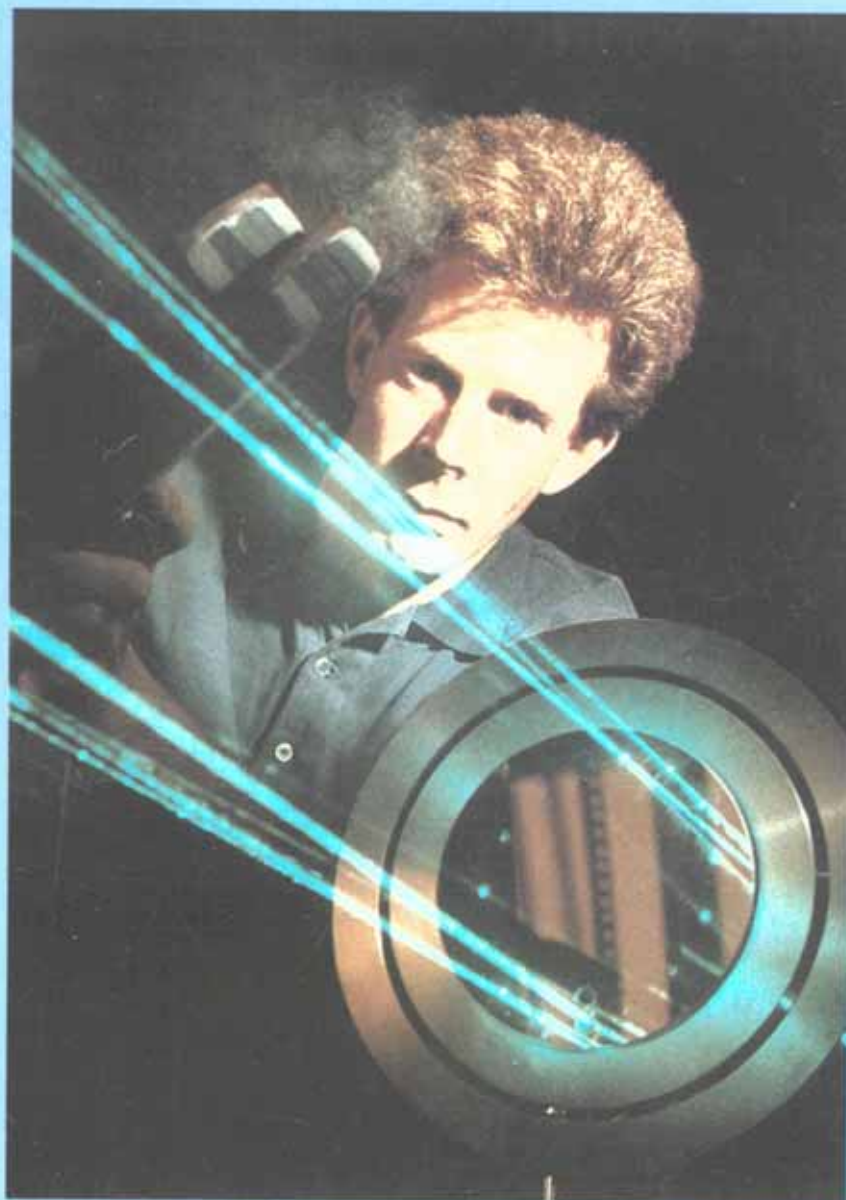




Science and Technology Budget Statement 1994-95



**Senator the Honourable Peter Cook
Minister for Industry, Science and Technology
Minister Assisting the Prime Minister for Science**

SCIENCE AND TECHNOLOGY BUDGET STATEMENT 1994-95

CIRCULATED BY
SENATOR THE HONOURABLE PETER COOK
MINISTER FOR INDUSTRY, SCIENCE AND TECHNOLOGY
AND MINISTER ASSISTING
THE PRIME MINISTER FOR SCIENCE

AUSTRALIAN GOVERNMENT PUBLISHING SERVICE
CANBERRA 1994

© Commonwealth of Australia 1994
ISBN 0 644 33468 1

This work is copyright. Apart from any use permitted under the *Copyright Act 1968*, no part may be reproduced by any process without prior written permission from the Australian Government Publishing Service. Requests and inquiries concerning reproduction and rights should be addressed to the Manager, Commonwealth Information Services, Australian Government Publishing Service, GPO Box 84, Canberra ACT 2601.

Cover photograph:

'Lasers shed light on Space Mystery' by
Nic Ellis of *The West Australian*. Winner of the
1993 Michael Daley Award for best photograph.

CONTENTS

HIGHLIGHTS.....	7
SUMMARY NOTES	8
SUMMARY TABLE	9
Science, Technology and Competitiveness	1
Introduction	3
Government strategies.....	3
Achievements.....	6
Leadership and co-ordination	8
Science and technology in an international environment.....	9
The future	10
Recent Major Developments.....	11
Science, technology and innovation in the context of the new framework for industry policy	13
Prime Minister's Science and Engineering Council (PMSEC)	14
Australian Science and Technology Council (ASTEC)	14
Coordination Committee on Science and Technology (CCST).....	14
Women in Science, Engineering and Technology (WISSET)	15
Australian participation in international high energy physics research.....	15
The Australian National Beamline Facility.....	15
Marine initiative in the Northwest	16
New steps to commercialise R&D in marine science	16
Broadband Services Expert Group.....	17
Telecommunications industry development plans - R&D	17
Research reactor review	17
Richards Review of the Australian Geological Survey Organisation (AGSO)	18
Monitoring progress in science, technology and innovation.....	18
Other initiatives in support of science and technology	18
Significant statements, reviews and reports	24

Science and Innovation in the Budget.....	27
Australia's national R&D expenditure	29
Commonwealth support for R&D in a national perspective	30
Commonwealth support for science and innovation through major programs	30
Changes in the balance of funding	35
Detailed data.....	36
Budget-based science and innovation data and ABS R&D	36
International Context	47
Broad international comparison of R&D levels	49
R&D expenditure in government agencies and universities	50
Business expenditure on R&D	53
Budget allocations and Portfolio achievements.....	55
COMMUNICATIONS AND THE ARTS	57
DEFENCE.....	60
EMPLOYMENT, EDUCATION AND TRAINING	63
ENVIRONMENT, SPORT, AND TERRITORIES.....	87
FINANCE	98
HUMAN SERVICES AND HEALTH.....	102
INDUSTRY, SCIENCE AND TECHNOLOGY.....	109
PRIMARY INDUSTRIES AND ENERGY.....	137
PRIME MINISTER AND CABINET	157
TRANSPORT	164

HIGHLIGHTS

Commonwealth support for major programs of science and innovation in 1994-95 is estimated to be \$3.25 billion, a rise of 2.1 per cent in real terms.

The base funding of the major research agencies, CSIRO, ANSTO, and AIMS, has been permanently increased by \$34 million a year.

The science base in higher education institutions has been expanded again, with a 3 per cent increase in funding, the fifth successive real annual increase. Funding for research in universities will be \$1380 million in 1994-95. Increased funding is provided for the Australian Research Council and related grant schemes, for specific-purpose R&D support and for general research support in the institutions.

Research infrastructure also will receive a \$60 million boost from a Major National Research Facilities Program to be funded over eight years (\$7.5 million in 1994-95).

A new \$3 million Nanotechnology Facility will be established, focused on engineering with atoms and developing working devices of one-billionth of a metre in size - for applications in health care, food, environmental and other industries.

Funding for the Industry Innovation Program is estimated to rise by 29 per cent in real terms, to \$52.3 million in 1994-95, while it is estimated that business R&D activity will increase by \$395 million due to the 150% tax concession scheme. Since the early 1980s, the Australian business sector has maintained an internationally top-ranking growth rate in innovation.

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

- Work of CSIRO's Sensory Research Centre (SRC) in Japan has enabled over 400 Australian food companies to produce foods more acceptable to consumers in the lucrative but demanding Japanese market. Japan now receives \$560 million of Australia's processed food exports. Experience gained by the SRC is being applied elsewhere in Asia.
- Survey work in three major mineral provinces, carried out by AGSO as part of the National Geoscience Mapping Accord, provided geological information which attracted record levels of interest from exploration companies, in terms of both numbers of customers and dollar value of the data sold.
- Scientists at Monash University's Victorian College of Pharmacy and the CSIRO have synthesised a potent new drug that may cure and prevent all new and existing forms of influenza. The approach developed in this research is likely to be used to combat other viral diseases such as AIDS and hepatitis.
- A device developed by the Australian Road Research Board automatically measures and records road condition data by taking laser profiles of the road surface at highway speed. It represents a new generation of road condition monitoring technology to reduce the cost of collecting reliable data for improved road management.
- Researchers at the Garvan Institute have identified the gene primarily responsible for determining bone density. This discovery permits assessment of an individual's susceptibility to osteoporosis and bone fracture, and points to new approaches to prevention and treatment.

SUMMARY NOTES

SUPPORT FOR SCIENCE AND INNOVATION IN 1994-95

- In 1994-95, Commonwealth support for major science and innovation programs is expected to rise by 2.1% in real terms to reach \$3253m (\$3118m in 1993-94).
- The Australian Research Council will receive \$308m to support university research, a real increase of 4% (\$290m in 1993-94). Total funds for university R&D are estimated to rise by about 3%.
- 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 \$539m in 1994-95, a real increase of 5% and continuing the substantial support to this area over the past decade. The major component of this increase is an estimated increase in the effect on business R&D of revenue forgone through the industrial R&D tax incentive, which increases to \$395m from \$377m.
- The Cooperative Research Centre Program is addressing the need for interaction between researchers in industry, government agencies and universities. Funding for CRCs rises this year by 21% in real terms, to \$113m. There are now 51 CRCs and this will increase to 61 during 1994-95.
- Funds for specific purpose R&D grant schemes (rural R&D, National Health and Medical Research Council grants, other health R&D and some smaller R&D grant schemes) together rise to \$300m (up 5% in real terms).
- A total of \$921m will be provided to the major research agencies in 1994-95 (\$936m in 1993-94), including \$219m on defence R&D (\$234m in 1993-94). Budget support for CSIRO will be \$467m, which includes an increase in base funding of \$28m, and the Organisation's external earnings will bring its total budget to \$680m. In terms relative to GDP, appropriations for research in Government agencies in Australia are among the highest in the OECD.
- In common with trends in many countries with high levels of Government R&D, policy in recent years has sought to encourage greater reliance on external earnings, particularly those resulting from productive interactions with industry.
- Budget support is provided in the expectation of useful outcomes and applications, including the development of the national skills base. The *Science and Technology Budget Statement* provides many impressive examples of the discoveries, advances in understanding and steps in commercialisation resulting from Government support for science and technology.

SUMMARY TABLE

COMMONWEALTH SUPPORT FOR MAJOR PROGRAMS OF SCIENCE & INNOVATION

	1993-94	1994-95	Real change
	\$m est	\$m est	
AUSTRALIAN RESEARCH COUNCIL ¹	290.1	307.7	+ 4%
OTHER HIGHER EDUC. R&D	1020.7	1072.0	+ 3%
CO-OPERATIVE RESEARCH CENTRES	91.7	113.1	+ 21%
INDUSTRY R&D & INCENTIVES ²	500.1	538.9	+ 5%
RURAL R&D	116.9	126.3	+ 6%
NH&MRC	118.5	125.5	+ 4%
OTHER HEALTH R&D	23.5	27.0	+ 13%
OTHER R&D GRANTS ³	21.0	21.3	- 1%
CSIRO ⁴	468.8	466.8	-3%
DSTO	230.3	219.1	-7%
OTHER R&D AGENCIES	236.5	235.4	-3%
TOTAL	3118	3253	+ 2.1%

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

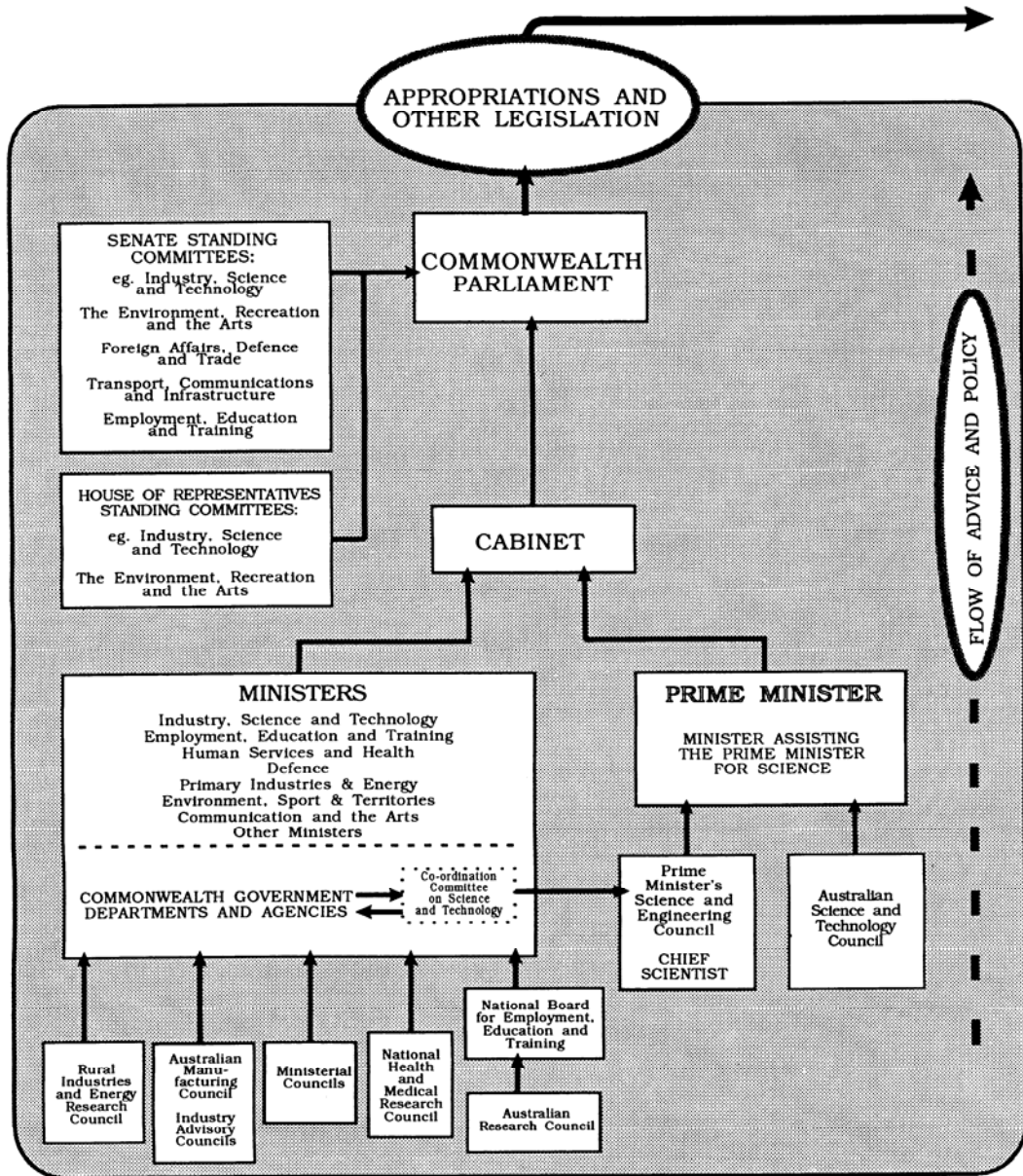
3 Australian Biological Resources Study, Greenhouse research grants, Energy R&D and Australian Road Research Board

4 Includes funding through DPIE for Australian Animal Health Laboratories and through DIST for the Kraft Pulp Mill study. Also includes funds received by CSIRO for one-off infrastructure projects and special loan repayments totalling \$30.0 million in 1993-94 and \$2.3 million in 1994-95.

For more detailed information see Tables 2 to 6

Figure 1

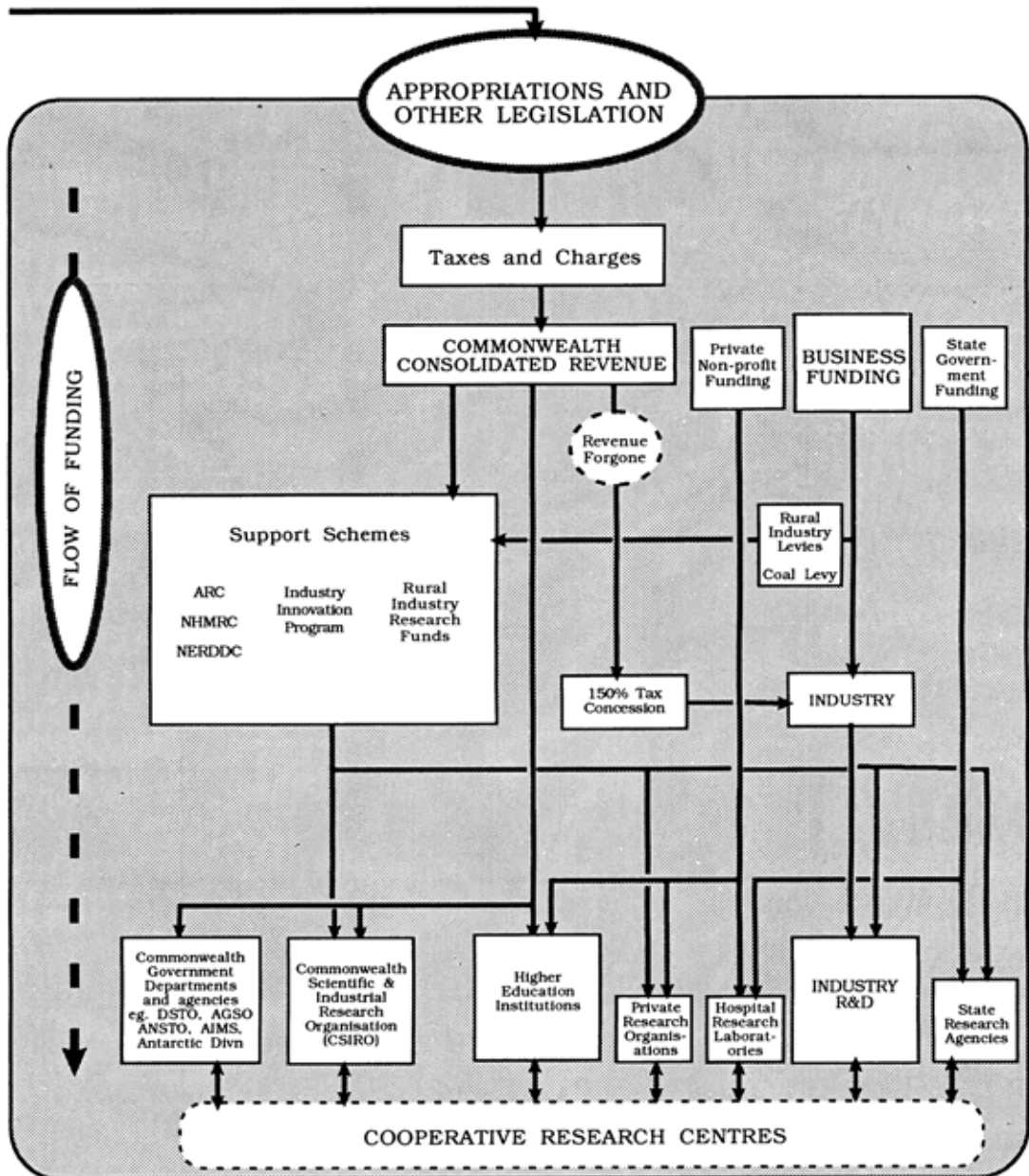
MAIN CHANNELS OF ADVICE FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY



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

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

Figure 2
FLOW OF FUNDING SUPPORT FOR R&D



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

SECTION

1

Science, Technology and Competitiveness

Introduction

Governments in all advanced economies have adopted increasingly sophisticated science and technology policies to encourage the development, absorption and application of new knowledge in order to enhance economic prosperity. The most successful countries are those that have evolved an innovative culture where knowledge and skills have been able to develop and be applied most effectively.

Innovation is a prime influence in the economic development of nations. For companies, sustained innovation in products and production methods is crucial to international competitiveness. At the level of national economies, innovation is a key factor contributing to economic growth and social welfare.

The Government's science and technology policy has pursued three major objectives:

- *to maintain a high quality science base within our universities and government research agencies*
- *to maximise the practical applications of the science base to industry and the wider community*
- *to encourage greater innovation by business, particularly through strengthening their research and development (R&D) activity*

To achieve these objectives, the Government has used a number of complementary strategies.

Government strategies

The science base

The Government's expenditure on public sector R&D is, as a proportion of GDP, in the upper bracket of OECD countries.

This year, 1994-95, the Government will provide \$1380 million for higher education research.

The Government established a higher education research infrastructure program in 1990. Funding has grown, in December 1993 prices, from \$29.5 million in 1990 to \$59.2 million in 1994. The Government decided in 1993 to continue the program from 1995 at an enhanced level. Funds have been directed both as block grants to be utilised by universities at their discretion, and targeted to specific major infrastructure developments on a cooperative basis between universities.

Cooperative research infrastructure development grants have been strategically directed to meet technology infrastructure needs in areas including emerging key technologies. Examples of grants under this sub-program over the 1990-94 period include totals of \$11 million for high performance computing, \$4 million for the Australian Academic and

Research Network, \$5 million for library and related information services, \$5 million for an animal holding laboratory, and assistance for Australian involvement in the International Ocean Drilling Program, the European Centre for Nuclear Research, and the Australian National Beamline Facility at the Photon Factory in Tsukuba, Japan.

In 1994-95, the Government will provide \$921 million in support of Government research agencies. The Government has increased base level funding for the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Australian Nuclear Science and Technology Organisation (ANSTO) and the Australian Institute of Marine Science (AIMS) by \$34 million a year for the next three years, taking their total funding to \$1562 million over the triennium. In addition, the Government will withdraw the efficiency dividend from the non-administrative element (70 per cent) of these agencies' funding.

The Budget provides an increased commitment of about \$93 million for health and medical research over the next four years, 1994-95 to 1997-98. The increase represents a substantial response to the Government's election commitment to work with researchers and the business sector to significantly lift medical research funding by the year 2000.

This year, the Government has introduced the Major National Research Facilities Program which will have a fund of \$60 million to be spent on establishing several major national research facilities over the next eight years. The newly named Department of Industry, Science and Technology will have primary responsibility for the administration of this program. The Government is also to provide in 1994-95 \$3 million to support a National Nanotechnology Facility to be used by Australian researchers and industry. This will form the hub of a National Nanotechnology Network.

Applying the science base to industry

The Cooperative Research Centres (CRC) Program, launched in 1990, will provide annual funding rising to \$137 million for more than 60 Centres linking research groups from industry, government laboratories and universities. Participating organisations have made commitments to contribute in excess of two dollars for every dollar of funding from the Program. The first 51 Centres are established. A fourth selection round to select a further 10 Centres will be held in the second half of 1994.

The CRC Program has set the scene to encourage further collaboration between research bodies and industry to achieve agreed goals without additional Government intervention or support, positively changing the relationships between Australia's research organisations.

Since 1988, external earnings targets have been set for government research agencies. These promote links with industry and other research end-users and encourage the development within the agencies of new, commercially

oriented skills. The entitlement to retain external earnings, introduced concurrently, has provided a valuable source of additional funding for the agencies.

To improve the commercialisation of Australian research, the Australian Technology Group Pty Ltd (ATG) was initiated in 1992 with a capital injection of \$30 million from the Government. The ATG is a technology commercialisation corporation that will contribute to the translation of Australian research and technology into products and services for the Australian and international market on a totally commercial basis.

The Commercialisation of Technological Innovation Scheme, to be introduced this year, will provide \$48.2 million over four years for concessional loans to small firms for early stage product commercialisation.

Uptake of new technologies by Australian industry lags behind that of our competitors. The Government has decided to allocate \$63.5 million over four years for a program to improve the existing infrastructure for technology diffusion and ensure that it meets industry requirements. The program will improve industry's access to institutional sources of technology and technical advice, and will increase awareness and uptake of key technologies by firms.

More direct market influence has been introduced into rural, energy and minerals R&D by placing management of the research funds in the hands of R&D corporations with strong industry representation and commercial management skills on their Boards.

As part of the Government's overall industry policy, it will increasingly promote the application of science and technology to the development of export opportunities.

Business R&D

A weak link in our R&D performance for many years has been the low level, by international standards, of R&D funded by, and performed in, Australian industry. This is a situation reflected in almost every area of manufacturing. There is a clear relationship between firms' R&D activity, and their innovativeness. Not only does R&D lead directly to product and process innovation, but it enhances firms' abilities to absorb the results of R&D conducted elsewhere. This issue, therefore, goes to the heart of Australia's ability to develop and maintain an internationally competitive industrial base.

Public sector agricultural research has been the foundation of Australia's high productivity levels in agriculture and considerable export successes in agricultural commodities. The challenge for Australia is for business to repeat this success in manufacturing and service industries.

To encourage an increase in business R&D, the Government introduced in 1985-86 a 150 per cent tax concession for R&D, together with a complementary scheme of grants for research and development to cover

firms not yet profitable enough to benefit from the tax concession. This year, to extend the benefits of the scheme to small firms, its threshold will be reduced from \$50,000 to \$20,000.

In industry sectors where Government has strong influence by virtue of being a major customer or regulator, such as information and communications technology and pharmaceuticals, measures have been undertaken to encourage transnational corporations to perform significant R&D in Australia.

In 1993, the Partnerships for Development Program in information technology and telecommunications delivered R&D in excess of \$300 million (up from \$60 million in 1988). Under the Factor (f) scheme in pharmaceuticals, which has received more than \$1 billion in budgetary support, companies can gain increased prices for some of their products listed on the Pharmaceutical Benefits Scheme in return for undertaking research and engaging in product and process development and manufacture. In the seven years to 30 June 1999, the twelve participating companies will have collectively spent over \$628 million on R&D.

Part of a healthy science and technology system is the existence in the community of a lively and informed debate on the role of science and technology in the nation's economic and social well being. The Government has encouraged this debate through the Science and Technology Awareness Program, which began in 1989. The Program also funds the Australia Prize. This is one of the major international awards for excellence in science and fosters Australia's image internationally as a scientifically advanced nation with a well developed appreciation of the role of science in human welfare.

Achievements

A number of indicators suggest that these strategies to achieve the Government's three major goals in science and technology policy are bringing success.

One indicator of the quality of the research within our universities and government research agencies is the number of scientific papers published per head of population. Australia ranks eighth in the world on this criterion. Our performance is strongest in the areas of our traditional export strengths - geosciences, plant and animal science, and agricultural science. Australia is seeking to maintain its internationally recognised strengths through developing a National Agricultural Research Strategy under the auspices of the Agricultural and Resource Management Council of Australia and New Zealand.

Higher education award completions (from diplomas to higher research degrees) in science and engineering have increased significantly, with science completions increasing more than 50 per cent since 1987.

A number of independent benefit/cost studies of individual projects carried out in recent years have confirmed the national benefits of public investment in R&D by CSIRO. In all cases, the estimated returns have been at least equal to funds spent. An innovation of the CSIRO and the wool industry, Sirospun, is expected to deliver benefits to Australian woolgrowers, in present value terms (discounted to 1990) of \$908 million, representing a benefit/cost ratio of 123. That is, the benefit is assessed as \$123 for every dollar of R&D invested. CSIRO has also developed a unique instrument for the rapid and accurate measurement of wool fibre diameter, now an international standard, which has generated more than \$2 million in revenue since 1992.

Linkages between public research establishments and research end-users have increased substantially. A Report of the National Board of Employment, Education and Training in November 1993 indicated that 10 to 15 per cent of total higher education research now involves industry linkages, as opposed to one or two per cent in the early 1980s.

The operation of the external earnings targets for CSIRO, ANSTO and AIMS was reviewed by the Australian Science and Technology Council (ASTEC) in February 1994. ASTEC found that there was clear evidence that the targets had been a strong focus for beneficial change within the agencies. Most importantly, ASTEC found that the target has increased the level of contact and effective communication between industry and Government research funded agencies. CSIRO's direct income from the Australian private sector grew from \$20 million in 1988-89 to \$75 million (10.8 per cent of all funds) in 1992-93. Two of the agencies have already exceeded their external earnings targets and the other is well on the way to achieving it within the allotted time.

Over the past decade, Australia had one of the highest growth rates in business R&D performance among OECD nations. We are currently second in the OECD and fifth on a world comparison and are steadily moving closer to the average OECD profile on government/business performance. An evaluation by the Bureau of Industry Economics, published in August 1993, concluded that the tax concession has played an important role in increasing business expenditure on research and development.

Patent data also provide confirmation of increasing innovation in our industry, with the rate of growth in patent applications made by Australians in foreign countries exceeding the corresponding rates of growth for all other OECD countries.

Further confirmation of increasing innovation in Australian firms has come in two recent reports. *Emerging Exporters* (June 1993), by McKinsey and Company and the Australian Manufacturing Council Secretariat, identified a base of 700 highly innovative small to medium firms which are producing more than half Australia's manufactured exports. Their exports have doubled in real terms since 1986-87. More recently, *Managing the Innovating Enterprise* (December 1993), by the Business Council of Australia, similarly

found that the opening of the Australian economy in the 1980s has been the stimulus for a burst of innovation in Australian industry in the past five years.

Leadership and co-ordination

The Government's recognition of science and technology as integral to Australia's economic performance is reflected in the emphasis it receives in major statements of economic policy, and in executive arrangements. This year, this emphasis has been further enhanced by the allocation of Government responsibility for science and technology to a Minister in the Cabinet.

In the past few years, there have been three 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.
- The 1992 White Paper on science and technology stressed the importance of innovation, community awareness, skills development, and maintaining public sector R&D infrastructure, to achieve the goals of economic prosperity, social equity, ecologically sustainable industries and a high quality, fulfilling lifestyle.
- The May 1994 White Paper *Working Nation* recognised the vital role of innovation in achieving economic prosperity, through a number of major new strategies and funding initiatives described in this Section, and in Section 2.

Consultative, advisory and coordination arrangements have steadily evolved over the last decade.

Twice a year the Prime Minister chairs a discussion forum, the Prime Minister's Science and Engineering Council (PMSEC), which brings together at the highest level representatives of all those who have a role to play in setting the nation's priorities in science and technology.

ASTEC provides independent advice to Government on major science and technology issues. It is currently developing a 'technology foresight' study to examine the ways in which future economic and social needs can be met more effectively by contributions from Australia's science, technology and engineering system. The study, which is being developed in close consultation with the Coordination Committee on Science and Technology and with the involvement of PMSEC, is related to a range of similar work by other OECD countries, but is focused on Australia's distinctive needs.

More than half the Government portfolios have programs in science and technology. The Coordination Committee on Science and Technology (CCST), chaired by the Chief Scientist and comprising senior officials of all the relevant Departments and agencies, meets four times each year, to ensure

consistency in goals, strategies and management practices in, for example, policy on the costing and pricing of research, and on the treatment of intellectual property.

The above arrangements provide effective mechanisms for monitoring existing policies and programs and assessing the need for new ones.

Government policy deliberations are informed by many other inputs. These include the reports of Parliamentary Committees, most recently that of the Senate Committee on Higher Education and Training on higher education research, of the National Board for Employment, Education and Training, and published evaluations of government programs, such as the Report by the Bureau of Industry Economics on the R&D Tax Concession. The Industry Commission is currently undertaking an inquiry into R&D in Australia, which is expected to be completed in 1995.

Science and technology in an international environment

The Government has recognised and responded to the increased internationalisation of science and technology and the growth in their social and economic significance. Science and technology are seen not only for their importance to Australia domestically, but as part of our international role.

Our participation in the OECD allows us to compare our science and technology policies with the best practice of the United States of America, Canada, Japan and Europe and also to maintain and build on good relationships. The Government recognises additionally that closer ties with Asia-Pacific economies will provide important spin-offs for industry, and links with these economies have been developing over the last decade.

The April 1994 Symposium on *Measuring Research and Innovation for Policy Purposes* in Canberra, brought together science and technology indicator experts from all over the world. Most significantly for Australia, representatives from seventeen other Asia-Pacific economies participated in the Symposium, which was an outstanding success.

Australia has also used the Asia-Pacific Economic Cooperation (APEC) forum to strengthen its networking in the region and to promote our capabilities in science and technology. We have been actively involved in its technology-related activities, for example the potential use of clean coal technology, a training program on photovoltaics and compressed natural gas in vehicles. Important recent initiatives include the expansion of the Australian Industry, Science and Technology Counsellor Network (ASTCON) to Indonesia, South Korea and Malaysia.

Following Australian commitment of support for improved global environmental monitoring and research at the Rio Earth Summit in 1992, agencies such as the Bureau of Meteorology and CSIRO have been especially active in the provision of scientific input to a range of international programs under the auspices of United Nations agencies such as the World

Meteorological Organisation and the Intergovernmental Oceanographic Commission of UNESCO. Australia is participating actively in the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP). We are also cooperating in the earth observing satellite programs of other countries and in the design of the proposed Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS) and Global Terrestrial Observing System (GTOS).

The future

A strong science and technology base, together with the application of its outcomes for economic, social and environmental goals are essential elements for our future national welfare and development.

To this end, the Government will continue to seek strong interaction between universities, research organisations, industry, and other agencies as part of its support for innovation, and for creative applications in other sectors.

There has been much progress in achieving the Government's objectives in science and technology, but challenges remain. Among these are the need to increase business expenditure on research and development, to strengthen the access of small and medium sized enterprises to technology and R&D, to improve the diffusion of technology into industry, and to forge stronger links with other nations in science and technology.

The remainder of this Statement provides ample evidence of the Government's record of achievement over the past decade, and the substantial base on which to build the future.

SECTION 2

Recent Major Developments

Science, technology and innovation in the context of the new framework for industry policy

In releasing the Government's White Paper, *Working Nation*, on 4 May 1994, the Prime Minister announced a broad-ranging package of industry, science and trade measures aimed at internationalising Australian industry through building export-oriented competitive firms, and a competitive environment in which they can flourish. The package targeted the elements critical for success in the global marketplace: innovation, technology uptake, business improvement, access to finance and skills development. The White Paper's extensive employment and training measures are underpinned by a new industry policy framework and a broad suite of initiatives which recognise:

- the critical importance of innovation to business success, and
- the necessity for a strong science and technology base, and better ways of diffusing and commercialising new technology, as a pre-requisite for successful innovation.

Initiatives on science, technology and innovation include:

- enhancement of the 150% tax concession for industrial research and development (R&D) to allow greater access by small firms.
- changes to innovation support programs (involving new expenditure of \$118 million over four years) by
 - combining five competitive R&D grants programs into one and creating a new concessional loans scheme for commercialising technology in small firms
 - establishing a national technology access and diffusion network
 - increasing awareness of and access to technologies essential for competitiveness among small and medium sized firms, joining the international Intelligent Manufacturing Systems program (see industry, science and technology section of 'Other initiatives' below) and reviewing best practice in the adoption and management of technology.
- development of an Information Technology Standards Program and implementation of new electro-magnetic compatibility standards (new expenditure of \$10 million over four years).
- continued support for the national science agencies - CSIRO, ANSTO, and AIMS - by increasing the level of their base funding (new expenditure of \$147 million over four years). In addition, the application of the efficiency dividend will in future be removed from the non-administrative component of the agencies' funding (70 per cent of the total).
- establishment of a Major National Research Facilities Program with funding of \$60 million over eight years; and a national facility for nanotechnology (\$3 million).
- establishment of a Marine Industries and Sciences Council.
- promotion of greater awareness of entrepreneurship and science and technology among young Australians.

Prime Minister's Science and Engineering Council (PMSEC)

The Prime Minister's Science and Engineering Council, which includes Ministers whose portfolios have a major science, engineering and technology interest, met in November 1993 and plans to meet again in June 1994. Reports presented to the November 1993 meeting included:

- *Research and Technology in Tropical Australia: Selected Issues*, which dealt with research for the sustainable use of tropical savanna and woodland landscape, and delivery of health services to Aboriginal and Torres Strait Islander peoples, and
- *Gene Technology*, examining the prospects for the technology, barriers to its wider development and use, and actions necessary to ensure that Australia can responsibly benefit from the technology.

PMSEC is scheduled to discuss science and technology aspects of food exports into Asia and the telecommunications industry when it meets in June 1994.

Australian Science and Technology Council (ASTEC)

ASTEC's work during the year included studies on energy research and technology, nanotechnology, the external earnings policy applying to Commonwealth research agencies, Australia's requirements for research data networks, research and technology in tropical Australia, and an assessment of gene technology. Reports on the latter two topics formed the basis for discussion at PMSEC, as indicated above. More detail on these studies is provided in Section 5.

In September 1993, Professor Michael Birt, who had been Chairman of the Council since April 1992, resigned from the position.

Dr Don Williams was appointed as the new Chairman of ASTEC, for a three year term beginning in December 1993. Dr Williams has a distinguished record of achievement in both technology development and business management. Four new members were also appointed to the Council, raising the total membership to thirteen.

Coordination Committee on Science and Technology (CCST)

The Coordination Committee met four times during 1993-94. During the year, the Committee's work included examination of issues arising from the Report of the Research Reactor Review, and on arrangements for marine science policy and organisation. The Committee examined access of foreign researchers to Australia's biological resources, and produced a report to help clarify the issues associated with such access. The Committee also provided advice on a program to support construction of national research facilities,

The Committee has a role in support of the Prime Minister's Science and Engineering Council. The Committee discussed agenda items for forthcoming PMSEC meetings and undertook follow-up action arising from the Council's discussions. During 1993-94, the Committee, at the request of PMSEC, prepared a response to the recent ASTEC report on research and technology in tropical Australia. The Committee has been similarly requested to prepare a report on progress in gene technology issues.

Women in Science, Engineering and Technology (WISSET)

WISSET was established in December 1993 as an expert group to advise the Government on ways to encourage greater participation and retention of women in science and engineering careers. WISSET's first meeting was held in December 1993 and it subsequently met again in March 1994. It is expected that WISSET will issue a report in October 1994 and make a presentation at the Prime Minister's Science and Engineering Council meeting in late 1994.

Australian participation in international high energy physics research

In November 1993 the Government announced funding for experimental high energy physics of over \$600 000 in 1994. This amount provides significant support for Australian participation in the European Centre for Nuclear Research (CERN) near Geneva, particularly the involvement of three experimental groups, which form the Australian High Energy Physics Consortium. These groups are from the Universities of Sydney and Melbourne and from ANSTO.

Australia's participation in international high energy physics brings valuable benefits, including excellent opportunities for training research scientists using the most advanced superconducting magnet and acceleration technologies yet employed. Access to international developments in this field will provide Australia's high technology industries such as materials science, optics, cryogenics and computer science with greater opportunities to develop new technology and to solve manufacturing problems.

The Australian National Beamline Facility

The Australian National Beamline Facility (ANBF) at the Photon Factory, Laboratory for High Energy Physics, Tsukuba, Japan, was formally inaugurated in October 1993. This marked the culmination of an eight-year collaboration between Australian and Japanese scientists to produce a versatile, high resolution X ray scattering facility. For the first time, Australian scientists working in a wide range of fields relevant to Australia's technological and industrial development will have routine access to a synchrotron radiation facility. This facility enables experimentation which would be impossible using conventional sources.

A consortium of Australian Government agencies (DEET/ARC, DIST, ANSTO, and CSIRO) and universities (Australian Defence Force Academy/University of New South Wales and the Australian National University) provided \$3.3 million over three years for the project. Research is proceeding in fields including metallurgy, ceramic technology, catalyst development, protein crystallography, drug design, and semi-conductor fabrication. Australian scientists now have the unique opportunity to further a wide range of studies using their own world-class facility wholly of Australian design and construction. Recent evaluation by international experts has proved that the ANBF is in the first rank of experimental facilities.

Marine initiative in the Northwest

The Australian Institute of Marine Science (AIMS) commenced research in the northwest of Western Australia in July 1993. Its research program is based upon extensive consultation with industry and government research users in Western Australia and will be focused upon key marine science issues related to the sustainable management of regional development. The region is the site for the nation's most intensive marine industrial activity (offshore oil and gas), while other activities include exporting of iron ore, salt production and pearl production. The region also contains a number of unique and sensitive ecosystems (Ningaloo Reef, arid zone mangroves and the Kimberley coast) and despite its remoteness is supporting a growing tourism industry. The AIMS research program consists of projects on: arid zone mangroves of the Pilbara coast; coral reef structures and the status of the main biological communities for Ningaloo and Dampier region reefs, Scott Reef and Rowley Shoals; climate records for the northwest, including adjacent areas; physical, biological, chemical and fisheries oceanography of the Northwest Shelf, reefs and islands; and bioactive compounds from marine organisms. The Institute's research vessel, the RV *Lady Basten*, was deployed to Western Australian waters for 4 months this year.

New steps to commercialise R&D in marine science

AIMS has significantly advanced the commercialisation of research in marine natural products chemistry by entering into two agreements with the Australian pharmaceutical company, AMRAD. In the first agreement, AIMS has become one of eleven member institutes of AMRAD, joining a network of Australian organisations committed to commercialisation of Australia's biomedical research. As part of the agreement, AMRAD has the first opportunity to consider projects arising from the Institute's research in human therapeutics and diagnostics. In return for this consideration AIMS gains the opportunity for further funding and benefits from AMRAD's substantial commercial experience. The second agreement funds a major research project (\$4.7 million over 5 years) concerned with the collection of marine plants, animal and micro-organisms to be screened for biological activity, as well as the extension of chemical and pharmacological research and identification and development of biologically active compounds.

Broadband Services Expert Group

The Broadband Services Expert Group (BSEG) was established in December 1993. It will examine the technical, economic and commercial aspects of the widespread delivery of broadband services to homes, businesses and schools in Australia - the so-called "Information Superhighway".

It is to look particularly at issues relating to likely consumer demand for broadband services, possible delivery systems, financial and R&D requirements, industry export and employment opportunities and the impact on the Australian community. BSEG aims to table a final report in December 1994.

Telecommunications industry development plans - R&D

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

Telstra has committed to investing more than 1.5 per cent of its sales revenue in research and development, and to fund 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 Telstra's business.

Under its industry plan, Optus Communications has agreed to invest in R&D to the extent of at least \$100 million in the 5 years to 1997 and \$400 million in the ten years to 2002. Vodafone has a committed expenditure of \$25 million on R&D over the five year period 1993-94 to 1997-98. Vodafone's strategic supplier, Ericsson Australia, has mirrored Vodafone's R&D commitments and is also investing \$25 million in R&D over the same period.

Research reactor review

The McKinnon Committee's Review of Australia's need for a new nuclear research reactor was completed and its report published in August 1993. The Government broadly accepted the review's findings, acknowledging both the costs and future benefits of neutron-based science and facilities to Australia, including the value of nuclear medicine for diagnostic and therapeutic purposes.

Richards Review of the Australian Geological Survey Organisation (AGSO)

In August 1992, the Government announced a Review of the composition, structure and administrative arrangements for the AGSO (formerly the Bureau of Mineral Resources, Geology and Geophysics), to improve the short and long term performance of Australia's geoscience effort. The results of the Review, chaired by Dr Max Richards, were published in June 1993. The Government's response to the Review was made in the context of the 1993-94 Budget in August 1993, and included several new funding initiatives. Details of these are listed under the earth science and technology section of 'Other initiatives' below.

Monitoring progress in science, technology and innovation

In April 1994, Australia was host to two key international meetings involved with monitoring national and international progress in science, technology and innovation.

The first was the 1994 Meeting of the OECD Group of National Experts on Science and Technology Indicators (NESTI) on 18-19 April. NESTI is an OECD working group concerned with many types of indicators required by national science and technology policy-makers. The meeting was the first to be held outside Europe.

The second was a Symposium, *Measuring Research and Innovation for Policy Purposes*, which followed the NESTI Meeting on 20-22 April. The Symposium brought together experts from OECD, Asia-Pacific, and other economies. It was attended by about ninety international visitors from some 37 countries. A range of issues affecting the information input to science and technology policy was covered. Topics included discussion of a new methodology which will permit the construction of international benchmarks on important aspects of business innovation.

The meetings were jointly hosted by the Department of Industry, Science and Technology and the Australian Bureau of Statistics.

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:

- in view of the success of the Cooperative Research Centres Program, and the number of high quality applications received in the third round, the Government last year announced support for an additional ten centres. Applications are now being sought and are due to close on 6 July 1994.

-
- the Australian Space Council, with representation drawn from industry and government, was established under the Australian Space Council Act 1994 to develop and implement an Integrated National Space Program for Australian space-related activities over the next five years. The Council is the reference point for national and international space policy and interaction, and coordinates space activities within government and between the public and private sectors.
 - the Industry Research and Development Board and the Institution of Engineers, Australia have jointly established a series of New Technology Forums. The Forums provide the opportunity for Australian companies to present their innovations to an audience of invited peers.
 - the Australian Research Council continued its review process of research strategies in particular disciplines with the release of a report on chemistry in September 1993.
 - an Audio-Visual Task Force was established by DIST in September 1993, with a basic mission to increase exports of audio-visual material to the Asia-Pacific region.
 - Australian firms and research groups were represented in a worldwide industry-led feasibility study to test the concept of international cooperation in the development of manufacturing technologies and systems (the Intelligent Manufacturing Systems or IMS program). Australian participation in the feasibility study was assisted by the Industry, Research and Development Board. The study demonstrated positive benefits and Australia will now join a full scale program of international cooperation.
 - an Agreement Relating to Scientific and Technical Cooperation with the European Community was concluded in February 1994. Australia was the first country to sign such an agreement with the EC.
 - a Memorandum of Understanding for Cooperation in Scientific Research and Technology between Australia and the Republic of Italy was concluded in December 1993.
 - a Memorandum of Understanding was signed by representatives of the Australian Research Council, the National Health and Medical Research Council and the *Deutsche Forschungsgemeinschaft* in February 1994, to facilitate research collaboration between Germany and Australia.
 - in March 1994, CSIRO and ICI Australia concluded a Memorandum of Understanding for a five year period to establish a commercial relationship and to facilitate collaboration on strategic and applied R&D projects involving several million dollars.
 - CSIRO has recently conducted its second triennial review of priorities for research. The Organisation will direct increased resources to support manufacturing, information and communications technology, and minerals research, while maintaining the level of research for the environment.

-
- A collaborative study was commissioned by CSIRO from McKinseys, to establish how it might strengthen interactions with small and medium-sized enterprises. A targeted approach will be adopted, with outreach groups being established across the Organisation and an emphasis on secondments to and from industry. Subject to overall funding, a commitment has been made to double CSIRO's interactions with small and medium-sized enterprises over the next five years.
 - A statement of corporate policy and best practice guidelines have been published in the form of the CSIRO Commercial Practice Manual. The Manual is based on Australian Quality Management Standard principles. Workshops and training are well underway to upgrade the commercial skills of staff. In a parallel move, a Corporate Business Department has been created to provide quality commercial services to the Organisation, particularly in the areas of legal affairs, strategic planning and evaluation and intellectual property management. The major emphasis is on the development of the relationship between CSIRO and the business community.

- in science and technology awareness:

- the 1994 Australia Prize was awarded in the field of sustainable land management to Professor Gene Likens, USA, for his work on the Hubbard Brook watershed in north-eastern USA, research which has helped lay the foundations for modern ecological science.
- the 1993 Michael Daley Awards for Science, Technology and Engineering Journalism were presented in April 1994. The highest award went to Ian Anderson, Australian editor of the *New Scientist*, for a story detailing the extent of radioactive contamination from British nuclear testing at Maralinga, South Australia, in the 1950s.
- financial support totalling \$1 million was provided from the Science and Technology Awareness Program for 24 continuing and 20 new awareness-raising projects. These projects include school curriculum resources, supporting materials for exhibitions, media-related projects and projects which focus on women and science.
- a survey of science and technology in the media was undertaken in July 1993. Initial results were reported during the 1993 ANZAAS Conference at Curtin University in Perth.
- the National Science and Technology Centre toured five major interactive science and technology exhibitions to science centres and museums in Australia (*IBM Mathematica*, *ICI Microcosm*, *NRMA Tomorrow's Drivers* and the *Shell Questacon Science Circus*, *AOTC Get the Message*). In an international move, the Centre toured its *Dinosaurs Alive!* exhibition to the Hong Kong Science Museum to support the development of an ongoing relationship with science centres and museums in Asia. There are plans to tour exhibitions to other countries in the Region.
- the National Science and Technology Centre provided education support through its *Starlab*, *Questacon Maths Centre* and *Primary Science Education* programs to support the teaching of science and technology in primary schools across Australia.

- in environment:

- the Office of the Supervising Scientist for the Alligator Rivers Region, including the Alligator Rivers Region Research Institute (ARRRI), was merged with the Commonwealth Environment Protection Agency (CEPA) in February 1994. An independent review of research needs in the Alligator Rivers Region has been undertaken, which will be used as a basis for reexamining the focus of ARRRI research.
- the second triennium program for research into the science and impacts of climate change has been implemented with total funding of \$17 million over the three years 1993-94 to 1995-96.
- a formal agreement establishing the Centre for Plant Biodiversity Research was signed between CSIRO and the Australian Nature Conservation Agency. The board of the Centre was convened and planning preparations were made to combine the botanical programs and collections of the CSIRO Division of Plant Industry and the Australian National Botanic Gardens. It is anticipated that the two operations will be amalgamated as a single functioning unit by the end of 1994, forming the focus of Commonwealth botanical biodiversity research.
- the EcoReDesign Program set up in June 1993 is well underway with two companies selected to demonstrate to industry the economic and environmental value in redesigning products from an environmental as well as a 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 National Science and Technology Centre developed and displayed an interactive exhibition on the environment which encourages the exploration of the science and technology behind environmental issues, and challenges people to consider their every day actions and the consequences of those actions. The *Environment* exhibition will tour to other science centres and museums from 1995.
- the Centre of Environmental Management (DASCEM) of the Department of Administrative Services established a Halon Bank which commenced operation on 1 July 1993. Halon, a volatile liquid used in many fire extinguishers, contributes to the depletion of the ozone layer. It is now being collected throughout Australia and securely stored at distribution sites and it is anticipated that DASCEM will commence to destroy halon about the end of 1994. The destruction phase is dependent upon having sufficient feedstock of halon to justify the establishment of a destruction facility.

- in certification and accreditation:

- the Scientific Services Laboratory (SSL) of the Department of Administrative Services entered into a joint venture with Warrington Fire Research to develop a scheme for passive fire protection systems. The scheme aims to raise the performance and quality of fire safety systems in buildings and offers easier access to Asia and Europe for Australian passive systems manufacturers.

-
- SSL has expanded its national accreditation service for fire equipment to include gaseous fire suppression systems and fire fighting foams. The SSL Register of Accredited Products has been recognised in the Building Codes of Australia.

- in earth science and technology:

- as a result of the Richards Review (see above), Cabinet approved expenditure of \$114 million for the construction of new office and laboratory facilities for the AGSO's Canberra based staff.
- from 1993-94, AGSO will receive an extra \$1.5 million annually for the Continental Margins Program.
- AGSO received \$0.5 million in 1993-94 and from 1994-95 an extra \$2 million annually as an incentive to attract increased State contributions to the National Geoscience Mapping Accord.
- from 1994-95, AGSO will receive \$0.5 million annually for a National Environmental Geoscience Mapping Accord, designed to address community concerns over issues such as land degradation.
- from 1994-95, AGSO will receive an extra \$0.5 million annually to further develop a National Geoscientific Information System.
- during 1993-94, the Bureau of Meteorology's global numerical weather prediction system was upgraded to incorporate an improved representation of atmospheric processes and a higher spatial resolution for depicting weather events. As a result, the Bureau has been able to provide timely forecasts for weather conditions over Australia from one to five days ahead, with forecasting skills comparable to major centres in the USA and Europe.
- the Bureau of Meteorology's National Climate Centre has implemented a range of improvements to its national and regional climate monitoring and seasonal outlook services. This follows from the success of a Townsville-based international field experiment on the role of tropical ocean in global climate and a US-Australian workshop on the potential for improved seasonal to interannual climate prediction in the Western Pacific.

- in primary industries and energy:

- a Forest and Wood Products Research and Development Corporation was established during 1993-94.
- the Chicken Meat Research and Development Council commissioned a series of major reviews to be undertaken during 1994-95 in the area of "Public Issues and Poultry Production". The reviews will concentrate on issues relating to the environmental impact of poultry production, welfare aspects of poultry production and public health issues relevant to either poultry consumers or poultry operators.
- in August 1993, the Agricultural and Resource Management Council of Australia and New Zealand accepted a recommendation that a review of certain animal welfare aspects of layer hen housing be undertaken.

-
- a research strategy for renewable energy sources and systems was published in December 1993 by the Energy Research and Development Corporation. The strategy targets areas for major investment and prioritises those technologies for future development and commercialisation.
 - a review of all Australia's fisheries resources was published jointly by the Fisheries Research and Development Corporation and the Bureau of Resource Sciences in December 1993.
 - the first national workshop on Asian foods was initiated by the Rural Industries Research and Development Council.

- in defence:

- DSTO strengthened its defence science links with South East Asia, through new joint activities with Singapore and Malaysia, and extensive high level planning support to Thailand. Visits to Indonesia by DSTO scientists are laying the foundations for future defence science and industry cooperation.

- in health:

- the Department of Human Services and Health commissioned an external review of the National Health and Medical Research Council (NHMRC) by Professor John Bienenstock of McMaster University. The subsequent 'Report of an External Review of the National Health and Medical Research Council' was released in December 1993, and contained various recommendations to enhance the efficiency and actions of the NHMRC.
- the Government has made a commitment to work with the private sector and researchers to lift the level of health and medical research to two per cent of total health expenditure by the year 2000.

- in the arts and heritage:

- the *Visions of Australia* national touring exhibitions grant program, established in the 1993-94 Budget, assists the touring of cultural exhibitions including science and technology.

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 :

- Department of Prime Minister and Cabinet - Prime Minister's Science and Engineering Council Reports
 - *Research and Technology in Tropical Australia*, November 1993
 - *Gene Technology*, November 1993
- Coordination Committee on Science and Technology
 - *Australian Activities Conducted Under Agreements, Treaties and Memoranda of Understanding Relating to Science and Technology with Countries in the Asia Pacific Region*, October 1993
 - *Access to Australia's Biological Resources*, March 1994
- Minister for Science and Small Business
 - *Science and Technology Budget Statement 1993-94*
- Australian Science and Technology Council
 - *Small Things - Big Returns: The role of nanotechnology in Australia's future*, Occasional Paper No. 26, May 1993
 - *Research and Technology in Tropical Australia*, summary report, August 1993
 - *Research and Technology in Tropical Australia*, final report, August 1993
 - *Gene Technology: Issues for Australia*, Occasional Paper No. 27, August 1993
 - *ASTEC Annual Report 1992-93*, 1993
 - *Energy Research and Technology in Australia*, Occasional Paper No. 28, 1994
 - *On Target?: Review of external earnings targets*, February 1994
- Australian Space Council
 - *A Plan for a Distributed Data Reception and Archive Network for Australia*: Technical Committee Report No.2, January 1993.
 - Australian Space Board- Report, July 1990 to June 1991
 - Australian Space Board - Report July 1991 to October 1992
- Australian Institute of Marine Science
 - *A Vision for the Future of Marine Science in Australia* - A Submission to the McKinnon Review of Marine Science Organisation, October 1993
 - *Submission to the ASTEC Review of the Operation of External Earnings Requirement for Government Research Agencies*, December 1993
- Australian Nuclear Science and Technology Organisation
 - *Research Reactor Review*, August 1993
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
 - *Towards successful support for Australia's small and medium-sized enterprises*, August 1993
 - *CSIRO Research Priorities 1994-95 to 1996-97: A progress report*, August 1993
 - *Partnerships in Telecommunications - A Discussion Paper*, July 1993
 - *CSIRO Land and Water Care Program -Outcomes '93*, February 1994
 - *Research for Southern Australian Dryland Farming: A Business System Approach*, August 1993
 - *Performance Evaluation of the Division of Entomology*, November 1993

-
- Department of Employment, Education and Training
 - *Mixed-Mode Approaches to Industry Training: Staff Attitudes and Cost Effectiveness*, September 1993
 - *Report on the Impact of the Discipline Review of Engineering*, November 1993
 - *Arts, Science and Work-Related Skills and the Generalist Courses in Higher Education*, November 1993
 - *The Influence of Discipline Reviews on Higher Education - Teaching Education in Mathematics and Sciences*, August 1993
 - *Creating Economic Growth through Enterprise Generation and Industry Research Partnerships: The Role of the Post-Secondary Education Sector*, March 1993
 - *National Report on Australia's Higher Education Sector 1992*, May 1993
 - Higher Education Series Paper No. 19 - "Research by Field", September 1993
 - Higher Education Series Paper No. 20 - "Research Grants", September 1993
 - Guide to Commonwealth Competitive Research Funding Schemes, September 1993
 - Higher Education Series Occasional Paper No. 6 - "Factors Affecting Graduate Employment Rates", September 1993
 - Higher Education Funding Legislation Amendment Act 1993, December 1993
 - Higher Education Funding for the 1994-96 Triennium, December 1993
 - Higher Education in Australia (second print), January 1993
 - National Board of Employment, Education and Training
 - *Advice on the Small Grants Scheme*, May 1993
 - *Postgraduate Support and Mobility*, May 1993
 - *Physics: A Vision for the Future*, February 1993
 - *Physics: A Vision for the Future: Comments on Discipline Research Strategies*, August 1993
 - *Crossing Innovation Boundaries*, Volumes 1 and 2 and Executive Summary, November 1993
 - *The Effects of Research Concentration on Research Performance*, November 1993
 - *Science and Technology Education: A Foundation for the Future*, February 1994
 - *The Strategic Role of Academic Research*, February 1994
 - *The Collaborative Activities of the Institute of Advanced Studies, ANU, the 1st Annual Report of NBEET*, February 1994
 - *Higher Education Research Infrastructure*, August 1993
 - Response by the ARC to Report No. 6: Ecology 1986-1990, May 1993
 - Response by the ARC to Report No. 7: Condensed Matter Physics 1986-1990, May 1993
 - Response by the ARC to Report No. 9: Mathematical Sciences 1987-1991, May 1993
 - *Planning and Funding Principles for the 1994-96 Triennium*, August 1993
 - Response by the ARC to Report No. 1: Economics 1986-1990, September 1993
 - Response by the ARC to Report No. 8: Materials and Chemical Engineering 1987-1991, September 1993
 - Response by the ARC to Report No. 10: Organic Chemistry 1987-1991, September 1993
 - Response by the ARC to Report No. 11: Fluid Mechanics 1986-1990, September 1993
 - *Chemistry: A Vision for Australia*, September 1993
 - *High Energy Physics in Australia*, September 1993
-

-
- Commonwealth Environment Protection Agency
 - *A Report on Water Quality Monitoring in Australia, (draft)*
 - Commonwealth Environment Protection Agency and Land and Water Resources Research and Development Corporation
 - *Core Indicators for Biological Assessment of River Health*, October 1993
 - *Identification of Research and Development Priorities for Biomonitoring*, October 1993
 - *River Bioassessment Manual*, February 1994
 - Department of Human Services and Health
 - *Report of an External Review of the National Health and Medical Research Council*, December 1993
 - Department of Industry, Science and Technology
 - *Review of Mineral Processing Research in Australia, Report on a seminar at the University of Newcastle*, July 1991, July 1993
 - *Review of Marine Research Organisation*, October 1993
 - *Australian Science and Technology at a Glance*, March 1994
 - *An Evaluation of the Bilateral Science and Technology Collaboration Program*, 1993
 - *Media Developments in Asia, Implications for Australia*, March 1994
 - Bureau of Industry Economics
 - *R&D, Innovation and Competitiveness: An Evaluation of the Research and Development Tax Concession*, Research Report 50, September 1993
 - *Evaluation of Syndicated R&D*, May 1994
 - Australian Geological Survey Organisation
 - *Review of the Australian Geological Survey Organisation; composition, structure and administrative arrangements (the Richards Review)*, June 1993
 - *The Government Response to the Richards Review of the Australian Geological Survey Organisation*, August 1993
 - *Mt Isa Geographic Information System*, January 1993
 - *Magnetic Map of Australia*, June 1993
 - *Gravity Map of Australia*, October 1993
 - Bureau of Meteorology
 - *Annual Report 1992-93*, November 1993
 - *Research in The Bureau of Meteorology Research Centre 1993*, August 1993
 - *Natural Hazards, Global Change and Meteorology*, December 1993
 - *Observing the Weather and Climate*, March 1994
 - *Climate Almanac for Capital Cities*, April 1994
 - *Climate Change and the El Nino-Southern Oscillation*, July 1993
 - Department of Administrative Services
 - *Halon Replacement Alternatives, Latest International Developments*, July 1993
 - Energy Research and Development Corporation
 - *Research Strategy for Renewable Energy Sources and Systems*, December 1993
 - Fisheries Research and Development Corporation and the Bureau of Resource Sciences
 - *Australian Fisheries Resources*, September 1993

A black square with the word "SECTION" in white serif font at the top and a large white number "3" in the center.

SECTION 3

Science and Innovation in the Budget

Australia's national R&D expenditure

Table 1 provides a broad outline of recent data on R&D expenditure in Australia, based on surveys by the Australian Bureau of Statistics (ABS). The most recent 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 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 in 1990-91 was due more to a sluggish 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

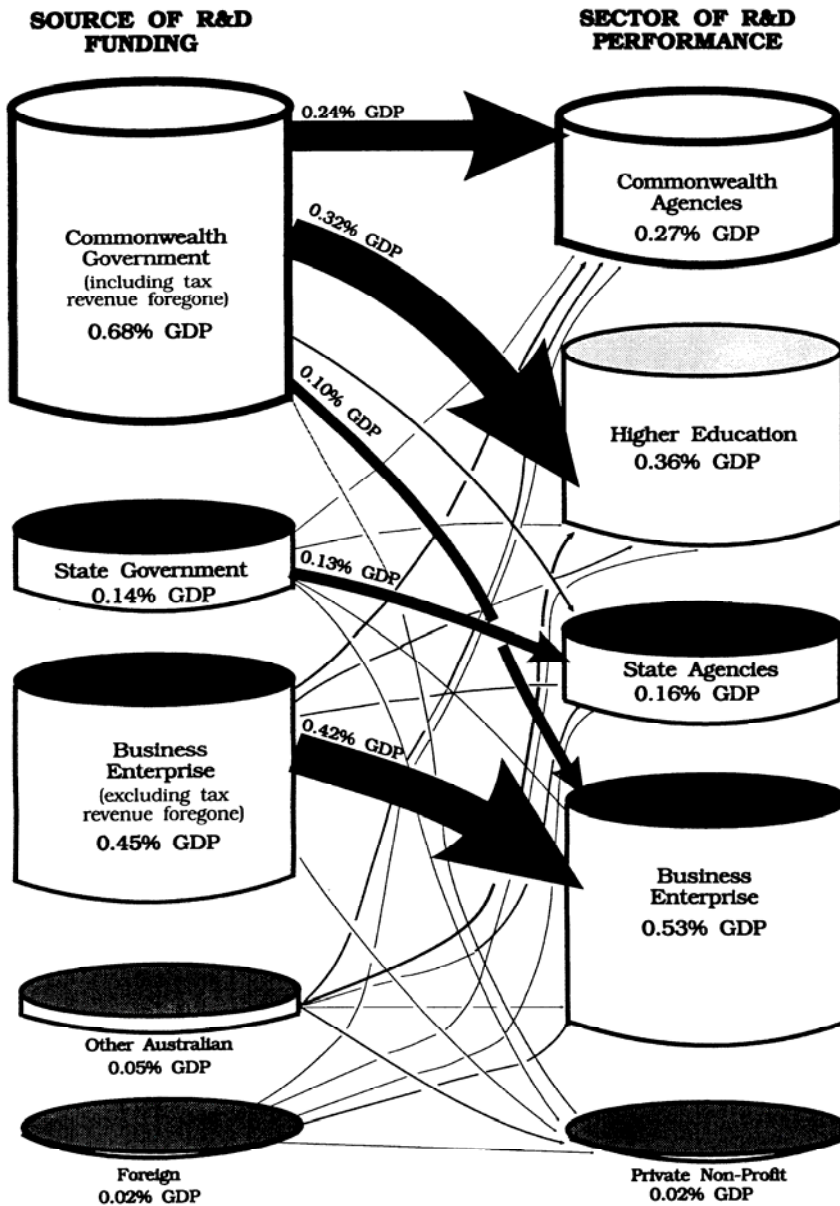
Commonwealth support for major science and innovation programs has risen from \$3118 million in 1993-94 to an estimated \$3253 million in 1994-95, a real increase of 2.1 per cent. Broadly, there have been significant increases over the whole period since 1983-84, with the tax concession schemes providing 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
- industry incentives through tax concessions.

Figure 3

COMMONWEALTH R&D SUPPORT IN A NATIONAL PERSPECTIVE



The figure illustrates major flows of funding support between sectors, based on 1990-91 data. It places Commonwealth funding of R&D in a national perspective.

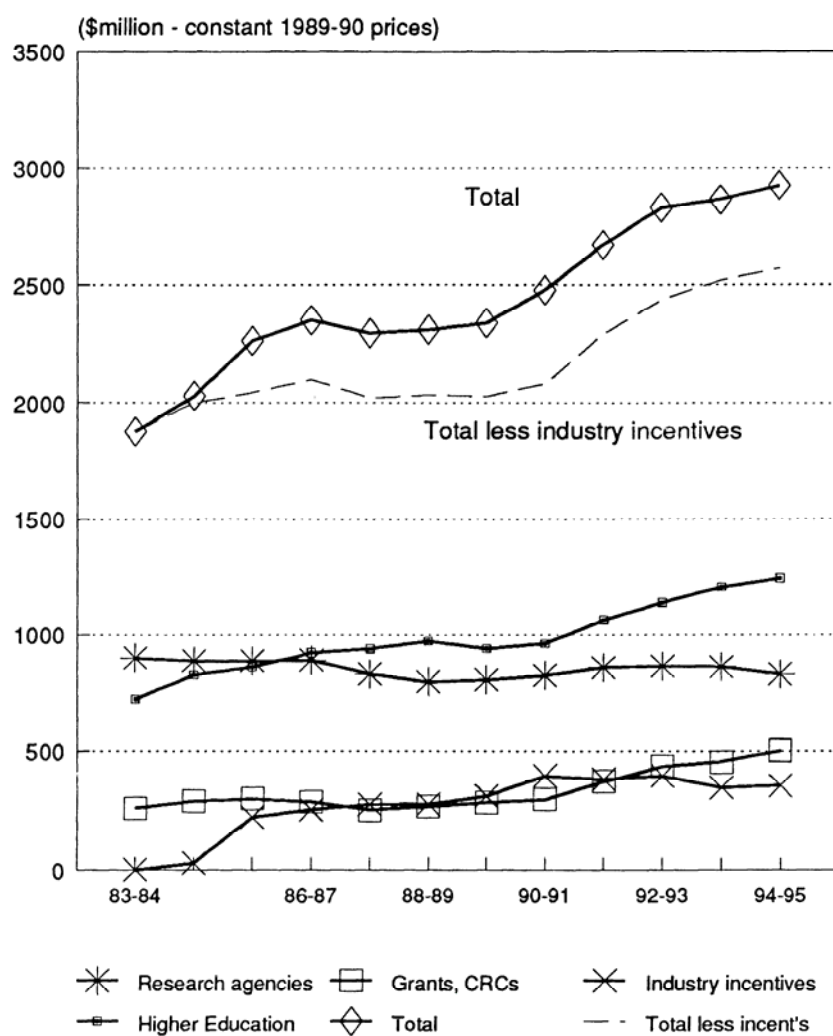
TABLE 2 Constant Price Summary of Major Commonwealth Support for Science and Innovation, Through the Budget and Other Measures (\$m at constant 1989-90 prices)

	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	(est) 1993-94	(est) 1994-95
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	219.8	224.4	218.9	225.0	215.2	223.0	225.2	217.9	218.9	216.1	211.7	197.0
• Civil	679.4	662.0	667.2	664.7	614.6	573.3	579.0	605.0	638.4	646.6	648.2	631.4
SUB-TOTAL	899.2	886.3	886.1	889.7	829.8	796.2	804.2	822.9	857.3	862.6	859.9	828.4
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	67.9	73.8	74.5	79.4	80.2	81.7	89.9	104.1	118.7	123.9	130.5	137.2
• Industry and space	107.4	129.3	138.2	109.1	90.3	91.3	92.8	94.1	122.1	143.7	113.2	129.4
• Cooperative Research Centres	-	-	-	-	-	-	-	-	17.2	42.3	84.3	101.7
• Rural	52.3	58.6	63.2	78.3	62.5	77.6	82.0	78.7	89.0	103.9	107.5	113.6
• Energy and environment	26.3	23.7	19.0	17.5	16.6	13.1	16.9	17.3	22.6	18.6	17.3	17.1
• Transport	5.1	4.0	3.4	2.5	2.3	2.1	2.0	2.1	2.1	2.1	2.0	2.0
SUB-TOTAL	258.9	289.4	298.4	286.8	251.8	265.7	283.6	296.4	371.6	434.5	454.8	501.0
COSTS OF IR&D & RELATED INCENTIVES	-	28.3	220.3	252.8	275.0	276.3	311.0	396.0	380.8	395.9	346.5	355.2
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	69.4	74.7	76.8	79.8	82.9	89.8	124.4	175.0	230.3	245.7	269.8	279.8
• Specific R&D support	155.9	158.6	155.7	154.6	154.2	170.0	165.0	163.0	172.7	183.7	191.4	196.6
• Est. general research support	494.8	592.1	626.6	687.1	702.0	712.0	650.0	623.2	659.8	709.6	743.6	764.4
SUB-TOTAL	720.1	825.4	859.2	921.5	939.0	971.9	939.4	961.2	1062.7	1139.0	1204.7	1240.7
TOTAL COMMONWEALTH SUPPORT												
AT ESTIMATED 89-90 PRICES	1878	2029	2264	2351	2296	2310	2338	2477	2672	2832	2866	2925
EST. REAL % INCREASE/DECREASE		8.1	11.6	3.8	-2.3	0.6	1.2	5.9	7.9	6.0	1.2	2.1

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 \$1380 million in 1994-95 from \$1311 million in 1993-94, representing a real increase of 3 per cent.

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

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

– *Research in Commonwealth Agencies*

The largest Commonwealth research agencies are CSIRO, DSTO, ANSTO, AGSO, Antarctic Division and AIMS. Support through Budget appropriations to these agencies, and some smaller ones, is expected to be \$921 million in 1994-95, compared with \$936 million in 1993-94 (a real decrease of 4 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 1994-95 are expected to amount to \$461 million (with a further \$6 million through DPIE, see Table 4), but the total budget of the Organisation is expected to be in the region of \$680 million. CSIRO also received funds for one-off infrastructure projects and special loan repayments totalling \$30.0 million in 1993-94 and \$2.3 million in 1994-95.

– *Special Purpose Research Grant Schemes*

Support for R&D through the special purpose research grant schemes is estimated to increase to \$557 million in 1994-95 from \$495 million in 1993-94, representing a real increase of 10 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 \$395 million in 1994-95 (\$377 million in 1993-94), up 3% in real terms.

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 \$539 million in 1994-95, up from \$500 million in 1993-94, a real increase of 5 per cent.

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 1983-84. 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 followed policy changes which recognised its important role in innovation and competitiveness. Australian business R&D has been shown to be at comparatively low levels (see Section 5) and there has been little effective interaction between industry researchers and those in government agencies and universities.

The higher education sector has also seen a significant increase in funding since 1983-84. 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. The slight fall since 1992-93, visible in Figure 5, has been due to the one-off payment in that year to initiate the Australian Technology Group Pty Ltd, and the decrease in the corporate tax rate (from 39 to 33 cents in the dollar) which reduced the tax revenue forgone from the 150% industrial R&D tax concession. However, the resulting improvement in firms' after-tax positions will have freed further business funds for R&D.

Detailed data

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

For the most part, the data series in Tables 4 and 5 are comprised of well-defined expenditures which can be readily identified from the Budget Papers. However, Table 6 presents a less clear-cut situation for the two largest items. The first of these is the estimated research component of the general Commonwealth funding for universities. This includes support for teaching activities as well as for research and the research component can only be estimated on the basis of the ABS R&D surveys. Since there were no ABS surveys in some earlier years, and survey results will not be available for some time in relation to the latest years shown, the effect of adding this series to others, as in Table 3, is to blur the assessment of overall trends. See the footnotes to Table 6.

A further blurring results from the inclusion of the estimated costs of Commonwealth revenue forgone through the taxation concession scheme for industrial R&D. As already indicated, the amounts shown are estimates. (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

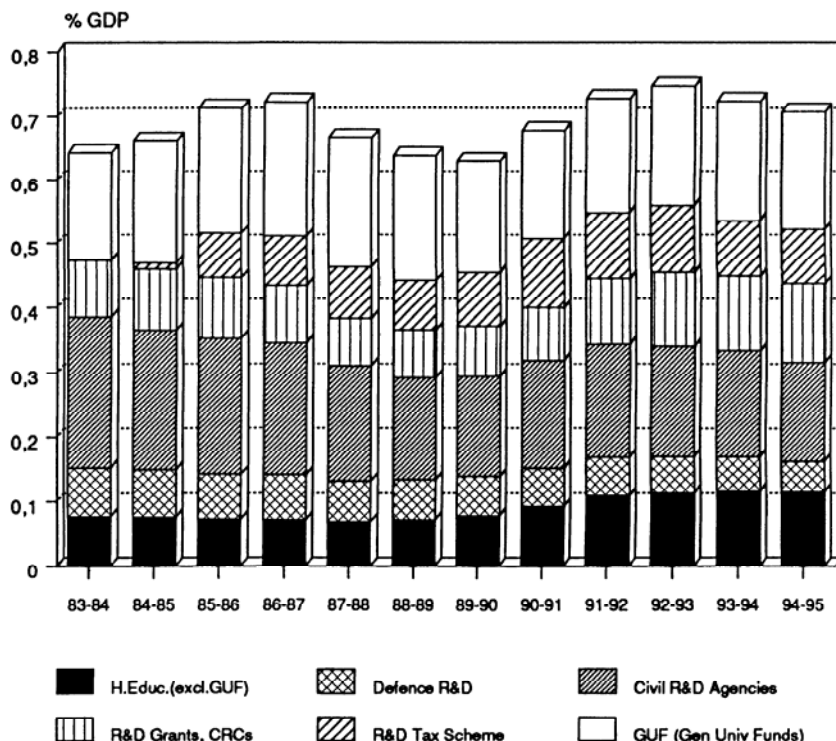
Over the past three decades there has been considerable international effort to reach agreed definitions of R&D. The resulting definitions have been applied with some rigour in periodic surveys conducted within most OECD countries. This so-called "Frascati" methodology has been applied in Australia since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

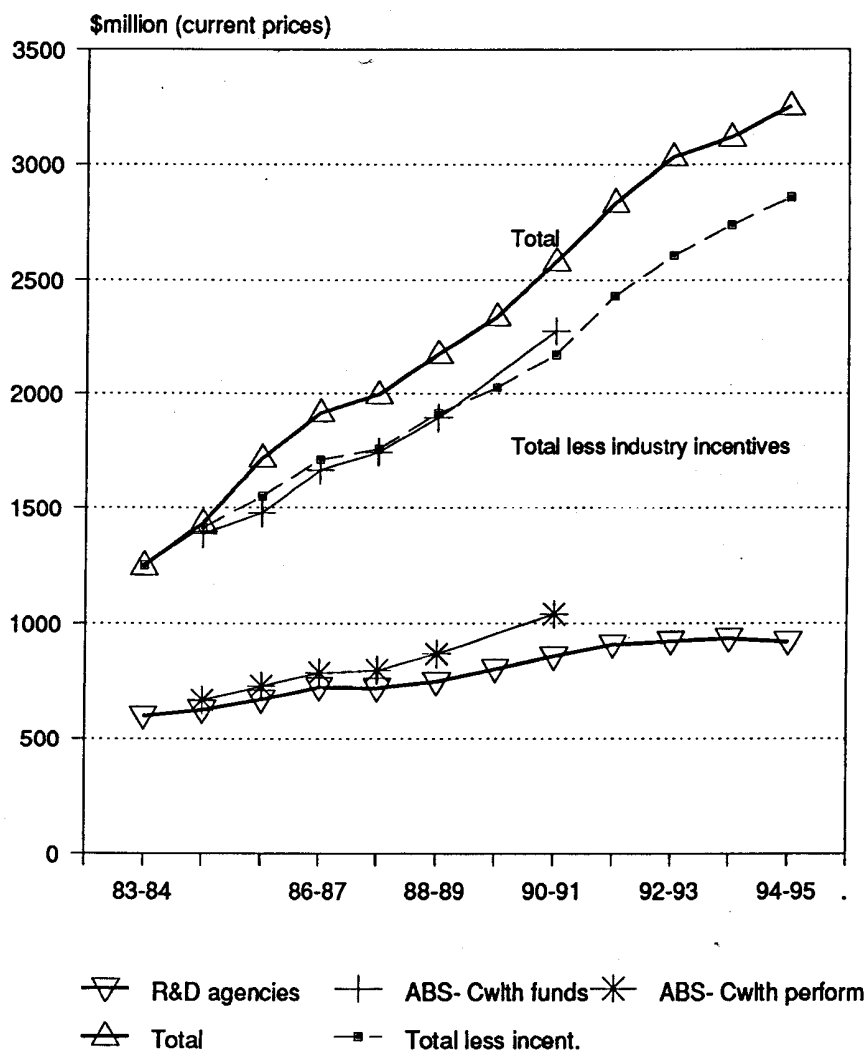


Source: See Table 2 and ABS 5206.0

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: DIST and ABS

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

	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	(est) 1993-94	(est) 1994-95
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	146.6	158.4	165.9	183.4	187.0	209.8	225.2	227.2	232.3	231.4	230.3	219.1
• Civil	453.2	467.3	505.8	541.7	534.1	539.5	579.0	631.1	677.3	692.5	705.3	702.1
• SUB-TOTAL	599.8	625.7	671.7	725.1	721.1	749.3	804.2	858.3	909.6	923.9	935.6	921.2
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	45.3	52.1	56.5	64.7	69.7	76.9	89.9	108.6	125.9	132.7	142.0	152.5
• Industry and space	71.6	91.3	104.7	88.9	78.4	85.9	92.8	98.2	129.6	153.9	123.1	143.9
• Cooperative Research Centres									18.2	45.3	91.7	113.1
• Rural	34.9	41.4	47.9	63.8	54.3	73.0	82.0	82.1	94.4	111.2	116.9	126.3
• Energy and environment	17.5	16.7	14.4	14.2	14.4	12.3	16.9	18.1	24.0	19.9	18.8	19.1
• Transport	3.4	2.8	2.6	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2
SUB-TOTAL	172.7	204.3	226.2	233.7	218.9	250.0	283.6	309.2	394.3	465.3	494.8	557.1
COSTS OF IR&D & RELATED INCENTIVES	-	20	167	206	239	260	311	413	404	424	377	395
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	46.3	52.8	58.3	65.0	72.0	84.5	124.4	182.5	244.3	263.1	293.5	311.1
• Specific R&D support	104.0	112.0	118.0	126.0	134.0	160.0	165.0	170.0	183.2	196.8	208.3	218.6
• Est. general research support	330.0	418.0	475.0	560.0	610.0	670.0	650.0	650.0	700.0	760.0	809.0	850.0
SUB-TOTAL	480.3	582.8	651.3	751.0	816.0	914.5	939.4	1002.5	1127.5	1219.9	1310.8	1379.7
TOTAL COMMONWEALTH SUPPORT	1253	1433	1716	1916	1995	2174	2338	2583	2835	3033	3118	3253
% GDP	0.643	0.662	0.714	0.723	0.668	0.638	0.630	0.679	0.728	0.747	0.724	0.707
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 1989-90 PRICES	1878	2029	2264	2351	2296	2310	2338	2477	2672	2832	2866	2925
EST. REAL % INCREASE/DECREASE		8.1	11.6	3.8	-2.3	0.6	1.2	5.9	7.9	6.0	1.2	2.1

SOURCE See Tables 4, 5 and 6

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

	1983-84	1984-85	1985-86	1986-87	1987-88	Outlays		1989-90	1990-91	1991-92	1992-93	(est.) 1993-94	(est.) 1994-95
THE ENVIRONMENT, SPORT & TERRITORIES													
Antarctic Division	35.2	37.4	42.2	47.4	49.2	46.3	57.7	62.8	67.3	65.4	63.6	59.4	
Bureau of Meteorology													
Research Centre (BMRC) ¹	1.7	1.8	1.8	2.3	2.5	2.2	2.4	2.8	3.3	3.3	3.6	3.7	
Supervising Scientist - Alligator Rivers Research Inst	4.5	4.7	5.5	6.1	5.9	6.6	5.9	5.1	5.6	7.5	6.5	5.2	
DEFENCE													
Defence Science and Technology Organisation	146.6	158.4	165.9	183.4	187.0	209.8	225.2	227.2	232.3	231.4	230.3	219.1	
EMPLOYMENT, EDUCATION & TRAINING													
Anglo-Aust Telescope	1.8	1.8	1.9	2.0	2.4	2.5	2.7	2.9	3.0	3.1	3.1	3.1	
HEALTH & HUMAN SERVICES													
Australian List, of Health (excl. grants)	4.0	4.6	5.1	5.2	3.4	4.2	4.4	4.2	5.0	6.8	7.2	6.9	
CSL Ltd (Budget component)	6.6	8.8	12.8	15.8	17.3	16.6	9.4	3.0	5.9	8.2	17.0	4.3	
Nuclear Safety Bureau	-	-	-	-	-	-	-	-	-	0.8	0.8	0.8	
INDUSTRY, SCIENCE & TECHNOLOGY													
Aust Nuclear Science & Technology Organisation ²	38.8	41.9	45.4	45.2	50.8	54.3	57.5	62.6	65.1	68.2	64.2	65.6	
Australian Institute of Marine Science	6.9	7.4	7.6	8.2	9.5	11.0	11.4	13.6	14.2	14.2	16.9	16.3	
CSIRO ²	331.6	324.9	344.3	367.8	347.8	348.1	375.2	414.4	446.3	456.2	460.9	461.1	
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	5.7	
AGSO ³	22.0	30.1	35.2	37.4	40.6	42.9	47.0	52.9	54.2	50.9	53.5	70.0	
TOTAL	599.8	625.7	671.7	725.1	721.1	749.3	804.2	858.3	909.6	923.9	935.6	921.2	

(1) BMRC was established on 1 January 1985. Prior data are estimated R&D expenditures by the Bureau of Meteorology.

(2) CSIRO and ANSTO figures for 1980-81 were adjusted to include superannuation on the same basis as in subsequent years.

(3) 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)

	1983-84	1984-85	1985-86	1986-87	1987-88	Outlays 1988-89	1989-90	1990-91	1991-92	1992-93	(est.) 1993-94	(est.) 1994-95
THE ENVIRONMENT, SPORT & TERRITORIES												
Aust Biological Resources Study	1.1	1.2	1.2	1.0	1.1	1.3	1.6	1.2	2.0	2.3	2.1	2.0
Greenhouse research	-	-	-	-	-	0.8	5.7	5.7	6.1	6.0	5.8	6.0
EMPLOYMENT, EDUCATION & TRAINING												
Research evaluation and Academies	-	-	-	-	-	-	-	1.6	2.0	2.0	2.0	2.0
ARGS & ARC grants/fellowships (including marine R&D grants) ¹	25.5	30.8	34.6	39.8	42.7	50.7	35.6	1.2	-	-	-	-
Post-graduate Awards ¹	15.1	16.3	17.8	19.3	20.3	21.7	11.3	-	-	-	-	-
Targetted Institutional Links Program	-	-	-	-	-	-	0.2	1.0	2.0	1.1	1.4	1.4
HEALTH & HUMAN SERVICES												
AIDS Research	-	-	0.8	1.5	3.0	3.5	5.0	7.1	10.8	10.5	11.6	12.1
Health and Community Services												
Research Grants	3.2	1.6	1.8	2.3	1.1	1.4	1.9	1.8	1.8	1.9	1.9	1.9
NH&MRC Research Grants	38.5	44.2	51.2	59.4	65.6	72.0	83.0	94.7	103.3	110.3	118.5	125.5
Capital Works for Medical Institutes	3.5	6.3	2.6	1.6	-	-	-	5.0	10.0	10.0	10.0	13.0
Funds for John Curtin SMR	-	-	-	-	-	-	-	-	8.2	16.8	17.3	17.6
INDUSTRY, SCIENCE & TECHNOLOGY												
IR&D Incentives Act 1976												
. Commencement grants	14.6	16.3	14.3	16.9	3.1	0.1	-	-	-	-	-	-
. Project grants	43.2	38.1	37.7	17.9	6.4	2.8	0.3	-	-	-	-	-
. Public interest projects	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	0.7	0.9	0.8	1.2	1.4	1.1	1.9	3.0	3.2	-	-	-
Industry Innovation Programs	-	-	-	-	-	-	-	-	-	43.5	39.7	52.3
National Research Facilities	-	-	-	-	-	-	-	-	-	-	-	7.5

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

	1983-84	1984-85	1985-86	1986-87	1987-88	Outlays 1988-89	1989-90	1990-91	1991-92	1992-93	(est.) 1993-94	(est.) 1994-95
InterScan support	2.5	-	-	-	-	-	-	-	-	-	-	-
National Space Program	-	-	3.0	5.0	3.2	5.4	2.4	5.5	5.7	5.4	5.5	9.3
Malaria Vaccine Joint Venture	-	-	0.3	0.4	0.8	1.2	0.8	2.3	9.4	-	-	-
Research associations ²	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	74.8
Australia Technology Group Pty Ltd	-	-	-	-	-	-	-	-	-	30.0	-	-
Cooperative Research Centre Grants	-	-	-	-	-	-	-	-	18.2	45.3	91.7	113.1
PRIMARY INDUSTRIES & ENERGY⁴												
Wool Research	10.0	11.7	13.0	14.4	12.1	21.7	20.8	11.7	13.8	13.2	11.2	12.7
Meat Research	5.4	4.0	5.5	8.4	8.6	11.9	13.8	13.6	20.8	23.8	23.5	21.5
Fishing Industry Research	3.1	4.3	5.0	6.2	6.2	5.4	8.1	8.4	6.6	7.5	8.6	10.1
Grains	10.8	14.1	15.2	17.9	11.2	11.1	13.3	14.4	14.8	15.7	21.2	23.3
Horticulture Research	-	-	-	-	-	0.6	1.2	3.1	4.4	8.3	10.8	11.4
Energy research	16.4	15.5	13.2	13.3	10.2	9.6	11.2	15.9	11.8	11.6	10.9	11.1
Land & Water research	0.7	1.5	1.8	4.9	7.8	10.4	9.9	13.3	13.3	13.7	11.1	11.1
Rural Industries R&D Corporation	0.1	0.3	0.4	1.5	3.0	4.0	5.0	6.0	8.4	11.3	11.5	11.5
Other rural research	4.6	5.4	7.0	10.6	5.5	8.0	10.1	11.7	12.3	17.9	21.3	24.7
TRANSPORT & COMMUNICATIONS												
Payments to Australian Road Research Board	3.0	2.3	2.0	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2
Railway R&D Organisation	0.4	0.5	0.6	-	-	-	-	-	-	-	-	-
TOTAL	213.3	251.5	278.5	292.8	281.9	322.5	330.7	313.0	406.5	485.2	515.4	578.1

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)

	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94 est	1994-95 est
Wool	9.30	12.32	11.88	15.25	18.31	14.21	19.63	17.11	14.05	12.32	11.20	12.66
Meat	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	25.55 ^a	23.50	21.49
Grains												
- Grain ^b	1.33	1.30	2.16	2.07	2.35	2.53	3.99	4.27 ^b	5.31 ^b	9.36	11.03	8.61
-Wheat	4.65	5.40	5.48	6.40	5.16	8.35	9.84	8.45	12.92	18.35	19.33	17.62
Coal ^c	2.14	4.17	3.28	4.82	7.07	15.02	17.05	14.95	13.88	16.10	1.48	-
Special Rural	-	-	-	-	-	-	0.20	0.30	0.15	0.99	1.20	1.37
Fish	-	-	-	-	-	-	-	0.50	1.12	1.01	2.12	3.37
Horticulture	-	-	-	-	-	0.20	1.62	3.26	4.94	7.24	9.32	12.23
Other Rural												
- Chicken Meat	0.23	0.24	0.29	0.38	0.40	0.38	0.46	0.55	0.78	0.65	0.60	0.65
- Cotton	0.67	1.00	0.89	1.04	0.86	1.55	1.87	2.66	3.87	3.89	2.40	2.34
- Dairying	0.57	0.60	0.67	1.26	1.64	1.57	2.94	4.82	5.21	5.65	6.12	6.73
- Dried Fruit	0.09	0.12	0.16	0.32	0.26	0.29	0.39	0.45	0.78	0.92	0.46	0.57
- Grape & Wine	0.38	0.49	0.52	0.67	0.82	0.94	1.28	1.25	0.96	1.60	1.69	1.87
- Honey	0.05	0.05	0.08	0.09	0.11	0.10	0.12	0.14	0.07	0.12	0.13	0.14
- Pig Industry	0.42	0.60	0.78	1.00	1.43	1.37	1.95	2.58	2.68	2.88	3.56	3.53
- Egg Industry	0.15	0.16	0.22	0.31	0.28	0.37	0.30	0.45	0.57	0.68	0.67	0.64
- Sugar	-	-	-	-	1.28	1.40	1.37	1.48	1.28	3.40	4.48	4.54
- Tobacco	0.55	0.67	0.66	0.69	0.64	0.94	0.77	0.59	0.59	0.92	0.57	0.45
- Forestry	--	-	-	-	-	-	-	-	-	-	-	2.60
Total	23.71	30.61	32.61	41.98	49.25	60.82	77.09	79.00	94.86	111.62	98.79	101.4

(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)

	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	(est) 1993-94	(est) 1994-95
EMPLOYMENT, EDUCATION & TRAINING*												
Higher Education Funding Act: special research assistance ¹	5.7	5.6	5.9	6.0	9.0	12.1	77.3	178.7	240.3	260.0	290.1	307.7
Identifiable research support for universities ^{2,4}	104.0	112.0	118.0	126.0	134.0	160.0	165.0	170.0	175	180	191	201
Estimated research component of general university funding for both teaching and research ^{3,4}	330	418	475	560	610	670	650	650	700	760	809	850
INDUSTRY, SCIENCE & TECHNOLOGY												
Tax Concession ⁵ for industrial R&D	-	-	147	186	219	253	292	379	404	424	377	395
Tax Deduction for equity subscriptions in Management Investment Companies (MICs) ⁶	-	20	20	20	20	7	19	34	-	-	-	-
TOTAL	440	556	766	898	992	1102	1203	1412	1519	1624	1667	1754

* 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, Centres and Infrastructure but excludes funding through Budget sources.
- (2) Indicative estimates of identifiable research expenditure data from universities' Operating Grants. Later years are projections based on data collected by DEET from institutions in respect of 1991. Funding of John Curtin School of Medical Research is not included after January 1992, when funding was transferred to the Health portfolio. Prior to 1989, data for the former Colleges of Advanced Education was not included.
- (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 1992-93 Statement).

	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94 est	1994-95 est
ANU Institute of Advanced Studies (estimate) ^a	81	87	93	97	100	108	122	134	133	128	129	130
Estimated research and research training component of higher education operating grants ^b	252	271	293	315	334	366	397	390	440	475	507	523

(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 HHS.

(b) This is an estimate of the research and research training funds within the operating grants of all higher education institutions. Based on the 1990 Relative Funding Model, the research training component is assumed to be 7.6 percent of the Operating Grant, and the non-training component, called the Research Quantum, is fixed at 6.2 percent of the 1990 Operating Grant, which in current dollars is \$210m.

- (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 forgone in each year. From 1985-86 to 1993-94 this series is nil, \$105m, \$150m, \$190m, \$250m, \$290m, \$370m, \$395m and \$415m.
- (6) Licensed Management and Investment Companies invest in approved high technology/growth activities. The equity subscription in these companies attracted a 100% income tax deduction in the year that subscriptions were made. The scheme concluded in June 1991.

SECTION

4

International Context

Broad international comparison of R&D levels

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

TABLE 7 Gross expenditure on R&D (GERD), GERD as a proportion of GDP, and change and growth rates since 1981 - selected international comparisons

	GERD (1985 US\$m)	GERD/GDP	Change since 1981	Average annual real increase in GERD	Average annual real increase in GDP
United States (1991)	124575	2.75	+0.32	3.8%	2.9%
Japan (1991)	54335	2.87	+0.73	7.4%	4.3%
Germany (1991)	28780	2.66	+0.23	4.3%	2.9%
France (1991)	20125	2.42	+0.44	4.3%	2.4%
China (1990)	19945	0.72	na	na	13.8%
United Kingdom (1991)	15385	2.08	-0.29	2.0%	3.0%
Italy (1991)	10384	1.32	+0.45	7.1%	2.6%
Canada (1991)	6280	1.50	+0.27	4.3%	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)	3904	2.00	+0.07	3.3%	2.4%
Sweden (1991)	3449	2.90	+0.60	4.4%	2.1%
Spain (1991)	3434	0.87	+0.45	11.4%	3.5%
Switzerland (1989)	3347	2.86	+0.57	5.8%	2.3%
AUSTRALIA (1990)	3217	1.35	+0.35	6.6%	3.2%
Belgium (1990)	2306	1.69	+0.07	3.1%	2.3%
Chinese Taipei (1990)	2241	1.69	+0.77	15.8%	8.5%
Austria (1991)	1673	1.51	+0.32	4.7%	2.5%
Finland (1991)	1306	2.02	+0.83	8.2%	3.0%
Denmark (1991)	1228	1.69	+0.60	7.0%	2.3%
Norway (1991)	970	1.84	+0.55	5.4%	1.3%
Ireland (1991)	337	1.04	+0.31	7.0%	3.7%
New Zealand (1990)	333	0.88	-0.13	-0.1%	1.3%
Singapore (1990)	307	0.90	+0.62	22.3%	6.6%
Average		1.75	+0.42	7.5%	4.0%
Average (OECD only)		1.90	+0.36	5.3%	2.7%

Source: DIST 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 economies. Since it is also useful to know the relative scales of R&D effort, the list is ranked by the total R&D expenditure level (in US dollars at 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. 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 economies, 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 Chinese Taipei) have dramatically increased their total level of R&D effort and show exceptionally high growth rates in GERD and GDP.

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

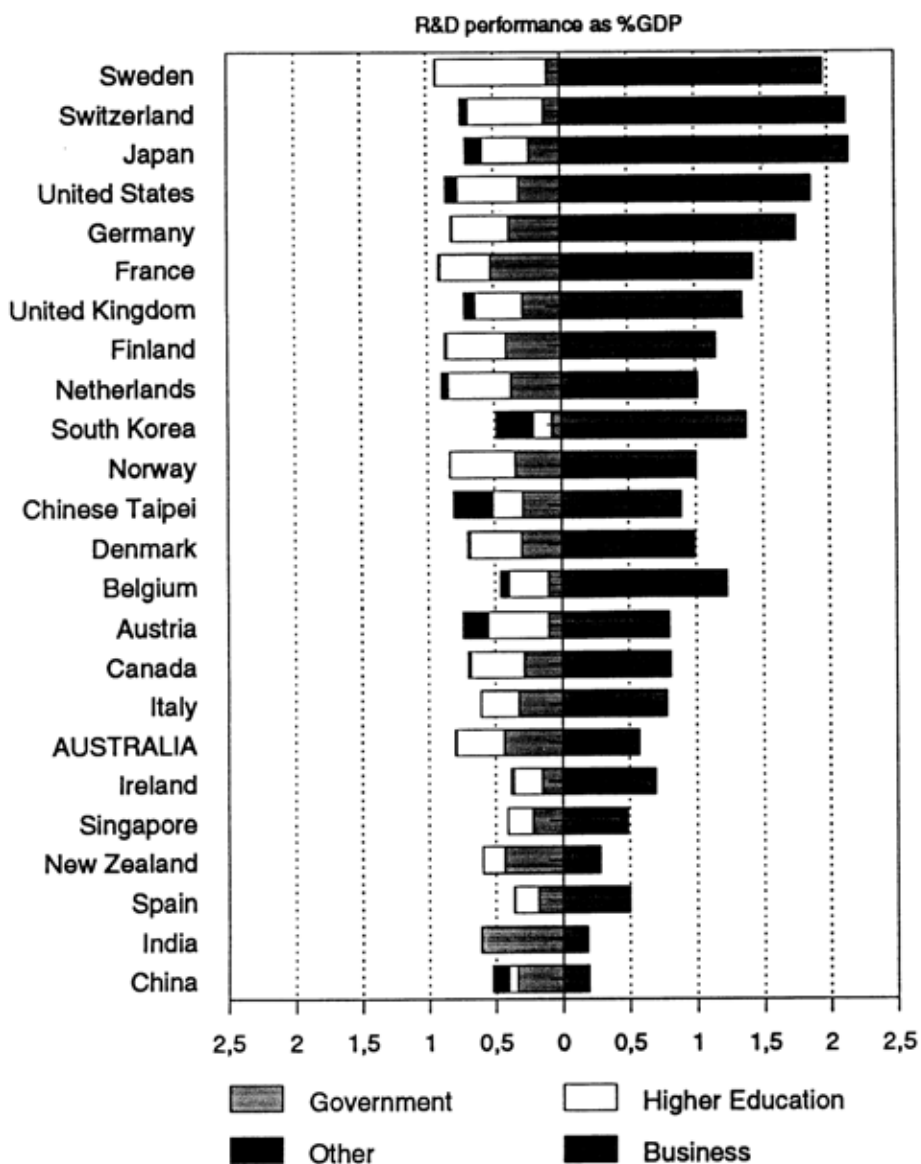
There is much advantage in comparing the sectors separately. A complication, however, is that there is great variation internationally in the scope of R&D activities and institutional structures in the government and academic sectors. The type of research or function typically undertaken in government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

R&D expenditure in government agencies and universities

Table 8 shows comparative international data for combined R&D expenditure within government agencies and universities. In this list, the arrangement is in order of R&D expenditure as a percentage of GDP. The Table also shows changes in this ratio 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: DIST 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 economies listed. 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 over the period. The eleven economies 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 - selected international comparisons

	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)	0.91	+0.12	3.4%
Finland (1991)	0.85	+0.32	6.9%
Netherlands (1991)	0.85	+0.04	2.3%
Norway (1991)	0.83	+0.23	5.1%
Germany (1991)	0.82	+0.11	4.4%
AUSTRALIA (1990)	0.79	+0.04	3.5%
United States (1991)	0.76	+0.11	4.4%
Switzerland (1989)	0.69	+0.10	4.6%
Denmark (1991)	0.68	+0.14	5.3%
Canada (1991)	0.68	+0.06	2.6%
United Kingdom (1991)	0.64	-0.17	-0.1%
India (1990)	0.61	+0.18	10.1%
New Zealand (1990)	0.60	-0.17	-1.5%
Japan (1991)	0.58	-0.05	3.4%
Italy (1991)	0.55	+0.17	6.6%
Austria (1989)	0.55	+0.06	3.7%
Chinese Taipei (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%
Ireland (1990)	0.37	-0.03	2.4%
Spain (1991)	0.36	+0.13	8.4%
South Korea (1990)	0.21	+0.06	14.1%
Average	0.62	+0.09	5.6%
Average (OECD only)	0.68	+0.07	3.7%

Source: DIST 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 list in this case is 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 - selected international comparisons

	%BERD/GDP	Change since 1981	Average annual real increase in BERD	Average annual increase in ext. patents
Japan (1991)	2.16	+0.75	8.8%	11.1%
Switzerland (1989)	2.14	+0.44	6.0%	4.9%
Sweden (1991)	1.97	+0.50	4.9%	8.9%
United States (1991)	1.92	+0.20	3.6%	10.2%
Germany (1991)	1.83	+0.13	4.2%	7.6%
France (1991)	1.49	+0.32	4.9%	8.1%
South Korea (1990)	1.38	+1.12	31.6%	na
United Kingdom (1991)	1.36	-0.14	2.8%	11.1%
Belgium (1990)	1.23	+0.18	3.9%	9.1%
Finland (1991)	1.15	+0.50	9.2%	16.6%
Netherlands (1991)	1.02	+0.04	4.2%	9.8%
Norway (1991)	1.00	+0.32	5.8%	15.0%
Denmark (1991)	0.99	+0.45	8.3%	15.3%
Chinese Taipei (1990)	0.89	+0.37	16.5%	na
Canada (1991)	0.81	+0.21	5.8%	8.8%
Austria (1989)	0.80	+0.15	4.9%	8.7%
Italy (1991)	0.77	+0.28	7.7%	9.5%
Ireland (1991)	0.65	+0.34	11.2%	12.4%
AUSTRALIA (1991)	0.57	+0.32	13.1%	16.9%
Spain (1991)	0.51	+0.32	14.0%	12.6%
Singapore (1990)	0.49	+0.34	23.8%	na
New Zealand (1990)	0.28	+0.06	5.0%	-2.6%
China (1990)	0.19	na	na	na
India (1990)	0.18	+0.02	7.2%	na
Average	1.07	+0.31	9.0%	na
Average (OECD only)	1.19	+0.28	6.7%	10.2%

Source: DIST 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 in most other economies 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 Chinese Taipei 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. Both indicators are partial and imperfect measures of different aspects of innovative levels or capacity. Data on external patent applications, at present available only for OECD countries, show Australia with substantially the highest growth rate. Since this information is statistically quite separate from the business R&D expenditure, it provides valuable confirmation that there was substantial growth achieved in Australia's business sector innovation over the 1980s - and that this growth was significantly higher than in most other OECD economies.

Table 9 thus confirms the picture of very significant increases in Australian business innovation over the 1980s, over a period in which an extensive range of Commonwealth programs was 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 the Asia-Pacific region - 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 international ranking is likely.

SECTION 5

Budget allocations and Portfolio achievements

Introduction

This Section presents selected information on science and technology arranged by ministerial portfolio. For each portfolio, there is a brief summary of pertinent allocations for the 1994-95 Budget compared with the expected expenditure outcome for 1993-94. 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.

COMMUNICATIONS AND THE ARTS

Science and Technology in the Portfolio Budget

The Communications and the Arts portfolio provides science and technology services through a number of organisations.

The Communications Laboratory was commissioned in August 1988 and has the task of providing to management and policy development units: explanations of current developments in broadcasting and communications technologies; and guidance and briefings on the possible interactions between technology and policy or regulatory practices. It costs about \$2.3 million per annum to operate the Laboratory including salaries, running costs and infrastructure costs.

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 Communications and the Arts 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.

The National Science and Technology Centre as been allocated \$4.1 million in 1994-95 (\$4.3 million in 1993-94). It plays a role in promoting confidence in, an understanding of, and creating positive attitudes towards science and technology. The Centre achieves this through providing nearly 200 interactive exhibits and the conduct of education programs to audiences throughout Australia including regional and remote communities. As part of its Outreach Programs, the centre has a number of travelling exhibitions touring Australia - with the assistance of private sector sponsorship.

MAJOR RESEARCH ACTIVITIES

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

Black and white film developers

The National Film and Sound Archive, in conjunction with Kodak research scientists, has developed analytical techniques to monitor and adjust the levels of bromide in the specialised film developers used in archival processing. Monitoring bromide levels is common throughout all forms of photographic processing to ensure that correct development is carried out.

High levels of bromide inhibit proper development and must be controlled by dilution with replenishers. This is a unique problem facing film archives, and is due to the extremely high levels of bromide needed to copy historical film. The solution to it relies on careful balancing of processing chemicals and the types of films preserved. This approach is now being recommended by Kodak to other moving image archives throughout the world.

Archive management system

The Archive is proceeding with the commercialisation of the AIMS (Archive Information Management System) software through a joint venture agreement with Wizard Information Services following market-research in Northern America. The AIMS software contains a number of unique features. It was selected by the Australian Broadcasting Corporation as an archival management system for integration with its D-CART (a digital storage and editing technology which is used in major radio broadcasting organisations throughout the world). An interface between AIMS and the D-CART was subsequently constructed. The interface enables AIMS users to query the database and, if a sound recording is available on the D-CART, they are able to hear the recording played at their work station less than a second after they have pressed the go-ahead button. This interface provides the Archive/Wizard with a very strong competitive edge in the marketing of AIMS.

Other Initiatives

Magnetic materials working group

In conjunction with the National Preservation Office and the Australian Archives, the National Film and Sound Archive has established a magnetic materials working group. The aim of the group is to determine the role of magnetic materials in audiovisual archiving. Areas being examined include the stability of the material, the obsolescence of equipment and preservation strategies to extend access to data on magnetic materials.

The group is working closely with similar research projects in the United States and the United Kingdom to ensure a unified effort.

DEFENCE

Science and Technology in the Portfolio Budget

The Budget allocation for the Defence science and technology function will be \$238.1 million in 1994-95 (\$221.9 million expected outcome in 1993-94.)

MAJOR RESEARCH ACTIVITIES

Defence Science and Technology Organisation (DSTO)

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

Recent Achievements

Policy and command

A number of projects were completed. These include:

- The second phase of the Wide Area Surveillance Study, to which DSTO was a major contributor, has been successfully completed. The outcome has been a full assessment of the effectiveness of all current and proposed Australian Defence Force (ADF) assets to conduct wide area surveillance of the sea/air gap to the north of Australia. The Study will ensure ordering of priorities in acquiring new surveillance equipment and upgrading existing equipment, and will also provide guidance in setting directions for research and development into surveillance.
- Important research and development on high frequency (HF) radio technology was completed. This allowed DSTO to provide technical advice leading to lower cost solutions for replacing dated HF radio equipment.
- A user-friendly software package as an aid to the monitoring and control of ballistic weapon technology was developed. It predicts the performance of ballistic weapons, including range, payload and course.

Maritime force capabilities

A study of options for upgrading the above-surface capabilities of the Australian Navy frigates was completed. Special attention was paid to improving their ability to deal with anti-ship missile attacks. The project was supported by assessment studies, sea experiments, algorithm development and general scientific advice. Other major projects included the Mine Warfare Systems Centre and DSTO's contribution to the acquisition of the Mine Hunter Coastal, a vessel to improve Australia's mine hunting capability.

Land force capabilities

Further improvements were made to the performance of a new radar device, the airborne synthetic aperture radar concept demonstrator. The radar has been demonstrated successfully in trials involving both static and moving Army targets.

Air force capabilities

Developments in this field include:

- A model for analysing the performance of maritime radar has been substantially completed and the results are being used to revise the radar system in upgrading the P-3C ORION surveillance aircraft.
- An interference-fit plug designed to reduce cracking in a critical location on the F-111C wing, and a composite bonded repair for a recently reported wing skin crack in an F-111C.

Commercial achievements

These include the following:

- Commercial exploitation of the composite bonded repair technology has been achieved with the successful demonstration to the US Airforce, and a subsequent contract to the Australian company Helitech.
- MetaCon, an artificial intelligence architecture, is being further developed with Ericsson Defence Systems, Melbourne under a Memorandum of Understanding between the Australian and Swedish Governments. If successful, MetaCon could be employed in Swedish radar systems.
- The low cost Infrared Imager, developed as a technology demonstrator for military applications, is now receiving considerable commercial interest in both Australia and overseas. It has been demonstrated to the Victorian and South Australian electricity authorities for the airborne monitoring of hot spots in power lines. An Australian company has been licensed to develop and market this equipment.

International cooperation

DSTO continued to build its defence science links with South East Asia and New Zealand. Joint projects with Singapore commenced on military communications and jet engine modeling, with two Singaporean engineers temporally posted to DSTO laboratories. DSTO provided Thailand with extensive support on high level planning of its defence science activities, and

initiated a joint project with Malaysia on ship magnetic ranging. Visits to Indonesia by DSTO scientists are laying the foundations for future defence science and industry cooperation.

The most important multi-lateral defence science forum continues to be The Technical Cooperation Program (TTCP) between the United States, United Kingdom, Canada, Australia and New Zealand. TTCP had many successes during the year. Eight Australian scientists received TTCP awards for their role in outstanding cooperative research programs on topics including surface wave radar, fatigue damage in composite materials, detection of buried sea mines, and personnel protection against chemical warfare agents.

EMPLOYMENT, EDUCATION AND TRAINING

Science and Technology in the Portfolio Budget

The Department of Employment, Education and Training will provide \$968 million in 1994-95 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 DEET's support for the research activities of higher education institutions is provided through operating grants which cover a substantial part of the cost of training postgraduate research students, research infrastructure costs, and internal research funding. In 1994-95, institutions have been notionally allocated \$313 million for research training and \$210 million 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 \$130 million in 1994-95 is provided by DEBT as operating grant funding for the research schools and centres of the Institute of Advanced Studies at the Australian National University, except for the John Curtin School of Medical Research which is funded through the Department of Human Services and Health.

Targeted Research Programs

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

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 1994-95, around \$312.8 million (over and above the operating grants components) will be allocated under the Department's research support programs, as follows: \$119.6 million for Research Grants (including Large, Small and Collaborative Research Grants); \$21.9 million for Research Fellowships; \$69.5 million for Postgraduate Awards; \$13.9 million in

Overseas Postgraduate Research Scholarships; \$18.9 million for Research Centres; \$57.8 million for Research Infrastructure; \$3.1 million for the Anglo-Australian Telescope Board; and \$2.0 million for grants to the learned academies and ANZAAS for research evaluation.

DEET administers the Targeted Institutional Links Program (TIL) and the Research and Development Internships in Asia Program (RDIA). The TIL aims at stimulating academic 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 1994-95, \$1.4 million will be allocated under this program.

The RDIA aims to promote Australian research and development capabilities through the development of long term collaborative links between Australian research institutions and commercial research organisations in the Asia Pacific region. It supports internships in international industrial research organisations by providing airfares, salaries and a package of allowances to researchers from Australian institutions to undertake an industrial internship in commercial research institutions in Asia. A budget of \$0.3 million is available in 1994-95.

Advanced Engineering Centres

DEET 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 1994, 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 1995 and 1996. The higher education and industry partners also contribute to establishment and operating costs.

MAJOR RESEARCH ACTIVITIES

Higher Education Operating Grants

The role of this major DEET program is 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.

Research Grants

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.

Research Fellowships

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).

Research Centres

This program supports 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.

Australian Postgraduate Awards and Overseas Postgraduate Research Scholarships

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.

Under the Australian Postgraduate Awards (APA) scheme, students are exempted from HECS. In 1994, 16 700 Equivalent Full-Time Student Units (EFTSU) are covered for HECS exemption under this scheme. In 1995, 18 300 EFTSU will be covered. In addition, 1 375 new students each year are given awards which provide stipends. These awards with stipend are tenable for up to two years in the case of a Masters student, or three and a half years in the case of a student undertaking a PhD. Most APAs are allocated to students undertaking research, but institutions are also able to offer Awards to students undertaking postgraduate study by course work.

Research Infrastructure

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

There are three components of the program:

- Research Infrastructure Block Grants (Mechanism A) are 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) are provided to institutions with advanced education components in specific areas of identified research strength or potential.
- Cooperative Research Infrastructure Development Grants (Mechanism C) encourage institutions to develop cooperative arrangements among themselves, across the higher education system as a whole or with organisations outside the higher education sector. Although Mechanism C grants are intended primarily to support large scale cooperative initiatives involving two or more institutions, applications from individual institutions for whom collaborative arrangements are impractical or inappropriate are eligible from 1994.

In 1995, Mechanisms A and B will be consolidated to form the Research Infrastructure (Block Grants) Program which will allocate funds on the basis of an institution's score on the composite research index.

Recent Achievements

Research activity in universities is supported by all of the above programs as well as funds from other sources including Commonwealth Government agencies, State Governments, business, private non-profit organisations and international sources. Any given group of researchers is likely to receive support from several sources, including more than one DEET/ARC program. The recent research achievements listed below have all benefited from DEET/ARC research support programs and are arranged by major field of research of the Australian Standard Research Classification. Given the increasingly multidisciplinary nature of research and technology, some

activities would involve major inputs from more than one major field of research. Given that, in this instance, the researchers themselves have not had the opportunity to indicate the appropriate field of research classification, some editorial judgement has been exercised in classifying the achievements by attempting to identify the field in which the major part of the research has taken place.

Mathematical Sciences

Statistical model for AIDS survival

Research work in the University of Adelaide's Department of Statistics is focusing on vital AIDS modeling and prediction issues. Statistical models have been developed which accommodate important aspects of the natural history of HIV disease, and other special features, such as changes in the Australian Government's policy on treatment availability.

To date, the research has established that there was a significant improvement in AIDS survival following the widespread introduction of the drug zidovudine in Australia in mid-1987, but that further changes in treatment policy, making the treatment available at an earlier stage of the disease, is not helping people with HIV/AIDS live longer. Such research is important because health-care planners need to ensure that adequate treatment and other resources are available for those requiring special care, and the affected individuals need to plan for their own futures.

Physical Sciences

Noise reduction in optics

A joint research project between the Australian National University (ANU) and the University of Queensland has led to a breakthrough in the control of quantum noise in light using feedback. Such noise places limits on the performance of optical devices such as lasers, and laser based measurements. For example, it limits the smallest quantity of pollutant that may be measured. Standard engineering approaches to feedback do not work for quantum noise. An Australian Postgraduate Award student working on the project at the University of Queensland has discovered a quantum theory of feedback perfectly suited to optical problems. This theory is now being put to the test in the laser laboratories at ANU. In this project, several alternative experimental techniques have been successfully demonstrated and their practical applications in interferometry and spectroscopy can now be investigated.

Semiconductor nanostructures

The inevitable drive towards miniaturisation of semiconductor devices (through the market requirements of faster switching speeds etc) has led to the development of semiconductor nanostructure devices with atomic-scale features. A Postdoctoral Research Fellow at the National Pulsed Magnet

Laboratory at the University of New South Wales and his colleagues are undertaking an extensive investigation of nanostructure devices aiming not only to uncover the physics and limitations of the progressively smaller electronic structures, but also to explore and exploit new operating concepts. The research team is using sophisticated optical and electronic techniques to study advanced semiconductor structures at very low temperatures and in intense magnetic fields. Optical signature of electron gas, liquid and solid phases (regarded to be new states of matter) have been identified in gallium-arsenide based structures and an electron liquid-solid phase boundary has been mapped.

Galactic surveys

The past year has seen the completion of the Molonglo Observatory Synthesis Telescope surveys of the Large and Small Magellanic Clouds by astronomers at the University of Sydney. Over three thousand previously unknown radio sources have been catalogued, and the most interesting of these are being investigated using other telescopes. The results have been carefully inspected for evidence of supernova remnants, and the number of confirmed or suspected remnants has been increased by 50% over previous counts.

Silicon solar cells

The silicon solar cell research group at the Australian National University has a program aimed at a reduction in the cost of solar modules. About half the cost of a photovoltaic module is the silicon wafer. The focus of the program is to reduce wafer cost while increasing cell efficiency, ie, the electrical energy output from a given input of solar energy. The project involves growing thin (50 micrometre) layers of silicon by a process known as Liquid Phase Epitaxy (LPE) on thick low cost, low quality silicon substrates. Solar cells are then fabricated in the high quality epitaxial layer. In this way the amount of the pure silicon required for efficient solar cells can be reduced. Smooth LPE grown layers of silicon have now been developed with increased efficiency. The research group has produced cells with efficiencies of around 14%.

Physics of complex structures

University of Technology, Sydney (UTS) researchers in Applied Physics have opened up a whole new class of structures to guide the direct solution of one of the central equations of mathematical physics, the Laplace equation. Transport of heat, electron or ion current, optical and magnetic properties and fluid flow depend on solutions of this equation. Traditionally direct analysis has been confined to just 12 simple geometries which can be defined by individual coordinate systems. Complex numerical methods are needed for other geometries and structures. These UTS researchers have used a three dimensional mapping which is formally expressed in terms of a three dimensional or hypercomplex variable. Several previously unsolved problems have been solved and more solutions are likely.

Chemical Sciences

New mass spectrometer

Researchers at the University of New South Wales have developed an innovative mass spectrometer which targets a wide range of applications in chemical analysis. The new device offers higher speed, sensitivity and resolution over conventional approaches in chemical analysis of environmental and biological samples. Ions from a sample are formed in a parallel beam which is subjected to pulsed orthogonal acceleration towards a detector. The arrival time of ions at the detector reveals the chemical composition of the sample. The mass spectrometer has been licensed exclusively to GBC Scientific Instruments Pty Ltd (Melbourne), an Australian owned company, which is commercialising it.

Buckyballs bonanza

Buckyballs are large molecules of carbon called fullerenes. They are named after Buckminster Fuller, the inventor of the geodesic dome which the buckyballs resemble in shape. Researchers at the University of New South Wales (UNSW) first detected fullerenes generated from coal. These researchers have now perfected the techniques for making fullerenes and their chemical compounds, in order to develop the anticipated high-tech materials derived from them. In the process they discovered that suitable treatment of blue-green algae residues could lead to buckyballs with metal atoms trapped inside. Such metallo-fullerenes would be unlike any other metal-carbon based substances. More recent research at UNSW has prepared fullerenes attached to hydrocarbons and other significant chemicals, generating ball-and-chain molecules which are being investigated for their interactions with light and electrons.

Advanced mineral products research

The Advanced Mineral Products Research Centre at the University of Melbourne has a special interest in the physics and chemistry of particles suspended in liquids. In the past year, the Centre has made progress in:

- Development of a quantitative link between surface forces between particles and the flow characteristics of particle suspensions. This is of importance to a wide range of processes, in particular, filtration, grinding and dewatering.
- Development of a link between the action of molecular additives and the compression of particulate fluids. This is of importance to the disposal of wastes and water recycling in the minerals and pigment industries.
- Significant advancements in the measurement of the forces of interaction between particles. This provides a route to a quantitative rather than empirical understanding of a large number of industrial processing problems.

Helical molecules

An Australian Postgraduate Award holder at the University of Sydney has been involved in a project concerned with the design and synthesis (molecular engineering) of helical molecules. She has succeeded in

preparing an extensive series of compounds in this family and has studied their physical properties. Besides the intrinsic importance of this study in chemistry, particularly as regards non-bonded interactions, there are very promising implications in the field of display devices.

Earth Sciences

Climatic change Atlas

The Climatic Impacts Centre at Macquarie University has produced an Atlas of the effects of climatic change due to the greenhouse effect. The Atlas is the "first fruit" of an international project to assess climate model projections. The Macquarie-led analysis team produced the Atlas from comparisons of modeling results coordinated by an international consortium established to advance the understanding of policy issues related to greenhouse-induced climatic change. The Atlas graphically displays the likely global rainfall patterns and temperature variations with different levels of carbon dioxide, the main greenhouse gas.

Flowing waves of destruction

Research in the Department of Earth Sciences at Monash University, into volcanic eruptions, has elucidated important information and insights on the phenomenon known as the pyroclastic flow. This is a lethal wave of hot ash and gas that can move across land and sea, leaving a trail of destruction. Much of the present research has concentrated on what happens when a gas-rich flow of ash comes into contact with a significant body of water. In a major eruption, the gas and ash column is impelled by the force of the explosion to great heights. When that momentum begins to wane, the column continues to rise from convection as it entrains air from the atmosphere around it, heating it up to 600 degrees C. If the column becomes overloaded with solids and is denser than the atmosphere, it collapses, producing pyroclastic flows, which acquire mobility from the continued expulsion of gas from the ash particles. This research provides greater insight into Australia's mineral wealth much of which is locked in ancient volcanic successions which have spanned the past 4 000 million years.

Mapping mineral deposits

Stress mapping is a relatively new technique applied to definition of sites of low mean stress which are commonly zones of increased hydrothermal fluid flux in the Earth's crust. The methodology is potentially of great benefit in the exploration for minerals. Recent studies at the Key Centre for Advanced Mineral and Materials Processing at the University of Western Australia, in collaboration with an industry partner, have demonstrated field relationships between economic mineralisation and zones of heterogeneous stress in gold deposits in Western Australia.

In other studies, two Australian Postgraduate Award holding research students at the Key, Centre have developed the use of Geographic Information Systems (GIS) in assessing the prospectivity of mineralised zones on both a regional and mine scale. These studies are among the first

applications of GIS to solution of problems in economic geology in Australia and have the potential to improve our exploration and mining competitiveness.

Ion microprobe

Researchers at the Research School of Earth Sciences of the Australian National University have designed and constructed a unique analytical facility called a Sensitive High Resolution Ion Microprobe (SHRIMP). The instrument has unique performance in obtaining accurate isotopic analyses of small parts or zones of individual mineral grains. This ability enables accurate radiometric dating of minerals, including different events in their growth history. There are many other applications in isotope and trace-element studies at the sub-millimetre scale in earth sciences and in material science. This has led to a commercial enterprise through the university's commercial arm, ANUTECH, in which an instrument (SHRIMP II) was built and sold to Curtin University of Technology, WA, in 1993 and a further instrument is under construction for the Canadian Geological Survey.

Use of satellite imagery in reef studies

Research on the Great Barrier Reef has shown that satellite imagery from the Landsat TM5 sensor, originally designed for mapping vegetation cover and land use, can be used to monitor algal growth on reefs, and water quality. The satellite data is archived by the Australian Centre for Remote Sensing (ACRES). ACRES is extending its database by acquisition of images through newly established links with NASA and collaboration with Griffith University and the Great Barrier Reef Marine Park Authority.

Carbon sink

The Environmental Biology Group at the Research School of Biological Sciences of the Australian National University with collaboration from the Centre for Resource and Environmental Studies and colleagues in the United States has identified the processes controlling the oxygen isotopic composition of atmospheric carbon dioxide. Vegetation has a key role, as do the oceans, but their isotopic signatures differ. Further, the Group has shown that latitude and type of vegetation have a strong effect on the vegetation signal. The work shows how it will be possible to identify the so-called missing sink for atmospheric carbon dioxide - the discrepancy in the global budget when known fossil fuel burning is compared with the increase in atmospheric levels plus the estimated flux into the oceans. The Group suggests that the biosphere is that sink, and that studies of atmospheric carbon dioxide levels, together with the oxygen and carbon isotope ratios, will distinguish between, say, tropical forests and boreal forests, as the main component. The techniques may also be useful for monitoring compliance to agreed measures for reduction of green house gas emission.

Information, Computers and Communication Technologies

Improving software quality

Researchers at Macquarie University's Joint Centre for Advanced Systems Engineering have developed a computer-based "toolset" and new methods for improving the quality of software. The Macquarie "toolset" software is able to rigorously assess a company's software development process. It will prove very useful in augmenting quality standards. Field trials with a major software developer are under way.

Testing electronic security codes

Collaboration between the Information Security Research Centre and the School of Mathematics at Queensland University of Technology has resulted in the development of a new PC package for testing the strength of cipher codes used in information security systems. The menu driven package, called *Crypt-X*, uses statistical techniques to appraise various properties of block or stream ciphers. The package has attracted international interest and has been sold around the world, subject to export approval from the Department of Defence.

Regional supercomputer network

The University of Melbourne and the Royal Melbourne Institute of Technology (RMIT) have collaborated to establish and maintain a high performance computing facility of regional and national significance, the 'Ormond Supercomputing Facility'. The two institutions have developed courses in applications of supercomputing to research and industry problems and deliver these courses to research groups and individuals nationwide. All Victorian universities are collaborating to design and establish the high speed Victorian Regional Network, providing continued efficient access to regional and national facilities. A very high volume electronic storage system is being established to provide researchers storage of and access to library research materials, research data and information via the established high speed networks. Evaluation by both the University of Melbourne and RMIT confirms that enhancement of systems currently at both institutions provides the highest quality of service. A new shared facility providing very high volume storage of library material and research data is being introduced.

Database service for molecular biology

The Sydney University based Australian National Genomic Information Service (ANGIS) was officially established in April 1991 to assist in research and development in molecular biology and biotechnology. The service is accessible Australia wide through the Australian Academic and Research Network (AARNet). At present the Service maintains nearly forty separate databases of use to the molecular biology and biotechnology communities which are updated through world-wide computer network links. Computer software, some 250 programs, have been developed, obtained and updated to assist those engaged in research and development to retrieve information, analyse their data and to compare their findings with that in the databases.

Currently ANGIS has a total user population exceeding 1 500, and on any given working day upwards of 350 researchers utilise the service. It has gained a world-wide reputation in information processing in molecular biology. The Service's quality and accessibility is such that research workers and research students have a facility equal to any available throughout the world.

Computer designed joint replacements

Using its sophisticated computer imaging equipment the Centre for Medical and Health Physics at Queensland University of Technology has developed a system to transfer complex data sets derived from CT scans to allow the construction of "custom-made" prostheses and medical models. The models are made by stereolithography equipment which uses lasers to generate plastic models from within a bath of liquid polymer. The value of computer-designed prostheses and models to surgeons and their patients is accuracy. The technique lends itself particularly to hip and other joint replacements, and facial reconstructions.

Applied Sciences and Technologies

Surface analysis

The Surface Analysis Facility within the University of New South Wales has developed a multidisciplinary approach to surface science and its application throughout all areas of science and technology. The facility has developed a state-of-the-art range of facilities for nationwide access to both industry and universities. Outcomes of recent research include improved adhesion of thin film polymeric coatings, development of efficient single source chemical vapour deposition of thin film semiconductors and improvements in the characterisation of oxide materials for use in optical fibres. In addition, such a multidisciplinary approach has resulted in the formation of a successful problem solving service to industry.

Infrared detector technology

Researchers at the University of Western Australia have developed the technology to fabricate state-of-the-art detectors of infrared photons. These detectors use the high purity semiconducting alloy, cadmium mercury telluride. Research is currently focused on optimising detection performance by investigating fundamental detector noise phenomena and using multilayered structures grown by advanced growth techniques such as molecular-beam-epitaxy (MBE). Devices have been fabricated for the Defence Science and Technology Organisation (DSTO) and have been tested in a unique infrared camera system. Collaborative work is also in progress with Fermionics, USA, to develop a new generation of detectors. The application of infrared detectors is pervasive and includes surveillance, medical imaging for tumours and arthritis, remote sensing of agricultural and mineral products, optical fibre communication, astronomy and fault in power systems.

Light guiding light

Members of the Laser Physics and Optical Sciences Centres in the Research School of Physical Sciences and Engineering at the Australian National University have collaborated to demonstrate a practical way of guiding of light by light as a route to developing very fast all-optical circuits for advanced optical communications systems or optical computers. To implement the concept, it will be necessary to devise novel non-linear optical materials suitable for processing into low loss planar waveguides. Further collaboration with the Research School of Chemistry to develop suitable organic materials is now underway.

Nanocomposite materials

University of Technology, Sydney researchers have developed special vacuum deposition techniques which enable them to produce a new class of thin film material. These materials are called nanocomposites because they involve very small particles embedded in another matrix. Their special properties arise because the inclusions are distributed in a non-random manner in the matrix. The type of clustering that occurs leads to large enhancements in optical and electrical response. This new technology has been proven in the development of a special type of window suited to warm climates.

Superconducting materials

Superconductivity is an important new field of high technology. Major features of super conductors include zero electrical resistance and the ability to tap or exclude very large magnetic fields. The superconductivity team at the University of Wollongong is supported by DEET/ARC Fellowships, Australian Postgraduate Awards and Overseas Postgraduate Research Awards. The team has achieved high critical current density of 40,000 Amp/cm² for short sample and 10 Amp/cm² for 50 meter Bi-based superconducting tapes, comparable with the best results from Japanese industry. Metals Manufactures Ltd, which has supported this research since 1987, has now decided to transfer the technology to industry through the building of a pilot plant.

Flora from the foundry

Research by an Australian Postgraduate Award (Industry) student at the University of Wollongong, with BHP as the Industry partner, has been examining growth of plants in iron- and steel-making waste products. This research has shown that, although some combinations of waste products are able to sustain good plant growth, different plant species respond differently. In particular, "soil mixes" which include bioremediated oil produce good growth of crop plants (lucerne) but growth of native plant species is impeded. Current work is examining the development of physical and chemical soil characteristics in artificial soils of varying ages since planting out.

New biomedical materials

Supported by a Queen Elizabeth II Fellowship and separate DEET/ARC funding, a research team at the University of Wollongong has invented a new class of materials: conducting polymer-hydrogel concepts. These patented

materials are attracting world-wide attention. They are currently being trialed as cell culturing substrates and as new haemocompatible surfaces. The team have also been involved in the development of:

- new polymer processing technologies with the University of Technology, Sydney, where a prototype continuous production model has been developed;
- new colloidal production techniques;
- a new patented biosensing technology that is attracting world-wide attention;
- a new chemical sensing technology about to be licensed to a US company; and
- a new membrane separation technology currently attracting support from Australian industry.

The vanadium battery

The vanadium redox battery falls into the general class of flow batteries employing solutions to store the energy and a cell stack where the energy conversion occurs. Flow batteries have the advantage that they can be mechanically recharged by exchange of electrolyte. The vanadium battery developed by researchers at the University of New South Wales (UNSW) has the added advantage that the positive and negative electrolytes cannot cross contaminate each other. Consequently, the vanadium battery will have a low impact on the environment with virtually 100% recycling being possible. A Mitsubishi consortium has been licensed by UNSW's commercial company UNISEARCH for use of the vanadium battery in load levelling applications. The agreement includes a commitment by Mitsubishi to contribute research funding to on-going battery research at UNSW. In another collaboration, the Thai Gypsum Products group has been licensed to use the vanadium battery with solar power in dwelling applications. UNISEARCH has recently entered into an agreement with Australian energy and power interests to undertake an extensive assessment of the viability of establishing an Australian based business to manufacture and distribute vanadium battery load leveling systems to the Asian region.

Engineering

Fuel efficient burning technology

Fundamental research into fluid mechanics in the University of Adelaide's Department of Mechanical Engineering has led to the discovery of the flow phenomenon known as the 'precessing jet'. With further work exploring possible configurations of the jet, a configuration useful for a natural gas burner has been developed. A Fellow of the University further developed the jet and, in collaboration with an industry partner, Adelaide Brighton, the jet has been used in cement kilns resulting in increased energy efficiency and reduced pollution (oxides of nitrogen emitted from the stack are reduced by two thirds). Laboratory tests and industrial trials conducted by the

University and Adelaide Brighton have found the technology to be more fuel efficient and more environmentally friendly than existing gas-fired burners in rotary kilns.

Ground penetration radar

Research at the University of Queensland using radar has produced images of a variety of objects buried in a test pit and demonstrated that a boundary between coal and shale layers can be detected. The radar may also be used to accurately control the cutting depth of a coal mining machine for more efficient operation. The research has led to a collaborative project with industry partners, and has attracted funding of \$2 million for a 3 year project.

Water engineering

Research at the University of Queensland has provided a better understanding of the mechanisms by which plunging water jets entrain air bubbles. Plunging liquid jets are important phenomena in civil engineering works, eg at weir overfalls, drop structures, dam spillways, cascades, and dissolved oxygen enhancement works. They are used in chemical and environmental engineering studies and they are found in nature, eg waterfalls, breaking ocean waves. Through this research, the design of civil engineering works can now be optimised to enhance or reduce air entrainment as desired, and to control the downstream water quality. The research has attracted a large grant commencing in 1994, and the attention of other researchers in Australia, Japan, and Taiwan.

Disposing of bauxite residue

Australia is the world's largest producer of alumina. Associated with the production of the alumina by the Bayer process is the generation of enormous quantities of a waste product, bauxite residue, called red mud, typically as much as 10 000 tonnes per day. Traditional practice has been to pump red mud to settling ponds, which can be as large as 150 hectares at a concentration of 25 percent by weight solids. Because of the low concentration of solids and high pH of the liquid, the bauxite residue can present a considerable environmental hazard. Techniques have been developed by a research group at the University of Melbourne for measuring the non-Newtonian flow properties of highly concentrated bauxite residues for the disposal of bauxite residue at concentrations in excess of 50 percent. Further developments allow much of the waste caustic to be recovered and a dry solid produced, significantly contributing to the minimisation of adverse environmental effects of bauxite residue disposal.

Offshore platforms - foundations

In the regions off the coast of Australia where hydrocarbon resources are being developed, the seabed soils consist primarily of calcareous sediments. These are very compressible and provide poor support for the foundations of offshore platforms. Research at the University of Western Australia has led to new conceptual models for the behaviour of both shallow (gravity-base) foundations and piled foundations, with particular emphasis on foundation response under cyclonic storm conditions. The research has been of

immediate benefit to industry, contributing to the successful foundation treatment for the recent Goodwyn A gas-production platform on the North-West Shelf.

Electronic controller

Researchers in the School of Electrical Engineering at the University of Technology, Sydney have developed a new electronic variable speed controller for low power AC motors. Its features of wide speed range, input current distortion lower than international standards, and suitability for single-phase supply, come at low cost and with high reliability. Local companies are currently assessing cost and performance. The control method has been patented in Australia, USA and Japan.

New use for polystyrene waste

University of Technology, Sydney researchers, assisted by Australian Postgraduate Award (Industry) funding, have developed a lightweight concrete using expanded polystyrene from the waste generated by the packaging industry. The research has shown that the polystyrene aggregate concrete is capable of absorbing considerable impact energy, allowing the use of marginal natural aggregates and suited to the construction of sandwich structural elements with ferrocement skin. This research has resulted in an innovative method of disposing of large quantities of expanded polystyrene boxes and packing materials.

MINECOM

An Underground Mine Communication System (MINECOM) has been developed by a research group in the School of Electrical and Computer Engineering at Curtin University of Technology. MINECOM is an advanced mobile communication system capable of simultaneous transmission of voice, data and video signals in underground mines. A commercial partner (Transcom Pty Ltd) is currently examining the feasibility of commercialising the system, which can be used in any underground mining situation. This research has been supported by DEET/ARC programs as well as by the Australian Mineral Industry Research Association.

Aircraft engine design

Researchers from the University of Technology, Sydney and the University of Tasmania have obtained highly significant results which are being used in the aerodynamic design of the fans, compressors and turbines of new generations of engines for large, long-range transport aircraft. Related work on turbulent spots, which constitute the principal physical mechanism of transition from laminar to turbulent flows, has been of a more fundamental nature. These joint projects between the two universities have received funding from the DEET/ARC Large Grants Program and from Rolls-Royce.

Warning system for mine collapse

Researchers at the University of Technology, Sydney have developed an intrinsically safe, highly accurate ultrasonic distance measuring system to measure the gradual sag of the roof in underground coal mines. The system can operate unattended, in conditions of high environmental noise and coal dust, as met in a working mine, and allows continuous remote monitoring of

the roof sag from the surface of the mine. If an excessive sag is detected, immediate measures can be taken to prevent loss of life and damage to expensive mining equipment. The prototype of the convergence transducer has been successfully tested, and series production of the instrument is envisaged before the end of 1994. A number of coal mines in Queensland and NSW have expressed interest for this instrument.

Biological Sciences

Manufacture of pharmaceuticals using plant cell cultures

Research at the University of New South Wales is paving the way for a new approach to commercial pharmaceutical manufacture. At present, pharmaceuticals of plant origin are obtained by extraction from raw plant material. This method is limited by seasonal and geographic factors so that many plant-derived drugs are in short supply worldwide. A biotechnological alternative is production of chemicals using plant cells cultivated in large-scale reactors. Recent research at UNSW with a range of medical species including Australian natives has identified the engineering factors important in design and operation of plant-tissue reactors. Work with several vessel prototypes has shown that product levels at least as high as in the plant can be achieved with better control over product quality and quantity.

Transport in fungi and plant nutrition

Fungi can be beneficial in transferring phosphorus from the soil to plants. Understanding this process is important to phosphorus conservation and biological sustainability, given the low phosphorus soils of Australia. A team of researchers at the University of New South Wales have discovered a system within these fungi that transports phosphorus from the uptake sites in the fungus. This raises exciting possibilities that it may also be responsible for long distance transport through the fungus to the plant root surface, providing a "fast transit lane" for phosphorus that by-passes the slow diffusion across the soil.

Genetics and molecular biology of the Queensland fruit fly

The Queensland fruit fly (Q-fly) is the major pest of east coast orchards in Australia. With current objectives of the fruit-growing industries to reduce reliance on chemicals, it becomes necessary to use insecticides as efficiently as possible and to develop methods of biological control. A research team at the University of Sydney has established a laboratory to investigate genetic systems which will aid in the control of Q-fly. The team is at present carrying out a major project to determine the population structure of fruit flies in Australia by "genetic fingerprinting". Several highly variable DNA sequences have been identified and have been shown to be suitable for typing individual flies from different areas. Flies have been collected from all over Australia by members of CSIRO's Double Helix Science Club and sent to the research team. The samples have been sorted and have already yielded important information for Plant Quarantine. Other work by the research team has included the cloning and sequencing of genes which

determine eye colour in flies, the selection of an eye colour mutant strain with orange eyes, the mapping of chromosomes of the fly, and the identification of some transposable DNA elements. These results will be useful in the future for designing effective biological control strategies, based on sterile insect release.

Fish endocrinology laboratory

A fish endocrinology laboratory has been established in the Department of Aquaculture at the University of Tasmania in 1994. The laboratory is the first of its type in Australia and will be used for fish reproduction studies by universities and all State fisheries departments throughout Australia. The laboratory will provide a focus for the developing aquaculture industry.

The private life of the fairy-wren

Researchers at the Australian National University have used the remarkable mating system of one of Australia's best loved birds, the superb fairy-wren, to uncover some basic rules that regulate the genetic and social structure. Fairy-wrens live in cooperative groups, where one to five males share a territory with a single female. The oldest, dominant male in the group punishes the young males if they do not feed the chicks, to the extent that they actually feed the chicks more than the dominant does. When the female lives in a pair, she allows her partner some paternity, apparently to encourage him to continue to care for her young. However, the young helper males in a group provide her with an alternative source of care, allowing her to cuckold all her social group. Instead, females mate with a small number of highly attractive males in nearby territories. Thus although all males help feed and care for the offspring on their territory, none of them sire the young they help rear. These data suggest that the benefits of female choice of genetic quality in males may be general, but only available when she can ensure continued care for her young.

Australian marine research

Researchers at the University of Wollongong and James Cook University and their Australian Postgraduate Awards funded students are using a combination of genetic and ecological approaches to:

- quantify levels of genetic variation within marine populations,
- determine the mating systems of marine organisms,
- determine the connectedness of marine populations (levels of gene flow and capacity for dispersal), and
- determine the importance of genetic variation for the survival and reproduction of these organisms.

Results have now been obtained for a range of temperate invertebrates and tropical corals and have applications to the management of Australian marine communities.

Rural Sciences

Drying of Australian hardwood timber

Research being undertaken at the University of Sydney into improving the quality of dried timber from Australian hardwoods is aimed at developing new combinations of drying conditions (air temperatures, humidities and velocities) for conventional commercial drying kilns. The basis of this work is to mimic the cyclic conditions which occur in nature. Commercial trials of proposed cyclic drying conditions by a sawmiller in Tasmania have demonstrated that these drying conditions cause less wastage and degradation in the timber than previously-used conditions. The new drying conditions proposed as an outcome of this work result in reduced energy costs compared with conventional continuous drying, since these conditions allow the use of off-peak power. In addition to DEET/ARC funding, this research is being supported by funding from other sources including the Australian timber industry.

Vaccine against tick paralysis

Researchers at the University of Technology, Sydney have succeeded in isolating the neurotoxin from the Australian paralysis tick, *Ixodes holocyclus*. They have recently received support from a local company to develop a vaccine to protect domestic and companion animals from the lethal effects of the tick neurotoxin. Tick paralysis is a major veterinary problem on the east coast of Australia causing an estimated 80 000 clinical cases involving dogs, cats, horses, calves and other animals each year.

Medical and Health Sciences

Brain research in sensation and perception

Brain research at the University of New South Wales has led to a revision of the concept that there are fundamental differences between primates and other mammals in the organisation of the cerebral cortical neural networks involved in sensory and perceptual processing. In each of the major sensory systems of the brain, in particular those for vision, touch and hearing, the sensory information is conveyed over the neural pathways of the brain in the form of coded patterns of nerve impulses. The impulses are distributed to a number of different sites within the cerebral cortex at which sensory and perceptual processing takes place. The principal sites for the sense of touch within the cerebral cortex of primates were thought to be organised in a strict hierarchical progression for the sequential processing of the coded sensory signals. However, the University of New South Wales studies demonstrate that these cortical target areas are each supplied directly by independent neural pathways that arise in the upper brain stem and project in parallel to the cortical target zones.

The results mean that sensory processing in the primate takes place simultaneously and in parallel at a number of spatially distributed neural networks in the cerebral cortex. Previous work from this research group has

shown how this operates in the cortex of non-primate mammals. The work establishes some of the fundamental mechanisms for sensory and perceptual processing within the cerebral cortex. It may therefore bring us closer to understanding those perturbations of perceptual mechanisms that are associated with certain psychiatric illnesses.

Flu cure in sight

Scientists at Monash University's Victorian College of Pharmacy and the CSIRO have synthesised a potent new drug that may cure and prevent all new and existing forms of the influenza virus. The economic impact of an effective drug to combat influenza would be of major significance. The drug has been tested successfully on ferrets, a species highly susceptible to human influenza viruses. All strains of the influenza virus possess a pocket-like feature that never changes. The research team set about custom designing a compound that would jam itself tightly into the pocket, neutralising the enzyme and blocking the replication cycle of the virus. The team has synthesised a drug which fitted into the pocket and when tested, was found to bind with enormous tenacity. Further tests are continuing to confirm that the drug will cure, as well as prevent, an influenza infection. Its mode of operation suggests, however, that it prevents infection and should also halt an established infection. Techniques developed during this research will also be used to combat other viral diseases such as AIDS and hepatitis.

Anti-cancer drugs

Research undertaken at the University of Sydney is contributing to the further development of platinum based anti-cancer drugs. While these drugs are most widely used and effective anti-cancer drugs, they have a number of serious side effects. The outstanding effectiveness of platinum based drugs against testicular cancer has prompted the researchers to search for less toxic drugs and drugs active against other cancers. Platinum based drugs kill cancer cells by binding to their DNA. A number of drug/DNA adducts are formed but it is still not known unequivocally which of the adducts is responsible. Work at the university has led to modeling of the adduct believed to be responsible for the anti-cancer activity and has allowed researchers to design new compounds which have the potential to be active against presently resistant cancers. Already, some compounds have been found that are as active as the currently used drugs, but less likely to have serious side effects.

Early detection of breast cancer

Current procedures for the detection of breast cancer involve several days' delay to obtain test results and incur significant costs for pathological tests after initial clinical diagnosis. Researchers at the University of Technology, Sydney have been working on a biophysics project in conjunction with a Brisbane breast clinic to improve the follow up process of assessing mammograms. The method is non-invasive and safe and results can be obtained more quickly at lower cost. It will also help reduce false negative and false positive results.

Disability awareness

The Community Disability and Ageing Program located in the Faculty of Nursing at the University of Sydney has had considerable success with its Disability Awareness Package. It is being used to train employees in government and non-government organisations in every state of Australia. It also is being used in several universities as part of pre-registration education for health, welfare and education professionals. Because of the demand for the package, preparation of a second edition is now underway.

Prevention of brain damage following stroke

One of the most promising areas of study of stroke has been the elucidation of the role of endogenous compounds in the protection of nerve cells following ischaemia. An Australian Postgraduate Award holder at the University of Sydney has recently clarified the role of one of these substances - adenosine - which does play a significant role in reducing nerve cell activity during the initial stages of ischaemia. This work provides a basis for the development of new drugs for use in the prevention of brain damage following stroke.

Child stuttering

Controlled treatment trials for stuttering in children aged 9 to 14 years have been completed in the University of Technology, Sydney. The research was designed to evaluate the effectiveness of treatment for a child development disorder that has proven difficult to manage. The results have demonstrated that many children who stuttered severely prior to treatment, can be successfully treated after one week of intensive intervention. Results have shown that at least 80 percent to 90 percent of stuttering can be eliminated. This research has potential for at least two reasons. First, the interventions investigated can be made available to community clinicians so that all children who stutter can benefit. The second, is the obvious potential increase in quality of life for the parents and child.

Detection of cancer promoting compounds

The overwhelming majority of human cancers are probably caused by at least two factors in the environment. The first environmental factor damages the DNA of the cell and alters its genetic composition; the second increases the probability that a cell which has been genetically damaged will develop into a cancer. Agents which do this are referred to as promoting agents. Over the past decade, researchers at the Flinders University of South Australia have been studying the mechanisms by which promoting compounds or potentially promoting compounds can influence the behaviour of cells. The information gathered during this process has fundamental implications for cell biology, but should also enable identification of potentially promoting compounds in the environment, and hopefully eliminate some of them, therefore decreasing the risk of some of the major forms of human cancer. One of the significant outcomes of the research has been the development of a test which is being widely used in Europe and North America for detecting promoting compounds.

Social Sciences

Mobile research facility

Research into teaching and learning of numeracy and scientific reasoning from primary to postgraduate levels will be greatly facilitated by the acquisition and fitting out of a special purpose vehicle by Queensland University of Technology's Centre for Mathematics and Science Education, using Research Infrastructure Mechanism A funds. The computerised testing and analysis facilities within the vehicle allow for interviewing and assessment of up to three students at one time, and data collected can be downloaded to a University computer for further analysis after each session. The sophisticated audiovisual equipment ensures a comprehensive record is kept of how students approach different problems. The van's internal environment is designed to make students feel at home and its mobility overcomes the difficulties of finding suitable interview space and setting up equipment at schools, or transporting students to the University.

Non-violent defence

Researchers at the University of Wollongong are studying how science and technology can be used to support non-violent defence. Through interviews and investigation of various disciplines, they have identified some specific areas, such as communications, where science and technology can be used to support non-violent resistance to aggression and repression. Their studies show that replacing military influences on science and technology with a priority on non-violent defence would change the relative funding of disciplines, change the areas considered important within disciplines and change methods of carrying out research.

International trends in science and innovation

The University of Wollongong's Centre for Research Policy (CRP) has shown that the international research and innovation scene is changing fundamentally - with much greater emphasis on webs of personal relations and movement of people than literatures, multidisciplinary programs and centres. CRP's findings have fundamental implications for government policy, and it has been advising the universities and the Australian Government accordingly on:

- university-industry links (in a report launched by Minister Beazley in December 1993);
- quantitative indicators of research (commissioned by the ARC);
- CSIRO's changing culture and management (based on a study of 200 scientists and four divisions);
- Australia's 800 academic research centres and CRCs (in reports to the Prime Minister's Office and to universities).

Plastics industry study

Researchers at the Flinders University of South Australia, with the assistance of a Collaborative Research Grant, have examined the structure of industry training in the SA Plastics Industry and factors leading to technological

change, research and development, competitiveness, export performance and the impact of Government policy on industry performance. The research has produced important results which will benefit industry as well as assist government policy directed at improving performance and international competitiveness. Significant research results include:

- the need to recognise the different characteristics of and opportunities available to firms of different sizes;
- that small firms place a higher priority on practical training in manufacturing rather than on management training. Therefore effective training should be conducted in-house; and
- that firms strongly believe in the role of new technology in enhancing competitiveness but feel that this can only be achieved if skills were upgraded and training undertaken.

The Anglo-Australian Telescope Board

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.

The facilities maintained by the Anglo-Australian Telescope Board include the Anglo-Australian Telescope (AAT) and the UK Schmidt Telescope (UKST) at Siding Spring Observatory outside Coonabarabran, and a laboratory in the Sydney suburb of Epping.

Recent Achievements

The detection of a white dwarf companion

AAT research has enabled the detection of the white dwarf companion to the pulsar PSR JO437-471. This discovery confirmed an expectation that the companions of millisecond pulsars are in fact white dwarfs.

Pulsars have long been known to be very rapidly spinning spheres of pure neutrons, formed when the inner core of a star collapses, probably in a supernova explosion. These neutron stars are extraordinarily small and dense. Typically, a star somewhat more massive than the sun collapses down to a radius of only about 10km, increasing its density by a factor of about 10^{15} .

The neutron star emits a jet of radiation that sweeps past the earth like a light-house beam once per revolution, to make the rapid and very regular pulses observed. Nearly all pulsars have been discovered at radio wavelengths and most are much too faint for direct optical observations. In

fact, only three have been seen optically so far. However, such is the importance of pulsars that every effort is made to learn about their nature and environs from optical observations.

The discovery of the first millisecond pulsar in 1982 sparked great excitement and a new era in pulsar astronomy. In order to emit such rapid pulses, these special neutron stars must rotate even faster, several hundred times per second. Given that a typical neutron star is the size of a city suburb and almost a million times more massive than the earth, such rotation rates are almost unimaginable.

ENVIRONMENT, SPORT, AND TERRITORIES

Science and Technology in the Portfolio Budget

The Australian Antarctic Division has a total budget allocation of \$58 million in 1994-95 (\$64 million in 1993-94). The Division both undertakes and supports scientific research in the Australian Antarctic Territory, the Southern Ocean and subantarctic islands, with priority on the study of global climate change and protection and monitoring of the Antarctic ecosystems.

The Division will support a major marine science program in 1994-95 including marine biology, major oceanographic transects for the World Ocean Circulation Experiment (WOCE), marine geology and sea ice studies using the *RSV Aurora Australis* in the Prydz Bay region and in the Southern Ocean between Tasmania and Antarctica. A feature of this marine research program will be seismic, dredging and coring work in the Prydz Bay and Kerguelen Plateau regions to determine evolutionary and palaeoenvironmental characteristics of the marine environment.

Other research will include retracing the 1993-94 glaciological traverse around the Lambert Glacier Basin to Mawson. This will be to measure changes in ice sheet flux and snow accumulation, further analysis of Antarctic ice cores for atmospheric compositions over the last 15 000 years and initial development of long term data bases on the climatology of the Antarctic middle atmosphere. A diverse program in many other disciplines will continue at each Antarctic station.

The Commonwealth Bureau of Meteorology has been given a total budget allocation of \$116 million in 1994-95 (\$119 million in 1993-94). The Bureau's activities include meteorological research. The Bureau's research priorities to be pursued in 1994-95 include particular emphasis on climate research including greenhouse studies, numerical weather prediction modeling, tropical meteorology, background air pollution monitoring, remote sensing and marine meteorology.

The central office of the Department coordinates research into the greenhouse effect. The Government has allocated \$17.1 million to this activity for the triennium 1993-94 to 1995-96. The priorities for the greenhouse research program are the development of the capacity for regional predictions of climate change, climate modeling, monitoring of sea level rise and the assessment of potential regional impacts.

The development and management of the National Greenhouse Gas Inventory is being overseen jointly by the Commonwealth, and the States and Territories through the National Greenhouse Gas Inventory

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 entry into force of the United National Framework Convention on Climate Change, and contributing to the ongoing discussions leading to the first Conference of Parties to the Conference, scheduled for March 1995 in Berlin. Australian research is also contributing to reducing the 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.

The Department of Environment, Sport and Territories including the Commonwealth Environment Protection Agency (CEPA), and the Land and Water Resources Research and Development Corporation (LWRRDC) are developing the National River Processes and Management Program (NRMP) worth nearly \$11.5m over 5 years. This Program includes nationally coordinated bio monitoring by the states and territories (\$3.5m) which is designed to lead to predictive models for river health. Supporting this bio monitoring are research and development projects (\$3.5m).

The Program also covers investigations into environmental flow requirements of rivers (\$2.6m). Other expenditure includes remote monitoring systems, information delivery and communication, river classification scheme, several reviews on specific issues and administration and program support. The Program incorporates most of the \$10m Monitoring River Health Initiative (MRHI) which was announced in the PM's Environment Statement of December 1992, and LWRRDC is contributing over \$2m.

In December 1992, the Government announced the establishment of a Cooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef (CRC). The CRC has established three research programs, an education program and an extension program. The research programs are:

- a regional environmental program looking at the 'health' of the Reef through further studies of the physics and chemistry of the waters, sediments and nutrients and their effects on organisms;
- an operations program involving tactical research to solve problems associated with the use of reef resources and addressing social issues and tourist activities; and
- an engineering program aimed at developing guidelines for structures on the Reef as well as looking at issues such as groundwater management.

The education program will provide for up to 23 postgraduate awards within the three research programs and a detailed strategic plan is being developed for the extension program. The International Tropical Marine Resource Centre (INTROMARC) located in Townsville (a consortium of AIMS, GBRMPA and JCU), 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).

Within the Land Use component of the Environment program, the Commonwealth and Queensland governments have jointly developed the Cape York Peninsula Land Use Strategy (CYPLUS). The aim of this strategy is:

To provide a basis for ecologically sustainable resource use and management in Cape York Peninsula in accordance with the obligations, responsibilities and objectives of the Commonwealth and Queensland Governments.

Stage I of CYPLUS is to collect information on natural resources, land use and institutional arrangements including cultural resources; the potential for mining, tourism and primary industries; conservation assessment and administration and transport needs and options in the area. Stage II will bring together the information to formulate the land use strategy and stage III will involve the review and implementation of plans and policies. It is expected that stage I will take two to three years.

In addition to the Cape York strategy, the Commonwealth is also working with State and Territory Governments, traditional owners, industry, the farming community and conservation groups to develop a National Strategy for Rangeland Management and Action Plan. A joint Working Group has been established by the Australia and New Zealand Environment Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) to develop the strategy and action plan. An issues paper was recently released for public comment and a series of regional and capital city workshops is being organised.

The Environmental Resources Information Network (ERIN) is establishing a network of environmental information systems for environmental planning, decision making and education. During 1993-94 major achievements included:

- extension of ERIN databases of species distributions to include over 3 million records;
- the development of systems to provide environmental information through the international electronic network (the Internet);
- establishment of an electronic network between Commonwealth and State/Territory nature conservation agencies; and
- development of information system education and training materials.

Within the biodiversity component of the environment program, a number of projects are being undertaken to support the implementation of the draft National Strategy for the Conservation of Australia's Biological Diversity and the early and effective implementation of the Convention on

Biological Diversity. These projects are primarily aimed at filling critical gaps in knowledge and methodologies.

Such projects include pilot testing of rapid biodiversity assessment techniques, development of a national approach for biodiversity monitoring, the application of remote sensing techniques for nationwide monitoring, the development of a bioregional resource information and accounting system, an investigation into changes in biodiversity related to artificial water sources in dry areas, and an investigation into the significance of refuges in arid and semi arid areas of Australia to biological diversity.

The Australian Sports Commission has various research projects to identify methods to assist in improving the performance of athletes. In 1994-95 major research projects will be in the area of athletic competition in humid heat (in preparation for the Atlanta Olympics in 1996); and the development of a carbon fibre bicycle frame and other alterations to design which may be suggested by computer model.

The Australian Heritage Commission has been given a total budget allocation of \$12 million in 1994-95 (\$14 million in 1993-94), including the state and territory components of the National Estate Grants Program (NEGP), for ongoing identification of Australia's natural and cultural heritage and associated activities related to its conservation and presentation. In the 1993-94 NEGP program, 271 projects across Australia received funding, of which 67 were related to ecological, biological and geomorphological survey.

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 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

Measurements of the Antarctic ice sheet

A 2250 km overland scientific survey around the hinterland of the Lambert Glacier, the world's largest glacier, was conducted to provide significant data for estimating the present state of mass budget of this major drainage basin, and for developing computer models of the region to predict its reaction to any future climatic warming. The snow accumulation over the basin and the ice discharge both have the potential to vary as a consequence of changes to climate and to dramatically impact on global sea levels.

Data on ice thickness, bedrock elevation, and surface elevation were obtained from a vast region of Antarctica previously unexplored. Shallow ice cores were obtained to provide a record of short term climate variability, and automatic weather stations were established along the route to provide realtime meteorological data via satellite. Markers were established for subsequent measurement of ice velocity and snow accumulation for the region. This will permit accurate estimation of the mass budget of the total basin.

Krill age analysis

Krill is the key component in the Antarctic and Southern Ocean ecosystem. To determine the age of krill techniques were developed which use measurements of eye size. These techniques are aimed at providing a reliable tool for obtaining more accurate assessments of the age, size and changes in the structure of krill populations. Such information will contribute to more effective ecosystem management models in a region that has major potential for an expanded krill fishery.

Heard Island fish survey

The third and final stage of a comprehensive fish stock assessment program was completed at Heard Island. This involved large scale specimen collection and acoustic analysis of the distribution, abundance and spawning seasons of major commercial fish species. Results from this program are contributing to the management of Australian fishing zones in the sub Antarctic region.

Marine Plain geological survey

Major geological and palaeoenvironmental studies were conducted in the Marine Plain region near Davis station to contribute to understanding the evolution of the environment around Davis over the last 3.5 to 4 million years.

Bureau of Meteorology

Role: *To observe and understand Australian weather and climate and provide meteorological, hydrological and oceanographic information, forecast, warning and advisory 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 modeling.

Research into atmospheric constituents, including the greenhouse gases such as carbon dioxide and methane, is conducted using data from the Bureau's Baseline Air Pollution Station at Cape Grim in north western Tasmania. Research into stratospheric ozone is also performed using data from the Bureau's ozone monitoring network.

Recent Achievements

Global weather prediction system

The global prediction system implemented in December 1992 with major scientific refinements, has been performing well over the last year.

The assessments of extensive experimental trials of a newer and higher resolution system throughout most of 1993 have shown that prediction performance can be further enhanced. The prediction period has been extended from five to seven days. Quantitative and synoptic assessments indicate improved prediction at five days. For the first time, useful forecast guidance is available in the Bureau beyond five days.

Forecasting ocean conditions

Improved forecasts of wave conditions in Australian waters will be possible by understanding the complex physical processes associated with ocean waves in this region of the world, especially with swell waves which travel vast distances across the Southern Ocean. A new Bureau forecast system will provide a more accurate and timely service to a range of ocean users: from tour operators and small boat owners to oil platform and container ship companies.

Analysis of ocean temperatures

A BMRC analysis system has been adapted to give a weekly picture of sea surface temperatures, both globally and in the Australian region. This system is being used as an input to computer models of the atmosphere as well as in monthly assessments of climate state. A second system developed in BMRC analyses temperatures through the upper layers of the ocean rather

than just on its surface. These more detailed analyses are also being used for monitoring and understanding climate variability on seasonal and interannual time scales.

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

Monitoring of Reef health

Longterm monitoring of the status of the Reef is continuing and the collection of repetitive photographs of fixed sites commenced in 1993-94. The use of historical photographs is also being undertaken, and images from as long ago as late last century are being compared with photographs taken at the same sites today. This is being done in conjunction with staff from the Queensland Department of Environment and Heritage who carry out day to day management within the Marine Park.

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

Actinium uptake

Uranium mine effluent water usually contains elevated concentrations of the radionuclide actinium 227 (Ac-227). Standards for the release of waste waters have in the past omitted consideration of actinium, in large part due to the paucity of information on its behaviour in the environment. However, what information is available indicates that its radiological impact on humans is comparable with other important radionuclides.

One of the main barriers to study of actinium has been the lack of a reliable and sufficiently sensitive measurement technique. Such a technique has now been developed by the Office of the Supervising Scientist, and is being applied to a study of the uptake of Ac-227 by fish, fresh water mussels and water lily.

Revegetation

Disturbed mine sites in the Alligator River Region are planned to be restored to native woodland communities. The Alligator River Region Research Institute is undertaking research on restoration techniques, predictive models of ecosystem development and restoration standards to assist mining companies and regulatory authorities.

Vegetation surveys on the Ranger lease area and other sites have been used to identify suitable plant species for mine spoils. Seed collection, storage and germination strategies have been investigated for a number of native species. A field trial was conducted on Ranger mine spoil to demonstrate the use of native grasses in surface stabilisation.

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 principal 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. 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 1993-94 the FPP funded 26 projects for a total of \$1.7 million. The majority of projects are directed at the control of foxes, feral cats and feral goats.

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 1993-94 \$0.9 million was provided for projects in the States and Territories.

The objective of the Research and Surveys Program (RSP) is to gather and maintain scientific, socioeconomic 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 1993-94 \$1.2 million was allocated for projects in those areas (parks) administered by the ANCA.

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 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.

The Grasslands Ecology Program (GEP) was established in 1993-94 with a budget of \$0.1 million over four years. The focus of research activities for the GEP are:

- the identification of important remnant native grasslands and grassy woodlands; and
- the development of strategies in consultation with the States and Territories to ensure their survival.

Recent Achievements

Australian Biological Resource Study (ABRS)

The ABRS coordinates the work of collecting, describing, classifying and determining the distribution of the flora and fauna which comprise the biological diversity of Australia. During 1993-94, grants were awarded for 72 research projects.

A publications program produces high quality reference series on the flora and fauna of Australia. During 1993-94, three major volumes were published:

- *Fauna of Australia* Vol 2A: Amphibia and Reptilia
- *Flora of Australia* Vol 49: Flora of Lord Howe Is
- *Flora of Australia* Vol 50: Flora of Oceanic Island Territories (Christmas Is; Cocos Is; Macquarie Is; Heard Is; Ashmore and Cartier Islands and the Coral Sea Islands)

Australian National Botanic Gardens (ANBG)

The ANBG aims to grow, study and promote Australia's flora. Through its involvement with the CSIRO in the jointly managed Centre for Plant Biodiversity Research, it conducts scientific investigations into the classification, distribution and conservation of Australia's native flora. It manages a large and scientifically documented collection of living and preserved specimens, implements recovery plans for endangered plant species and is active in the development of standards and systems for the storage and exchange of botanical information.

During 1993-94, the ANBG pioneered the use of the World Wildlife Web on the Internet to deliver botanical information. It became the first botanical institution in the world to make its database, textual and graphical information available in this manner.

A major research program of the ANBG involved the classification of the Orchidaceae (orchids), using an integration of conventional morphological techniques and innovative embryological, biochemical and ecological methods to provide new insights.

Australian Heritage Commission

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

This role encompasses the natural and cultural environments, the latter including those of Aboriginals and Torres Strait Islanders and the historic environment. The main focus of the Commission's work to identify the National Estate is through systematic, thematic or regional surveys, where possible in cooperation with relevant state agencies. The Commission is also compiling two national thematic databases to assist in heritage identification.

Recent Achievements

The National Wilderness Inventory (NWI)

Baseline surveys for the NWI, which maps wilderness quality (remoteness and naturalness) for national areas, are now completed for most of Australia. The NWI has received international recognition at the Fifth World Wilderness Congress in 1993; and at the 1994 IUCN General Assembly which acknowledged use of the NWI as a possible basis for a global 'wildlands' mapping program.

Forest regional assessments

As a result of the joint regional assessment by the Australian Heritage Commission and the WA Department of Conservation and Land Management, in March 1994, the Commission placed 75 places in the Southern Forest Region of Western Australia on Interim List of the Register of the National Estate. A refined version of the regional assessment model, developed during the WA project, has now been used in two regional projects in Victoria, ie East Gippsland and the Central Highlands.

FINANCE

Science and Technology in the Portfolio Budget

The Department of Administrative Services (DAS) was incorporated into the Ministry of Finance in March 1994. The administrative arrangements for the Department and its agencies have remained unchanged. Science and technology services are provided through a number of organisations.

The Australian Government Analytical Laboratories operate through the DAS Business Services Trust Account on a fee for service basis. The Laboratories' projected 1994-95 turnover is \$17.5 million, of which \$5.9 million is provided through appropriation for public interest activities.

The Ionospheric Prediction Service is budget funded at \$3.2 million in 1994-95.

The Scientific Services Laboratory (SSL) is part of DAS Australian Construction Services, which operates through the DAS Business Services Trust Account largely on a fee for service basis. SSL offers important advisory services including specialist advice, industry support and export facilitation activities, particularly in the areas of building fire safety, paint technology and security systems.

The DAS Centre for Environmental Management (DASCEM) is a business unit which operates along commercial lines within the DAS Business Services Trust Account. The DASCEM Halon Bank has been established to collect, store, decant and destroy halon. Halon is found in yellow fire extinguishers and fire suppression systems. Although very effective in fire fighting, halon severely depletes the ozone layer. Government organisations and large corporations are required to pay for the collection, storage and destruction of their halon. The Government has provided \$4.6 million over 4 years to subsidise small business and community holders of halon.

The Genetic Manipulation Advisory Committee (GMAC) is a non-statutory body established in 1987 to oversee the development and use of novel genetic manipulation techniques in Australia. This is so that risks to the safety of workers or potential hazards to the community or environment associated with the genetics of manipulated organisms are identified and can be managed. GMAC carries out work previously undertaken by the Recombinant DNA Monitoring Committee (RDMC). GMAC is supported by a Secretariat within the Department and is budget funded at \$496,000 for 1994-95.

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 made significant advances in developing improved analytical methods which minimise the use of environmentally harmful solvents. For example, new methods for the analysis of contaminants in environmental and food samples using supercritical fluid extraction, and for the profiling of narcotic drugs by capillary zone electrophoresis have been developed. Both these techniques offer enhanced analytical capabilities while involving minimal consumption of solvents.

AGAL has applied the technique of direct electrospray analysis by mass spectrometry to the rapid identification of constituents of various drug mixtures and to the rapid and direct detection of toxins in water contaminated by blue green algae.

New applications for polymerase chain reaction (PCR) techniques to allow detection of species substitution of meat, fish or fruit juices have been developed. PCR techniques have also been refined for the identification of pathogenic microorganisms in foodstuffs.

AGAL has also taken a leading role in ensuring the validity of analytical measurements undertaken in Australia. This is important in ensuring that all measurements are fit for the purpose for which they are made. As part of this, AGAL is preparing a series of standard reference materials to be used nationally and internationally in establishing comparability of analytical results between laboratories.

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

Predicting ionospheric behaviour

Changes in the ionosphere are a direct result of the solar terrestrial environment responding to changes in the solar outputs, in particular to the solar wind. A variety of techniques are applied at IPS to predict the future state of the ionosphere given a wide variety of observations of the present state. Two possible improvements in ionospheric forecasting have been investigated. One method makes better use of available magnetic data, using a numerical filter, to produce improved regional forecasts of ionospheric behaviour. The second method investigates data sets that will become more common in the next five years and uses solar wind data to develop prediction filters for translating changes in solar wind features into ionospheric changes. Both methods show promise as potential predictors and can support the current manual forecasting methods.

Scientific Services Laboratory (SSL)

Role: *To provide the Department of 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

Certifire

SSL has entered into a joint venture with a major international company, Warrington Fire Research, to develop a scheme for passive fire protection systems called Certifire. This scheme aims to significantly raise the performance and quality of fire safety systems in buildings and offers easier access to Asian and European markets for Australian passive systems manufacturers.

National fire safety

SSL continues to contribute to the development of the Fire Code Reform Centre and is actively pursuing research into more cost effective fire protection for Australian buildings. This past year has seen the commencement of a major project on fire detection and publication of research findings in the area of smoke control and occupant evacuation. A highlight was the full scale fire testing of a mock up of part of the new Brisbane International Airport.

Appraisal and accreditation

SSL has expanded its national accreditation service for fire equipment to include gaseous fire suppression systems and fire fighting foams. The SSL Register of Accredited Products has been recognised in the Building Codes of Australia. SSL has been pushing ahead with mutual recognition agreements with other major fire equipment listing agencies and hopes to conclude agreements with China, Malaysia and Canada in the near future.

Genetic Manipulation Advisory Committee (GMAC)

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

Recent Activities

Planned release of genetically modified organisms

During 1993-94, GMAC assessed an increased number of proposals for the planned release of genetically modified organisms into the environment. These proposals were developed and assessed within planned release guidelines developed by GMAC. These guidelines were developed in the light of the Government's response to the report by the House of Representatives Standing Committee on Industry, Science and Technology, *The Threat or the Glory?*

HUMAN SERVICES AND HEALTH

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 \$125.5 million in 1994-95 (\$118.5 million in 1993-94). The AIDS research program will be \$12.1 million in 1994-95 (\$11.6 million in 1993-94).

In 1994-95, ARL expects to spend around 50% of its total budget of \$5.5 million on research and development.

The appropriation to the Australian Institute of Health and Welfare for 1993-94 was \$7.3 million.

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 1,555 research projects, as well as providing block funding for five major research centres and institutes.

Recent Achievements

Prevention of cardiac arrhythmia

Heart arrhythmia, rapid useless contraction of the heart, is the common cause of death after a coronary thrombosis. Researchers at the Baker Institute and Alfred Baker Medical Unit in Melbourne have simulated heart attack in rats. They have shown the heart releases a phosphorylated lipid which is normally part of the within cell communication. This release can be prevented by neomycin, better known as an antibiotic. Drugs based on neomycin would represent the first real advance in treatment of arrhythmia in fifteen years. The advance, and its possible therapeutic implications, have been patented by the Baker Institute.

Osteoporosis

Osteoporosis is a major and, as the population ages, an increasing health care problem in western countries. Up to 60% of women suffer osteoporosis fractures resulting from low bone density. A significant and increasing number of men are also struck by the debilitating disease. In Australia during 1992, hip breakages affected 14,000 people and cost \$300 million. Researchers at the Garvan Institute have identified the gene primarily responsible for determining bone density. This discovery not only allows identification of an individual's susceptibility to osteoporosis and those at risk of bone fracture, but will lead to new approaches to prevention and treatment of osteoporosis.

Asthma

The prevalence of asthma is increasing in all countries and appears to be related to changes in lifestyle. The predisposition to asthma is inherited but the condition is induced by environmental factors. A study of 253 families by the Princess Margaret Hospital for Children and the University of Western Australia examined the evolution of asthma in children from early pregnancy. The study found that more than 30% of infants wheeze in the first few years of life. The wheezing does not develop into asthma for many infants as it is due to preexisting airway dysfunction and exposure to tobacco smoke during pregnancy and early life. Better understanding of genetic predisposition to asthma, the critical period for its development, and its environmental trigger factors, such as smoke, could assist prevention.

Breast cancer

Ataxia-telangiectasis (A-T) is a human genetic disorder whereby affected individuals are prone to developing a number of different cancers. Carriers of one defective copy of the gene have a propensity to develop breast cancer. A group of researchers at the Queensland Institute of Medical Research have developed an assay system for the detection of A-T gene carriers which has further developed for use among patients with breast cancer. This may be of assistance in the detection of at-risk individuals and in the management of patients with breast cancer.

Relaxin

The Howard Florey Institute in Melbourne has cloned and commercially developed the hormone, Relaxin. This hormone is structured like the insulin family of hormones and has a well recognised action of remodeling the ligaments and tissue of the pelvic girdle to provide greater ease for women giving birth. Recent studies have shown that Relaxin has a unique action on the heart, increasing the strength and rate of contraction. It also acts on the brain to reset fluid balance mechanisms. These newly discovered actions offer further scope for commercial development and therapeutic application of the hormone.

Prevention of childhood firefighting

Approximately 20% of all fire reports to the Melbourne Metropolitan Fire Brigade are attributed to children. Over the past 6 years, researchers at the Royal Children's Hospital have worked closely with the Metropolitan Fire Brigade to establish a fire awareness and intervention program. They conducted a randomised controlled trial of such a program by trained fire fighters, which was aimed at educating children who are lighting fires. Overall, the program achieved a marked decrease in the number of reported fires attributed to children.

The number of participants in the program has continued to rise since the completion of the study and the intervention program has been substantially modified on the basis of the findings. Perhaps most importantly, the Metropolitan Fire Brigade now has a systematic response to families concerned about their children's fire lighting habits.

Biological control of malarial mosquito

Mosquito borne diseases pose a continuing threat to public health, particularly in tropical areas. Microsporidia are naturally occurring mosquito parasites which kill many mosquito larvae in nature. Researchers at the Army Malaria Research Unit have evaluated these parasites for biological control of disease vectors. Computer simulation experiments undertaken in collaboration with scientists at Cornell University have identified the most favourable characteristics for control purposes and have shown that some have considerable promise for development as biological control agents.

Bone loss in breastfeeding women

Oestrogen deficiency after menopause results in bone loss and increased risk of osteoporotic fractures. During breastfeeding, women are also oestrogen deficient but have an increased demand for calcium secretion into breast milk. A multidisciplinary research team at Sir Charles Gairdner Hospital, WA, has found a rapid and large loss of maternal bone during the first 6 months of breastfeeding. This physiological loss occurred at selective sites in the mother's skeleton (that is, hip and spine) and over a wide range of dietary calcium intakes. By 6 months after weaning, the bone loss during breastfeeding has been restored. The effectiveness of oral calcium supplements to limit bone loss during breastfeeding and to assist recovery

after weaning, will be known at the completion of the study in 1994. This will provide clear indication of the amount of calcium that should be consumed by breastfeeding women.

Cell death genes and cancer

One in four Australians is destined to die of cancer unless some radically new treatments emerge through research. The cancer cell has mistakes within its DNA, and uncovering the nature of these mistakes could be a pathway to new therapy. Until recently, the DNA damage related to either oncogenes, namely genes which can promote excessive cellular growth, or tumour suppressor genes (which retard growth), the loss of which causes cancer. Now scientists at the Walter and Eliza Hall Institute of Medical Research have discovered the function of a third group of genes, the cell death genes. Some of these promote cell death, others prevent cell death. Perturbation of these genes through mutation or loss can materially affect growth processes, through allowing cells to live far beyond their allocated life span or else causing them to die prematurely. Unravelling this gene family has opened a new and exciting chapter in cancer research.

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.*

In 1994, CARG is providing 145 research grants across all major research disciplines, as well as support for three national research centres: in HIV Virology Research; HIV Epidemiology and Clinical Research; and HIV Social Research.

Recent Achievements

Development of an HIV antibody test kit

CARG has provided funding to researchers at St Vincent's Institute of Medical Research in Melbourne to develop a rapid HIV antibody test kit based on autologous red cell agglutination. This test has been commercialised by AGEN Biomedical Ltd, Queensland, and the technology has been extended to the measurement of antigens, fibrin D-dimer (for blood clots) and hepatitis B. Further support has been provided by CARG to improve the sensitivity of the test.

AIDS vaccine

Development of an effective AIDS vaccine is made difficult by the nature of HIV, in that it destroys the very cells that initiate antiviral immune responses and can evolve at very high speed. Antibody may be important in preventing infection with other types of virus, but appears to be ineffective in neutralising field strains of HIV. At this stage, cell-mediated immunity acting on white blood cells, appears to be the most likely way to produce protection against HIV. Researchers at the John Curtin School of Medical Research have pioneered the use of inserting genes for lymphokines onto non-pathogenic viruses, which then deliver the genes into the body. Lymphokines influence the magnitude and type of immune response - the objective is for this vaccine to stimulate a strong cell-mediated immunity against HIV. This work has now progressed to the stage where clinical trials are planned for later in 1994.

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

Progress towards national waiting lists statistics

AIHW was involved during 1993-94 in ongoing discussions about elective surgery waiting lists in public hospitals. This work includes the development of a set of nationally agreed definitions and the inclusion of those definitions into the National Health Data Dictionary for Institutional Health Care. Significant progress also was made towards a national consensus regarding the emphasis for waiting list reports. The objective of this work is for waiting list reports to relate to the number of patients waiting longer than clinically appropriate, rather than to the raw count of people waiting at a given time.

In March 1994, AIHW released the report *Australians waiting for elective surgery*. This report used available data to describe, as completely as possible, public hospital elective surgery waiting lists.

Cost of diseases studies

The Institute has, over a period of two years, developed methods for costing the impact of diseases and disabilities on the Australian health care system. This work has led to a series of publications which include papers on cost of diet related disease, tobacco and alcohol consumption, tuberculosis and syphilis, and hepatitis B.

Injury occurrence and circumstances

The Institute's National Injury Surveillance Unit (NISU) completed a major consultancy for the Department of Human Services and Health which produced reports on the occurrence and circumstances of injury in Australia, and on programs and activities for the control of injury. The reports provide a more complete description of injury in Australia than was previously available.

Injury information

The NISU Road Injury Information Program is undertaking a program of data base development, research and publication which is improving the understanding of road injury (especially non-fatal injury) to guide improvements in road safety. The program currently holds information on hospital admissions, hospital attendances, and fatalities.

CSL Limited

***Role:** To be a growing Australian public company specialising in biological projects benefiting Australian and international health care.*

Recent Achievements

Biosynthetic human growth hormone

The development of an Australian biosynthetic human growth hormone was initiated as a public interest project funded by the Australian Department of Industry, Science and Technology and involved the Garvan Institute of Medical Research, California Biotechnology, the University of NSW and CSL. Following the successful completion of the initial phase, CSL has designed and commissioned a plant dedicated to the production of a pharmaceutical grade of the hormone and has completed full process validation and preclinical testing of the project. Clinical trials are underway in Australia and several overseas countries.

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.*

ARL has been chosen by the Australian Government's Maralinga Technical Advisory Committee to provide radiological services during the clean-up operations at the former British nuclear test sites in South Australia.

Recent achievements

Radiation protection standards

The Department (through ARL) has participated in the development of new international recommendations on radiation protection by the International Atomic Energy Agency, World Health Organisation and co-sponsors. A final Technical Committee meeting was held in Vienna in December 1993 to complete the text and, following editorial correction, the draft of the basic safety standards will be presented to the sponsoring organisations by mid year.

On behalf of the NHMRC and the National Occupational Health and Safety Council, ARL has also co-ordinated the development of Australian recommendations on radiation protection.

Ultraviolet radiation protection

The Ultraviolet Protection Factor (UPF) scheme for clothing fabrics, developed at ARL, is coming into widespread use. Now over 60 companies, varying in size from small to very large, have signed licence agreements with ARL to use the scheme resulting in sales to date of more than 500,000 UPF swing tags for retail products.

The Eye Protection Factor (EPF) scheme (developed by ARL for rating the UV protection of sunglasses) is also being widely used and accepted, with many of the major retail stores selling large numbers of sunglasses with either EPF ratings or ARL trademark EPF logos.

INDUSTRY, SCIENCE AND TECHNOLOGY

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 are also 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.

Programs include those directed at building competitive firms and a competitive environment through:

Innovation;

- *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%.
 - *Grants for Industry R&D* provided to assist firms:
 - develop internationally competitive and internationally traded goods, services and systems;
 - adopt new products, materials and methods to improve manufacturing capability, productivity and quality;
 - strengthen linkages between technology developers and technology users;
 - develop technologies, including emerging and enabling technologies, that are likely to have wide application in Australian industry; and
 - foster collaboration between firms and research institutions.
 - *Commercialisation of Technological Innovation* aimed at encouraging industry research and development by providing concessional loans to small, high technology oriented firms to undertake specified early commercialisation activities.

- *Development and Application of Technology in Industry* aims to encourage firms to adopt and adapt appropriate technology. Its first element provides financial assistance to projects which accelerate the development or diffusion of strategic technologies which would not proceed without assistance. The second provides funding to improve the institutional sources of technology and technical advice available to industry.
- *The Australian Technology Group Limited (ATG)*, a small commercially focused company, evaluates research with commercial potential, particularly but not limited to, research from the public sector.
- *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 transfer of overseas technology to Australia. The organisation operates on full cost recovery.

Industry development;

- *National Space Program* aims to improve the competitive position of Australian firms to supply space-related goods and services, and to provide support for the application of space-related science and technology by the Australian public and private sectors.
- *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.
- *The Information Technology Development Program* aims to assist the development of companies in the information technology industry by providing information on, and access to leading edge methodologies and approaches to product development, manufacturing and service provision. The program has been enhanced through the inclusion of the *Information Technology Standards Program* which aims to streamline the information technology standards environment in Australia by improving the development of new standards, and testing, certification and accreditation infrastructure.
- *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.

Program or agency	Budget estimate 1993-94 \$m	Budget estimate 1994-95 \$m
Factor (f) Pharmaceutical Industry		
Development Program	129.5	113.5
AIMS	16.9	16.2
ANSTO	64.2	65.6
CSIRO	461.3	461.6
Kraft Pulp Mill Study	1.9	-
Industry Innovation Program grants	39.7	52.3
CRC Program	91.7	113.1
Industry Technology Program	1.5	2.3
Computer Bounty	78.0	74.8
NIES -Commonwealth	3.7	14.1
-States	16.1	17.8
National Space Program	5.5	9.3
Science and Technology Awareness	1.7	1.7
International S & T Program	5.4	5.5
National Research Facilities	-	7.5
TOTAL	917.1	955.3
PORTFOLIO TOTAL	1495.9	1513.6

- *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.
- *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 will be enhanced through the newly created Australian Marine Industries and Sciences Council.

Science, technology and industry linkages;

- *Cooperative Research Centres (CRCs) Program* provides support for long term collaborative ventures linking research and research users from universities, Commonwealth and State - funded research organisations and business enterprises. It promotes high quality cooperative research and education programs through centres of research concentration, strengthening the links between research and its commercial and other applications.

- *The Space Industry Development Centres (SIDC) Program* is a component of the National Space Program and is directed at the development of an Australian commercial space industry. The objective of the program is to encourage industry to divert R&D funds from more traditional areas of technology to space related activities through collaborative ventures with university based space research centres. At present, three SIDCs have been established at Griffith University, Queensland University of Technology and the University of South Australia.
- *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.
- *Policy advice* for the establishment and delivery of Government services in science and technology is provided through the Science and Technology Policy Branch (Science and Industry Policy Division), the Ministerial and Portfolio Co-ordination Division, the Bureau of Industry Economics and other Divisions of the Department of Industry, Science and Technology.

Firm capability and management skills;

- *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.

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

MAJOR RESEARCH ACTIVITIES

The Australian Institute of Marine Science (AIMS)

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

Recent Achievements

Prawn farming

AIMS scientists have taken the first steps towards domestication of the giant tiger prawn (*Penaeus monodon*) by successfully rearing a large number of fertile spawners from pond-reared prawns. This is the first time the full life cycle of this important aquaculture species has been achieved on a scale sufficient to advance commercial development in Australia. Domestication of the prawn is essential for a cost-effective, competitive aquaculture industry with a reliable and sustainable growth into the future.

Effect of nutrients on the Great Barrier Reef

As part of a wider effort to measure natural and human-derived inputs of nutrients (nitrogen, phosphorus) to waters of the Great Barrier Reef (GBR), an extensive sampling program has been carried out over the last seven years to measure nutrient and sediment concentrations in North Queensland rivers. Analysis of these samples is now showing relationships between river flow rates and nutrient delivery to GBR waters. Most nutrient delivery from rivers occurs during the summer wet season, with peak delivery rates during early season flood events. Detailed analysis of nutrient data from the South Johnstone River show that nutrient delivery rates decrease over the course of the wet season as available nutrients are washed out of the catchment.

Nutrient flux model for mangroves

A milestone in the study of the dynamics of mangrove forests has been the completion of a nutrient flux model for mangroves in North Queensland. The model of nitrogen flux reveals that the major inputs of nitrogen into the

ecosystem are via nitrogen fixation by sediment microbes and by exchange in tidal water of dissolved ammonia and organic nitrogen. Major losses of nitrogen are by tidal export of nitrate, ammonia and particulate nitrogen (as bark, root and other plant matter). Overall, the model shows that inputs and outputs are balanced for this finely-tuned ecosystem.

Billfish Atlas

Gamefishing is growing in importance as part of the tourism industry in tropical Australia and the Pacific. The Coral Sea Rim Billfish Atlas provides a unique collection of data relevant to the management of these economically important species. It was prepared following requests from the governments of the Solomon Islands, Papua New Guinea and Vanuatu for information relevant to the development of gamefishing tourism in these countries. The Atlas combines monthly commercial fishing maps of the distribution of billfish throughout the Coral Sea Rim region together with ecological information on black, blue and striped marlin, sailfish and broadbill swordfish. It also includes regional environmental maps of the best available scientific information on underwater bathymetry, water currents and weather.

The WetPC

The Institute has developed what is thought to be the world's first wearable, underwater computer - the WetPC. The result of a 2-year development project, the WetPC combines innovative display and keyboard technologies that were developed overseas. Able to display text and graphics at any depth, the WetPC has potential application in a number of areas apart from marine research including defence, offshore oil exploration and environmental impact assessments.

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

Novel radiopharmaceuticals

ANSTO has been successful in the synthesis of iodinated radiopharmaceuticals for clinical and pre-clinical evaluation of human disorders. One agent specifically used to image particular neurotransmitter systems has shown great promise in examining changes in neuroreceptors, of major importance in normal brain function, and appears useful in the early diagnosis of temporal lobe epilepsy. A second product is about to undergo clinical evaluation for the early diagnosis of idiopathic Parkinson's disease and Parkinsonian syndrome as well as schizophrenia.

A radio-labelled monoclonal antibody developed through a collaboration with Agen Biomedical Ltd, Queensland is currently being evaluated as a diagnostic agent to detect lung and ovarian cancer.

Mine rehabilitation contracts in Germany

ANSTO entered into two scientific contracts concerned with the rehabilitation of the former uranium mining sites near Chemnitz in Germany. Both projects include geochemical assessment of the impact on the aquifer systems of the rehabilitation options following the flooding of the Königstein and Ronneburg mines.

Radon concentration in air

A set of very sensitive detectors for measuring radon concentration in air and radon exhalation rates from surfaces was developed. These detectors are used to quantify the danger to health and the environment in energy production technologies involving uranium, coal, oil and gas. The evaluation of some radon-related health and environmental hazards have been the subject of reports to operators in the oil and gas industry.

Rapid PCB screening of oils

Polychlorinated biphenyls (PCBs) continue to be an environmental problem. The major pathway for PCB contamination of the environment has been through contaminated oils. Legislation has since regulated the disposal of existing PCBs and severely restricted future production and use. Many of the oils in use today still contain PCBs. Recent developments at ANSTO and in overseas laboratories have resulted in a nuclear analytical technique being accepted as superior to other testing procedures. More than 9,000 oil samples have been surveyed to date for electricity generating authorities in NSW, with a saving in analysis costs of about \$500,000.

Climate studies

Studies to provide well documented records of past climates with an accurate timeframe were undertaken in close collaboration with Monash University. Long core samples taken from lakes in Queensland and Victoria were analysed using natural uranium isotopes. These studies show major shifts in climate, from warm interglacial to cold glacial. ANSTO developed procedures to produce an accurate measurement from these ancient lake sediment samples.

Neutron scattering

Neutrons have special properties which make the scattering of neutrons a powerful technique for the investigation of materials. The neutron scattering facilities at the ANSTO reactor, HIFAR, are used extensively by scientists from universities, government laboratories and industry. Two major upgrades were undertaken during the year. First, the commissioning of a new Medium Resolution Powder Diffractometer (MRPD). Second, the installation of a small angle neutron scattering facility is of great interest to materials scientists studying problems in polymers, catalysts and porous materials, as well as to those with an interest in biological systems. The MRPD has been used very successfully to examine the changes which occur in engineering ceramics at high temperatures.

Synroc

Synroc is an Australian-developed synthetic mineral which offers promise as a safe, long-term means of storing radioactive waste. Significant progress has been achieved at ANSTO in the development of a free flowing Synroc precursor powder that can be impregnated with 20% of high-level waste. If powder can be used to replace slurry in the Synroc production process, then the size of the plant needed for the process can be reduced. This would be a big advantage in dealing with highly radioactive material.

Sol-gel ceramic coatings

Sol-gel technologies developed at ANSTO to provide ceramic feedstocks for the Synroc process are being transferred to local industry with diverse applications. Corrosion and abrasion resistant sol-gel coatings of alumina were developed for deposition on graphites used in the mineral processing industry. This innovative technology permits ANSTO to deposit coatings of up to 10 micrometres using a single dip-coating cycle. The previous best achievement by others is 1 micrometre. The work has been funded by a DIST grant and involves a consortium of industry and university partners.

Sol-gel technologies have also been exploited by ANSTO, in conjunction with the University of New South Wales and CSR Pty Ltd, to produce prototype micro- and ultra-filtration membranes with controlled pore sizes. The membranes are constructed from titania for use at high temperatures and in corrosive environments where conventional polymer membranes cannot be used.

Plasma surface engineering

Plasma Immersion Ion Implantation is an ANSTO patented process that has been developed for improving the wear resistance of engineering alloys. The treatment has been found to be particularly effective for stainless steel, the surface of which can now be hardened without sacrificing corrosion resistance. An order has been received for the supply of an Implanter to the Technical University of Clausthal, Germany. Joint research will be carried out under a collaborative agreement aimed at identifying further applications for the process.

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 Australian 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 (APS)

Measurement of atmospheric pressure at the Earth's surface is an essential element of meteorological forecasting, but accurate forecasting is hampered by the lack of data, especially from remote areas such as the southern oceans. Measurement of atmospheric pressure from a suitable satellite platform would solve this problem. Following the success of a CSIRO laboratory model in demonstrating the viability of the scientific principles, the Office initiated a project with Vipac Engineers and Scientists Ltd to determine the scientific and engineering feasibility of a spaceborne APS. In conjunction with CSIRO, an improved APS model was developed and ground and flight trials are presently in progress. Recent flight results have been most encouraging and a final concept study report will be published in about November 1994.

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.*

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 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 all Australians and the wise long term use of the nation's natural resources for these purposes.
- *Institute of Industrial Technologies*
To increase the international competitiveness, efficiency and scope of Australia's manufacturing industries and to 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 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 major 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*
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 natural 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 Organisation's funds come from external sources. These include collaborative ventures with industry, granting schemes funded by both industry and government, and earned revenue. In 1994-95, it is estimated that \$215.9 million of CSIRO's \$677.5 million budget will come from these external sources.

CSIRO commercial practice

CSIRO's commercialisation mission is:

- *To achieve commercialisation of CSIRO's intellectual property and research skills through arrangements that maximise benefits for Australia.*

To achieve this mission, CSIRO is continually improving its relationships with clients in industry and the business community. This involves firstly, the upgrading of the skills of all staff and secondly, the creation of a Corporate Business Department.

Derived from the work of the Commercialisation Task Force, a statement of corporate policy and best practice guidelines has been published in the form of the *CSIRO Commercial Practice Manual*. The Manual is based on the Australian Quality Management Standard (AS3901) principles. It defines corporate practices which will be supplemented by defined procedures which meet the needs of individual Divisions. Workshops to introduce the Manual to senior staff have been held. Divisions and Institutes are now implementing further programs which will ensure that the contents of the Manual are understood by all staff.

A focus of the Corporate Business Department is the provision of quality commercial practice services to the Organisation, particularly in the areas of Legal Affairs, Strategic Planning and Evaluation, and Intellectual Property Management. However, the major emphasis is on developing the relationship between CSIRO and the business community. This is a two way process, providing a reference point for the business community to make contact with CSIRO and providing advice for CSIRO about how best to gain business partners to commercialise research ideas.

CSIRO is dedicated to delivering the requirements of its customers on time and within budget.

Planning and Reporting

CSIRO has adopted the Socio-Economic Objectives (SEO) classification of the Australian Bureau of Statistics' (ABS) Australian Standard Research Classification (ASRC) as the basis for strategic planning and reporting outcomes of the Organisation'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, with the exception of 'Rural Based Manufacturing' which is not an SEO under the ASRC.

Recent Achievements

Plant Production and Primary Products

National bushfire model

The National Bushfire Model, a decision support software package, has been completed. The software enables fire controllers to simulate fires on computer using local geographic information and weather conditions. The model can be used to train fire controllers, and also as an aid to predicting short term fire behaviour, allowing more effective deployment of resources. Negotiations are under way to arrange testing in the field.

Field trial of transgenic cotton

The first field trial of genetically engineered insect-proof cotton has been harvested, and CSIRO researchers are assessing the results. Preliminary indications are that good insect defence was achieved. Other aspects involve fulfilling Genetic Manipulation Advisory Committee requirements, including a check on how far pollen has travelled.

Help for rice farmers

CSIRO in collaboration with NSW Agriculture has developed a decision support system, 'maNage rice', that will benefit rice growers in the Riverina. This package works on personal computers and gives a range of options that will help optimise the use of nitrogen fertiliser, one of the most expensive inputs to rice growing.

The package calculates the likely yields and profits for the application of varying rates of nitrogen, enabling growers to select the optimum application. Earlier this year, the package was demonstrated to advisers and 100 rice growers in the Murray Valley when the decisions to apply nitrogen fertiliser were being made. Reactions have been very favourable and minor changes have been included in the updated version being released for the next rice growing season. Development of the package was funded by RIRDC and the rice industry.

Improved tropical acacia seed

The first crops of improved tropical acacia seed from seed orchards on Melville Island have been harvested and will be used in genetic trials. The seed orchards were planted after collection of seed from the geographic range of certain critical species in northern Australia, Papua New Guinea and Indonesia. The work is a collaborative project with the Conservation Council of the Northern Territory, the Tiwi Aboriginal people, and the Queensland Department of Primary Industry.

Fertiliser breakthrough

Plants commonly use only 20-60% of nitrogen applied as urea, due to heavy loss of ammonia through hydrolysis at the soil surface. One way of reducing ammonia loss is to inhibit the urease enzyme. CSIRO has shown that the newly synthesised inhibitor cyclohexylphosphorictriamide (CHPT), greatly out-performs other compounds tested for this purpose. In a field trial in Thailand supported by the Australian Centre for International Agricultural Research CHPT slowed the hydrolysis of urea for 10 days and reduced ammonia loss by 90 per cent.

Managing insecticide resistance in cotton pests

A diagnostic kit developed by CSIRO's Division of Entomology has just been released for commercial sale by Abbott Agricultural Products Division. The kit, based upon the use of monoclonal antibodies, will be used to manage insecticide resistance in the major pests of cotton in Australia. The benefits lie in direct savings to growers through making correct spray decisions which contribute to the long term sustainability of the industry by effective insecticide management. The Cotton Research and Development Corporation (CRDC) commissioned the kit.

Control of breadfruit mealybugs

CSIRO research has yielded a possible biological control agent for breadfruit mealybug, a pest which devastates crops of breadfruit which is the staple diet of islanders in Micronesia. In some years, the total crop has been lost to the insect. Egyptian mealybug probably originated in the Indian region, and scientists believe that it spread through Asia on plant material during World War 2. The research team has just sent a batch of a particular Australian ladybird species to Micronesia for biological control of the pest. This is an unusual case where an Australian native insect is being used for biological control overseas.

Animal Production and Primary Products

Combating drench resistance

Worms cost Australia's pastoral industries about \$340 million per annum in lost production and control costs. As these internal parasites develop resistance to the newer chemical drenches, costs increase. Drench resistance can only be managed if reliable information about the problem is available to the producer. Current tests involve multiple visits to the property and time consuming counting of eggs in faeces samples.

CSIRO has developed and commercialised a new test system which will allow farmers to more easily detect drench resistance, enabling them to modify their management practices and delay its spread.

Animal disease detection

New tests established at CSIRO's Australian Animal Health Laboratory have boosted Australia's capability to detect exotic animal diseases such as African horse sickness, equine influenza, porcine reproductive and respiratory syndrome (PRRS), and African swine fever.

Should, for example, an outbreak of equine influenza ever occur in Australia, the establishment of these tests has considerably enhanced our ability to combat it. A recent outbreak of this disease in Hong Kong cost the racing industry several hundred million dollars in lost turnover.

Rabbit control

High security laboratory tests of rabbit haemorrhagic disease virus (RHD) have demonstrated that the RHD virus kills rabbits efficiently. Also, RHD shows no indication of infecting any other animals. A limited field release at a remote quarantine facility is being planned to further test this biological control method of reducing Australia's 200 - 300 million rabbit population.

Bovine genetic map

An international scientific network established by CSIRO's Division of Tropical Animal Production has constructed a genetic linkage map for cattle, a world first for any livestock industry. The genetic map is an important tool used to locate the genes for important production traits and is the first step in several ambitious projects which will use the map as a springboard for pinpointing genes for meat quality, growth and parasite resistance traits.

The project has been supported by the cattle industry through the Meat Research Corporation as well as by the Commonwealth Department of Industry, Science and Technology via the International Science and Technology Program.

Minerals Industry

Managing salt stockpiles

Operations research undertaken by CSIRO has enabled Dampier Salt to improve productivity in its salt mining operations. The company is Australia's largest salt producer and the second largest exporter of salt in the world. It is known for both its high quality product and its reliability in meeting customer demand. However, this reliability comes at the cost of maintaining a large stockpile of highly processed, and therefore expensive, salt. CSIRO developed a model which has assisted the company in their salt mining operations, so that stockpile sizes could be reduced without jeopardising reliability of meeting customer demands.

3-D model of Kambalda Dome

Using advanced computer graphics and 3-D visualisation techniques, CSIRO researchers in collaboration with Western Mining Corporation and Port Management Services have produced the first 3-D model of the Kambalda Dome (Western Australia). The model which shows geological relationships in three dimensions based on information from thousands of drill holes, will be used in planning further exploration in this nickel-rich area.

Energy Resources and Supply Industries

Fossil fuels from the Permian age

CSIRO has shown that the carbon preserved in the organic matter of late Permian (250 million year old) rocks shows the same level of change in isotope composition over the entire earth. This change (a 1% shift in isotopic composition) is significant for understanding this global extinction event, the largest in the last 600 million years.

The extent of change in the carbon isotope composition can be explained as a consequence of the release of enormous quantities of methane from sediments on the continental shelf, after a massive burial of plant matter. The burial was the first stage in the formation of coal, oil and gas.

Conventional tools for correlating different types of sediments are dependent upon the occurrence, which may be rare, of specific age-diagnostic fossils in the sediments. Future exploration of late Permian age sediments can now be carried out by isotopic analysis instead.

On-line analysis of low rank coal

CSIRO has developed nuclear and microwave techniques for the determination of moisture, ash, specific energy and fouling index in Victorian brown coals. These techniques have been licensed to Mineral Control Instrumentation Pty Ltd, an Australian company based in Adelaide, and the first commercial gauge was installed in the Loy Yang power station in late 1993.

Lead-acid battery technology

A new forklift truck battery with increased capacity and power has resulted from CSIRO research. Developed commercially by GNB Industrial Batteries, a Pacific Dunlop Ltd subsidiary, the new Exide powerlift battery represents the leading edge in lead-acid battery technology. The new technology, which has an international patent pending, results from redesigning the battery's positive plate to promote a more efficient and robust energy-conversion structure. The benefits to forklift operations are decreased down-time, increased operating power and efficiency.

Cast bonding

CSIRO's patented cast bonding technique has been used to produce a number of composite bearer plates for trial in a coal pulveriser mill at Queensland Alumina's Gladstone plant. The cast bonding process enables steel components to be clad with a heavy wear resistant overlay of alloy white iron. The composite product produced combines the toughness and weldability of the steel with the hardness and wear resistance of the cladding alloy. In the coal pulveriser application, the composite material significantly improved wear resistance when compared with the conventional steel product.

Manufacturing Industries

SAFE-T-CAM

SAFE-T-CAM, a CSIRO developed technology being pioneered in Australia, is a traffic monitoring system aimed at eliminating speeding and unsafe heavy vehicles from our roads. Trials have demonstrated the capability of SAFE-T-CAM to monitor speed over long distances and to identify number plates correctly. The NSW Roads and Traffic Authority (RTA) has now commissioned a consortium comprising Telecom, CSIRO and ICONIX to develop a road safety and traffic management system, and has signed a contract to purchase a further 20 SAFE-T-CAMs for use on NSW roads.

FADS in machine tools

The filtered arc deposition system (FADS) is used to produce super-hard, super-smooth coatings on tools, dies, and bearing surfaces, etc. The Royal Australian Mint has used FADS to extend the life of coining dies by a factor of more than 20. Manufactured by Dynava Engineering Pty Ltd, FADS was awarded an Institution of Engineers Engineering Excellence Award in 1993.

Shrink proof polymers

The volume shrinkages that occur during polymerisation prevent many polymeric materials from reaching their full potential. Affected materials include those used in precision casting, general adhesives, dental adhesives, optical lenses, and polymeric coatings or matrix resins for composites. Typical problems associated with volume shrinkage are void formation, stress cracking, poor adhesion, delamination and composite warping. CSIRO has developed a new class of free radical, ring opening polymers that shrink only half as much as that expected of comparable materials.

Adding value to Australia's meat exports

Traditionally, Australian meat destined for retail sale has been distributed as carcass sides or as primal cuts. A new packaging technology developed by CSIRO enables retail-ready consumer portions to be distributed directly to both local and overseas retailers for immediate display on supermarket shelves.

Retail cuts are first vacuum-skin sealed in a specially formulated carbon dioxide and oxygen permeable skin film and placed in a master pack for storage and distribution. This master pack is gas-flushed and filled with an atmosphere of elevated carbon dioxide concentration and very low residual oxygen to maintain the quality of the meat cuts. After unpacking at the destination, the oxygen permeable skin enables the cuts to bloom to a rich red, - ready for retail display.

Rural Based Manufacturing

Improving autumn milk for cheesemaking

Cheddar cheese made in late summer or autumn often has a high moisture content which reduces product quality. Cheesemaking is therefore generally limited to the earlier part of the season, resulting in poor capital utilisation. The problem was believed to be due to the cows being in a late stage of lactation as a result of calving being synchronised with maximum pasture growth. Collaborative research with the Victorian Department of Agriculture has found that the quality of diet is the important factor in overcoming the problem. If protein and energy supplements are added to the diet when pastures are poor, the milk will make good quality cheese. A cost effective diet has been developed, and a large scale commercial trial is being carried out by a major dairy company.

Taste research in Japan leads to new markets in Asia

CSIRO's Sensory Research Centre (SRC) cross-cultural research in Japan has provided valuable information for the Australian food industry and has enabled companies to produce foods acceptable to consumers in this lucrative market. More than 400 food companies have been assisted by this research, significantly contributing to Australia's \$560 million processed food exports to Japan. The experience gained by the SRC in Japan is now being applied in Asia. Facilities for undertaking both generic and contract research for Australian companies in other important markets in the Asian region including Korea, Taiwan, Indonesia, China, Malaysia and Singapore have been established.

Wood preservatives

Plans have been approved in Germany to build the first overseas Pigment Emulsified Creosote (PEC) treatment plant. PEC is a new generation emulsion preservative developed by CSIRO's Division of Forest Products in collaboration with Koppers Australia. The German plant will use creosote oil meeting the Western European Institute specification, and will initially be treating hardwood and softwood railway sleepers.

Wood adhesives

Laminex (Australia) Pty Ltd, one of the largest manufacturers of medium density fibreboard (MDF) together with other manufacturers has been looking for water resistant adhesives. Most MDF adhesives have been based on urea-formaldehyde and melamine-formaldehyde, or their combinations. The CSIRO/Huntsman formulation of phenol-formaldehyde (PF) releases very low levels of formaldehyde after curing, to provide water-resistant bonding with a curing rate equivalent to that of the composites. Laminex has started using this formulation at its NSW plant.

Information and Communications Industries

Land information system

Access to data such as property boundaries is a pressing problem for many business enterprises and government departments. In South Australia, there are around 10,000 land-related queries every day. To address this problem, the CSIRO Division of Information Technology and South Australia Lands have jointly developed a distributed land information system, LISA. LISA provides rapid access to relevant data, such as property boundaries, details of valuation, legal encumbrances, land use and planning proposals by a large number of concurrent users.

Multibeam antenna for satellite communication

By the turn of the century, there are likely to be over fifty satellites beaming as many as 1200 channels of television into the Asian region. The conventional way of receiving signals from satellites requires one antenna to be dedicated to each satellite. CSIRO in conjunction with Defence Industry Development Organisation, has developed a new kind of antenna that can communicate with up to twenty satellites simultaneously. This "Multibeam" antenna substitutes for up to twenty earth stations with consequential saving in costs and increased ease of use.

Amplifier for high frequency radio systems

CSIRO has recently built an amplifier that operates in the 60Ghz band. This millimetrewave amplifier is a major milestone in the construction of radio systems that operate at frequencies way above the conventional, overcrowded radio bands. The advantages of these radios will be that they will be very small and low cost, because they can be made using processes similar to those used for computer chips, while having very high bandwidth. One of these radios could carry the equivalent of 100 television channels, yet be small enough to slip into a shirt pocket.

Environmental Aspects of Economic Development

Environmental effects of offshore oil

CSIRO scientists from the Division of Oceanography's Marine Resources and Pollution Program, in conjunction with Envirotech Health, Environment and Workplace Pty Ltd, completed a major report for the Australian Petroleum Exploration association (APEA), as part of APEA's Offshore Petroleum Environmental Review Project. The report provides a comprehensive review of issues relating to the effects of oil spills on the marine environment, including effects on biota, as well as aesthetic and commercial values. The review highlights the good environmental record of the offshore and exploration industry to date. Less than 100,000 litres of oil has been spilled over 1,000 wells drilled, and this has resulted in minimal damage to marine ecosystems.

Biological control of spinyhead sida

A Mexican weevil *Eurinobothrus sp.* was released by CSIRO's Division of Entomology for the biological control of the weed, spinyhead sida (*Sida acuta*). Sida comes from Mexico and Central America and has become a severe problem in agricultural areas in the Northern Territory and Queensland. The weevil is the second insect to be released for the biological control of this weed. The first, the beetle *Calligrapha pantherina*, was released in 1989 and had a significant initial impact. Work is continuing on this insect. Scientists expect that the two insects will attack different parts of the plant and their actions will complement each other. Research and testing for this long running biological control project has involved both CSIRO and the Northern Territory Department of Primary Industry and Fisheries.

Environmentally friendly pesticide

CSIRO recently developed a new fumigant that may replace the widely used ozone layer depleting gas methyl bromide. The new gas is carbonyl sulphide, a simple compound of carbon, oxygen and sulphur. Its use as a fumigant for the control of insects and other pests was patented by CSIRO in 1993.

The gas occurs naturally, being released by compost heaps, marshes and fires. It is the most common form of sulphur in the stratosphere. Because carbonyl sulphide breaks down quickly, and does not build up in living systems, it avoids many of the problems we have with persistent chemicals. Tests have shown that it will control a wide range of pests such as beetles, fruit flies, moths, mites, termites and nematodes. Research on the new fumigant was funded by CSIRO, the Australian Wheat Board and the state bulk handling authorities.

Land degradation assessment

CSIRO has completed trials of a grazing gradient method of assessing land degradation. The method utilises remotely sensed data as an operational means of determining grazing impact in arid rangelands. It compares favourably with conventional ground-based monitoring in terms of cost and

labour requirements. The cost-benefit studies indicated that aggregated property-level benefits for the rangelands-based cattle industry in the Northern Territory would be in the order of \$40-70 million.

The remote-sensing method is capable of providing comprehensive objective and repeatable analysis of optimum stocking rates on grazed country after future significant rainfalls have been taken into account. It also offers the additional advantage of immediate information about landscape condition through analysis of archived remotely-sensed data.

Environmental Knowledge

Automatic water quality monitoring

CSIRO has developed technology to provide cost-efficient data gathering on water quality in remote locations. Called Aqualab, the technology can be left in the field for long periods, no matter how remote or hostile the environment, to gather and transmit essential water quality data. Development has been in collaboration with the Urban Water Research Association of Australia, and the Engineering and Water Supply Department of South Australia.

Aqualab can monitor temperature, conductivity, turbidity, depth, pH and a range of chemicals. Applications are now in place in SA, NSW, Queensland and the ACT. Commercialisation and marketing of Aqualab in Australia and overseas is being undertaken through the Queensland based company, Greenspan Technology Pty Ltd.

Mapping vegetation health

CSIRO and international space agencies from Europe and the USA co-operated throughout 1993 to produce the world's first high-resolution vegetation condition map. The study, known as the Global 1 km AVHRR Land Data Project, supports the research objectives of the International Geosphere Biosphere Programme in uncovering the causes and consequences of natural and human-induced changes to the earth's life support systems.

Twenty five ground stations throughout the world supply daily environmental satellite data for the project which commenced 1 April 1992 during International Space Year. The first product, a global map of vegetation health during late June 1992, was released by the United States Geological Survey in 1993. Six participating ground stations from the Australasian region are co-operating with the CSIRO Office of Space Science and Applications to supply data for the project.

Construction

Saving steel in industrial buildings

Modern wind design techniques being developed at CSIRO and Ruhr University in Germany could result in substantial savings in the cost of industrial and commercial buildings. CSIRO's approach could help designers select steel framing that is lighter than current requirements. The technique takes account of variations in time and space of the wind pressures acting on major structural elements such as portal frames and roof purlins. The result is a subtle difference in design requirement, but multiplied many times over could lead to economy in steel use. BHP and several steel fabrication companies sponsored a twelve month investigation into this aspect.

Health

Toxins in lupin feeds

A simple test procedure that monitors the level of a fungal toxin, phomopsin, in lupin seed is now available. This will boost quality control and improve the safety of Australia's lupin industry. Significant numbers of deaths have occurred when animals have been fed contaminated feed, and the new grain assay enables grain authorities and food manufacturers to quickly and accurately monitor the level of phomopsin in grain lupins used for human consumption. Regulations provide for a maximum level of only five parts of toxin per billion in lupin used to raise protein and fibre levels in bread and other foods.

Cardiovascular benefits of fish oil

CSIRO's Division of Human Nutrition has been in the forefront of defining the cardiovascular benefits of fish oil. Recent biotechnological advances have now led to the fatty acids in fish oils becoming available in pure form. Access to these through a major collaborative project has enabled the Division to identify unequivocally the key fatty acid which protects against heart arrhythmias (otherwise fatal), lowers blood pressure and maintains normal coronary blood flow. This opens opportunities for both food and pharmaceutical products enriched with this fatty acid.

Social Development and Community Services

Computer map speeds emergency vehicles

ARC-Dispatch, a new mapping system developed jointly by CSIRO and ARC Systems will be an aid to assist police, ambulance and fire vehicles reach the scenes of emergencies more quickly. The continually changing locations of emergency vehicles and sites of emergencies are displayed by this mapping system. Dispatchers can use the system to quickly identify the most appropriate response vehicle and the fastest and safest route to the incident.

The system can be used to access databases of site information, for example floor plans with emergency exits, sprinkler systems, electrical control panels, and other detail critical to fire control.

Advancement of Knowledge

High resolution image of a supernova remnant

The Australia Telescope Compact Array has been used to make high-resolution images of the radio source arising from Supernova 1987A. This was the brightest supernova in more than 300 years and gave astronomers a wealth of information on how stars explode. In 1990, a radio source was detected at the site of the explosion. Using the highest angular resolution available on the Australia Telescope Compact Array, astronomers have produced images of the remnant radio source. These images reveal a spherical, shell-like structure and, combined with previous observations, show that the remnant's rate of expansion appears to have slowed significantly.

The life and times of Eta Carinae

Australia Telescope observations show unusual, and so far unexplained, changes in the radio emission from a rather bizarre star. Eta Carinae is one of the most massive and luminous stars in the galaxy. During the 1840s, it was the second brightest star in the sky. However, on several occasions it has ejected a lot of material and is now surrounded by a dust cloud which makes it a much dimmer object.

Observations made with the Australia Telescope show that the radio source associated with Eta Carinae is becoming dramatically brighter and is also changing shape. A recent Hubble Space Telescope picture shows a jet emerging from the star while the Australia Telescope image clearly shows that very rapid motion is occurring along that jet.

The Cooperative Research Centres (CRCs) Program

The objectives of the Program are:

- to contribute to national objectives, including economic and social development, and the establishment of internationally competitive industry sectors through supporting long-term, high quality scientific and technological research;
- 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 promote cooperation in research, and through it a more efficient use of resources in the national research effort by building centres of research concentration and strengthening research networks; and
- to promote the active involvement of researchers from outside the higher education system in educational activities, thus stimulating a broader experience in education and training, particularly in graduate programs and to offer graduate students opportunities to be involved in major cooperative, user oriented research programs.

The Cooperative Research Centres Committee, which is appointed by the Minister Assisting the Prime Minister for Science, provides advice on the Program. The Program was launched in May 1990. Under the Program, new Government funding, rising to \$138.2 million annually by 1996-97, will be provided to support up to sixty one Centres.

Selection of Centres

Three rounds of Centre selection have now been completed and the selection of ten more Centres is underway with applications due to close 6 July 1994. The following fifty one CRCs are now established:

- CRC for Intelligent Manufacturing Systems and Technologies
- CRC for Alloy and Solidification Technology
- CRC for Aerospace Structures
- 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
- 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 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

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 designed to encourage Australian companies to become more innovative and internationally competitive by increasing their R&D activity. The program is effectively market driven, being structured in a manner which is neither industry nor product specific, allowing companies to determine both the area of innovation and the direction of their R&D activities. It allows a tax deduction of up to 150% of expenditure incurred on eligible R&D activities and thus enables companies to reduce their after-tax cost of R&D to 50.5 cents in the dollar (based on the current corporate tax rate of 33%).

Syndication enables access to critical mass finance for new R&D for firms which would otherwise be unable to use the tax concession.

Recent Achievements

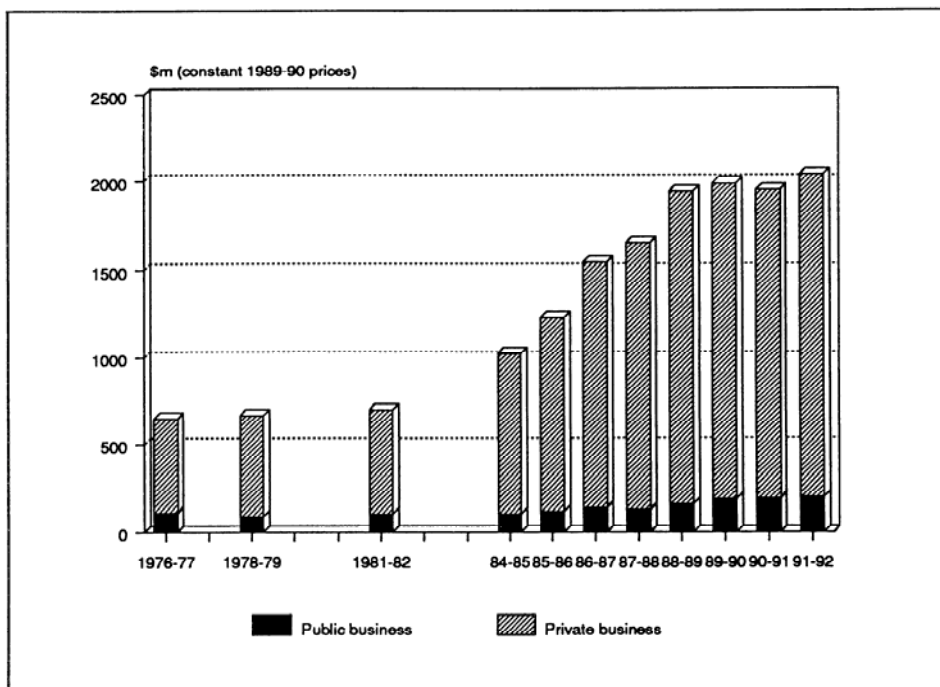
Effectiveness

The Bureau of Industry Economics (BIE) completed a major review of the concession in September 1993. It found that the concession has induced between ten and seventeen per cent of additional R&D spending a year (the total expenditure trend is shown in Figure 8), has a positive net social benefit and enhances management attitudes towards the role and importance of R&D as part of competitive business strategy. The BIE also concluded that the concession clearly contributes to increased innovativeness and is likely to contribute to increased international competitiveness.

The BIE is also undertaking an evaluation of syndication, expected to be completed by April 1994. Early results show that syndication is highly effective in achieving the Government's aims, with an inducement factor of 2.6. That is, for every \$1 million of R&D conducted without syndication, this

Figure 8

BUSINESS EXPENDITURE ON R&D



Source: DIST based on ABS data

financing scheme induces an extra \$2.6 million of R&D. To date 99 syndicates have been registered, involving new R&D expenditure in excess of \$550 million.

Approximately 1000 firms consistently perform R&D each year and claim the concession, with about 2000 firms registering for the scheme each year. In 1992-93 the estimated gross cost to revenue of the incentive in terms of company tax forgone is \$340 million.

Wheel alignment

Narellan Truck Wheel Align Pty Ltd is a small, award winning manufacturing and service company established 17 years ago. It provides diverse alignment repair services, engineered adjustment 'fixes' for cars, trucks and four-wheel drives and design of alignment measuring systems. While only employing three people on R&D, the results have been very impressive. With the assistance of the R&D tax concession, the company has developed a unique range of engineered products to correct the steering geometry of vehicles to make them suitable for Australian high-crowned roads. This improves safety by eliminating the tendency to pull left and substantially improves tyre life. One successful product is a portable, cordless, laser-based wheel alignment indicating system for which the company holds international patents.

Electronic banking equipment

Keycorp Ltd produces a range of financial transaction devices, including innovative point of service and security peripherals for the banking industry. The company's turnover in 1993-94 is expected to be \$27 million, of which \$10 million will be from export sales. Growth in revenue and profit during the past three years has been very rapid, at an annual compound rate of more than 100 per cent. This success was in large measure due to the company's use of the R&D syndication scheme.

- Grants

IIP grants provide support for a range of research and development projects, including:

- *market driven R&D in dynamic firms needing assistance but unable to use the 150% Tax Concession for R&D;*
- *collaborative R&D activities, which are high risk but could provide extensive benefit to Australia;*
- *trial and demonstration activities between technology developers and potential customers; and*
- *collaborative R&D activity between industry and research institutions*

Recent Achievements

Refrigeration gas recovery

Javac Pty Ltd is a company developing and manufacturing high pressure vacuum pumps. Javac successfully developed a light weight gas recovery system for use with refrigerators. The system evacuates the gas from the refrigerator, tests the unit and refills the unit all without exposure to the environment. Javac has expanded its expertise in this field and has begun development of a system for non-CFC gases.

Building maintenance units

E W Cox Australia Pty. Ltd has developed the capability to significantly reduce the size and weight of the maintenance units used to scale tall buildings for window cleaning and maintenance. E W Cox is making strong inroads into Asian markets with their innovative designs, fast service and competitive prices.

Laser display systems

Laservision (Australia) Pty Ltd, a small Australian company operating in the niche market of laser communications, has developed a laser display/billboard system for use in advertising and for special effects. The system can produce images and animated displays on many different surfaces using either on-site or remote control.

Blue flower pigments

Calgene Pacific Pty Ltd received support for isolating, through the use of genetic engineering technology, the gene responsible for the determination of the blue colour in flowers and the subsequent transfer of this gene to the rose, chrysanthemum, carnation and gerbera. Technical and commercial trials are underway to ensure the integrity and quality of the new blue flowers. Calgene is currently working on factors such as improved keeping quality and the endurance of the blue pigment in the flower stalks. The company estimates that 1997 will see the first sale of hardy and beautiful blue roses.

Hazardous waste disposal

Matrix Technology developed a safe system for the disposal of wastes which are biologically hazardous. The Matrix system overcomes the known disadvantages of the disposal of waste material, including pathogenic and biomedical wastes, and provides for the safe disposal of organic wastes. The new system has been tested by a certified hospital laboratory and proven effective in completely inhibiting the growth of indicator organisms from clinical hospital waste. Following use of the Matrix system, the final product is suitable for disposal on a land fill site.

PRIMARY INDUSTRIES AND ENERGY

Science and Technology in the Portfolio Budget

The principal aim of the research and development programs operating within DPIE is to contribute to the efficiency and competitiveness of Australia's primary and energy industries and to the efficient effective management of the resources on which they depend. Strong linkages with industry and relevant parts of Government, at both corporate and program levels are essential to ensure that the structural and administrative arrangements for research and development facilitate these outcomes. Portfolio R&D structure and arrangements are designed to take into account Government and industry needs and objectives in the development of research programs, and to facilitate the rapid integration of outcomes from new technologies into industry so that it benefits directly from the R&D.

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

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

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

Research Bureaux

The Department maintains three research bureaux:

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

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

predominantly from consolidated revenue and totalled around \$100 million in 1993-94, Research is generally directed to areas where the external benefits are high, at the more basic lines of research, in research that may have a wide social impact, and where user pays funding is not generally cost effective. In addition, the Bureaux undertake research on a contract basis for other agencies and industry.

R&D Corporations and Councils

The Forest and Wood Products R&D Corporation was established in 1993-94 bringing the number of R&D Corporations and Councils to nineteen. R&D Corporations and Councils were established to encourage greater end user participation in research, to work with industry and research organisations to facilitate and actively pursue the commercialisation of research and the realisation of industry opportunities and to promote and become involved in technology transfer. Research expenditure through these bodies in 1994-95 is expected to be around \$271 million, of which approximately 50 percent is contributed by the Commonwealth and 36 percent will be collected from industry levies. The balance comprises reserves and other income.

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

- Cotton R&D Corporation
- Dairy R&D Corporation
- Fisheries R&D Corporation
- Forest and Wood Products R&D Corporation
- Grains R&D Corporation
- Grape and Wine R&D Corporation
- Horticultural R&D Corporation
- Meat Research Corporation
- Pig R&D Corporation
- Sugar R&D Corporation
- Wool R&D Corporation
- 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 (up to 0.25 percent GVP matching and 0.5 GVP percent Government appropriation for the fishing industry). The Government's matching

contribution is designed to provide an incentive for the primary sector to increase its R&D funding and to become more responsible for its own R&D priority setting.

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

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

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

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

MAJOR RESEARCH ACTIVITIES

Australian Bureau of Agricultural and Resource Economics (ABARE)

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

Recent Achievements

Farm level income variability

Statistical techniques were developed to estimate the temporal income distributions of farms from data collected by ABARE in its farms surveys. These distributions were used to assess regional variation in the relationships between risk and returns in Australian broadacre farming and hence played a significant role in the examination of farm performance in the broadacre industries.

Benefits and costs of fisheries research

A benefit-cost framework was used to provide Fisheries Research and Development Corporation (FRDC) with step by step procedural guidelines on research prioritisation, ex-ante project evaluation and research portfolio selection. These guidelines, with some modification, have been adopted by the FRDC in its effort to improve research evaluation and the selection of the research portfolio for funding.

Seafood marketing efficiency

A major assessment of the efficiency of Australian seafood marketing was undertaken, the conclusions of which were adopted by the peak fishing industry policy body. The analysis has formed the basis for the development of a national seafood marketing strategy and reform of domestic seafood marketing arrangements.

ABARE model of irrigation farming

This model was developed to analyse the impacts on irrigated agriculture of water pricing and allocation reform. The results are being used by the Murray-Darling Basin Commission in the development of an irrigation management strategy for the basin.

Model of world markets for iron ore, coking coal and steel

A model of the world markets for iron ore, coking coal and steel was developed for use in analysis of changes in steel trade policies and long term projections for prices and volumes in these markets. The model has been used to assess the effects of a removal of steel tariffs, which are currently under discussion as part of a possible Multilateral Steel Agreement.

MEGABARE

ABARE has developed a global macroeconomic general equilibrium model (MEGABARE). This can be used to quantify the impacts of greenhouse response policies on trade and industry structure at the international and domestic levels. It can also be used to identify least-cost greenhouse response strategies. The model will assist policy making at both the national and the international levels.

Bureau of Resource Sciences (BRS)

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

Recent Achievements

Resource assessment of Shoalwater Bay

BRS, in collaboration with the ABARE and the AGSO, published a comprehensive scientific and economic assessment of the Shoalwater Bay military training area. This area is important for the conservation of biodiversity and it may also contain mineral deposits of high commercial significance. The report became a submission to the Government's Shoalwater Bay Commission of Inquiry and was extensively quoted in the Inquiry's Interim Report.

Attractiveness of offshore petroleum acreage

BRS carried out regional petroleum prospectivity studies over areas proposed for acreage release offshore. These studies, which contain a summary of published data, new geological or geophysical interpretation, approaches to exploration, and digital databases, provide a data package to assist petroleum companies in assessing gazettal areas. The studies have had a positive impact on industry perception of prospectivity of the areas and have been used as reference material in industry bids for gazettal acreage. Recently, studies of areas released in the Beagle SubBasin (WA) and the Eastern Bass Basin (Tas) have attracted attention from overseas exploration companies.

Indicators of sustainable agriculture

In November 1993, BRS published a report on indicators of sustainable agriculture that arose from a working group, coordinated by BRS for the Standing Committee on Agriculture and Resource Management. The report suggested a scheme of indicators that has now been adopted for testing at regional level in most States and is expected to improve evaluation of the long-term viability of Australia's agricultural practices. These indicators also allow assessment of the environmental status and level of management practised in Australian agriculture.

Low level radioactive waste

A decision support system based on geographic information system software was developed to assist in identifying regions suitable for the location of a repository for low level radioactive waste. The BRS system provides for a range of data themes to be integrated, each theme being ranked as to its suitability for a repository. The site selection methodology and the regions identified as potentially suitable for a repository were published by BRS for public comment. Subsequently, a report on the comments received was also published.

Australian Geological Survey Organisation (AGSO)

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

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

- the effective development and implementation of Commonwealth Government policy in sustainable natural resource and environmental management;
- the improved management of Australia's natural resources consistent with the principles of ecologically sustainable development;
- the development of a more competitive and diversified Australian mineral and petroleum exploration industry;
- the development of effective strategies to mitigate natural geological hazards;
- the achievement of Australia's foreign policy and trade objectives; and
- the fulfillment of its global and regional responsibilities.

Recent Achievements

New data acquired in key exploration areas

In 1993-94, AGSO's aircraft acquired over 200 000 kilometres of new airborne geophysical data in three major mineral provinces - the Eastern Goldfields (WA), the Tanami Desert (NT) and the Lachlan Fold Belt (NSW). The information obtained from these surveys has been in great demand with

exploration companies, and a record number and dollar value of data products have been provided to customers. This work was carried out as part of the National Geoscience Mapping Accord to improve the basic geological information base over the Australian continent and encourage mineral and petroleum exploration and sustainable land resource management.

Increased exploration activity in the Kimberleys

In the Kimberley region, mapping by AGSO in collaboration with the Geological Survey of Western Australia has outlined new mafic-ultramafic intrusions with potential for base metal, chromium and platinum group element mineralisation. It has resulted in an increase in exploration activity in the region.

Officer Basin seismic survey

Approximately 600 kilometres of deep crustal seismic data were collected during 1993 in the central Officer Basin in South Australia as part of a joint project undertaken by AGSO and the South Australian Department of Mines and Energy. The data have helped to define the shape of this huge (300 000 square kilometres), largely unexplored basin. The work has raised the prospectivity of the region and helped AGSO to develop a better understanding of the geological events that formed the Amadeus and Officer Basins in central Australia. A major feature of the project that has important ramifications for the resource industry was the signing of land access agreements with the Maralinga and Pitjantjarjara peoples in South Australia.

Understanding the North West Shelf

Research conducted by AGSO in the North West Shelf area of north western Australia has had a significant impact on the petroleum industry's interpretation of the area, thus improving the effectiveness of their exploration activities. AGSO completed the first pass deep seismic coverage of the area. The unique dataset obtained has led to major re-definitions of the key tectonic elements, changed concepts of how continental margins form and led to a reassessment of the timing assumed for the initiation of many of the geological features.

Groundwater modelling

AGSO has developed a computer-based model of groundwater movement in the lower Lachlan River. The model simulates impacts on the groundwater and related river systems resulting from changes in land use and management. For the first time, implications of various land management decisions can be modelled to understand resultant short and long term changes in the environment.

Cape York Peninsula Land Use Strategy [CYPLUS]

During the year, the first two year phase of the investigations for the development of CYPLUS was completed. AGSO contributed to the joint Commonwealth/Queensland Government National Resources Assessment Program by providing bedrock geology, regolith terrain, coastal geoscience, groundwater resources and airborne geophysical survey data. These geoscientific datasets have been digitally compiled into a geographic

information system developed by DPIE's National Resource Information Centre to allow better land resource management decision making on Cape York Peninsula.

Chicken Meat Research and Development Council (CMRDC)

Role *To develop, fund and administer an efficient and effective research and development program which will contribute towards a more profitable and sustainable chicken meat industry for the benefit of both Australian producers and consumers.*

Recent Achievements

Improved control of diseases caused by *Mycoplasma* sp.

Mycoplasma galliseptum and *Mycoplasma synoviae* are bacterial pathogens of poultry. Alone, or in combination with other organisms, they cause a variety of respiratory and other disease conditions in Australian chicken flocks, costing the Australian poultry industries millions of dollars every year.

A new vaccine for *M. galliseptum*, which was developed at the University of Melbourne with Council funding, is now in use in Australia providing improved control of diseases associated with this organism in domestic poultry flocks. The vaccine is now registered and selling well in the USA and its registration is currently being sought in a number of Asian countries.

A new test for reliably detecting infections in flocks of both the above pathogens, has also been developed at the Victorian Institute of Animal Science and is currently being trailed on field samples submitted by industry.

Chicken products and public health

Research undertaken at two different centres over the year has demonstrated that it is possible to use various vaccination strategies to simulate an immune response in the gut of chickens. This information will now be used to establish whether colonisation and spread of *Campylobacter* sp. and *Salmonella* sp. in the gastro intestinal tract of chickens can be reduced. These bacterial organisms can cause gastroenteritis in humans. If successful, such strategies would be a novel way of reducing contamination by these organisms in chicken products.

Dairy Research and Development Corporation (DRDC)

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

The DRDC funds R&D projects in four key portfolios: farm; manufacturing; economics and marketing; and human resources.

Recent Achievements

Manufacturing portfolio

The Manufacturing Portfolio plays a key role in helping the industry to add value to Australian dairy products. DRDC's policy is to select projects which will assist manufacturers in becoming more efficient and to increase demand for dairy products by improving quality and developing new products. Key R&D programs include milk quality and safety, new products, waste management and process engineering.

The DRDC played a major role in establishing the Australian Food Ingredients Application Centre. The Centre is a joint venture between the DRDC and four dairy manufacturers. The Food Ingredients Centre will assist dairy manufacturers in developing and marketing dairy products for use as ingredients in other food products (eg pizzas, confectionery). This follows the success of another joint venture - the Australian Starter Culture Research Centre which is being used as a model for the Food Ingredients Centre. The Dairy Industry Quality Centre continues to provide manufacturers with an information and advisory service on maintaining and improving the quality of Australian dairy products. The Quality Centre is fully funded by the DRDC.

Economics and marketing portfolio

The highlight of the Economics and Marketing Portfolio was an industry benchmarking study which covered all sectors of the Australian dairy industry. The study highlighted potential gains of about \$400 million a year through improvements in dairy farming, manufacturing and marketing. The study gave the industry an indication of how it was placed on the domestic and international scene. The industry gave overwhelming support for the study and is now implementing the recommendations. One of the key findings was the benefit if more exports were sold as differentiated products rather than bulk commodities.

Fisheries Research and 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.

Recent Achievements

Australian Fisheries Resources

This is a major review of all Australia's commercial fisheries resources which was published jointly by the FRDC and BRS in September 1993 as *Australian Fisheries Resources*. This book draws together the existing knowledge of fisheries resources and their responses to exploitation. The book is the culmination of 7 years work based on the expertise of over 350 contributors and contains details on more than 100 species.

Sharks and rays of Australia

This is the definitive reference work for sharks and rays present in Australian waters. The known physical characteristics, habits, biology and distribution of each shark is described in detail. Eighty four quality colour plates and over 1,400 black and white illustrations are included to aid in the identification of every species.

Grains Research and Development Corporation (GRDC)

Role *The Grains Research and Development Corporation (GRDC) is a statutory authority funded jointly by a levy on grain growers which is matched by the Commonwealth. There are, at present, 25 leviable crops spanning temperate and tropical cereals, oilseeds and grain legumes. The Corporation has a mandate to plan, develop and oversee research and development in the industry which encompasses these crops. The Corporation's primary goal is to invest in research, development and related activities to benefit Australian grain growers, within a wider grains industry and community context.*

Recent Achievements

Noodles from white wheat

The Australian wheat industry is demonstrating its commitment to quality marketing with the release of a new white wheat variety developed especially for making fine noodles. West Australian farmers sowed this variety, named Cadoux, for the first time in 1993. It joins the varieties Gamenya, Eradu and Rosella, which the Australian Wheat Board already segregates for supply to the noodle market. Cadoux has superior milling qualities and its exceptional starch paste viscosity sets it apart as a noodle variety. Cadoux is expected to capture a major share of the premium-paying market, which has the potential to reach 1.2 million tonnes. It is higher yielding than present noodle wheats and very competitive with other varieties with the \$15 per tonne or better premium it attracts.

Japanese noodle manufacture

GRDC-supported research demonstrated why flour from the wheat cultivars Gamenya and Eradu is suited to Japanese noodle manufacture. The secret lies in the chemistry of the starch. The correct characteristics are now known and can be recognised in tests. The research has shown that many wheats have the right type of starch but expression of this advantage is masked by other properties, preventing production of top quality noodles. As a result of this research, plant breeders now have access to tests for the presence of good starch and will know that their efforts should be directed to exposing the quality that may already be present. They will usually not have to introduce it from other lines.

Flour swelling volume test

A flour swelling volume (FSV) test funded through the GRDC and developed in Western Australia was modified for testing of weather-damaged grain. Even before its adaptation to weather-damaged grain, the FSV test had already proven useful as a rapid test for lines with potential for the Japanese noodle market. The test was developed at the Grain Products Laboratory of the Western Australian Department of Agriculture and is now in regular use in breeding programs. It allows breeders to select for noodle quality at a much earlier stage than was previously possible. The Victorian Crops Research Institute also uses the test.

Grape and Wine Research and Development Corporation (GWRDC)

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

Recent Achievements

Fingerprinting grapevines

R&D activities at the CSIRO Division of Horticulture have resulted in the development of molecular techniques and a management system to definitively identify different grapevine varieties. This work was supported by GWRDC and the Dried Fruits Research and Development Council. Continuing international collaboration supported by GWRDC and DIST is aimed at commercialization and international acceptance via laboratory contacts in France, Italy and the USA. This further work involves automation of the technique and establishment of agreed reference varieties against which typing can be validated. Acceptance of this technique will reinforce quality assurance regarding vine and wine varietal composition at all stages of the production chain.

Biological control of mites

Work undertaken at Yanco Agricultural Institute, and at a range of commercial vineyards across Australia indicates that biological control of mites does work effectively in a number of regions and has potential to extend throughout inland Australia. Mass rearing techniques have been developed to ensure supplies of selected beneficial predator mites which prey on the pest mites. Other work has defined a range of 'soft' fungicides, important for disease control, which can be used without harm to the beneficial predator mites.

Horticultural Research and Development Corporation (HRDC)

***Role** By its R&D efforts, to foster efficient, competitive and adaptable horticultural industries with a view to improving their overall performance and well-being of horticulturists and the community at large.*

Recent Achievements

Green vegetable bug management

Green vegetable bug is a widely distributed pest of nuts, fruits and vegetables. The research has resulted in the development of management practices to control of the bug, eliminating the need for pesticides. This control method has already significantly reduced the previous annual losses to growers, estimated at more than 10% of yield. For example, control of the green vegetable bug in pecan orchards led to cost savings to one property of at least \$1 million.

Modified atmosphere packaging

Sea freight trials of broccoli and cauliflower to Singapore and Japan have been successfully conducted using modified atmosphere packaging to prolong storage life.

Spray for citrus leaf miner

A novel spray formulation for the control of citrus leaf miner has been discovered. It is safe to use and is compatible with sustainable integrated pest management programs.

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.*

Recent Achievements:

Commercial pig breeding

Australian pig breeders are selecting stock on the basis of a new blood test for a specific gene, the Halothane gene. During the past five years, with the support of PRDC, several scientific groups have identified the nature of this gene, its function and its relationship to pig performance and to meat quality. Unless the gene is well managed, it has adverse effects on profitability of meat production.

The problem has been to identify those pigs carrying the Halothane gene. Since mid 1993 nearly 3,000 pigs have been tested and the results suggest that the Halothane gene is carried by 25% of the pig population in Australia. PRDC have now licensed a DNA test for the Halothane gene and it has been made commercially available through the Queensland Department of Primary Industries.

Nutrition strategies for sows

Problems of seasonal infertility in sows will be reduced markedly as a result of PRDC funded research. It has been conservatively estimated that in most years the industry loses up to \$20 million due to poor reproductive performance during the summer months. New research has demonstrated an increased farrowing rate of between 10% and 23%, as a result of improved nutritional strategies over the summer/autumn period.

Sugar Research and Development Corporation (SRDC)

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

Recent Achievements:

Productivity management

Procedures were developed to transfer production data from mill computers to personal computers, and to use customised software to quickly produce tables and graphs for mill area productivity reports. These have been used successfully to enhance the presentation of extension material, both on an individual basis and in group extension activities. Provision of readily understandable productivity data is already producing beneficial results for growers in the four mill areas initially targeted, with recent expansion to two additional areas.

Australian Wool Research and Promotion Organisation (AWRAP)

Role *A WRAP's role is the generic promotion of Australian wool nationally and internationally, the maintenance of the quality of the wool clip and to allot funding and give coordinated direction to wool research and development within Australia as well as overseas.*

The R&D aims include 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

Low temperature dyeing

Wool growers, through AWRAP, funded research by the CSIRO's Division of Wool Technology into dyeing processes. Conventional dyeing methods need temperatures around boiling and have a high waste element through dye that is not taken into the fabric.

CSIRO developed the low temperature method of dyeing which saves energy because it allows effective dyeing at temperatures 10 to 15 degrees Celsius below boiling. The method produces less waste and a brighter coloured fibre because more of the dye is taken up into the fibre, as well as giving a softer handle to the wool.

ICI Valchem, CSIRO and AWRAP signed a joint commercialisation project to market it internationally. There has been widespread interest from processors globally.

Wool scour effluent treatment

The first step in processing a fleece is cleansing in giant scour baths. These baths require huge amounts of water and the resultant effluent is of major concern to processors. It poses quite a problem with disposal in terms of logistics, environment and cost.

CSIRO, with AWRAP funding has developed a process for treating the effluent that removes 95 per cent of the wool wax and 99 per cent of soil. The resulting sludge is easily managed for disposal and leaves a much cleaner liquid. Processors save on disposal costs and the environment benefits.

The process is also being commercialised with interest being shown from major international processing companies.

Egg Industry Research and Development Council (EIRDC)

***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

New egg

EIRDC is progressing the commercialisation of research results which may lead to the marketing of a new type of egg. Trials are underway to assess market place acceptance of this new low cholesterol egg. Negotiations on commercialisation rights are also taking place with industry marketing organisations. If successful, a new range of low cholesterol egg products may also be developed.

Dried Fruits Research and Development Council (DFRDC)

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

Recent Achievements

Bulk handling systems for sultanas

The concept of an inclined flight elevator to break up dried sultanas which was devised at the University of South Australia has been developed for commercial application by Australian Dried Fruit Sales (ADFS). The company has developed a bulk handling system for processed fruit. The system enables fruit to be transported in one tonne reusable containers rather than 14 Kg cardboard cartons. ADFS estimates the system will provide savings of \$1 million per annum within its retail packeting operation and negotiations are continuing for its installation by major manufacturing users.

Cleaning systems

The industry's processing sector has installed improved cleaning systems to remove waste contamination in processed fruit. Equipment developed at the University of South Australia significantly reduces the incidence of stone, snail, immature berry, and bunch stalk contamination of processed fruit. The major industry processors have also installed laser scanning and air jet systems for identifying and ejecting contaminants. As a result of these and other developments, the quality of Australian sultanas, as assessed by a major manufacturing user's system, has improved from 55% to 91%.

Energy Research and Development Corporation (ERDC)

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

The objectives of its investments are to:

- increase the efficiency of energy supply and use;
- increase the development of competitive Australian industries;
- increase the diversity of energy supply;
- reduce adverse environmental effects of energy supply and use;
- reduce the amount of energy required to be supplied; and
- reduce customer energy costs.

Recent Achievements

Vanadium prototype battery development

Research has continued into the development of vanadium redox batteries which store electrical energy by a charge exchange mechanism between two vanadium-based solutions. In effect, the amount of energy stored can be decoupled from the power required to be delivered to a load.

There are many possible applications for such batteries, among them:

- electrical load levelling at the end of long or heavily loaded distribution lines;
- energy storage for Remote Area Power Supply (RAPS) systems; and
- electric vehicles.

The technology has been licensed overseas recently, and ERDC is currently conducting a study to look at the commercial prospects for its manufacture in Australia.

International standard for water heaters

ERDC sponsored the proceedings which enabled the adoption of International Standards for the construction and performance of solar water heaters in Australia. This means that domestic solar hot water system manufacturers are now able to export their products, and be certain that they will meet the requirements of the international market.

Solar driven water pumping systems

This successful project investigated the possibilities of commercialising solar powered motor drive technology. The results of the project confirmed that the effectiveness of standard water pumping systems can be improved when coupled with very high efficiency, brushless DC motors. The volume of water pumped using the new system was greater than the best commercially available alternative. In addition, a new style of solar tracker has been developed, which can also boost the amount of water pumped each day.

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 Achievements

Farm enterprise management

Under this project, researchers at the University of Queensland developed a computer package which, for the first time, includes all information needed by land managers to evaluate their land use options in a realistic and practical way. The package is designed to combine data on soils and other natural resources, farm enterprises, and economic conditions, to help managers calculate production risks, crop yield estimates, net return probabilities, and the suitability of their land for various enterprises. The computer package was tested extensively in the Herbert River region of Queensland, where it successfully evaluated the economic performance of a wide range of enterprises.

Rural Industries Research and Development Corporation (RIRDC)

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

To achieve this, the Corporation organises and funds research to support small, emerging and new rural industries such as Asian foods, spices and herbs, wildflowers and ostriches and emus. RIRDC also addresses broader issues which affect most if not all agricultural industries (such as agroforestry, agribusiness, extension and rural education). The Corporation also provides services for the five semi-independent research and development councils (Chicken Meat, Dried Fruits, Egg, Honeybee and Tobacco).

Recent Achievements

Australia's first Asian food workshop

RIRDC has established an innovative Asian Foods program to help the Australian food industry become involved in the growing world-wide market for Asian-style foods. A national workshop on Asian foods brought together, for the first time, Asian food processors, growers, materials suppliers, distributors, import buyers, researchers and policy makers to discuss how Australia can benefit from the Asian food market. The workshop has generated industry proposals for joint R&D to develop Asian food products for world markets. Supporting RIRDC projects aim to improve the availability of Asian market and distribution information for Australian industry.

Study of Asian food market trends and prospects

The Corporation commissioned a study that examined on-shore and off-shore movements of Asian foods, to determine key countries, markets, foods and likely movements over the longer term. RIRDC has found the study to be a valuable background document in helping it identify priorities for scientific and marketing R&D. Response from both researchers and the Asian business community in Australia to this initiative has been very positive.

New rice varieties

NSW Agriculture, through RIRDC support, is making substantial progress towards the development of shorter season rice varieties that can be sown later and hence need less water. Two new rice varieties were released in March 1994: Kyeema, a fragrant long grain and Langi, a high yielding semi-dwarf grain. The release of these varieties, which have been designed to increase yields while maintaining existing high quality standards, will improve Australia's export competitiveness. The new varieties are replacing two lower yielding varieties (Goolarah and Peldi) and the increased yields will allow the industry, which is 80 - 90% export oriented, to extend existing markets.

New lentils

The South Australian Research and Development Institute, with RIRDC's support, has released varieties of lentils which provide a sound basis for a lentil industry in southern Australia. Following the crossbreeding of 535 lines of lentils, 200 varieties were field tested. This resulted in 2 red lentil

lines being selected for commercial release. These lines are of premium quality and produce yields which are significantly higher than previous varieties.

Tasmanian green tea

The Tasmanian Department of Primary Industries and Fisheries together with RIRDC supported research into developing a new green tea industry worth \$10-\$20 million per annum within five years. Six thousand plants, introduced through quarantine, are now established at five trial sites throughout Tasmania. The success of this first stage of research has led to Roberts Ltd, a prominent Tasmanian company, joining the commercial venture to establish a pilot green tea processing plant.

Personal safety on the farm

RIRDC funded an investigation by the Kondinin Group of personal protection equipment for farm safety. The survey found that 36% of farm chemical users surveyed suffered ill effects from using agricultural products. Of those, 25% were attributed to animal health products such as dipping or blowfly control chemicals. The survey also found that 32% of farmers do not carry a supply of clean water for washing hands when handling chemicals, more than half never use a faceshield or goggles when using farm chemicals, and 32% never use a respirator around agricultural products. Kondinin has published recommendations for farmers in its monthly journal and is producing a comprehensive handbook for farmers to help reduce the number of farm injuries.

Australian competitiveness built on new crops

RIRDC commissioned Agrans Research to examine 35 crop industries and identify factors that have affected the successful or unsuccessful commercialisation of new agricultural ventures. These factors include production, processing, marketing, government, and R&D issues. The authors found that new crops have accounted for 67% of the growth in Australian crop industries over the past 40 years and that R&D played a key role in that. The report is proving to be an invaluable guide to all involved in the development of new rural industries.

Development of heat pump dryers

RIRDC and the Queensland Department of Primary Industries jointly funded a research project to develop heat pump dryers which result in higher quality dried food products and greater energy savings. This project won a 'National Energy Award' which was announced in October 1993. The dryers are now being used by sixteen food companies in Australia. Increasing industry adoption of heat pump dryers will allow Australia to replace imported dried products with local products.

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 \$1.8 million in 1994-95 (\$2.6 million in 1993-94).

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 the 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.

The Council usually meets twice a year, with each meeting addressing at least one major presentation and one or more short discussion sessions. Papers for these are prepared by independent working groups, or by ASTEC working parties. The groups preparing presentations generally consist of leading

executives and specialists from the private and public sectors, who compile short reports on major topics which are generally published and released at the time of the PMSEC meeting.

PMSEC has played a valuable role in involving senior Ministers in discussions of current issues in science and technology, with a particular emphasis on the application of research to economic and social objectives. It 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; and
- to examine Australia's science and engineering infrastructure and the effectiveness with which it achieves the application of science and technology in the economic and social development of Australia.

Recent Achievements

The Council met in November 1993, to discuss aspects of research in tropical Australia, and the possibilities of gene technology. It is expected to meet again in June 1994.

Following the November 1993 meeting, working groups were established to follow on from the Council's discussion of the tropical savanna landscape, delivery of health services to Aboriginal and Torres Strait Islander peoples, and gene technology.

A working group comprising the Department of Human Services and Health, the Aboriginal and Torres Strait Islander Commission, and the National Health and Medical Research Council, met in March 1994, to discuss the delivery of health services to Aboriginal and Torres Strait Islander people.

The Australian Nature Conservation Agency and the Land and Water Resources Research and Development Council will follow up the discussion of the tropical savanna landscape.

The Coordination Committee on Science and Technology has formed the working group to follow up the recommendations of the Council paper on gene technology.

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.*

Recent Achievements

The Coordination Committee has, during 1993-94, taken a major part in:

- evaluating a proposal for the establishment of a national nanotechnology fabrication facility;
- reviewing the Commonwealth's effort in research and research training in the solid earth sciences;
- preparing a report on issues associated with access to Australia's biological resources;
- completing a survey of the practices of Commonwealth departments and agencies in setting priorities for science and technology performance and funding;
- discussing the science and technology input to the Government's White Paper on employment, industry and regional development;
- considering a range of reports from ASTEC, including research and technology for tropical Australia, external earnings targets for science agencies, and energy research and development; and
- discussing medical research funding issues, including the recent review of the NH&MRC, and the target for health and medical research expenditure as 2% of total health expenditure.

The Minister Assisting the Prime Minister for Science attended all meetings of the Committee in 1993-94.

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 on strategic and operational issues affecting the science and technology system and its contribution to national goals.*

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 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; and
- advises on the work of the Structural Adjustment and Trade Committee of Cabinet and other Committees, as appropriate; and
- initiates and develops new policy proposals, where appropriate, in consultation with other departments.

Recent Developments and Achievements

The Office chaired an Inter-Departmental Committee which examined the case for a national nuclear regulatory body and provided advice on other aspects of nuclear science and technology, marine science arrangements, women in science and funding for science in the 1994-95 Budget. Advice was also provided on a proposed program of major national research facilities and a proposal for a national nanotechnology fabrication facility.

The Office played a central role in arranging the establishment of additional Cooperative Research Centres (CRCs) and in the administration of the Program including the selection of ten more CRCs. The CRC Program was transferred to the Department of Industry, Science and Technology in March 1994.

Following Minister Schacht's statement of 24 June 1993 concerning arrangements for the provision of science policy advice to the Government, the Chief Scientist, Professor Michael Pitman, OBE, FAA was appointed as a member of ASTEC in December 1993.

Australian Science and Technology Council

Role *To provide independent advice to the Government on science and technology 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; and*
- *improving efficiency in the use of resources by the application of science and technology.*

Recent Achievements

Research and technology in tropical Australia

ASTEC was commissioned in April 1992 by the Prime Minister to undertake a study of research and technology in tropical Australia. ASTEC consulted widely with government, industry and research organisations. The summary report of the study was tabled in Parliament in October 1993.

The final report was released at the November 1993 meeting of the Prime Minister's Science and Engineering Council. The report:

- *reviews* research and technology across the different sectors in tropical Australia;
- *examines* the social, cultural and economic needs as well as the research and technology issues of Aboriginal and Torres Strait Islander peoples in tropical Australia;
- *identifies* future opportunities for tropical zone R&D and associated technologies for the next decade; and

- *recommends* actions to capitalise on those opportunities and to rectify deficiencies.

The Prime Minister has asked the Coordination Committee on Science and Technology to examine the ASTEC report and to prepare a response for the Commonwealth Government to consider.

Energy research and technology in Australia

ASTEC released the results of this study as an Occasional Paper in February 1994. The Paper examines the challenges facing the energy sector; the structure of the energy industry; the commercialisation and export of energy research and technology; the funding of energy research and development; the organisation and distribution of energy research and technology development; and priority setting in energy research and technology.

The Paper:

- *considers* that the present funding, allocation, priority setting and infrastructure arrangements do not adequately address the challenges facing the energy industry in Australia;
- *finds* that the conduct and support of energy research and technology development in Australia are operating reasonably well for present circumstances but that the present system will not respond well to future changes in the use and delivery of energy; and
- *identifies* opportunities for improved coordination and a sharper emphasis on selected areas of activity, which will result in improvements in the efficiency and effectiveness of Australian energy research and technology development.

Nanotechnology

As part of its technology assessment function, ASTEC conducted a study on nanotechnology, or science and technology at the atomic scale. The study examined nanotechnology's scientific promise and its role in contributing to economic development. An early draft of the study formed the basis of a presentation to the Prime Minister's Science and Engineering Council in December 1992.

The final report ASTEC Occasional Paper No 26: *Small Things - Big Returns; the Role of Nanotechnology in Australia's Future*, was released in July 1993. It concluded that: nanotechnology should be a priority area for Australia; the establishment of a National Nanotechnology Fabrication Facility should be examined; and before the establishment of such a facility, a business plan should be developed and committed to by stakeholders. At the launch of the report a consortium was formed to submit a detailed business plan to the then Minister for Science and Small Business.

Gene technology

ASTEC completed its study of gene technology with a presentation and release of its Occasional Paper No 27: *Gene Technology; Issues for Australia* at the November meeting of the Prime Minister's Science and Engineering Council (PMSEC). The Paper provides a comprehensive assessment of gene

technology issues and opportunities in Australia. Recommendations called for a program of action involving communication and public acceptance, a regulatory system that is efficient, effective and open, and, the development of effective linkages between researchers and industry. The Prime Minister has referred the gene technology recommendations to the Coordination Committee on Science and Technology to prepare a response for Government to consider.

Review of external earnings targets

In October 1993, the Minister Assisting the Prime Minister for Science commissioned ASTEC to review the operation of the external earnings targets policy for three major Commonwealth research agencies: CSIRO, the Australian Nuclear Science and Technology Organisation (ANSTO) and the Australian Institute of Marine Science (AIMS).

In 1988, the Government set CSIRO the target of attracting 30% of its total annual funding from external sources by 1991-92. Comparable targets were subsequently introduced for ANSTO and AIMS and other Commonwealth research agencies. A major objective of the targets was to promote links between Government research agencies and industry and other research users.

ASTEC has:

- *reviewed* the effectiveness of the external earnings requirement as a mechanism for promoting links with research users;
- *evaluated* the impact of the current targets on the level and quality of interaction with users, the performance of core research responsibilities and the balance of research effort, and the management of staff and other resources within the agencies; and
- *assessed* the appropriateness of the targets as a measure of interaction compared with alternative performance indicators.

The ensuing report recommends that the targets be retained, and that they be set in future through a process of negotiation between the agency and its Minister in the context of triennial funding arrangements. Standardised guidelines for reporting the targets need to be established and indicators of links with industry should be included in annual reports. ASTEC recommends that agency strategies for interaction with small and medium-sized enterprises should be developed, complemented by an active science and technology brokerage mechanism.

This report was tabled in Parliament in March 1994.

TRANSPORT

Science and Technology in the Portfolio Budget

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

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 Qantas, the Federal Airports Corporation, the Civil Aviation Authority and a number of other organisations.

MAJOR RESEARCH ACTIVITIES

Australian Road Research Board (ARRB)

***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.*

Recent Achievements

Measuring road conditions

The Australian Road Research Board's (ARRB) new Multi-Laser Profilometer automatically measures and records road condition data by taking laser profiles of the road surface at highway speed. ARRB designed and manufactured laser systems have been used to improve the definition of road surface measurements and increase the scope of data that can be collected. The device represents a new generation of Australian road condition monitoring technology designed to reduce the cost of collecting reliable, objective data for road system audits and improved road management.

Federal Office of Road Safety (FORS)

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

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

Recent Achievements

Bus safety

Over recent years, a bus safety package has been introduced, specifying improved seat and seat anchorage strength and bus roll-over protection requirements.

An Australian Design Rule requiring lap / sash seat belts in all new non-route service buses will be introduced in the second half of 1994. Sled testing on bus seats incorporating lap/sash belts has concluded and will assist manufacturers in the development and certification of their seats.

Mass media road safety campaigns

Mass media road safety campaigns from around the world were reviewed. A report has been released highlighting the effectiveness of various types of campaigns and details of methods of maximising campaign benefits. It provides valuable information for road safety and enforcement agencies which use the mass media to convey road safety messages and indicative estimates of expected road safety gains that result from the use of various types of campaigns.

Speed review

A comprehensive review of existing research relating to speed and speed controls was recently completed. It examined the relationship between speed and crashes, the role of speed limits on travel speed, the effects of speed enforcement on travel speed and driver behaviour, and the influence of the environment on speeding. The review identifies promising countermeasures that are ready to be tested in field trials or demonstration projects, as well as priorities for basic research.

Main street environmental design

Local area traffic management treatments have shown to have a marked potential to improve the safety and amenity of the local environment. In a project jointly funded by the Federal Office of Road Safety and the Roads and

Traffic Authority of NSW, a team of researchers was commissioned to examine and document issues relating to the environmental adaptation of main streets in country towns. The report establishes principles for planning, analysis and design of local area traffic management treatments for the main street in country towns and formulates guidelines for the environmental adaptation of such streets.

Fatigue research

A program of research into fatigue in the long distance road transport industry continued with a report of the survey of bus and coach drivers released in July 1993. On-road trials were conducted to evaluate the effects of staged and single driving and fixed versus flexible scheduling on driver fatigue and performance using a range of behavioural and performance measures. Further on-road testing has been commissioned to examine factors which affect fatigue and performance in two-up driving (drivers sharing the driving with the relief driver sleeping in the truck).

Statistical analyses

The major focus of statistical projects over the past year has enabled a better understanding of road crashes resulting in injury and how the causes and circumstances of these events differ from fatal crashes.

One aspect of this approach has been to explore the reliability and completeness of police records of non-fatal road crashes. Various studies have, for example, attempted to quantify the degree of under-reporting of injury crashes of various severity levels and have described the nature of crash misclassification in police records.

Studies have also looked at some of the reasons why information on blood alcohol levels is often missing on crash databases and some of the implications for the monitoring of the scope of the drink drive program.

In addition, research on fatal crash data has tended to concentrate on distinct road user groups that have not been focused on in the past. One such group would be female car drivers, who now account for a significant minority of fatal car crashes.

Road safety research grants

Each year the Office awards a number of small scale research grants to encourage researchers to enter the road safety field and to promote innovative research projects. The maximum grant is \$20,000. Since July 1993 the following projects have been completed:

- Elderly Drivers and Visual Impairment;
- Factors involved in the long term benefits of Random Breath Testing in NSW;
- Estimation of Truncated Ordinal Regression Models (a new statistical procedure for evaluating factors affecting injury outcomes in road crashes);
- Road Traffic Injury in Western Sydney; and

- A preliminary assessment of the feasibility of using 'willingness To pay' methods to value road safety measures in Australia.

Support for Other Research Activities

In addition to significantly contributing financially to the work of the Australian Road Research Board (ARRB), a limited amount of Federal funding is also made available for 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.

Projects recently assisted include a contribution towards the development in Australia of intelligent vehicle and highway systems technology, financial assistance for the establishment of a national bicycle strategy database and the funding of research into the development of alternate fuels technology.

This Statement was prepared by the Science and Technology Analysis Section, Department of Industry, Science and Technology, 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 the diverse range of current research and development projects is presented, including an environmentally-friendly pesticide, a computer mapping system for emergency vehicles and a new weapon to fight the battle against the influenza virus.

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.



9 780644 334686

A43032 Cat. No. 94 1976 3