisphere Meteorology
- CRC for Tropical Rainforest Ecology and Management
- CRC for Waste Management and Pollution Control
- CRC for Soil and Land Management
- CRC for Catchment Hydrology
- CRC for Biological Control of Vertebrate Pest Populations
- CRC for the Antarctic and Southern Ocean Environment
- CRC for Vaccine Technology
- CRC for Tissue Growth and Repair
- CRC for Cellular Growth Factors
- CRC for Biopharmaceutical Research
- CRC for Eye Research and Technology
- CRC for Cochlear Implant, Speech and Hearing Research
- CRC for Cardiac Technology

In the light of the success of the program, and the number of high quality applications in the third round, the Government announced a fourth round of applications in April 1993, with a closing date of 6 July 1994.

Australian Science and Technology Council

Role *To provide independent advice to the Government on science and technology policy matters, including:*

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

Recent Achievements

Bridging the Gap - The social sciences, humanities, science and technology in economic development

The broad issue of the relationship of the social sciences and the humanities to economic development was consistently raised during the consultations for the preparation of ASTEC's 1991 report entitled *Research and Technology: Future Directions.* Accordingly, the Council in March 1992, appointed a working group to address this issue. The report, *"Bridging the Gap - The social sciences, humanities, science and technology in economic development",* was tabled in parliament by the Federal Minister for Science and Small Business, and Minister assisting the Prime Minister for Science, the Hon Chris Schacht MP, on 20 May 1993.

Nanotechnology in Australia's future

As part of its technology assessment role ASTEC has undertaken a study of nanotechnology. A useful description of nanotechnology is science and engineering at the atomic scale. The study has had two major outputs; a presentation to the Prime Minister's Science and Engineering Council and an occasional paper *Small Things - Big Returns: The Role of Nanotechnology in Australia's Future.*

Australia-Indonesia collaboration

In a collaborative arrangement with the then Department of Industry, Technology and Commerce (DITAC), ASTEC undertook a study on S&T links between Australia and Indonesia. A senior Indonesian official, Mr Adi Saptari, was seconded to ASTEC for a period of three months to participate in this study. The occasional paper *Indonesia and Australia, Science and Technology Linkages - Case Studies of Remote Sensing, Telecommunications and Biotechnology was* published in December 1992.

Research and technology in tropical Australia

In April 1992, the Prime Minister commissioned ASTEC to undertake a study of research and technology in tropical Australia and their application to the social and economic development of the region. The study has been characterised by extensive consultation with the people of tropical Australia and those outside the region who conduct and/or fund research and technology development. ASTEC received over 140 submissions to the study. In July 1992, ASTEC commissioned a survey of tropical research and technology and the findings have been published in an Occasional Paper *Research and Technology in tropical Australia: Survey.*

In November 1992, ASTEC organised two Symposia on tropical research and technology (Townsville and Darwin). The papers provided to the two symposia have been published in an occasional paper *Research and Technology in tropical Australia: Symposia.*

In May 1993, ASTEC released *Research and Technology in tropical Australia: Draft Report.* Public workshops were held in Townsville, Darwin and Perth) in late May and early June to discuss the draft.

Gene technology

A draft occasional paper *Gene Technology: Issues for Australia* was distributed for public comment in April 1993. On 30 April 1993 ASTEC held a Gene Technology Round Table to a provide comment on the draft report. The Round Table discussed the draft report in considerable detail, as well as analysing, in sectoral working groups, those issues which participants felt should be highlighted by the study. Representatives of environmental and consumer groups stressed their concerns regarding applications of gene technology and brought home to participants the need for enhanced dialogue on matters of controversy.

Energy research and technology

After holding a forum in June 1992, involving key players in the energy industry and agencies involved in energy research and technology, ASTEC defined the terms of reference for the study and advertised for submissions. Over 80 submissions were received. During the year, two consultancies were let: a minor one assessed publicly available information on energy research and development expenditure; and a more significant one was jointly funded by the Energy R&D Corporation, to determine more detailed energy R&D expenditure data, particularly in the private sector. The Working Party undertook a comprehensive round of consultations in capital cities to broaden the scope of input.

TRANSPORT AND COMMUNICATIONS

Science and Technology in the Portfolio Budget

There are three organisations in this portfolio dealing with scientific services and supported from the budget outlays. They are the Australian Road Research Board (ARRB), the Federal Office of Road Safety (FORS) and the Communications Laboratory

A large number of Government Business Enterprises in this portfolio deal with scientific services and conduct research. Their activities do not appear in the Budget. These include Telstra Corporation (Telecom), Qantas, Australia Post, the Federal Airports Corporation, the Civil Aviation Authority and a number of other organisations.

MAJOR RESEARCH ACTIVITIES

Federal Office of Road Safety (FORS)

Role *To minimise deaths, injuries and crashes on the roads and their social and economic consequences, to promote safety in road travel, to administer and coordinate road-user and vehicle safety programs in a cost-effective manner.*

Collection and analysis of statistical data and a targeted research program are central to this role.

The objective of the Road Safety research program is to provide a sound basis for development of effective and cost-effective road safety initiatives, including vehicle standards, public education programs, and other road user initiatives.

Recent Achievements

Occupant protection research
Following extensive research over the period 1988-1992 a new Australian Design Rule (ADR) has been introduced which will see all new cars sold after 1995 with a range of new safety devices, which may include airbags. Developmental research for this ADR included in-depth analysis of crashed vehicles and injury data, a series of barrier crash tests, a cost benefit analysis and a study investigating the amount new car buyers would be prepared to pay for a range of new occupant protection measures. The latter study provided evidence of strong buyer support for these measures.

Bus safety
As part of a bus safety package ADRs specifying improved seat and seat anchorage strength and bus rollover protection requirements were introduced. These design rules were developed following extensive research including crash testing, and a survey of passenger attitudes.

With the impending introduction of lap/sash seat belts in non-route service omnibuses in 1994, sled testing of bus seats incorporating lap/sash seat belts has commenced. This research is aimed at simplifying the test requirements for buses complying with the new design rule.

Fatigue studies
A report of the first stage of a study of fatigue in the road transport industry was released in June 1992, describing current practices and attitudes to change in the industry. A survey of long distance truck drivers and industry representatives found that fatigue was considered a serious problem and showed considerable agreement on a range of fatigue management strategies.

To ensure that drivers were kept informed of this research a brochure was compiled detailing the main findings in simple terms. Over 20,000 of these brochures were distributed to drivers through trucking companies, industry groups, unions and truckstops.

A separate survey of long distance bus and coach drivers has been completed and is expected to be released in July 1993.

Alcohol and other drugs
The program of research into drugs and driving which commenced in 1991 has progressed, with Australia-wide surveys of the general driving population, heavy vehicle and bus drivers completed. Analysis of the results of the surveys and validation of self-reported drug use by examination of saliva samples is currently being performed.

Young drivers
A three year program of research into unresolved issues in young driver safety is continuing with detailed analysis of crash information, and undertaking surveys to determine when, where, why and with whom young drivers are on the road. The program will continue with experimental work

on day/night differences in young drivers' crash risk and the development of measures to improve their safety.

Involvement with Local Government
FORS has undertaken a number of research projects aimed at fostering the involvement of local government in road safety initiatives. A comprehensive colour manual of implemented Local Area Traffic Management (LATM) and Black Spot treatments has been prepared for use by local government authorities as a guide to dealing with specific traffic safety problems.

In addition, a summary and evaluation of an earlier FORS project on improving older pedestrian safety in local contexts has been completed and made available to Councils.

Statistical analyses
Research into long term trends in road fatality rates in Australia provides a detailed statistical breakdown of road fatality trends by a range of factors and compares Australia's performance with that of other OECD countries.

An analysis of causal variables involved in fatal road crashes provides insights into the effects of a range of factors such as speed, alcohol, fatigue, driver age, and combinations of these factors which contribute to fatal road crashes.

A project involving time series modeling of factors affecting fatal road crash trends estimates the contribution of factors such as economic activity and weather conditions on the road toll and develops a technique for making predictions on future trends.

A study of the long term effects of road crashes describes the long term consequences of road crash injuries and identifies high risk groups and crash types.

The Fatality File is an extensive database containing information about every fatal crash occurring in Australia in a particular calendar year.

Australian Road Research Board (ARRB)

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.*

Recent Achievements

ARRB has developed a software package known as the Signalised and Unsignalised Intersection Design and Research Aid (SIDRA) software package, which is used to analyse intersection capacity and optimise signal timing. The package is applicable to a wide range of environments and intersection types including roundabouts and intersections controlled by give-way and stop signs. The software package is used by more than 270 organisations in over 40 countries.

ARRB is also developing a roll-over warning device to provide drivers of articulated vehicles with information on the roll-stability of their trailer. The first phase of the study, investigating the roll behaviour of trucks around curves has been completed and a prototype warning device is being developed. Such a device would assist road safety in the transport industry.

Support for Other Research Activities.

In addition to significantly contributing financially to the work of the Australian Road Research Board, a limited amount of Federal funding is also made available to research projects, whose aims are consistent with those of the Australian Land Transport Development Act, in promoting efficient and effective Federal investment in land transport.

Nearly $1.1 miliion was paid to organisations in 1992-93 undertaking such research. Projects included the development of a flat wheel detector to assist railway operators in avoiding derailments, research into means of lessening the effects of heavy motor vehicles suspension and tyres on the road surface and the development of pilot studies relating to the introduction of uniform self regulatory standards for the road transport industry.

Department of Transport and Communications - Communications Laboratory

Role *The Communications Laboratory of the Department of Transport and Communications was commissioned in August 1988. It has the task of providing to management and policy development units information in the form of:*

- *explanations of current development in broadcasting and communications technologies;*
- *guidance and briefings on the possible interactions between technology and policy or regulatory practices.*

The Laboratory is staffed by a team of about 20 people, primarily engineers and technical officers with training and expertise in broadcasting and radiocommunications technology. It costs about $2.3 million per annum to operate the Laboratory including, salaries, running costs and infrastructure costs. The Laboratory's work is mainly in the areas of literature and desk study supplemented by bench and field test, and participation in standards development work.

Recent Achievements

The achievements of the Laboratory are presented in the form of briefings, seminars and demonstrations on new technologies and reports dealing with aspects of communications technology developments. Particular fields of study at present include, video and broadcast television systems development and digital audio broadcasting systems. During 1992-93 the Laboratory produced 24 internal reports dealing with the various aspects of its work.

Off-budget Portfolio Related Initiatives

Telecommunications Industry Development Plans - research and development

The telecommunications carriers Telstra Corporation Limited (now trading domestically as Telecom Australia and Telstra Corporation-OTC internationally), Optus Communications and the recently selected third public mobile carrier, Vodafone Pty Ltd are required through their licence conditions to submit an industry development plan to Government and to report annually on progress against their commitments. The carriers' industry plans have a major research and development component.

Telstra is committed to invest greater than 1.5% of its sales revenue in research and development and to fund a certain number of new Australian products and services through its Product Development Fund. Telstra also has a range of R&D contracts in place with academic institutions, the CSIRO and industry to investigate areas of interest to Telecom's business.

Under its industry plan, Optus Communications' has agreed to invest in R&D, at least $100 million in the 5 years to 1997 and at least $400 million in the ten years to 2002.

Vodafone is due to lodge its industry plan with Government shortly. Its plan is understood to include specific commitments to R&D.

Industry Development Arrangements (IDAs) and Customer Premises Equipment (CPE)

The Industry Development Arrangements (IDAs) were introduced in 1989 as a transitional mechanism for the Customer Premises Equipment (CPE) sector (PABX, small business systems, standard telephones and cellular mobile telephones) to adjust to the progressive deregulation of the telecommunications industry.

Under the IDAs, suppliers have to be committed to certain levels of R&D (as well as local content and exports) in order to earn the points required for their equipment to be connected to the network. Points for R&D are calculated on a pro rata basis of 20 points for each 1% of a firm's CPE turnover devoted to R&D to a maximum of 100 points.

The scheme has been extended until mid-1996 with certain changes, but all companies supplying CPE are still required to devote at least 5% of their turnover in R&D.

This Statement was prepared by the Innovation Policy and Strategic Analysis Section, Department of Industry, Technology and Regional Development, 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 1252.

Each year, the Government compiles this record of publicly funded scientific achievements. Information on a variety of current research and development projects is presented, ranging from viral diseases in cultured prawns to 'Mister Plod', the walking robot. The achievements included in this edition highlight the flair, ingenuity and imagination of Australian scientists.

This publication provides many useful insights into our national research accomplishments and the Government funding arrangements which underpin them. It will be of interest to all members of the community, including students, academics, business leaders, government officials, scientists and engineers.

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