



SCIENCE AND TECHNOLOGY BUDGET STATEMENT 1991-92

CIRCULATED BY
THE HONOURABLE ROSS FREE, M.P.,
MINISTER FOR SCIENCE AND TECHNOLOGY
AND MINISTER ASSISTING THE
PRIME MINISTER FOR SCIENCE

BUDGET RELATED PAPER No. 6

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No. 6 Science and Technology Budget Statement 1991-92

Outlines Commonwealth support for science and technology with a particular focus on major Commonwealth research agencies and programs supporting research-related activities.

No. 7 Social Justice for Indigenous Australians 1991-92.

Outlines Commonwealth programs and services for Aboriginal and Torres Strait Islander people.

No. 8 Program Performance Statements

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Describes the major structural problems facing Australia's health care system, and outlines reforms in the 1991-92 Budget to the equity and efficiency of the health care system.

Report of the Auditor-General

A report on the Financial Statements prepared by the Minister for Finance for the year ended 30 June 1991.

(This document is to be released in November 1991.)

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PREFACE

The *Science and Technology Budget Statement* was first produced as a Budget Related paper in 1989, following the major policy statement, *Science and Technology for Australia* issued in that year. That policy statement clearly underlined the Government's understanding of the importance of science and technology to the economic and social well-being of the nation. The Statement confirmed the Government's commitment to supporting scientific endeavours across a broad range of activities, a commitment which underlies the continuing development of policy for a strong science and technology capability in Australia.

This *Statement* covers only part of the science and technology system, concentrating mainly on Budget issues relating to research conducted in the major Commonwealth agencies and through major Commonwealth programs. Nevertheless, Government policy on science and technology recognises the critical and interdependent role of all elements in the science and technology system, including the private sector, in meeting national objectives. These include fostering the cultural role of science and technology, while placing greater emphasis on their role in addressing the economic and environmental problems facing the country.

SUMMARY NOTES

SUPPORT FOR SCIENCE AND INNOVATION IN 1991-92

In 1991-92, Commonwealth support through major science and innovation programs is expected to rise by 4.3% in real terms to reach \$2607m (\$2422m in 1990-91).

Direct Government support for major research agencies will remain at the same real level in 1991-92 as in 1990-91. Appropriations to the agencies will increase to \$892m in 1991-92 from \$860m in 1990-91, but civil R&D agencies alone increase to \$671m from \$633m (up 2.7%) offsetting a fall of 6% in funding for defence R&D. Budget support for CSIRO will rise to \$448m, but the Organisation's external earnings (funds from business, from licensing fees, and other sources) will bring its total funding to about \$635m.

Funds under the control of the Australian Research Council (ARC), directed to supporting university research, have risen to \$242m (\$172m in 1990-91). This represents a real increase of 37%. Total funds for university R&D are estimated to rise by about 6%.

Total support for industrial R&D and innovation, including both direct support through appropriations and the estimated effects of tax revenue foregone, is expected to be \$362m in 1991-92, up from \$360m in 1990-91, but has decreased by 3% in real terms because of the expiration of the Management Investment Companies Program. The major component of these amounts is the estimated effect of tax revenue foregone through IR&D tax incentives, which rise to \$250m, up 4%. Funding increases for industrial R&D over recent years have followed policy changes which recognize its important role in innovation and competitiveness. Australian business R&D has been shown to be at comparatively low levels in relation to other OECD nations and there has been little effective interaction between industry researchers and those in government agencies and higher education. This problem of interaction is being addressed through the Cooperative Research Centre (CRC) initiative. Up to fifty CRCs will be established over five years, with Budget funding for establishment of the first ones set at \$19.5m in 1991-92.

Other specific purpose R&D grant schemes (support for rural R&D, the National Health and Medical Research Council grants, other health R&D and the smaller R&D grant schemes) together rise to \$253m (up 14%).

While there is a natural focus on financial inputs, it should be emphasized that all 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 examples of the discoveries, advances in understanding and steps in commercialization resulting from Government support for science and technology. The achievements are impressive and provide strong justification for the level of the Government's commitment.

SUMMARY TABLE

COMMONWEALTH SUPPORT FOR MAJOR PROGRAMS OF SCIENCE & INNOVATION

	1990-91	1991-92	Real change
	\$m outlays	\$m est.	
CSIRO ¹	421.1	448.2	+3%
DSTO	227.2	221.1	-6%
OTHER R&D AGENCIES	211.6	222.4	+0%
AUSTRALIAN RESEARCH COUNCIL ²	172.4	241.8	+37%
OTHER HIGHER EDUC. R&D	815.0	840.0	-6%
CO-OPERATIVE RESEARCH CENTRES	-	19.5	na
INDUSTRY R&D & INCENTIVES ³	360.4	361.7	- 3%
RURAL R&D	82.2	104.7	+23%
NH&MRC	94.7	103.3	+6%
OTHER HEALTH R&D	11.6	18.7	+56%
OTHER R&D GRANTS ⁴	26.2	26.0	-4%
TOTAL	2422	2607	+4.3%

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

- 1 Includes funding through DPIE for Australian Animal Health Laboratories and through DITAC for the Kraft Pulp Mill study.
- 2 Represents total of Budget and HEF Act funding.
- 3 GIRD grants plus estimated effect of tax revenue foregone via 150% IR&D and 100% MIC concession schemes.
- 4 Australian Biological Resources Study, Greenhouse research grants, Energy R&D and Australian Road Research Board

For more detailed information see Tables 1 to 5

SECTION 1:

POLICY OVERVIEW

SCIENCE AND TECHNOLOGY FOR AUSTRALIA'S FUTURE: RAISING LEVELS OF INNOVATION AND AWARENESS

Introduction

The important roles played by science, technology and engineering in promoting our national well being have been given increasing prominence by a number of activities over the past year, with initiatives having been taken to consolidate and further develop our existing strengths.

The thrust of recent developments has been to reinforce our infrastructure and to harness our science, technology and engineering effort to better meet the country's real needs, so building on the strategic framework described in last year's policy overview. The announcement of the first fifteen Cooperative Research Centres and the initiatives announced in the March 1991 Statement *Building a Competitive Australia* were two significant milestones. Section Two of this Statement provides details of these and other recent major initiatives.

Policy development over the next year will place particular emphasis on two important and interrelated areas: the better integration of science and technology with user needs; and the promotion of an increased appreciation and understanding of the roles played by science and technology in our social, cultural, economic and environmental development.

Developing National Science and Technology Policy

A major process of consultation and policy development is underway to identify impediments inhibiting the more effective operation of Australia's science and technology system and the mechanisms needed to overcome them. The reviews, consultation, debate, and analysis which together make up this process will culminate in a White Paper on Science and Technology which will be tabled in Parliament in the first half of 1992 after endorsement by the Prime Minister's Science Council. This will be the first such white paper to be produced in Australia.

The Government has asked the Australian Science and Technology Council (ASTEC) to prepare an issues and options paper as a basis for the White Paper. The issues and options paper will be based on a

wide-ranging examination of Australia's science and technology system. The preparation of the paper has involved extensive consultation with both public and private sector organisations in all States. Representatives of all parts of the science and technology system, including the users of research, have been participating in the consultative process, and this has allowed Australia's science and technology system to be viewed, not just in a static or purely descriptive way, but in terms of the dynamics, the interrelationships and linkages that make it work. The issues and options paper is to be completed by September 1991.

The White Paper will draw on studies additional to the issues and options paper. Two inquiries, announced in the March 1991 Statement *Building a Competitive Australia*, are expected to make significant contributions to improving Australia's return on the investment it makes in research and development. These inquiries are being conducted by the Commercialisation of Research Task Force, established by the Minister for Science and Technology to report on ways to better exploit Australia's research capabilities; and a task force on the commercialisation of medical research which will report to the Minister for Health, Housing and Community Services.

Another important study is the investigation by ASTEC of Australia's future demands for major items of capital equipment, particularly those which fall outside the funding capability of existing mechanisms. This work will provide an opportunity for attaching priorities to 'big science' items, particularly in terms of their importance to meeting Australia's overall science and technology infrastructure requirements.

In addition to the investigations already described, the activities of bodies such as the Prime Minister's Science Council and the Coordination Committee on Science and Technology, have made a major contribution. Some of their activities are described in later sections of this Statement.

Although the consultation process is still continuing, two clear messages have already emerged. These are:

- the need to take a broad view of the contribution made by science and technology to national goals, and to move away from too narrow a focus on public sector research; and
- the need to understand how the science and technology system operates as a whole, in order to identify the real impediments to obtaining a more effective return on the nation's investments in these areas.

These messages are not new. Indeed, they were reflected in the Government's strategic framework for science and technology, as described in last year's policy overview. However, there is still a need to explore further their wider implications and to obtain widespread community and industry commitment to future directions and, where necessary, the need for bold changes.

A major objective of the Government is to ensure that scientific and technological activity is able to meet high priority national needs and is sufficient to assist Australia's socioeconomic development. This is not just a matter of providing funding. It is also necessary to make sure that decisions are made on priorities and the distribution of resources among the various groups competing for them; and that the world class facilities and other infrastructure necessary to achieve national goals are provided.

In this context, the study by CSIRO of priority setting to meet national needs is a substantial achievement.

Another essential element of the strategic framework is to create and maintain an environment within the science and technology system, such that the funders, performers and users of research are responding to each other's needs and making effective use of each other's outputs. The Government recognises that an effective science and technology system provides for longer-term, science-driven research which allows researchers to take advantage of the opportunities they have themselves identified, as well as an appropriate level of research responding to the shorter-term and longer-term needs of society, industry and the market.

The Government's strategic framework for science and technology emphasises cooperation. One reason for this is that increased levels of communication between the different players in the science and technology system can help develop a better understanding and appreciation of the roles played by the other partners. Activities such as the development of proposals for the Cooperative Research Centres program will result in increased interactions, particularly between the public and private sectors. Such interactions serve to create a much improved awareness of the functions carried out by each part of the system and of the interdependencies between them.

One of the factors most necessary to ensuring the effective operation of the science and technology system is to have a pool of suitably trained people to carry out research and development, and to use research findings and work with new technologies. We need technicians as well as scientists and engineers. More generally, we need a scientifically literate population to ensure informed debate and a proper appreciation of the ways in which we should, or should not, use the scientific and technological opportunities that may arise.

Science and Technology Awareness

If Australia is to reap all the benefits it can from its science and technology effort - whether these benefits be the generation of wealth, improvements in the quality of life, or cultural - it will be necessary to develop a much wider appreciation of the ways in which science and technology relate to, and interact with, community concerns and aspirations.

We must do this in ways that do not detract from the significance of other fields of activity, but rather develop harmonious relationships between the various facets of social and economic development which enhance our quality of life.

Just as the private sector should be better informed about the role of science and technology in achieving international competitiveness, so scientists, and particularly those who conduct research, need to develop a better understanding of the ways in which business makes use of science and of the factors governing business involvement in science and technology. Without such an understanding, the research community will not be able to respond as well, or as quickly as it might wish, to the needs of industry and other users of research outputs.

The Government has recognised the importance of creating an improved understanding and awareness of the role played by science and technology in our social, economic and cultural life if decision-makers at all levels and in all sectors are to develop positive and realistic attitudes to science and technology. Developing attitudes takes a long time and has to operate at many levels - from children in primary school to senior decision-makers in industry.

A number of significant initiatives have taken place in this area.

The Government's Science and Technology Awareness Program aims to increase public awareness of the central role that science and technology play in national life, including economic and social development. The contribution of science and technology to industry, and the contribution of our manufacturing and services industries to national development, are not widely recognised by Australians. This lack of recognition appears to be one reason for the reluctance of Australians to adopt new technologies and innovative practices in the workplace.

The strategy adopted for the Science and Technology Awareness Program involves activities targeted at raising the level of awareness of young people, women and industry leaders in particular. The inclusion of the Australia Prize within the Program allows the development of an integrated set of activities to focus on excellence and international linkages, and to celebrate the practice of science and technology as a career option for young Australians.

Adoption of the new salary structure for CSIRO has also given a very clear message of Government support for science as a profession.

Another important initiative involves the national curriculum frameworks that are being established by the Australian Education Council for subjects including maths, science and technology. These frameworks aim to establish a set of curriculum principles that are consistent throughout Australia. The science curriculum framework will stress the relevance of science to everyday life and will be built on the notion that equity and excellence must complement each other.

Through this national process, the Australian education systems will be aiming not only to produce a necessarily small band of first class students of science, but also to provide a higher quality of scientific literacy for all students. This higher quality literacy will better equip them later to participate in discussion of scientific issues within the Australian community.

Innovation and the Application of Research Results

One reason for increasing the general awareness of the importance of science, technology and engineering is to develop a culture more open to innovation. Economic and social benefits do not arise from research, but from the successful application and exploitation of research findings. This exploitation is an example of innovation.

Successful innovation depends on the availability of expertise and resources, and particularly on the planning and management skills required to develop a vision for the future and make it work. Innovation requires a good research base, but strong research is not sufficient in itself to ensure that innovation occurs.

To improve our performance at a rate greater than that of our competitors requires the management skills necessary to recognise the relevance of science and technology and to use them in successful innovation. Moreover, these skills are needed, not only when the results of the research become available, but also in the initiation of research projects and during the research phase itself.

A pool of people with ability to apply science and engineering is one of the most important products of our higher education system. It is also worth noting that one of the major objectives of the Cooperative Research Centres program is to further develop research and innovation management skills and to increase the awareness of their importance.

When research is intended to result in outputs that can be applied directly to improve our quality of life or to improve our international competitiveness, it is important that the management of the research takes into account the needs and capabilities of those intending to use the research outputs. Particular problems in this regard relate to the structure of Australian manufacturing industry.

Many Australian enterprises, particularly in the manufacturing sector, are small by international standards and lack the resources needed for major innovation, which can involve considerable risk. If they 'pick losers', they may often lack the size to remain in business. Their most appropriate strategy, therefore, is to buy the research which is already embodied in the best technology available. They can then devote their development efforts to using this technology as efficiently and effectively as possible. Seeking incremental changes in technology will continue to draw on longer term fundamental and strategic research.

In most cases the advances made by Australian firms as a result of applying science and technology will be small improvements to existing products and processes, the result of a creative adaptation rather than a completely novel approach. In many cases the idea for the improvement will have originated from customers, rather than the researchers. The encouragement being given by the Government to the formation of linkages within the science and technology system, will assist researchers to respond to the need for this incremental approach as well as create a greater receptiveness among users to the important major advances that researchers may achieve.

Recent discussions at the Prime Minister's Science Council have emphasised the role that industry associations can play in the development of these linkages.

Private Sector Research and Development

The success of the Government's strategic framework for science and technology has been demonstrated by the impressive increase in the level of research conducted by industry. Over the whole of the 1980s, Australia had one of the strongest rates of increase in business research and development of any country in the OECD. In the period 1981-82 to 1989-90, the average real rate of growth in business research and development expenditure has been about 14 per cent per year.

The growth in business sector research and development expenditure is itself an indication that the commercial importance of research is becoming better understood. This indicator is supported by others, not the least of which is that the number of overseas patent applications made by Australians has been growing at a rate of over 17 per cent per year. This rate of growth in patent applications to foreign countries is by far the highest growth rate in the OECD, and bodes well for future improvements in Australia's competitiveness.

In drawing attention to these increases in research expenditure and in patenting activity, it is important to remember that research and intellectual property management are only two of the inputs needed to capture the benefits of research. The commercialisation of research requires business and engineering skills and infrastructure which are often costly to acquire and difficult to use. The reports of the task forces currently investigating the issue of research commercialisation should lead to some real improvements in this area.

In seeking to lift the level of private sector research and development, the Government's progress has been remarkable. However it is important not to lose the gains we have made. Our competitors are continuing to increase their expenditure on research and Australian businesses should not take the apparently easy option of reducing their research and development expenditure to contain costs during the current recessionary period.

Expenditure on research has to be seen as an investment in the future of the business, an investment that is essential if the business is to survive, improve its competitiveness and create opportunities for growth and development. The Government has recognised this and is assisting industry through the indefinite extension of the research and development tax concession.

The private sector also contributes significantly to the rural research effort. Priorities for research funding are determined by a number of rural Research and Development Corporations and Councils which receive funds from levies on production. These are matched dollar-for-dollar by Government up to 0.5 per cent of the gross value of production.

Although the current difficulties being experienced in the rural sector will affect the level of funds collected through levies in some commodity areas, the use of reserve funds is expected to cushion the impact and smooth out major fluctuations in research and development investment.

In some commodities, however, research and development expenditure will be higher due to levy increases, indicating that the provision of matching funds as an incentive for investment has been effective in increasing awareness in rural industries of the value of research and development. Overall there is expected to be a significant increase in the total funds available through the rural Research and Development Corporations and Councils in 1991-92.

Capital Works Funding for Science Agencies

The Government has committed itself to triennium funding arrangements for the three Industry, Technology and Commerce portfolio science agencies (CSIRO, ANSTO and AIMS) and has now built on this commitment by providing an immediate injection of funds to enable the agencies to embark on a capital works restoration program.

The introduction of fundamental changes in the way science was funded during the 1980s, with an increased emphasis on the competitive funding arrangements for research, has sometimes made it difficult for those agencies to maintain an adequate level of capital works funding. The injection of specific Government funds for 1991-92 will enable work to occur in this area without significant reductions to research activities.

Capital funding for the remaining two years of the triennium will be considered in the context of the White Paper on Science and Technology.

The Year Ahead

The year ahead will be an important one for science and technology in Australia. The processes leading to the White Paper are well under way and the Government intends that the White Paper will renew the sense of direction and purpose given by the 1989 Statement *Science and Technology for Australia*. The Paper will address issues of vital importance for the effective application of science and technology to Australia's economic and social development.

Other inquiries currently under way, notably the commercialisation of research task forces, will also make an important contribution to the process of developing science and technology policy in Australia.

It is not only in policy development that the coming year will mark important developments in the organisation of science and technology. In March 1991, the then Minister for Science and Technology announced the first fifteen Cooperative Research Centres. These are now receiving funding and will commence operation over the next few months. A further selection process is underway and a second group of Centres will be announced in December 1991. The Cooperative Research Centres Program is one of the major achievements of the Government's current term of office.

The winner of this year's Australia Prize will be announced in January 1992. It will be the second time that the Australia Prize, another important Government initiative, has been awarded. This year it will recognise outstanding achievement in 'Physical Sciences related to Mining or Processing of Mineral Resources'.

The vision and imagination that led to programs such as these will continue to guide the Government in its search for new ways to enhance the contribution of science, technology and engineering to the prosperity and well being of all Australians.

SECTION 2:

RECENT MAJOR DEVELOPMENTS

Prime Minister's Science Council

Two meetings of the Prime Minister's Science Council were held during the year, in October 1990 and May 1991. Two topics were discussed at the October meeting:

- **Value-adding in the Australian minerals industry**

The papers presented to the Council discussed marketplace realities in adding value to Australia's minerals, the role of research and development in this process, and impediments and opportunities to adding value to Australia's mineral products.

- **Capturing innovation in Australian manufacturing industry, a case study of the scientific and medical equipment industry**

A number of general discussion papers were presented that covered various aspects of supporting innovation in this industry. These included Australian government policy, international comparisons in innovation policy, opportunities and issues within the scientific equipment industry, the specific case of opportunities in medical device technology, and overall challenges facing Australian public and private sectors to draw from research strengths and commercialise.

Topics discussed by Council at its May meeting included:

- **Engineering in Australia**

The major issues raised in the presentation included the introduction of three year degrees for engineering technologists, the establishment of institutes to provide advanced post-trade vocational training for engineering associates, and the further development of the concept of Advanced Engineering Centres.

- **Commercial opportunities in waste management**

The working group that prepared the paper spoke of the need to set appropriate national standards for waste disposal and financial performance goals for public water and waste management authorities. Other key issues included the establishment of an

engineering and commercialisation development fund and support for the Environment Management Industry Association.

- Food processing

The paper presented to Council outlined the current situation of the Australian processed foods industry, the opportunities that existed for expanded exports, particularly to Asia, and the impediments to be overcome to take advantage of these opportunities.

- A White Paper on Science and Technology

The Government has decided to produce a White Paper on Science and Technology for release in 1992. This will provide an opportunity for a review of the Government's policies on science and technology and more generally, for the directions being taken by science and technology in Australia. Preliminary discussions on the development of the White Paper took place at the May meeting.

Following the May meeting, three Science Council *ad hoc* committees were established to prepare papers that define more clearly the issues raised in the presentations to the Council and identify the broad options generally supported in the Council's discussions. These papers will provide a clear basis for the development of government responses to the issues raised in the Council's discussions. The committees will report to the Council on the outcomes and any government action taken.

Coordination Committee on Science and Technology

Four meetings of the Coordination Committee were held during the past year. A subcommittee of the Coordination Committee was established to discuss preparations for the White Paper on Science and Technology.

In addition to the White Paper, topics of discussion have included:

- commercialisation of research,
- mobility of researchers,
- Australian genome sequencing activity and funding,
- costing and pricing of research by public agencies,
- coordination of resource and environmental databases, and
- coordination of international science and technology.

Working parties were set up to investigate the last three of these.

The Cooperative Research Centres Program

The Cooperative Research Centres Program, launched in May 1990, completed the first selection round during the year. This selection was highly competitive, with 120 applications received, involving (mandatory) higher education institutions, CSIRO, industry and research agencies from Commonwealth and State governments. This

round concluded in March 1991, when the first fifteen Centres were announced (see Section 3 for further details).

Seventy-four applications have been received for the second round, and decisions on further Centres are expected to be announced later in 1991. Up to fifty Centres will be supported under the Program, with Government funding rising to provide total annual support of \$100 million (in 1990 dollars) by 1994-95.

Advances in Setting Priorities for Research

During 1990, CSIRO developed and instituted a new methodology for assessing national research priorities and deciding its own priorities and strategies in response. The method is based on assessment of:

- *attractiveness*, combining: the potential benefits to Australia in economic, environmental and other social terms; and Australia's ability to capture these benefits by converting technological progress to commercial or other gains.
- *feasibility*, combining: what research could potentially accomplish; and the national capacity to achieve research goals in a timely way.

In an information based exercise involving many steps, CSIRO's senior managers examined 16 major areas of research directed to national economic, environmental and social objectives to reach conclusions on national priorities. These were then used as a basis for assessing CSIRO's role in responding to them. The Organisation has now commenced significant resource reallocations, including to strategic research in the minerals sector and to research on the environmental aspects of economic development. Priority assessments will be regularly repeated both at the corporate level and in individual parts of CSIRO. The methodology has potential for wide application in other organisations.

Upgrading the Capital Infrastructure for Research

New funding of \$12 million in 1991-92 will be provided for a capital asset management program at CSIRO, the Australian Nuclear Science and Technology Organisation (ANSTO) and the Australian Institute of Marine Science (AIMS). The program will include site redevelopment, building refurbishment, the upgrading and replacement of obsolete facilities and temporary buildings, and improved preventative maintenance. CSIRO will receive \$10.7 million for these purposes, with the balance divided between ANSTO and AIMS.

Review of the Institute of Advanced Studies of the Australian National University

The report of this review, chaired by Sir Ninian Stephen, was presented to the Minister for Higher Education and Employment Services in

November 1990. The government's response to this report was announced in March 1991. The Institute, which carries out research and postgraduate training in the physical, biological and social sciences, will have a special responsibility to carry out research of national importance, and combine a search for fundamental understanding with a concern for the use of the research results. It aims to be a research resource for other Australian universities as well as maintaining strong contacts with universities and research institutions in other countries.

Interim Australian Standard Research Classification

Over the last two years, a major review of existing classifications of research has been conducted by the Australian Bureau of Statistics (ABS), resulting in new field of research and socioeconomic objective classifications. Participating organisations are seeking the widespread adoption of the classifications to improve the comparability of data, and thus improve analytical measures for science, technology and research policy in Australia. The review was conducted in consultation with the Departments of Industry, Technology and Commerce; Employment, Education and Training; Primary Industries and Energy; Arts, Sport, the Environment, Tourism and Territories; Defence; and other user organisations including CSIRO; ASTEC; NH&MRC and the Australian Vice-Chancellors' Committee. Early in 1991, work from the review provided the basis of an interim Australian Standard Research Classification which is now being introduced into a number of statistical systems.

Other Initiatives in Support of Science and Technology

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

- in industry, science and technology

- the Commonwealth and South Australian governments signed an agreement giving approval to the Multifunction Polls (MFP), based north of Adelaide, as a national and international '21st century project'
- depreciation law changes, announced in the Industry Statement of March 1991, mean that the effective life of assets is to be defined in the Income Tax Assessment Act to take full account of technological obsolescence
- the tax concession for industrial R&D will be continued beyond 30 June 1993, when a rate of 125% will apply
- an Advanced Manufacturing Technology Strategy was announced in the Industry Statement
- further legislative provisions were introduced allowing appeals to decisions of the IR&D Board to be brought before the Administrative Review Tribunal

- 18 syndicates were registered under the new joint registration provisions of the tax concession for industrial R&D
 - an R&D commercialisation task force established
 - a new emphasis within NH&MRC funding is to be given to commercialisation of the results of medical research
 - major changes were made to salary structures within CSIRO
 - international linkages in S&T were strengthened through: a visit by the French Minister for Science and Technology; establishment of new collaborative programs with India and China; and a program of major collaborative project grants; and identification of areas for collaboration with Germany
- in education and research training**
- additional funding of \$27 million over the 1992-94 triennium has been provided for Australian Research Council grants, including funding to assist with the increased demand for grants resulting from growth in the higher education system
 - to address deficiencies in Australia's engineering skills base, establishment funding of \$5.8 million and annual recurrent funds of \$ 1.4 million will be provided to three advanced engineering centres to be established over 1992 and 1993
 - an additional 2000 Higher Education Contribution Scheme exemption scholarships for postgraduate research students will be provided in 1992 to encourage students to undertake research degrees and to help ease the forecast shortage in academic staff
- in environment**
- funding of greenhouse effect research commenced, through grants made to major research agencies and the Dedicated Greenhouse Research Scheme which funded eleven selected projects
 - additional funds to AIMS to extend its Great Barrier Reef Program to include a full investigation of factors affecting the Reef's health, complementing research on the crown-of-thorns starfish
 - substantial increases in herbarium material have been gained and major taxonomic work conducted on Australian flora at the Australian National Botanic Gardens
 - a Chief Science Adviser was appointed to the Department of Arts, Sport, the Environment, Tourism and Territories
 - the Centre for Environmental Management was established by the Department of Administrative Services
- in science and technology awareness**
- a Science and Technology Communicators Conference was held at the National Science and Technology Centre in August 1990
 - a Science and Technology Communicators Register was published and a quarterly newsletter was initiated for those

- engaged in communications aspects of science and technology
- a study of science and technology news in the media was published
- the magazine 21C was launched by the Commission for the Future
- *Sheer Genius* documentary on commercialisation of Australian research was produced and broadcast on national television
- national operation of Family Maths, Family Science and primary teachers workshop programs were supported
- several science summer schools programs were assisted.

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. The Industry Statement, *Building a Competitive Australia*, released on 12 March 1991, noted the importance of developing an innovative research and development culture.

Significant publications include:

- Department of Prime Minister and Cabinet:
 - *Building a Competitive Australia, Statements by Prime Minister Bob Hawke, Treasurer Paul Keating, Industry Minister John Button*
- Minister for Science and Technology:
 - *Science and Technology Budget Statement 1990-91, Budget Related Paper No. 7*
- Reports presented to the Prime Minister's Science Council:
 - *Science and Mathematics in the Formative Years*
 - *Innovation in the Australian Scientific Instruments Industry*
 - *Value Adding in the Australian Minerals Industry*
 - *Commercial Opportunities in Waste Management*
 - *Food Processing*
 - *Engineering in Australia*
- ASTEC reports:
 - *Setting Directions for Australian Research, A Report to the Prime Minister by the Australian Science and Technology Council in association with the Australian Research Council*
 - *Environmental Research in Australia - A Review*
 - *Environmental Research in Australia - A Compendium*
 - *Environmental Research in Australia - The Issues*
 - *An Australian International Gravitational Observatory - A Case Study for Construction of Large National Facilities*
- ASTEC Occasional Papers:
 - *Funding the Fabric - Should Commonwealth Government*

Competitive Research Granting Schemes Contribute More to Research Infrastructure Costs?

- *The Assessment of Impacts of Climate Change by Working Group 2 of the Intergovernmental Panel on Climate Change*
- *The Demand and Supply of Scientists and Engineers in Australia*
- Department of Employment, Education and Training:
 - *Report of the Committee to Review the Institute of Advanced Studies of the Australian National University*
- Department of Industry, Technology and Commerce:
 - *Australian Science and Innovation Impact Brief 1991, Measures of Science and Innovation 2, A Report in a Series on Australia's Research and Technology and their Utilisation*
 - *Direction Setting for Science, Technology and Engineering, A Strategic Framework - A Submission to ASTEC's Issues and Options Paper on Setting Research Directions for Australia*
 - *Science and Technology Communicators Conference, 28-29 August 1990, Conference Proceedings*
 - *Australian Science and Technology Communicators Register*
 - *Waste Management Technologies - Opportunities for Research and Management in Australia*
 - *Management and Technologies of Waste, A perspective - Australia 1990*
 - *Waste Technology and Management*
 - *Sensor Technology Part 1 - Materials and Devices*
 - *Biomaterials - Materials for Medical Devices.*
- Reports prepared by the Centre for Technology and Social Change (University of Wollongong) for the Department of Industry, Technology and Commerce:
 - *Technology Policy for the 1990s - Lessons of the 80s*
 - *Innovation and Competitiveness in the Australian Processed Food Industry.*

SECTION 3:

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 1991-92 Budget compared with the expenditure outcome for 1990-91. 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.*

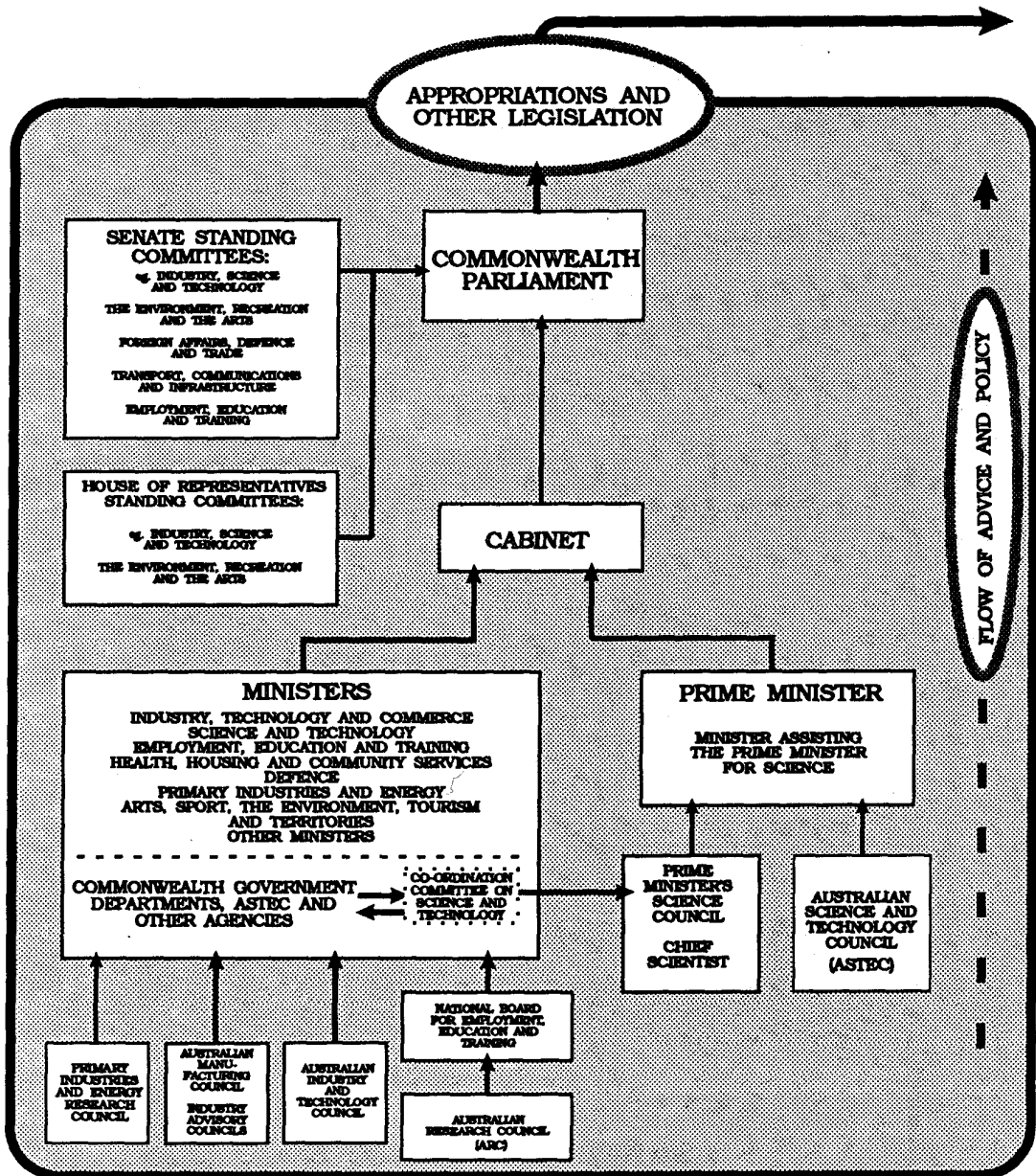
The intention has been to complement the financial discussion with an account of selected outcomes (recent achievements) for the major research agencies and programs. While necessarily selective, these are intended to be illustrative of the discoveries, advances in understanding, or steps in commercialisation which are the end results of the financial support received.

It should be noted that no attempt has been made to present a grand total for 'science and technology' outlays across portfolios. There are a number of difficulties involved in developing such a figure. Not least, judgements have had to be made as to whether particular programs were to be regarded as science and technology for the purposes of this *Statement*. Based on the better-defined area of research and development (R&D), however, data series have been developed in Section 4 and used to present indicative trends for an aggregate described as 'Major Commonwealth Support for Science and Innovation'.

The workings of advisory and funding mechanisms are of interest to many. Figures 1 and 2 are provided as a working guide to the operation of the infrastructure now in place for Commonwealth support of science and technology.

Figure 1

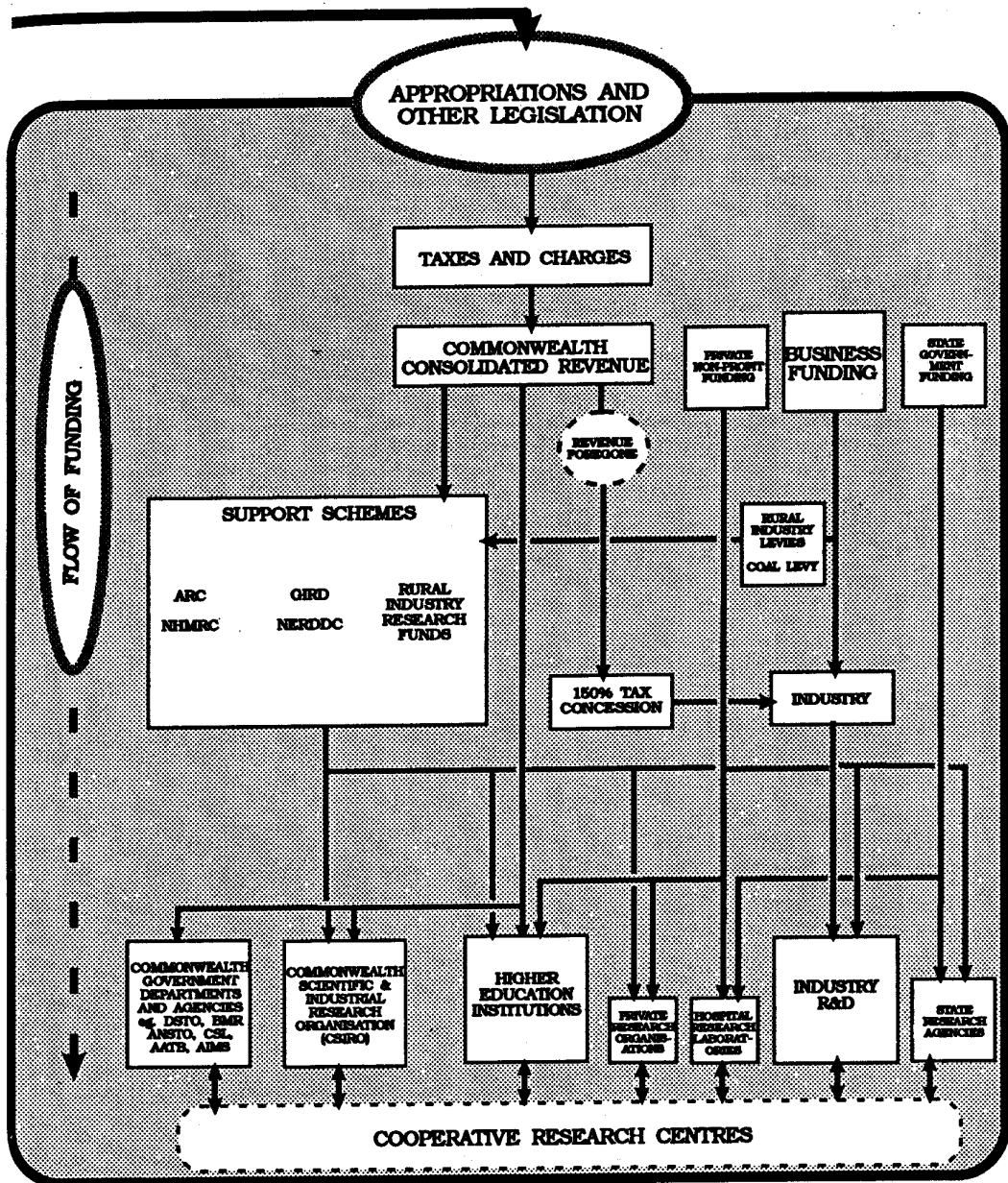
MAIN CHANNELS OF ADVICE FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY



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.

ADMINISTRATIVE SERVICES

Science and Technology in the Portfolio Budget

This portfolio provides scientific services through four agencies.

The Australian Government Analytical Laboratories operates through the Department of Administrative Services (DAS) Trust Account on a fee for service basis. Its projected 1991-92 turnover is \$21 million (of which \$5.8 million is provided through appropriation for public interest activities), representing an increase in turnover of \$3.5 million over 1990-91.

The Ionospheric Prediction Service (IPS) is budget-funded at \$2.4 million in 1991-92 .

The Scientific Services Laboratory (SSL) is part of Australian Construction Services (ACS) which operates on a commercial basis through the DAS Trust Account. Income for SSL was \$2.8 million in 1990-91. Projected income for 1991-92 is \$4.0 million.

The DAS Centre for Environmental Management (DASCEM) was established late in 1990-91. This new business is part of the Property Services Program and also operates through the DAS Trust Account. Due to its very recent commencement, DASCEM received no income in 1990-91.

MAJOR RESEARCH ACTIVITIES

Ionospheric Prediction Service (IPS)

Role

To enhance economic and social progress in Australia by providing reliable radio propagation and space environment services to the Australian community, especially to government departments and authorities that operate in the fields of communications, defence, aviation, geophysical exploration, space activities and national and international science.

Recent Achievements

Ionospheric modelling

The average ionospheric model depends on two important ionospheric parameters - the maximum amount of ionisation in the ionosphere and the height above the earth's surface at which this maximum occurs. The maximum ionisation and the height both change with time of day, with season and with solar activity. These two ionospheric parameters have recently been remodelled, upgrading our knowledge of the average ionosphere, thereby producing more reliable operating conditions for communicators. The new models of the height of maximum ionisation are the first attempt to improve this aspect of the model in thirty years.

Scientific Services Laboratory (SSL)

Role

To provide Australian Construction Services with a research and investigation capability in relation to its technical advice, design and construction operations and to provide a commercial scientific service to external clients in the construction and related industries.

Recent Achievements

National Fire Safety Code

SSL has been a major contributor to the development of a new National Fire Safety Code. This code is based on risk assessment methodology, and when completed and accepted should result in fire protection in Australian buildings being provided in a much more economical and logical manner than is presently the case.

ARTS, SPORT, THE ENVIRONMENT, TOURISM AND TERRITORIES

Science and Technology in the Portfolio Budget

There are a number of agencies and programs within the Portfolio that undertake scientific activities.

The Australian Antarctic Division has been given a total budget allocation of \$68.7 million in 1991-92 (\$64.3 million in 1990-91). The Division's activities include the undertaking of and support for scientific research in the Australian Antarctic Territory, the Southern Ocean and subantarctic islands. The science program supported by the Division in 1991-92 will include marine science voyages by the Research and Supply Vessel *Aurora Australis* in the Southern Ocean, Prydz Bay and Heard Island regions. A winter research program in biology and glaciology will be conducted at Heard Island in 1992, while geology programs will be undertaken at the Southern Prince Charles Mountains and deep ice drilling on Law Dome in the summer of 1991-92.

The Commonwealth Bureau of Meteorology has been given a total budget allocation of \$137.3 million in 1991-92 (\$131.2 million in 1990-91). The Bureau's activities include meteorological research. The Bureau's research priorities to be pursued in 1991-92 include particular emphasis on climate research including greenhouse studies, numerical weather prediction modelling, tropical meteorology, air pollution monitoring, remote sensing and marine meteorology.

The central Department coordinates research into the greenhouse effect. The Government has allocated \$5.9 million to this activity in 1991-92 (\$5.7 million in 1990-91). (The Bureau of Meteorology also participates in this program; \$0.6 million in 1990-91 and also in 1991-92 of the total allocation for greenhouse research being included in the Bureau's budget allocations identified above). The priorities for the greenhouse research program are the development of the capacity for regional predictions of climate change, climate modelling, monitoring of sea-level rise and the assessment of potential regional impacts.

There are a number of other diverse portfolio agencies that engage in research. The Great Barrier Reef Marine Park Authority has been given a total budget allocation of \$13.4 million in 1991-92 (\$10.2 million in 1990-91). The Office of the Supervising Scientist has a total budget allocation of \$7.4 million in 1991-92 (\$6.8 million in 1990-91). The budget allocation for the Australian National Parks and Wildlife Service is \$47.7 million in 1991-92 (\$44.8 million in 1990-91).

The Australian Film Commission and the Australian Sports

Commission also have some involvement in research activities. The Australian Film Commission has provided assistance for research and development of a series of advanced technologies which promise significant benefits for both cinema and scientific applications. The Australian Sports Commission has various research projects to identify methods to assist in improving the performance of elite athletes in several sports.

The National Science and Technology Centre, which has been allocated \$5.7 million in 1991-92 (\$5.4 million in 1990-91), has a role in promoting confidence, understanding and a positive attitude to science and technology.

MAJOR RESEARCH ACTIVITIES

Australian Antarctic Division

Role

To provide scientific knowledge for the effective management of the environment and the living and nonliving resources of the Antarctic and to promote Australia in the international scientific forums in order to increase credibility and influence in relation to Australia's Antarctic interests.

The Division conducts research in glaciology, terrestrial and marine biology, oceanography, upper atmosphere physics, cosmic ray physics and medicine, as well as providing various science support facilities for external agencies. It also administers research grants under the Antarctic Science Advisory Committee research grants scheme.

Recent Achievements

Research ship facilities assist Prydz Bay studies

Last year (1990-91) was the first full Antarctic season of the RSV *Aurora Australis* which conducted marine science studies in the Prydz Bay region. The scientific equipment on the new ship operated most successfully and data was collected for later analysis by the scientists at the Antarctic Division and external agencies both nationally and internationally. Research included the first complete survey of pelagic fish in the Prydz Bay area, a potential fishing resource and important food source for birds and seals. The vessel also allowed the first substantial studies of squid and octopus in the same area. The abundance and biology of krill were also investigated with advanced new echosounder technology.

Other Antarctic activities

Research was conducted through long term observations at Antarctic stations and by the conduct of summer land-based programs. Summer programs in geology and glaciology were supported in the northern Prince Charles Mountains and around the Lambert Glacier with geomorphology also being conducted at Law Base.

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 prediction, climate, tropical meteorology, severe weather, satellite meteorology and greenhouse modelling.

Some research into atmospheric constituents (eg carbon dioxide, methane, ozone) is also conducted using data from the Bureau's Ozone Network and its Baseline Air Pollution Station at Cape Grim (Tasmania). Much of this research is undertaken in collaboration with the CSIRO Division of Atmospheric Research.

Recent Achievements

Advances in numerical weather prediction

With the introduction of a Cray XMP14 supercomputer into the Bureau in August 1990, more advanced BMRC numerical weather prediction systems have been implemented on the supercomputer for actual operations and further research. The systems provide global weather predictions at higher resolution out to 5 days ahead and 36 hour predictions in the Australian region.

Tropical cyclones

Scientists from BMRC were involved in the design and execution of a major international experiment. Tropical Cyclone Motion '90 held in August-September 1990 in the north west Pacific. Results from the experiment, which acquired comprehensive data on several tropical cyclones, will assist in improving our ability to predict the motion of tropical cyclones.

Remote sensing

A four-year project with the US National Aeronautics and Space Administration to obtain detailed radar and rain gauge measurements of rainfall in the Australian tropics has been completed. The project obtained data to support the USA/Japan satellite program, Tropical Rainfall Measuring Mission, which aims to launch a rain detecting radar into orbit in the tropics in the mid- 1990s.

Greenhouse modelling

To complement simulation studies of possible climate change under an enhanced greenhouse effect, the BMRC has cooperated in an international program, sponsored by the US Department of Energy. Results from this program will make it possible to reduce uncertainties in the predictions from global climate models.

Baseline Air Pollution studies

A fourteen-year record compiled from measurements at Cape Grim Baseline Air Pollution Station shows a steady ongoing rise in the atmospheric concentrations of the 'greenhouse gases', including carbon dioxide, methane and the chlorofluorocarbons. Cape Grim data are also providing new insights into the global cycling of elements, such as carbon and sulphur and their role in climate, a role which involves not only the atmosphere but also the ocean and the biota.

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.

The Authority's research program is focused on a number of priority issues of critical importance to management of the Great Barrier Reef. The program covers a wide range of disciplines including marine biology, and the physical, chemical and social sciences.

Recent Achievements

Crown-of- thorns starfish

Last year (1990-91) was the second year of a three year program of investigation into the crown-of-thorns starfish and their impacts on the Great Barrier Reef. This program has already led to major advances in

the understanding of the biology of crown-of-thorns starfish. A total of 31 projects were funded under the program in 1990-91

Greenhouse Effect Research

Role

To respond to the global threat posed by the Greenhouse Effect, through a national research program.

In May 1990, the Government committed \$5.7 million for each of the next three years for greenhouse research. This includes the continued funding of a Core Research Program (\$3.5 million), the Dedicated Greenhouse Research Grants Scheme (\$1.5 million) and participation in international greenhouse research.

The National Greenhouse Advisory Committee advises on priority areas for further greenhouse research, overviews the core research and sets objectives for a dedicated greenhouse research grants scheme. The committee also has the role of promoting public understanding of greenhouse issues.

Recent Achievements

Dedicated Greenhouse Research Grants Scheme

Eleven projects were selected for funding for the next three years. Proposals considered for funding covered the following three areas:

- understanding the scientific processes which underlie greenhouse-induced climate change,
- understanding the impacts of climate change, and
- development of effective mitigation and adaptation.

Office of the Supervising Scientist - Alligator Rivers Region Research Institute

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 in the Alligator Rivers Region of the Northern Territory.

Recent Achievements

Land application of waste waters

In collaboration with the CSIRO, research has been conducted on the long-term environmental impact arising from the use of land application for the disposal of waste water from the Ranger Uranium Mine. The soils have little absorptive capacity for the major chemicals present in Ranger's waste water. Heavy metals and metal radionuclides are found to be absorbed in the top few centimetres of the soil profile and the adsorption processes should operate for many years. Calculations indicate that soil retention could lead to a significant radiological risk to members of the public. This will have to be taken into account in the rehabilitation of the area to meet the government's long-term rehabilitation goals for the mine site.

Radiation exposure of the public arising from atmospheric transport of radon

Members of the public who live near a uranium mine are subject to radiation exposure resulting from the inhalation of radon and its radioactive daughters. This exposure has two components; a mine-related term and a background term arising from naturally occurring uranium in the surface soils of the region. In collaboration with the Australian Nuclear Science and Technology Organisation, a method has been developed for distinguishing between these two components. Following application of this method over a period of one year, the mine related exposure of members of the public was found to be well below accepted international limits.

Toxicity of cyanide to aquatic animals of the Alligator Rivers region

At the request of the Resource Assessment Commission Inquiry into mining in the Kakadu Conservation Zone, a preliminary assessment of the toxic effects of cyanide on aquatic species of the South Alligator River was undertaken so that the Commission's risk assessment could be based on local native species. Lethal and sublethal endpoints were examined for species of water flea, hydra and fish. Results obtained for safe concentrations of cyanide were consistent with the recommendations of the US Environmental Protection Agency.

Australian National Parks and Wildlife Service (ANPWS)

Role

The ANPWS sponsors scientific research, survey and monitoring as part of its role of enhancing the protection, conservation and management of the Australian natural environment and native Australian flora and fauna.

The ANPWS is the principal nature conservation agency of the Commonwealth Government.

Recent Achievements

Australian Biological Resources Study (ABRS)

The ABRS promotes the description, classification and distribution of Australia's plants and animals, both as a record of the natural heritage and as an essential database for conservation and resource management. This is achieved through both grants for research and a publications program of high quality. Sixty-five new grants were awarded under this program during 1990-91. The Census of Australian Vascular Plants, a complete list of all vascular plant species described from Australia, and four volumes of the Australian Plant Name Index were published.

Environmental Resources Information Network (ERIN)

ERIN made significant advances in 1990-91 in relation to database design and progress towards the demonstrator stage of an Environmental Decision Support System. Collaborative arrangements were also established with agencies throughout Australia to upgrade and maintain data which will be accessible through the network.

Australian National Botanic Gardens (ANBG)

The in-house database of plant records now holds 78,000 accession records of living plants and 58,000 records of preserved herbarium specimens. The latter represents a 40% increase over last year.

The ANBG is now custodian of two datasets of Australian plant names: the "Census of Australian Vascular Plants" covering about 17,000 records of native and naturalised species and the "Australian Plant Name Index" covering 63,000 scientific names formally published for higher plants in Australia. These databases, transferred from the ABRS, represent major perspectives on the biological diversity in the nation.

Other achievements include:

- major taxonomic analysis undertaken on orchids, resulting in discovery and naming of 150 new species of Orchidaceae,
- major field work undertaken to resolve taxonomic and systematic problems in the Australian species of Orchidaceae, mosses, lichens and liverworts,
- the development of tissue culture techniques from shoot material of a rare form of *Acacia* was commenced with a view to improved propagation,
- international collaborative projects in the Orchidaceae and mosses, and the development of international standards in plant databases, and

- improved propagation methods of rare terrestrial orchids and epiphytic orchids drawn from studies of mycorrhizal associations.

DEFENCE

Science and Technology in the Portfolio Budget

The Budget allocation for the Defence Science and Technology Organisation (DSTO) will be \$212.5 million in 1991-92 (\$215.0 million in 1990-91). The Defence Industry Development Program is to receive \$12.3 million in 1991-92 (\$11.7million in 1990-91).

MAJOR RESEARCH ACTIVITIES

Defence Science and Technology Organisation

Role

To enhance Australian defence capabilities through scientific and technological assistance to the Australian Defence Force and the Department of Defence and, as necessary in the national interest, to assist the development of Australian industry.

Recent Achievements

Support to Navy operations in the Gulf

DSTO drew on its substantial research base to provide scientific support to the Navy throughout deployment of Australia's ships in the Persian Gulf, including enhancement of their effectiveness through:

- expertise in chemical warfare - chemical protection and monitoring equipment, chemical protective gear, decontamination equipment and procedures, and medical therapy - to meet the unique environment and threat;

- upgrade of the ships' communications equipment to permit interaction with US forces in the area;
- studies and solutions to reduce the vulnerability of ships and helicopters to possible sea mines and missiles through electronic countermeasures and reduced radar, infrared, magnetic, acoustic and electromagnetic signatures; and
- provision of DSTO-designed Mine Actuation Simulators to help train the Navy's clearance diving team.

Command, control and communications

DSTO research was a major influence in determining the Defence policy to integrate Defence communications with the civil network, to enhance capabilities and reduce costs. Joint work has been undertaken with Telecom in integrated communications network research. This will enable the demonstration of network architecture concepts. Significant progress has been made in research into uncommitted radio technology, which allows extraordinary flexibility in radio communications.

Jindalee operational radar network (JORN)

Recent signing of a \$680 million JORN contract by Telecom marks the culmination of 15 years of research by DSTO to develop Australia's own Jindalee over-the-horizon radar (OTHR) technology. DSTO has designed an automatic system that selects the most effective frequency of operation for the transmitters (as the ionosphere changes during the day) and a realtime radar processing system that can automatically detect and track targets hundreds of kilometres away.

During the design, development and construction phase, DSTO will continue research to help optimise the operation of the Jindalee network. This includes a program to examine the effects of high sunspot activity on OTHR performance. Ongoing work also includes programs to enhance the resolution and readability of the data displays, and to optimise the linking together of radar data from the widely separated OTHR stations.

DSTO's technology transfer initiatives were responsible for placing Australian industry in a prime position to win the contract for JORN. Australian industry content in the project will be 70 per cent with defence offsets lifting overall involvement to 80 per cent.

Air safety and effectiveness

DSTO's research has continued to improve air safety. Mechanisms of vortex breakdown are being studied to assess remedies for F/A-18 fin buffet and to achieve superior overall performance. Studies last year produced a better understanding of the airflows around aircraft and air-launched weapons and the loads upon their structures. Other studies included the prevention of failure in engines and transmission systems and the reduction of aircraft plume visibility.

Intelligence

A substantially increased commitment was made to the enhancement of Defence capabilities for intelligence collection, processing, assessment and dissemination. DSTO's assessment of the information technology requirements of the new distributed organisation of Defence Intelligence has guided research into key aspects such as system architectures, security, data fusion, image processing and geographic information systems. Decisive contributions have also been made in the field of crypto-analysis.

Mine and torpedo countermeasures

DSTO's methodologies and performance models allowed comparative testing of mine-hunting sonars, through side-by-side trials in relevant Australian underwater environments. Computer-based operational planning systems for the Minesweeper and Minewarfare Systems Centre have been developed and assessed during mine countermeasures exercises conducted by the Fleet.

Support to Australian initiatives on chemical disarmament

DSTO increased its research contribution towards international measures to prevent trading in chemicals and equipment that could be used in the manufacture of chemical weapons. The Organisation carried out research into verification and intelligence techniques which will assist in the establishment of an international Chemical Weapons Disarmament Convention. A DSTO scientist led the first United Nations Special Commission inspection team in Iraq to investigate its declared inventory of chemical weapons.

Non-carcinogenic anti-rust process

DSTO patented a cerium chemical pre-treatment process for metal surfaces. The immersion process, which is simple and quick, offers a superior and safer alternative to chromate, the most commonly used anti-corrosion material used in the metal industry, but which is a known carcinogen. Cerium is found in large quantities in rare earth ores, of which Australia is a world supplier.

General Motors support for engine modification

The Commonwealth of Australia, represented by DSTO's Aeronautical Research Laboratory, entered into a joint venture company (Defence Technologies Australia) with Pacific Aviation (A'Asia), and signed a business agreement with Allison Gas Turbine Division of General Motors Corporation, to market a low smoke modification for the Allison T56 gas turbine. The modification was developed initially to reduce the detectability of the smoke-trail of the anti-submarine RAAF Orion aircraft but also reduces environmental pollution and fuel consumption. The T56 engine is also installed in RAAF Hercules aircraft. The potential market for this modification covers over 16,000 T56 engines world-wide, and expected earnings for DSTO from royalties are \$16 million.

EMPLOYMENT, EDUCATION AND TRAINING

Science and Technology in the Portfolio Budget

The Department of Employment, Education and Training supports research and research training at higher education institutions throughout Australia. The bulk of the portfolio's support for research is provided through the operating grants of higher education institutions to cover the cost of training postgraduate research students, research infrastructure costs, and internal research funding. In 1991, institutions have been notionally allocated \$229 million on the basis of their postgraduate research student load and \$189 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, the Department provides direct research funding of about \$130 million for the Institute of Advanced Studies at the Australian National University. For other higher education institutions, direct research funds are provided through research grants, special research centres, key centres of teaching and research and infrastructure grants which are allocated on the advice of the Australian Research Council (ARC). The Department also provides Australian Postgraduate Research Awards and ARC Research Fellowships.

In 1991-92, \$225.9 million will be distributed on the advice of the Australian Research Council. Of this, \$83.3 million will be provided in ARC Research Grants (including small grants) and a further \$3.3 million in large equipment grants. Special Research Centres and Key Centres of Teaching and Research will receive a total of \$20.4 million. \$14.9 million will be provided in ARC Research Fellowships and \$45.7 million in infrastructure funding. Grants to the learned academies will amount to \$1.2 million in 1991-92.

This portfolio also provides funding for Postgraduate Awards. Funding for Australian Postgraduate Research Awards (APRAs) and Australian Postgraduate Research Awards (Industry) is estimated at \$49.0 million in 1991-92. Funding for Overseas Postgraduate Research Scholarships (OPRSs) in 1991-92 is estimated at \$7.4 million. The Government's March Industry Statement provided for an increase in the number of APRAs from 1100 to 1300 awards annually, commencing in 1992. In addition, the Statement announced an increase in the number of OPRSs to 300 awards.

Funds are provided to the Anglo-Australian Telescope Board (AATB) to support its operations. In 1991-92, the AATB will receive \$3.0 million, up from \$2.7 million in 1990-91.

The *Australian Research Council Research Infrastructure Program* supports high quality research by remedying deficiencies in current research infrastructure, enhancing support for areas of research strength and ensuring that areas of research potential are able to obtain the support necessary for development. The program supplies block grants to pre-1987 universities, development grants to former advanced education institutions and supports cooperative research between higher education institutions.

The program has resulted in significant support for research infrastructure in former advanced education institutions with \$15.8 million being provided in development grants in 1991, including \$11.3 million in research infrastructure support to the universities of technology. Major collaborative grants have included the Australian Parallel Computing Initiative (\$1.3 million to ANU, University of Queensland, University of Melbourne and RMIT), and a grant for the development of resources for breeding and holding of animals (\$2.5 million to the University of New South Wales and the University of Sydney).

The *Targeted Institutional Links Program* stimulates academic research cooperation between Australian universities and their Asian counterparts. The program includes provision of postgraduate research scholarships for Korean and Taiwanese students.

MAJOR RESEARCH ACTIVITIES

Higher Education Operating Grants

Role

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

Recent Achievements

Relative funding model

The Department has devised a relative funding model in response to the Government's commitment to develop a method of funding based on

what institutions do rather than historical precedent and arbitrary classification. The model identifies a research component of institutional operating grants and allocates it in two ways: funds for activities relating to postgraduate research training are allocated on the basis of weighted student load, while funds for research activities other than those related to postgraduate teaching are allocated according to institutions' success in obtaining funds through Commonwealth competitive research grants schemes (the 'Commonwealth competitive grants index').

It was recognised that an index based on Commonwealth competitive grants only is not a completely satisfactory method of allocating resources for research and that methods need to be developed which give appropriate consideration to research funds obtained from industry and other non-Commonwealth sources. A joint ARC/Higher Education Council/Department working party will advise on the development of a composite index for this purpose.

The Institute of Advanced Studies, The Australian National University

Role

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

The Institute's budget of approximately \$130 million and the full-time commitment of its staff to research, permit it to concentrate on fields of research and large scale endeavours which take advantage of its particular range of facilities and expertise. It has a special responsibility to carry out research of national importance and to combine a search for fundamental understanding with a concern for the use of the research results. It aims to be a research resource for other Australian universities and also maintains strong contacts with universities and research institutions in other countries.

Recent Achievements

Computer modelling of seismic reflection

The application of computer modelling to data from seismic reflection has been used to produce new images of the deep crust and upper mantle of the earth and reveals evidence of the movement of tectonic plates. The technique has been used in the Canning Basin of Western Australia.

Groundwater in the Murray-Darling Basin

The University's 14UD accelerator has been used to provide information about the age and movement of groundwater in the Murray-Darling Basin. The results are being used to increase our understanding of the increasingly serious problem of soil salinity in one of Australia's major agricultural areas.

Dating man's first arrival in Australia

The new thermo-luminescence dating technique has been applied to materials from the first human occupation of a rock shelter in the Kakadu region. This demonstrates Aboriginal occupation of Australia for at least 50 000 years, extending significantly the earliest known human occupation of the continent.

Colonisation of the South Pacific

Studies of the Austronesian family of languages and of the use of Lapita design on pottery and artifacts have been used to trace the colonisation by Austronesian-speakers of the south-west Pacific between Australia and Asia.

The Australian Research Council (ARC)

Role

The ARC'S mission is to devise, develop, and help to implement an effective higher education research system which will make the greatest possible contribution to the social, cultural and economic well-being of Australia.

The principal functions of the Council are:

- to make recommendations to the relevant Minister on the distribution of resources provided under research support schemes for which it is responsible; and
- to inquire into, and provide information and advice to the National Board of Employment, Education and Training on matters referred to the Council by the Minister or the Board.

The Australian Research Council has responsibility for advising the Minister on the allocation of funds through ARC Research Grants, the ARC Research Fellowships Scheme, Australian Postgraduate Awards, Grants for Special Research Centres and Key Centres of Teaching and Research, Research Infrastructure Funding, the Large Equipment Program, and Grants to the Learned Academies and ANZAAS.

Recent Achievements

Review of the Institute of Advanced Studies, The Australian National University

This review was formally announced in January 1990 and was undertaken by a distinguished review team, chaired by Sir Ninian Stephen, a former Governor-General and High Court judge. The Review Committee received over 160 submissions and had extensive discussions with staff members of the Institute and representatives of the University.

A major recommendation of the review was that the mission of the Institute now include three functions: to be a major performer of research, to provide research education and training at the highest level and to be a resource for the higher education system and the Australian research system as a whole.

Australian Research Council Research Grants

Role

The Australian Research Council Grants Scheme is to support high quality research by individuals or research teams throughout Australia. The grants are allocated/or specific research projects on a competitive basis.

Recent Achievements

Chemistry of Antarctic lakes

A team from the University of Tasmania has examined the chemistry of highly saline Antarctic lakes in order to obtain some understanding of their evolution and assist with the prediction of the effect of changing climatic conditions on the Antarctic environment. The vapour pressures of the lakes have been measured over a range of temperatures and a computer program developed for the prediction of vapour pressure. The freezing point and final solidification point of several lakes has been determined by thermal analysis.

Novel methanol synthesis

Researchers from the University of New South Wales have developed a new copper-zinc oxide-alumina catalyst which has been shown to produce methanol from synthesis gas at twice the rate of commercial catalysts. Australian patents have recently been granted on the catalyst and international patents are pending. Discussions are currently under way with potential partners to commercialise the new catalyst. Successful commercialisation would create a value-added

export of Australian-produced metals worth an estimated \$20-30 million per annum.

Raising an Old Glider's Ghost

The Mahogany possum was first described 108 years ago, but was not sighted again until recently. Working from old records discovered by chance, a team from the Queensland Museum rediscovered the possum in lowland rainforest near Tully in North Queensland. This possum is one of Australia's rarest marsupials and its habitat is threatened by development. The Museum has determined the range, status, and habitat requirements of the species in the coastal tropics between Cardwell and Cape Tribulation using an ARC research grant.

Estimation of the extent and degree of gambling related personal problems in the Australian population

Gambling in Australia is a leisure activity generating 9-11% of the taxation revenue in all states. It is well documented that a small percentage of gamblers may experience severe gambling related problems. For over a decade, it has been widely recognised that the assessment of the extent and degree of such problems is essential. There is a need to provide educational/counselling services (where appropriate) and to complete social impact studies. This study has assessed the impact on the individual and family of the introduction of poker machines and considered some of the broader issues involved.

Special Centres Program

Role

Special Research Centres aim to support research on the basis of excellence and its potential to contribute to the economic, social and cultural development of Australia.

The Special 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 \$400,000 and \$800,000 per year, depending on the Centre.

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 co-operation between higher education and industry. They are funded at a rate of around \$200,000 per year.

Recent Achievements

Multiple-channel cochlear implant

The multiple-channel cochlear implant (Bionic Ear) developed by the Human Communication Research Centre at the University of Melbourne in collaboration with the Cochlear Corporation was approved by the US Food and Drug Administration as safe and effective for use in profoundly/totally deaf children from two to 17 years of age. This was the first time the FDA or any other world regulatory body had approved a cochlear implant for use in children.

Orbtrack satellite tracking system

The Centre for Industrial Control Science at the University of Newcastle has developed enhancements to the Orbtrack satellite tracking system to enable it to meet new application categories. The system has been implemented at several sites including Nauru, Antarctic bases, Christmas Island and Perth. The Centre has also participated in the development of a superheater temperature control working system for power stations of the NSW Electricity Commission.

Computer Integrated Manufacture

The Key Centre of Teaching and Research in Computer Integrated Manufacture at Swinburne Institute of Technology has expanded its advanced technology consultancy services to manufacturers to include computer aided design, robotics, plastic moulding, product design and factory simulation.

Australian Postgraduate Research Awards and Overseas Postgraduate Research Awards

Role

Australian Postgraduate Research Awards (APRAs) provide competitive awards for Australian students undertaking research leading to a Masters degree or PhD. Australian Postgraduate Research Awards (Industry) promote joint industry-higher education research opportunities, especially in areas such as engineering and computing. Postgraduate Course Awards are provided to assist students undertaking Masters degrees by coursework. Overseas Postgraduate Research Scholarships aim to assist overseas students to undertake research degrees at Australian universities.

Recent Achievements

Proteins involved in DNA replication

A postgraduate award holder is part of a research group which has isolated over twenty proteins involved in making copies of the bacterium *E. coli*. These have included DNA polymerases that synthesise polynucleotide chains and nucleases that hydrolyse such chains. In addition, other proteins involved in preparing the template for DNA replication or for assembling multiprotein complexes responsible for early events in DNA synthesis have been isolated.

Termites in tropical woodlands

Another award holder has examined the ecology of termites on tropical woodlands in Kakadu National Park. The project has found that the presence of buffalo has a marked effect on some termites as does water availability. However, vegetation exerts the major influence on the distribution of termite communities. Detailed surveys of termite and different plant species distributions have indicated strong interrelationships between different ecological groups of termites and various components of the vegetation.

Australian Research Council Fellowships

Role

Australian Research Council Fellowships include Australian Postdoctoral Research Fellowships (for researchers normally with less than 3 years postdoctoral experience), Australian Research Fellowship (for researchers normally with at least 3 years postdoctoral experience). Queen Elizabeth II Fellowships (for outstanding researchers who would normally have no more than six years postdoctoral experience). Senior Research Fellowships and Australian Research Fellowship (Industry) (ARFI) (for research with an industrial company).

Recent Achievements

Long-term coral reef disturbance

An ARC Kevin Stark Fellow has studied long-term coral reef disturbance. Coral reef disturbance is widespread throughout the Indo-Pacific, especially due to effects of crown-of-thorns starfish and cyclones. The long-term damage to the reef is uncertain, but an historical perspective is available in Papua New Guinea from a series of continuous fossil reefs spanning the last 340,000 years. Study of the effects of disturbance on the fossil reef communities allows predictions about the long-term effects of disturbance on modern reefs. It also contributes to our understanding of how predicted global climate shifts

and sea level changes will affect the Great Barrier Reef ecosystem during the next 100 years and so aid conducting reef management prudently.

Reconstruction of the history of movement of Australian Aboriginal languages

An ARC Senior Research Fellow has assembled the data and completed much of the comparative work required for a study of reconstruction of the history of movement of Australian Aboriginal languages. This study may reveal a definite link with languages found outside Australia and may provide evidence for the paths taken by immigrants in the past millennia.

The Anglo-Australian Telescope (AAT)

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/or the advancement of scientific knowledge.

Recent Achievements

A New View on the Early Universe

Using the AAT, astronomers have probed the hydrogen gas clouds near the edge of the observable Universe. These clouds are believed to be left over in essentially pristine condition since the time of the Big Bang and they may hold vital clues about the way galaxies have formed, a problem that modern astronomers are keen to pursue. By studying the light emitted from quasars, the most distant objects known, astronomers have been able to study the intervening dust clouds and glean information on conditions prevailing in the Universe's infancy.

IRIS

Commissioned in January 1991, this new infrared instrument enables astronomers to study celestial objects at infrared wavelengths in a way never before possible. With 16 000 individual detectors simultaneously looking through the telescope, astronomers using IRIS will at last be able to study the infrared radiation from almost any object that can be observed at optical wavelengths. This is important as infrared radiation holds a great deal of information about the universe that cannot be obtained through other types of astronomy. IRIS was designed and built by the staff of the Anglo-Australian Observatory.

HEALTH, HOUSING AND COMMUNITY SERVICES

Science and Technology in the Portfolio Budget

This portfolio includes four agencies dealing with research and scientific services. These are the National Health and Medical Research Council (NHMRC), the Australian Institute of Health (AIH), the National Acoustics Laboratory and the Commonwealth Serum Laboratory. AIDS research and health research programs are also funded through the portfolio.

Medical and public health research funding through the NHMRC increases to \$101 million in 1991-92 (\$94.7 million in 1990-91). The AIDS research program has increased to \$9.8 million (\$7.1 million in 1990-91). AIDS research is also funded through the NHMRC. Health research funding through Health and Community Services Research and Development Grants has decreased to \$1.8 million (\$2.1 million in 1990-91).

The Commonwealth Serum Laboratories are receiving from the portfolio \$1 million for Commonwealth sponsored research and a further \$1.2 million for World Health Organisation collaborative projects.

The National Acoustics Laboratory's direct administrative expenses are currently estimated at \$2 million for 1991-92 (\$2.3 million in 1990-91).

The Australian Institute of Health's principal source of funds is from the Commonwealth. The operating appropriation for 1991-92 is \$4.2 million (\$4.2 million in 1990-91).

Funding for capital works in medical research institutes for 1991-92 totals \$10 million. Institutes were assessed by an expert team and those that received funding demonstrated the greatest capacity to contribute to the advancement of medical science.

Support for these agencies and programs in 1991-92 comprises \$131 million out of a total portfolio budget of \$15,423 million.

MAJOR RESEARCH ACTIVITIES

Commonwealth AIDS Research Grants Program

Role

To develop means of preventing infection with Human Immunodeficiency Virus (HIV), to develop better methods of diagnosis and treating HIV and complicating conditions, to define the factors which place people at risk of infection and to establish means of reducing them. Also to monitor the personal and social impact of HIV infection and its spread within the community.

Recent Achievements

Animal tests

A group in Western Australia has devised an assay for quantifying the amount of virus in cats infected with feline immunodeficiency virus. These feline tests will enable antiviral agents to be trialed for effectiveness and toxicity. Another group in Queensland is investigating factors regulating the way HIV is incorporated into host cell's genetic material using mice.

Study of intravenous drug users

A major national study has collected data from more than two thousand intravenous drug users in 1989 and 1990. The data has provided comprehensive information on sexual and drug using practices and attitudes. Preliminary analysis of the data has been undertaken and will continue in 1991.

Treatments

Significant research findings relating to treatment of AIDS include the following:

- A group of researchers in Melbourne have designed and synthesised new compounds with demonstrated *in vitro* activity against HIV.
- Colostrum from cows that have been exposed to *Cryptosporidium*, a parasite that causes a common form of diarrhoea among AIDS patients, has been collected. This colostrum contains antibodies against *Cryptosporidium* and is being prepared in drug form suitable for clinical trials in AIDS patients.
- Few effective treatments are available for combatting the HIV virus itself. Zidovudine, known as AZT, is the only antiviral drug approved in Australia for marketing. National clinical trials of antiviral therapies are being coordinated by the National Centre in HIV Epidemiology and Clinical Research.

Australian Institute of Health (AIH)

Role

In collaboration with relevant Commonwealth, State and Territory agencies, and non-government organisations, to undertake analyses and compile statistics on the health of Australians, and the provision, use and cost-effectiveness of health services and health technologies in Australia.

An expanded role has been proposed for the Institute to encompass the collection, analysis and publication of data from social welfare, community services and housing assistance programs, with the objective of developing national data sets in the longer term.

Recent Achievements

Health status assessment activities

The Screening Evaluation Co-ordination Unit (SECU), set up in 1988 as a unit of the Institute at the request of the Australian Health Ministers' Advisory Council, completed reports on the evaluation of options for breast cancer and of cervical cancer screening programs. These two reports recommended a national mammography screening program for the early detection of breast cancer, with an organised approach. The reports were submitted to the Australian Health Ministers' Advisory Council and published by the Institute in September 1990 and February 1991 respectively.

Commonwealth Serum Laboratories (CSL)

Role

To be Australia's leading manufacturer of biological pharmaceuticals and to meet both the medical and veterinary market's needs for such products. Also to identify new and improved products and processes and to market and implement them to enhance the overall profitability of the business.

Recent Achievements

Veterinary diagnostics

CSL Ltd. Research and Development Division has successfully collaborated with CSIRO Animal Health and DARA to develop and commercialise novel diagnostic tests for two major mycobacterial diseases of cattle. The bovine interferon test has been shown in an Australia-wide field trial to be significantly better than the current skin test for bovine tuberculosis, a major disease of economic importance

both in Australia and worldwide. The Johnes absorbed enzyme immunoassay has similarly been shown to be significantly better than other rapid tests for the diagnosis of Johnes Disease (*Mycobacteria paratuberculosis*), a significant disease of dairy cattle worldwide. Both tests are being manufactured here at CSL for the regional markets and have been licensed to a US manufacturer for sale in the US and Europe.

New diagnostic technology

A new technology has been developed for rapid enzyme immunoassays for clinical diagnosis. This enables clinical specimens to be examined for the presence of a range of microbial pathogens. The first product using this technology is the Snake Venom Detection Kit released in July 1991.

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 funding 1131 research projects, as well as providing block funding for several major research centres and institutes.

Recent Achievements

Meloma detection

Australians have, on average, a 2% lifetime risk of developing melanoma, a particularly aggressive skin cancer which can be lethal unless removed by surgery at an early stage. Researchers at the Queensland Institute of Medical Research, on a project funded by NH&MRC, have discovered new antibodies which seek out and attach themselves to proteins in melanoma cells, thus helping pathologists to correctly diagnose certain types of melanoma.

***In vitro* fertilisation breakthrough**

Infertile men with low sperm counts or poor sperm motility (ability to swim) make up nearly 40% of the total infertile population. A technique has been developed by researchers at Monash University's Centre for Early Human Development which microinjects sperm through the outer shell of an egg. The treatment is revolutionising the treatment of male infertility for couples seeking to start their own families.

Obesity

Researchers funded by NH&MRC have discovered that capsaicin, an ingredient found in chillies, increases the rate at which the body burns off energy and therefore has potential in the treatment of obesity.

Anorexia nervosa

A study undertaken at the University of Melbourne shows that people with anorexia nervosa, the so-called dieting disease, can suffer mental impairment and shrinkage of brain caused by their emaciation. The conclusion that sufferers of anorexia nervosa may not be able to make safe judgements about the state of their own health or about their need for treatment, has important clinical ramifications.

Health and Community Services Research and Development Grants

Role

To improve through research and evaluation, the administration, planning and delivery of health and community services in Australia.

Recent Achievements

Research priorities in women's health

Consistent with the National Women's Health Policy Statement, a research program directed specifically at the health of women was targetted. A number of contributing projects have been undertaken which provide useful information on young women and risk-taking behaviour, including associations with sexual and IV drug-using practice.

INDUSTRY, TECHNOLOGY AND COMMERCE

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 a number of agencies and programs supporting technological development in industry through the provision of grants, concessions and services. The Industry Research and Development (IR&D) Board which includes both industry and government representatives is concerned with promoting the development, and improving the efficiency and international competitiveness of Australian industry by encouraging research and development activities. The IR&D Board has responsibility for administration of the tax concession, the Discretionary Grants Scheme, the Generic Technology Grants Scheme and the National Procurement Development Program.

Grants or incentives to industry include the following:

- *The tax concession* for industrial research and development.
- *Generic Technology Grants* provide support for research and development in nominated areas of technology which are important for the international competitiveness of Australian industry into the 1990s.
- *Discretionary Grants* provide support to companies which have insufficient taxation liability to obtain adequate benefit from the tax concession for research and development but have the potential to fully exploit the results of their research and development projects.
- *National Procurement Development Program (NPDP)* provides financial assistance to support joint projects to trial and demonstrate and/or research and develop new products, services and systems, including prototypes, which link into forward procurement requirements of government departments and agencies.
- *The computer bounty* provides assistance for the production of computer hardware, certain assemblies, electronic microcircuits, printer circuit boards, systems design and systems software.
- *The Factor (f) Pharmaceutical Industry Development Program* provides higher prices for some products, in return for a

commitment by individual manufacturers to undertake increased activity in Australia, including new investment, production, research and development.

- Australian Building Research Grants Scheme (*ABRGS*) provides funds to encourage building and construction research of long term benefit to the building industry.
- *The National Teaching Company Scheme* aims at creating links between public sector research institutions and companies in the manufacturing and services sectors. It does this by supporting suitably qualified graduates to work on industry-based projects jointly supervised by participating institutions and companies.

Services to industry and community include the following:

- *The National Industry Extension Service (NIES)* is a joint Commonwealth/State program which provides extension services to small to medium-sized firms to increase internal efficiency and international competitiveness.
- *The Vendor Qualification Scheme (VQS)* provides assistance to export oriented firms in the Information Technology sector seeking accreditation to internationally recognised quality and regulatory standards.
- *The Patent, Trade Marks and Designs Offices* provides industrial property rights services. The offices operate on full cost recovery.
- *The International Science and Technology Program* aims to stimulate Australian involvement in international research collaboration and generate awareness of Australian S&T capabilities. A longer term aim is to build commercial opportunities through collaborative research.
- *Policy advice* for the establishment and delivery of Government services in science and technology is provided through the Science and Technology Policy Branch (Innovation Division), the Policy and Projects Division, the Bureau of Industry Economics and other Divisions of the Department of Industry, Technology and Commerce.
- *A Commercialisation Task Force* has been established to report by October 1991 on ways of better matching Australia's research effort to its industrial capacity. It will also examine impediments to local technological developments, including lack of venture capital in Australia, limited international marketing capability and restrictive business regulations.
- *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.
- *The Marine Science and Technology Program* aims to align marine R&D more closely with industry requirements and to play a key role in international co-operation in marine science and technology. Closer links between the marine industry, government and research agencies are being developed through the Consultative Group on Marine Industries Science and

Technology (C-MIST) and the Oceans Australia conference series.

- *The Malaria Vaccine Joint Venture (MVJV)* is a consortium of Commonwealth, State and private research institutions aiming to develop a malaria vaccine.

Budget support for these programs is shown below. Funding for the three science agencies in 1991-92 includes \$12 million for capital infrastructure (Section 2).

Program or agency	Budget expenditure 1990-91 \$m	Budget estimate 1991-92 \$m
AIMS	13.6	14.2
ANSTO	62.6	64.9
CSIRO	414.4	440.7
Kraft Pulp Mill Study	1.4	1.9
GIRD		
-Generic	15.2	15.4
-Discretionary	14.0	16.1
NPDP	4.2	9.3
Motor Vehicle & Component		
Development Grants	4.7	2.8
Computer Bounty	51.1	53.8
Factor (f) Pharmaceutical Industry		
Development Program	16.5	46.0
ABRGS	0.3	0.3
NIES		
-Commonwealth	4.6	5.5
-States	10.5	10.8
VQS	1.2	1.3
National Space Program	5.5	6.7
Tech Development Program	3.0	3.1
MVJV	2.3	9.3
International Collaborative Program	5.0	5.2
TOTAL	630.1	707.3
PORTFOLIO TOTAL	1588.0	1724.1

It should be noted that the Patent, Trade Marks and Designs Offices are not included in the above figures as they operate on full cost recovery.

The Department is also responsible for administering the *Science and Technology Awareness Program*, which has annual funding of \$0.8 million. The Program aims to make Australians more aware of the importance of science and technology.

MAJOR RESEARCH ACTIVITIES

The Australian Institute of Marine Science (AIMS)

Role

To advance the development of national knowledge of the marine environment; to communicate this knowledge so that it can be applied to the development, conservation and management of marine resources; to create opportunities for technological and commercial development and to foster cooperation between researchers with similar interests.

AIMS will receive additional funds of \$1.3 million over three years from 1991-92 to extend its Great Barrier Reef Program to a full investigation of factors affecting the Reef's health, including nutrients, trace elements, fish stocks and hydrodynamics, in addition to the crown-of-thorns starfish research covered in the present program.

Recent Achievements

Sediments and nutrient effects on the marine environment

AIMS has developed interdisciplinary studies on tropical coastal ecosystems affected by land based developments such as major farming and urban activity, including studies of the Fly River, the Gulf of Papua, Torres Strait, and Great Barrier Reef Regions. The studies include the fate of sediment and chemicals and the impact on marine organisms, and have special relevance to the understanding of the effects of harbour developments and maintenance of navigational channels. Special equipment has been developed at AIMS to measure suspended sediment at different depths.

Influences on coral growth

Work on coral density banding provides information about coral growth over long time periods. AIMS have found evidence for a decline in coral growth in the last few decades in the central and northern Great Barrier Reef. However, longer growth records show that such declines have occurred in the past, and consequently the recent decline cannot be ascribed to increased human-induced nutrient levels.

AIMS scientists have discovered and employed fluorescing bands in long cores from massive corals, to reconstruct the annual weather patterns of the last 250 years for the Burdekin River region of North Queensland. The identification of extreme events in the past such as long periods of drought and severe wet seasons, may lead to re-appraisal of part of the approach to tropical planning, especially in relation to development of economic infrastructures.

Screening of biologically active substances

Collection of some active organisms has begun in the Institute's bioassay program. A large number of new species and some new genera have emerged as a result of examination of the collection by specialist taxonomic consultants. In addition, some of the bioactive compounds isolated in the program are candidates for patent protection as potential anti-cancer drugs.

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. Maintain a core of essential nuclear expertise and nuclear facilities and to further Australia's non-proliferation, nuclear safeguards and wider nuclear technology policies.

Recent Achievements

Removing mineral contamination from drinking water

Building on earlier consultancy work for Queensland's Gold Coast and Wyong Council, NSW, detailed studies were undertaken on the optimal methods of removal of iron and manganese from waters of the Avon, Woronora and Macarthur systems on behalf of the NSW Water Board. The dirty water results from the formation of particulate manganese oxide through natural processes acting on the low concentrations of iron and manganese naturally occurring in soluble form.

These detailed studies have required process skills that are considered unique to the Environmental Science Program at ANSTO

Synroc

The Synroc Study Group, comprising BHP, CRA Ltd, ERA Ltd, WMC Ltd, ANSTO and the ANU have completed the Phase I study of the potential for the Australian invention Synroc. Synroc provides a promising method for the safe disposal of nuclear wastes. The results of the initial

study have been promising and all members of the Group decided to proceed with the study to Phase II in March.

In September 1990, ANSTO signed a Memorandum of Understanding with a number of Institutes in the USSR to open the way for cooperation on the immobilisation and disposal of nuclear wastes.

Testing high-temperature engineering components

The year has seen a substantial increase in the demand for ANSTO's plant remaining-life assessment methodology in the determination of safe and economic operating conditions for high temperature engineering components. Major clients included the electricity supply industries of NSW and Victoria and the petroleum refiners, Ampol, BHP and Caltex.

Glassy carbon

Glassy carbon has been identified as a likely candidate material for surgical implants (and other applications requiring inertness and chemical stability). While its biocompatibility makes it suitable for this purpose, its wear performance has been found inadequate for such a demanding application. This has led to research aimed at improving the wear resistance of material. Recently, ANSTO succeeded in improving the wear resistance of glassy carbon via metal ion implantation. It has also been found that the modified glassy carbon is significantly more stable in certain environments.

The Australian Space Office

Role

The aim of the Australian Space Office is to encourage greater local industry involvement in space R&D and to promote the development of commercially viable industries based on space technologies.

The sum of \$ 7.0 million has been allocated under the National Space Program for 1991-92.

Atmospheric pressure sensor

The Atmospheric Pressure Sensor (APS) is a passive remote sensing instrument developed at the CSIRO to measure atmospheric pressure at the earth's surface from an orbiting satellite. In order to prove the concept, a laboratory model of the APS was built and successfully flight tested in the CSIRO research aircraft. The benefits to be derived from deploying the APS in a spacecraft relate to the significant improvement in the accuracy and extended range of meteorological forecasting, particularly in the southern hemisphere where atmospheric pressure data is scarce because of the vast expanses of ocean. The next stage in

the development of the APS will be funded by the Australian Space Office and will involve a design definition and project feasibility study for the spaceborne instrument.

Along Track Scanning Radiometer-2 (ATSR-2)

The ATSR-2 is a remote sensing instrument which will be flown on the second European Remote Sensing Satellite ERS-2 in 1994. Under a collaborative agreement with the Rutherford Appleton Laboratory (RAL) in the UK, the Space Office is participating in the procurement program for RAL's ATSR-2 by providing two items of equipment. The two items being provided are the Infrared Focal Plane Assembly and the Electrical Ground Support Equipment which will be supplied by two Australian companies under contract to the Office. In return for these items, Australia will obtain access to the scientific data produced by the instrument. Australian participation in the science program for the instrument will be coordinated by CSIRO. The total cost of the Australian participation in the procurement program will exceed \$3 million.

Space Industry Development Centres (SIDC) Program

The SIDC Program is a research and development activity, introduced under the Infrastructure Program of the Government's Space Industry Development Strategy. The aim of this program is to promote space-related R&D in order to develop Australian products and services capable of competing in international markets. Four Centres embracing signal processing, microwave technology, satellite navigation and space engineering technologies have been selected for funding by the Space Office. Matching funding, provided by the SIDC participants and the Space Office on a dollar for dollar basis, will involve the latter in the provision of up to \$2 million per financial year in total, over the next three to five years.

Automotive Industry Authority

Role

The Authority's role is to promote change and encourage the development of the industry in line with the Government's policy objectives and to monitor and report on the industry's progress towards those objectives.

The Authority is responsible for administering the Motor Vehicle and Components Development Grants (MVCDG) Scheme, established in 1984 as a five year program to provide funds to assist the industry in the local design and development of motor vehicles and components. The Scheme closed on 30 June 1989 but the Authority continues to progressively fund and monitor the progress of projects approved prior to that date.

In 1990-91, the Authority made payments of \$4.7 million under the MVCDG Scheme. The Budget estimate for 1991-92 is \$2.8 million and the balance of obligated program funds of \$1.0 million is due in 1992-93.

Recent Achievements

Design projects

The following design projects were completed with assistance from the MVCDG Scheme:

- a Magna replacement wagon designed by Mitsubishi Motors Australia for the local and export markets
- the Pintara Superhatch designed by Nissan Australia for the local market and for export, and
- General Motors Holden's Australia designed Statesman/Caprice and Holden Ute for the long wheel base luxury and utility markets.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Role

The main role of CSIRO is to carry out research which can be applied by Australian industry, or by government, for the well-being of the Australian people. CSIRO aims to give Australians a better future by:

- *Being a leader in developing the scientific and technological capability of Australia through conducting strategic research to*
 - *develop technologies for all sectors of Australian industry;*
 - improve the management of Australia's natural resources;*
 - protect Australia's unique environment; and*
 - promote the well-being of the Australian people.*
- *Collaborating closely with industry and government agencies, and with other research organisations to ensure:*
 - the nation derives the greatest benefit from CSIRO's research,*
 - and*
 - the rapid adoption of research results by industry, resource management agencies and other users.*
- *Providing authoritative and independent advice and information on matters of national importance that are within CSIRO's expertise.*

Structure and Organisation

CSIRO is governed by a Board comprising up to ten members, one of whom is the Organisation's Chief Executive. The research carried out by CSIRO's 7000 staff is undertaken in six research institutes which have the following objectives:

Institute of Animal Production and Processing

- improve the range, quality and marketability of products, the efficiency of production and international competitiveness in Australian animal and food industries in an ecologically sustainable manner, and
- enhance human nutrition in Australia.

Institute of Industrial Technologies

- increase the international competitiveness, efficiency and scope of Australia's manufacturing industries, and be a leader in strategic research for those industries.

Institute of Information Science and Engineering

- 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,
- help increase the international competitiveness and export orientation of the Australian information, telecommunications and space industries, and
- assist other industry sectors to improve their competitiveness through the use of advanced computer, communications and space systems.

Institute of Minerals, Energy and Construction

- increase the international competitiveness of the minerals, energy and construction industries and assist in the development of new industrial and export opportunities that maximise the contribution of the sector to the sustainable development of the Australian economy.

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.

Institute of Plant Production and Processing

- improve and sustain the productivity and profitability of industries based on field crops, pastures, horticulture and forests, and improve knowledge of Australia's soils, plants and insects.

While CSIRO is funded primarily by direct appropriations from the Commonwealth, an increasing proportion of the Organisation's funds come from collaborative ventures with industry and government, from granting schemes funded by industry and government and from earned revenue. In 1991-92, it is estimated that more than \$194 million of CSIRO's \$635 million budget will come from these external sources.

Planning and Reporting

During 1990, CSIRO adopted the Australian Bureau of Statistics' interim Australian Standard Research Classification socioeconomic objectives as the basis for planning and reporting 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.

Plant Production and Primary Products

Recent Achievements

Linola- a new edible oil

CSIRO scientists have produced Linola, a top grade polyunsaturated edible oil with world wide market potential, which is transforming linseed oil from an unglamorous industrial product into a new crop for farmers as an alternative to wheat and other cereals. Recent tests by margarine manufacturers indicate that Linola equals sunflower oil in quality, and CSIRO is collaborating with Australian vegetable oil processors for the rapid introduction of Linola oil into a range of vegetable oil products.

Following extensive testing in collaboration with State Departments of Agriculture, two varieties of Linola have been selected for release in Australia in 1992 under the Plant Variety Rights Scheme. CSIRO is now negotiating with Australian seed companies for the marketing of Linola seed, to enable large scale plantings to be made in time for products made with Linola to appear on supermarket shelves early In 1993.

Control of root diseases

Major root diseases cost Australia many millions of dollars in lost crop production annually. Progress made by CSIRO scientists in the control of these diseases includes the first release in Australia of a genetically engineered biocontrol bacterium to test for field control of Takeall disease in cereals. In addition, soil bacteria were isolated which are potential control agents for *Phythium* and *Rhizoctonia* infections of nursery bedding plants, and phosphorous acid has been demonstrated to have potential in controlling root disease in regenerating medic pastures in South Australia.

Disease-free grapevines

CSIRO scientists have developed highly sensitive techniques for the rapid detection of grapevine viral agents and their elimination by tissue culture procedures. In combination, these procedures have made possible the production of clones of grapevine varieties free of: leafroll disease, which causes significant yield reductions; *Agrobacterium*, which is responsible for crown gall disease; and some viroids. The viroid detection methods utilise the Polymerase Chain Reaction (PCR) technology. Disease-free grapevines arising from the research program are being marketed under the CSIRO trademark VITECH by the licensed agent, Phytotech Australia Pty Ltd.

Animal Production and Primary Products

Recent Achievements

New test for bovine tuberculosis

The National Brucellosis and Tuberculosis Eradication Campaign aims to rid Australia of both diseases by 1992, to ensure that Australia has continued access to international beef markets. Whilst Australia was officially declared brucellosis free in July 1989, the eradication of tuberculosis has encountered some problems in the more remote areas.

CSIRO has developed a relatively simple diagnostic procedure which detects a hormone, gamma interferon, which is produced by the white blood cells of infected animals. The Australian cattle industry can expect to save about \$80 million by using this test, largely through reduced mustering costs.

CSL has now produced a commercial version of this kit for use in Australia, and sales have been made to New Zealand, Taiwan, Argentina and Ireland. An international veterinary diagnostic company has also been given permission to manufacture and market the kit world-wide.

Vaccine to combat infectious bursal disease of chickens

The veterinary products company, Arthur Webster Pty Ltd, is now preparing to market a genetically engineered vaccine developed by CSIRO, to combat the infectious bursal disease virus which causes an AIDS-like disease of poultry, weakening their immune system, and leaving them vulnerable to other infections.

The disease is not transmissible to humans, but can disrupt the poultry industry, which operates on tight schedules and small profit margins. The new vaccine protects birds against all known strains of the virus, including overseas types, and, on the international market could be worth \$50 million annually. It is only the second genetically engineered vaccine of its type developed in the world, after the vaccine developed for human hepatitis B.

Growth factor as a replacement for foetal bovine serum

Foetal bovine serum, which is used for cell culture applications used in the manufacture of human therapeutics, is not only in short supply, but is also at risk from viral contamination. CSIRO, in association with the University of Adelaide, has designed a recombinant growth factor LR31GF-I, which is being marketed worldwide by the CSIRO Joint Venture Company, GroPep Pty Ltd. GroPep has concluded a contract to supply LR31GF-I, to the largest US distributor of foetal bovine serum, so that the two companies can jointly access the \$200 million market for serum replacements.

Minerals Industry

Recent Achievements

CSIRO-BHP imaging spectrometer project

CSIRO and BHP have agreed to design and construct an advanced airborne scanner called an Imaging Spectrometer, a remote sensing instrument which views the earth with high spectral and spatial resolution. It will be 20-40 times more powerful at measuring reflected wavelengths than the current Landsat instruments, and will be able to identify objects only five metres apart on the ground.

The Imaging Spectrometer will have applications in mineral exploration, environmental monitoring and management, and in the monitoring of soil erosion, salinity, deforestation and overgrazing. CSIRO and BHP are committing equal funding to the design and development of the Spectrometer. BHP proposes to set up a commercial operation to operate the Spectrometer for mining and environmental applications.

Energy Resources and Supply Industries

Recent Achievements

Coal bed methane

Methane locked in the black coal seams of Australia's coal basins represent an enormous potential resource, conservatively estimated at several times greater than the current reserves of conventional gas.

CSIRO has established a research program aimed at developing techniques to target "sweet spots", that is, areas with higher gas content, higher permeability and/or lower stress conditions for preferential development. The program also aims to develop stimulation and recovery technologies for Australian conditions, that will improve the efficiency of current methods, and make larger areas of

Australia's coal basins containing most of the resource away from "sweet spots" economically viable. Negotiations with a major Australian resource company for a multi-million dollar collaboration on coal bed methane are close to completion.

Diamond exploration

CSIRO has developed a nickel thermometer to assist diamond explorers to assess prospective areas and exploration targets rapidly and cheaply. The method involves the analysis of nickel in garnets, separated either from rocks that may contain diamond or from stream sediment and soil samples collected during exploration programs. As the nickel content of garnet gives a reliable estimate of the temperature at the time of its entrainment in the host rock, the nickel thermometer provides an estimate of the depth of origin of each grain, a vital factor in the formation of diamonds.

Application of the technique requires analysis of only a small number of garnets, rather than a statistically large sample, thus avoiding the costs of bulk testing of clearly barren prospects. The development of the nickel thermometer was supported by several companies who are now using it in their exploration programs.

SIROSIZE

SIROSIZE, a system developed by CSIRO provides the facility to size rock fragments on conveyor systems and muck piles on a routine basis, which greatly aids the efficient handling of materials in the mining environment. An image processing technique, active stereopsis, is used which makes use of a light stripe projected on to the surface of the fragments. A TV camera is used to capture the shape of the distorted light stripe. A computer processes the video image of this shape so that the 3D profile of the surface can be obtained by triangulation. The size of the rock fragments travelling on the system are then calculated from this profile.

SIROSIZE eliminates the traditional sampling and screening procedures, because no operators are required after the initial calibration procedure. The technique is rapid and highly parallel, so that it is able to operate in real time, making it applicable for use with conveyor systems. Printed reports and data storage for fragment size can be obtained over any time interval.

Manufacturing Industries

Recent Achievements

Gear geometry

The performance and life of the very expensive and large gears, sometimes up to eight metres in diameter, used in machinery for the

Australian mining and agricultural industries depends critically on their geometry.

CSIRO scientists have developed, in collaboration with industry, a set of portable instruments to enable gear geometry to be measured. The axial pitch instrument measures the left and right alignment errors of a gear without the need for careful adjustments, whilst the Flank Tracing instrument measures the profile errors of a complete tooth flank. Profile errors can cause vibration and high tooth stress, and prevent proper lubrication of a gear drive. This instrument is accompanied by software that handles data analysis, database management, instrument error compensation and instrument control. Measurements are made under computer control with a minimum of operator intervention, and the results are presented graphically. The CSIRO instruments will help both the manufacturers and users to identify the causes of poor gear performance, and be confident of the performance of new gears produced using this technology.

Measuring money

The Australian Mint now has one of the world's most advanced coin production methods, thanks to an instrument it developed jointly with CSIRO to help improve quality control. The Optical Surface Profiler (OSP) produces high-resolution relief maps of the surface of dies and other tooling, that enables the Mint to assess the quality and design of master tooling and to see how faithfully coin designs are transferred from the die to the coin blank.

Using light to create a picture of the surface of coins and dies, plus special software to produce quantitative reports and contour relief maps that can detect any departure from the die specifications, the OSP can measure all the dimensions of a coin mould in fifteen minutes, instead of the four hours required by traditional surface measuring equipment. Several overseas mints are showing interest in buying an OSP, which retails for about \$250,000. The instrument has potential in other areas of industry, for example in the measurement of parts for cars and aeroplanes.

Narrow gap welding

As part of a project on high productivity welding supported by the GIRD scheme, CSIRO researchers have made significant progress in developing a novel, multiprocess narrow gap welding system, a technique for joining heavy sections of metal. It has advantages over more traditional methods, because it uses a minimum volume of welding consumables. Joints are completed more quickly, there is less distortion of the structural elements, less dilution of the weld metal, and the finished joint has improved mechanical properties.

Though narrow gap welding is well established overseas, its use in Australia is restricted by the high cost of the necessary equipment. CSIRO's development uses concepts which are different from those on which overseas equipment are based. CSIRO is now licensing the

system for commercial use. An early prototype is being used by a Ballarat firm to produce heavy wall valve bodies, and the mining and mineral processing industries are also showing interest in the technique.

Rural Based Manufacturing

Recent Achievements

Fingerprints for fabrics

Worldwide the textile industry loses approximately \$500 million annually because finished garments have not turned out as predicted by the traditional hand and eye method of checking a fabric prior to its use in manufacture. With support from the Australian Wool Corporation, CSIRO has developed a new technology SIROFAST, which makes a "fabric fingerprint" which is then analysed to predict how the fabric will perform, after it has been made into a garment. The system is so reliable that manufacturers can be assured in advance that the finished garment will turn out exactly as planned.

Pilot trials with leading overseas textile organisations have been so successful, that the manufacturer, Associated Controls Pty Ltd, having sold 30 units during the trial, is now moving to full scale manufacturing. The key to SIROFAST's success is that users are able to compare data about common problems using identical methodology, and a SIROFAST User's Group has already been formed in the UK.

A wool quilt from CSIRO

Using a blend of pure wool with a special polyester additive that keeps the wool light and airy so that it has "warmth without weight", CSIRO has developed a wool quilt that has all the qualities of a continental quilt. CSIRO's woolrich quilt uses wool fibres with an average thickness of 24 micrometres, the same thickness as the wool comprising a large part of the Australian wool stockpile. Being cheaper than the equivalent down product, naturally superior in warmth and ventilation, and non-allergenic, the quilts are being sold by the Van Winkle Company using the "Bungaree" label. Each year, several hundred thousand polyester, feather and down quilts are sold in Australia, and about 13 million in Europe, thus increasing the potential use of Australian wool for bedding both here and overseas.

Information and Communications Industries

Recent Achievements

Vehicle-mounted antennas for Mobilesat

The second generation of AUSSAT satellites to be launched in 1992-93, will give Australia the world's first dedicated mobile satellite communications system, Mobilesat. Mobilesat will be ideal for those who wish to maintain communications away from the main cities. It will provide voice and data communications, such as phone and paging services, and can be used in cars, trucks, and coastal shipping anywhere in Australia. CSIRO has developed a low cost electronically tracking antenna which will enable the communications channel to remain locked to the satellite as the vehicle on which it is mounted moves. The compact shape of the antenna allows relative ease of attachment to most vehicles.

CSIRO is currently negotiating with several Australian companies to manufacture the antenna and subsystems, including the low noise amplifier and diplexer, to develop the associated acquisition and tracking control network, and to market and sell the system. CSIRO will continue to perform the electromagnetic design, develop comprehensive testing techniques and facilities, and maintain close liaison with overseas operators designing their own Mobilesat systems concerning technical specifications and developments.

Economic Development, Environmental Aspects

Recent Achievements

Disposing of saline ground waters

Researchers from CSIRO have investigated the relative contributions of evaporation and seepage to the disposal of saline groundwater at the Wakool/Tullakool Subsurface Drainage Scheme, one of 90 artificial groundwater disposal basins designed to reduce salinity in the fields of the Murray Darling river basin. The results of the project, whilst providing valuable data on measurement techniques, enabling scientists in other locations to compare readings and equipment, and to improve our understanding of the workings of saline water evaporation and storage, raises some doubts about the efficiency of these artificial disposal basins. An exciting alternative is to use existing salt lakes as sites for the disposal of saline groundwater, because they would be cheaper to use than man-made alternatives, and would not alienate arable land. This proposal raises a crucial question: will the addition of saline groundwater to these lakes disturb their equilibrium and release the megatonnes of salt accumulated in the sediments below them

during the past 30,000 years? CSIRO researchers are now using mathematical modelling, laboratory simulations and field measurements in an attempt to answer this question.

Spanish dung beetles in Western Australia

Dung beetles previously introduced into WA to bury dung and control flies, came from warmer, subtropical climates. They are not adapted to summer drought and cold winters, with the result that, by the start of summer, several generations of bushflies have bred by the time that the beetles have become active. CSIRO and the WA Department of Agriculture are collaborating to introduce three new beetle species from Spain to bridge the late spring gap. The new beetles are being bred at the Australian Animal Health Laboratory before being released.

Mediation in forest disputes

Using a database assembled from the Batemans Bay forestry region, that would allow interested parties such as conservation groups and the timber industry to identify areas of varying values for conservation and forestry, CSIRO has developed SIRO-MED, a decision support system for mediating conflicts between competing interests in forest land use.

At mock negotiating sessions held in Canberra to experiment with SIRO-MED, it was possible for opposing teams to define areas of obvious usage, and to negotiate towards a balanced plan. The SIRO-MED system has been demonstrated to various federal and state ministers, and been commended by the Resources Assessment Commission. The SIRO-MED system could be valuable for solving possible conflicts on the north coast of New South Wales, where both timber and conservation values are greater than in the highly-publicised southeast forests.

Environment

Recent Achievements

The impact of climate change

Following increased demand from State Governments for estimates of probable regional climate change, CSIRO's Climate Impact Group is now producing annual reports covering possible changes in temperature, rainfall, sea level and weather phenomena, and the influence of these changes on activities such as agriculture, water supply, snow fields, fire danger, floods and temperature extremes. The Group uses results from local and overseas general circulation models for the Australian region, limited area models that stimulate specific meteorological phenomena and analyses of historical records and palaeoclimatic information.

Environmental Decision Support System (EDSS)

In close collaboration with the Environmental Resources Information Network (ERIN) of the Australian National Parks and Wildlife Service, CSIRO has developed a prototype Environmental Decision Support System (EDSS), which features user-friendly operation for people who are not specialists in using geographic information systems.

The EDSS can integrate many forms of data and can incorporate specialist modelling and analysis packages. The prototype has been tested with data from Tasmania, and includes information concerning rare or threatened Australian plants, World Heritage areas, vegetation maps, river systems and rainfall maps. With EDSS, users are able to access map data, satellite images, photographs, drawings, tabular data, abstracts and textual documents. Based on all the information available, they can apply EDSS' powerful analytical and modelling tools to selected subsets of this data to help them visualise problems and potential solutions quickly and intuitively.

Construction

Recent Achievements

BCAider

BCAider is an expert system for the Building Code of Australia (BCA) developed by CSIRO in collaboration with the Australian Uniform Building Regulations Coordinating Council (AUBRCC), Jennings Housing and Butterworths Pty Ltd. BCAider is available in either a home building version for residential housing and outbuildings, or a full version, which covers all buildings including offices, shops, hospitals, schools, factories, theatres and multi-storey car parks. It runs on personal computers and helps improve the ease and accuracy of applying and checking the regulations. Since the first version of BCAider was released in April 1991, over 80 orders have been received. It is attracting international interest.

Advancement of Knowledge

Recent Achievements

High resolution images from the Australia Telescope National Facility (ATNF)

The year 1990-91 saw the production of the first images using the full six-telescope Compact Array. An image of the luminous radio galaxy PKS 2356-61, made using four baselines, and in collaboration with

astronomers from the ANU, revealed areas of extended radio emission which had not been detected before for galaxies of this type. In March 1991, the full six antenna array was brought into operation, three months ahead of schedule, to allow astronomers to detect a transient radio source near the galactic centre and to observe supernova 1987a (a star which exploded in 1987). The improved resolution of the Australia Telescope allows astronomers to form images of the supernova, rather than seeing it just as a point.

At the Parkes radiotelescope, collaborative efforts over the past year included the completion of a survey of the southern sky by ATNF and US astronomers, which turned up more than fifty thousand new radio sources (galaxies, quasars, pulsars, and gas clouds), and the discovery of thirty new pulsars, which has doubled the known number of short-period pulsars.

Industrial Research and Development Board

Tax Concession for Industrial R&D

Role

The objective of the tax concession/or industrial research and development is to make Australian companies more innovative and internationally competitive through improving innovative skills in Australian industry by:

- *increasing companies' investment in R&D;*
- *encouraging better use of Australia's existing research infrastructure;*
- *improving conditions for the commercialisation of new process and product technologies developed by Australian companies; and*
- *developing a capacity for adoption of foreign technology.*

The tax concession for industrial research and development is a major program in the Government's package of measures to encourage the performance of R&D in industry. The concession will apply at a rate of 150 per cent until 30 June 1993, after which a rate of 125 per cent will apply indefinitely.

Recent Achievements

Syndication

The joint registration provisions of the tax concession allow a group of companies to form a syndicate to undertake significant R&D projects

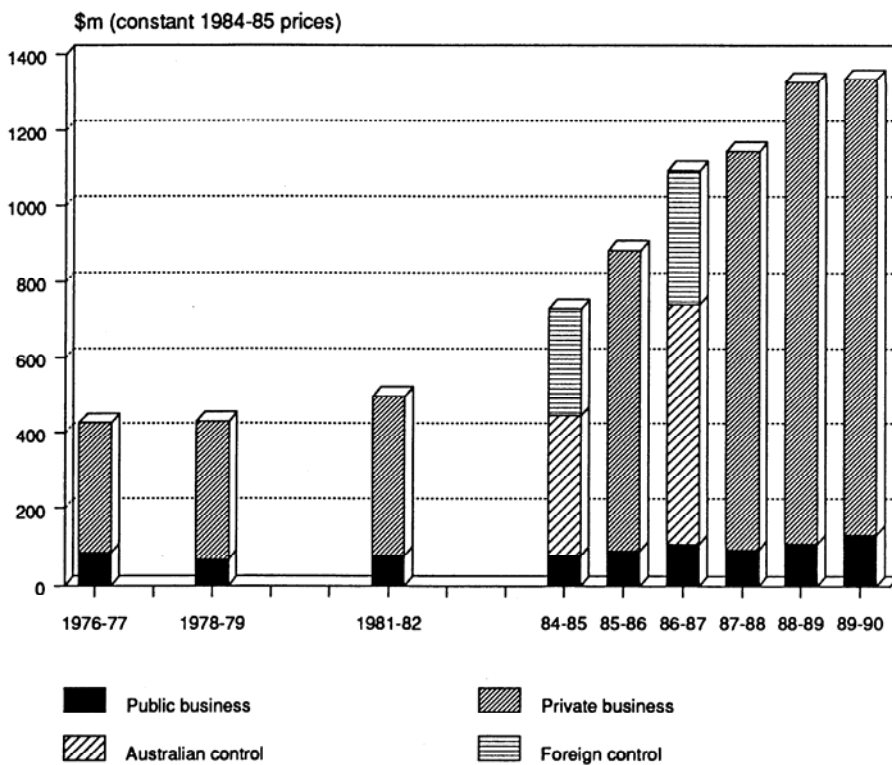
which are beyond the resources, or are considered too risky, for a single entity to undertake. The Board received 19 applications for syndication during the year. To date, 18 syndicates have been registered and funded with total eligible expenditure of approximately \$325 million.

Effectiveness

Australian Bureau of Statistics R&D data show the level of private business expenditure on R&D has increased substantially in real terms over the period since the introduction of the concession (see Figure 3).

Figure 3

BUSINESS EXPENDITURE ON R&D



Source: See *Australian Science and Innovation Resources Brief 1991* (forthcoming)

Much of the growth may be attributed to the concession. It provides a considerable incentive to industry, with an estimated \$230 million of company tax revenue foregone in 1990-91. It is available to all companies conducting eligible R&D in Australia and is used by about 1600 companies each year.

Mining equipment

Dale B Elphinstone Pty Ltd is internationally competitive in the manufacture of underground mining machines. The company acknowledges the assistance given to its R&D projects on specialist equipment by the tax concession. The ongoing development of the R1500 load, haul and dump loader is one outstanding success. These huge vehicles have been rolling off the production line at the rate of one per month since the first unit was commissioned and sold in 1986. Fifty of this model have now been produced, with exports comprising 25 per cent of production.

Cheese production

The Murray-Goulburn Co-operative Company Ltd collaborated with CSIRO scientists and an engineering company, APV-Bell Bryant, to develop APV-Sirocurd. This is the world's first continuous automated high-yield cheddar cheese process and is now operating at Cobram, Victoria. The multi-million dollar product has put the company ahead of world competition with a process that yields up to five per cent more cheese from the same amount of milk. Murray-Goulburn's part was to scale up the process on factory equipment supplied by APV-Bell Bryant. The venture received impetus through the tax concession.

Discretionary Grants Scheme

Role

To provide support to companies which have insufficient taxation liability to obtain adequate benefit from the tax concession for research and development but have the potential to fully exploit their results.

Recent Achievements

Air transport

The Preston Group has exploited a major breakthrough developed by CSIRO in computer software simulation technology. A Total Airspace and Airport Modeller (TAAM) computer software program was developed that produces realistic simulation of airspace and airport operations and generates meaningful reports and statistics for subsequent analysis. TAAM has been sold to the Civil Aviation Authorities in Australia, Germany and the UK. Germany is using TAAM to remodel the

at present congested airspace around Dusseldorf Airport, and also to model East and West German airspace, following re-unification.

Water purification

UVS Nominees Pty Ltd has developed a powerful ultra-violet light based system for germicidal treatment of water. The system expands the volume of water that can be disinfected for a given power consumption. It provides potable water conforming to World Health Organisation Guidelines. The clean environmental aspects of using ultra-violet light for this disinfection give this product considerable growth potential.

Generic Technology Grants Scheme

Role

To provide support and directions for the development of strategic technologies, which are important/or the international competitiveness of Australian industry.

Recent Achievements

Detection and location of blood clots in humans

Blood clots inhibit bleeding from injuries. Unfortunately, clots can form in blood vessels and interfere with normal circulation. If this happens in the lungs, the result may be fatal. Current methods for detecting blood clots are not always accurate and may be harmful. AGEN Biomedical Ltd has developed a specific antibody which attaches to blood clots and can be photographed when a tiny amount of radioactive material is added. In collaboration with ANSTO, blood clots in the legs were readily detected. Patients suffered no side effects.

Polymeric Materials for Hostile Environments

Flexichem Pty Ltd is manufacturing new research based silicone polymer products. Research was conducted by the Queensland Institute of Technology and the University of South Australia. The new materials have improved resistance to cracking, crazing and embrittlement in harsh Australian conditions. One of the new materials is a gel coat additive which increases water resistance and reduces blistering on coatings used for swimming pools and boats.

Bioceramics for medical implants

The Australian Nuclear Science and Technology Organisation in collaboration with Teletronics, a manufacturer of heart pacemakers, has developed a ceramic material for use in bio-medical implants. Teletronics required a means of fabricating a collar to fit behind the tip of a heart stimulating electrode. The device is required to slowly release

an anti-inflammatory drug, and a means of fixing the electrode by ingrowth of heart tissue into the large pores of the ceramic. The material has both large and small sized pores which allows tissue growth into the large pores for implant fixation and controller drug release from the small sized pores.

New aerial mapping techniques

The CSIRO Divisions of Exploration Geoscience and Water Resources, in conjunction with World Geoscience Corporation, are developing an airborne electromagnetic instrument, SALTMAP, to allow accurate 3-dimensional mapping of electrical conductivity of the land surface layer. SALTMAP allows rapid assessment of water table heights and drainage patterns in salt-induced threatened land degradation areas in Australia, enabling countermeasures to be taken before salt outcropping causes almost irreversible damage to the agriculturally vital surface layer. SALTMAP uses modern digital signal processing hardware and new sensor technology. A by-product of the development is that improved airborne electromagnetic technology may enable the building of better mineral exploration tools, and provide a significant boost to Australia's mining industry.

National Procurement Development Program (NPDP)

Role

To provide grants for industry and government to collaborate in the research, development, trialling and demonstration of internationally competitive, innovative Australian products.

The NPDP was established in 1987 and is to run till 1994-95. It was expanded from 1 July 1990 to formally include the participation of State and Territory Governments in providing financial, administration and promotion support.

Overall, 190 projects have been considered and 85 projects funded to a total commitment of \$23.6 million. To date, around one third of the projects have completed their technical objectives to the satisfaction of their government partner. Of these, 19 projects have resulted in sales to the government partner; supported projects have achieved domestic sales of around \$50 million and export sales of around \$5 million.

An important long term objective of the program is to overcome risk aversion by government purchasing agencies in the purchase of Australian products and services. The program is having a positive impact, evidenced by strong interest from both government and industry. Already 25 Commonwealth and 40 State Government departments and agencies have participated in the program.

Increasingly, government bodies are seeking to use the program to develop Australian products to meet their future procurement needs.

Recent Achievements

Electronic ticketing system

Associated Electronic Services Ltd used a \$205,000 NPDP grant to develop a special unit to validate multi-journey smartcard passes for bus passengers. The company's government partner was the Western Australian transport authority, Transperth. The unit both validates passenger smartcards and retains data on time of boarding, fare, zone, ticket type and stage of route. Sales have been secured in Sweden and Norway with further tenders being submitted worldwide.

Electronic flagman

Teknis Systems approached Queensland Railways with an idea to develop an 'Electronic Flagman' as a portable warning device to advise railway work gangs of an approaching train. The project was awarded a \$137,000 NPDP grant. Queensland Railways have taken delivery of the first production unit and are helping to market the Electronic Flagman nationally and internationally.

Domino Myne Dozer

Domino Mining Equipment Pty Ltd, in partnership with the Electricity Commission of NSW (Elcom), was awarded a \$ 141,500 NPDP grant to develop its latest underground mine dozer, the Domino Myne Dozer. The dozer is a heavy duty prime mover with a range of 'quick attach' implements, including extendable arms. A number of Elcom's subsidiaries have since purchased dozers to the value of \$2.5 million for use in their mines.

PRIMARY INDUSTRIES AND ENERGY

Science and Technology in the Portfolio Budget

The mission of the Department is to increase the contribution that the agriculture, minerals, energy, fisheries and forestry industries make to the wellbeing of Australians. Responsibility for achieving research and development objectives falls to different authorities at a number of levels within the portfolio. Three key institutional arrangements influence the strategic and operational aspects of portfolio research objectives and priorities. These are:

- the Primary Industries and Energy Research Council,
- three research bureaux, and
- eighteen R&D corporations and councils.

The *Primary Industries and Energy Research Council (PIERC)* was established to provide advice to portfolio Ministers on policies, priorities and strategies for portfolio R&D, and to provide a link to Australia's major science and technology bodies and industry. The Council comprises senior members from research funding bodies, government organisations, community groups, R&D corporations, industry, and the States. PIERC provides strategic directions for the portfolio's research effort, facilitates the networking and consultative processes within and outside the portfolio and advises on opportunities for collaborative research. The Council operates at a level where broad principles applying to the organisational and administrative structures within the primary industries and energy portfolio are examined. Its role is to assess whether the institutional arrangements within the portfolio are encouraging research resources toward the most appropriate areas and level of commitment.

The Department's three research bureaux are the *Australian Bureau of Agricultural and Resource Economics (ABARE)*, the *Bureau of Mineral Resources (BMR)*, and the *Bureau of Rural Resources (BRR)*. Expenditure by these three Bureaux in 1991-92 is expected to be \$84 million. These three bureaux play a vital role in the conduct of public sector research and provide scientific and economic advice to assist the process of Government. The research undertaken by these bureaux is funded predominantly from consolidated revenue. Their research output is mostly in areas where the external benefits are high and where user-pays funding is not generally cost-effective.

Eighteen *R&D Corporations and Councils* have been established to encourage greater end-user participation in research and to ensure industry research organisations are more active in the commercialisation of research and the realisation of industry opportunities, and more involved in the transfer of technology.

Research expenditure undertaken through these bodies in 1991-92 is expected to be \$188 million, of which approximately 40% will be collected from industry levies.

Fifteen of the R&D Corporations and Councils are industry based:

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

Provision is made for Government funding of these Corporations and Councils on a dollar-for-dollar basis up to the maximum of 0.5 per cent of the gross value of production (GVP) of the commodity. 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. Within the portfolio, the R&D Corporations and Councils are the vehicles for decentralised management.

Three R&D Corporations are predominantly funded by Government:

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

Direct funding of R&D by Government was judged as being appropriate for these Corporations, particularly where the private sector is likely to under-invest in R&D and where substantial benefits would 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.

MAJOR RESEARCH ACTIVITIES

Bureau of Mineral Resources, Geology and Geophysics (BMR)

Role

BMR's role is to contribute to the sustainable and environmentally responsible development of Australia's natural resources and the mitigation of hazards to life and property through:

- generating publicly accessible information necessary for the exploration and assessment of the nation's petroleum, mineral and groundwater resources,*
- participating in monitoring and developing an understanding of the natural environment,*
- participating in global and regional geoscientific programs of importance to Australia, and*
- providing independent scientific advice to government, industry and the public for the management of Australia's resources, development of multiple land use policies and environmental protection, mitigation of earthquakes and other natural hazards and detection of underground nuclear explosions.*

Recent Achievements

Exhaustive study of the offshore Perth Basin

Petroleum exploration in the offshore Perth Basin was stimulated by the completion of an exhaustive study of the Basin Structure. The result has been a radical change in our understanding of the process of basin formation.

Model of the groundwater processes in the Murray Basin

The BMR provided high level technical and scientific advice about the groundwater issues in the Murray Darling Basin. The Rice Growers' Association of Australia now base their strategic planning and management decisions on BMR's model of the groundwater processes in the Murray Basin.

New models for the structure and evolution of the Canning Basin

The BMR enhanced the prospectivity of petroleum resources in the Canning Basin, Western Australia, by providing significantly revised models for the structure and evolution of the Basin. The work revised the known Basin stratigraphy to enable more accurate exploratory drilling, identified untested petroleum plays off the shelf margin, and

improved the understanding of Basin brines and base metal mineralisation.

Dairy R&D Corporation

Role

To lead effective change through excellence In research and development for a profitable and competitive Australian dairy industry.

Recent Achievements

Pestivirus test

Pestivirus is widespread in Australian dairy cattle and may be causing early abortions. Laboratory tools were unable to prove that pestivirus caused abortions. Researchers at the New South Wales Department of Agriculture have used Dairy Research and Development Corporation funds to develop a fast, accurate test for pestivirus. The test will enable scientists to determine the role of pestivirus in reproduction. If, as suspected, the virus is causing significant early abortions, the new test will enable scientists to develop strategies to reduce the problem. The test may have the added benefit of opening up new export markets for live cattle. Many importing countries require proof that cattle are free of pestivirus. The new test will be able to do this.

Enzootic Bovine Leukaemia

Enzootic Bovine Leukaemia (EBL) is a disease of dairy cattle, most widespread in Queensland. Several new diagnostic tests have been developed and will enable the disease to be eradicated sooner than expected. The research was a joint effort involving the Queensland Department of Primary Industries and the University of Queensland, using funds provided by the Dairy Research and Development Corporation.

Grains R&D Corporation (GRDC)

Role

The activities of the Corporation focus on research and development aimed at enhancing the productivity and sustainability of the Australian grains industry by improving the production, processing, storage, transportation and marketing of grains sector products.

The commodities for which it has so far been given responsibility to support research and development are wheat, barley, grain legumes, oilseeds and triticale.

Recent Achievements

Launch of two new barley health products

Successful research has been funded by the GRDC's Barley Committee and undertaken by the CSIRO Division of Human Nutrition, Adelaide into the effect of barley on human serum cholesterol levels. This has enabled the production and launch of two new products, Barley Bran, similar to Oat Bran but considered more effective, and Barley Quick, a high-fibre, quick cooking alternative to rice. The Barley Committee can foresee the potential for significant increases in the high-value, human consumption of barley to the ultimate benefit of the individual as well as to the industry.

Canola oil resulting from successful oilseed research

Canola is the term applied to rapeseed oil that meets or exceeds accepted international standards for erucic acid. It is a premium grade oil high in oleic acid - the major component of olive oil. Oleic acid is a mono-unsaturated fatty acid particularly suited for deep frying. It is also seen as a health product with highly desirable prospects for inclusion in the diet of humans.

Improvements in Australian-bred rapeseed cultivars funded by the GRDC's Oilseeds Committee have resulted in canola oils of superior quality to those previously produced in Australia. Seed from the new Australian varieties is superior to much of the canola produced in Europe and North America.

Rural Industries R&D Corporation (RIRDC)

Role

The Corporation's mission is to enhance the sustained economic contribution of agricultural industries to the national economy. To achieve this it organises and funds research and development to support small, emerging and new rural industries. RIRDC also addresses issues which are generic to the agricultural industries generally and provides services for the semi-independent research and development councils.

Recent Achievements

Increasing forest tree productivity

Improving the growth and survival of eucalypts in plantations, agroforestry and rehabilitation sites has been difficult, as fertiliser

applications are too costly. It was found that ectomycorrhizal fungi associated with the roots of eucalypts increased the trees' capacity to take up necessary mineral nutrients from the soil. A recently completed project developed, and made available to industry, a source of the appropriate fungi as well as the technology for getting the fungus into commercial plantings effectively and efficiently.

Lentil trials in South Australia

Over the past few years, the Grain Legume Breeding Unit of the South Australian Department of Agriculture, has been evaluating new lentil crossbred lines in statewide trials. Various new yellow and red lentil lines are tested for yield, maturing time and seed size against established varieties. Successful lines have been multiplied for release as new varieties.

Wool R&D Corporation

Role

The Corporation's objective is to plan and recommend a research and development program that will maximise the net return to woolgrowers and to the national economy by improving the quality and performance of wool products and by improving the efficiency of wool production, marketing and processing. The Wool Research and Development Corporation is responsible for planning, funding and co-ordinating the wool research and development program for the Australian wool industry.

Recent Achievements

Detection of contaminants in wool yarns

An optical sensing device called SIROCLEAR which detects coloured contaminants in undyed yarn is expected to become commercially available in 1991. Developed by CSIRO Division of Wool Technology and extensively trialed in industry by the International Wool Secretariat, SIROCLEAR has been licensed to a Swiss manufacturer of yarn clearing devices. It dramatically reduces the cost of removing contaminants such as vegetable matter, dark fibres and baling twine from wool yarn. When detected by SIROCLEAR, these contaminants are automatically removed from the yarn during winding, eliminating the laborious and expensive manual procedures which otherwise would be needed to remove them at the fabric stage.

Increased production through improved pasture species

Wool production is directly influenced by the quality and quantity of pastures grazed by sheep. Subclovers and medics are important components of pasture due to their symbiotic association with *Rhizobium* bacteria which can convert atmospheric nitrogen to

plant-available nitrogen. Ability of legumes to fix nitrogen not only increases plant protein levels but also helps raise soil fertility. National plant breeding programs for subterranean clover and medics have produced new varieties with various attributes including increased yield, higher seed production, tolerance to waterlogging, suitability to acid or alkaline soils and lower oestrogen levels which can affect sheep fertility.

New improved varieties of *Phalaris*, a perennial pasture grass, are soon to be released. *Phalaris* is a productive grass that is used in the drier areas of southeastern Australia. It stands up well to grazing and resists fire, waterlogging and attack by insects. Its persistence together with its surface structure also helps to reduce erosion whereas less persistent grass species may not survive prolonged drought conditions.

PRIME MINISTER AND CABINET

Science and Technology in the Portfolio Budget

Expenditure on science and technology policy through the independent, high level advisory body ASTEC is expected to be \$1.7 million in 1991-92 (\$1.6 million in 1990-91).

Expenditure on science and technology policy and programs through the Office of the Chief Scientist is expected to rise to \$20.3 million (\$1.1 million in 1990-91), reflecting the initial establishment of the Cooperative Research Centres (CRC) Program, which is administered by the Office. This amount incorporates \$19 million as the expected amount of grants towards the establishment of the first CRCs (of which \$4 million is a carryover from 1990-91).

Funds for the Resources Assessment Commission are \$6.3 million in 1991-92 (\$6.2 million in 1990-91) to undertake resource assessment activities.

MAJOR POLICY ACTIVITIES

Prime Minister's Science Council

Role

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

The Science Council is chaired by the Prime Minister and includes other senior Ministers with strong portfolio interests in science and technology. Additional members are drawn from the scientific and technological community and from industry.

Recent Achievements and Future Directions

The Science Council held meetings in October 1990 and May 1991. Preparation of material for consideration by the Council was organised through independent working groups, the holding of seminars, and wide consultation with government departments, industry, and the research community. Topics of discussion at these meetings included adding value to mineral products, the scientific and medical equipment industry, engineering in Australia, food processing, and commercial opportunities in waste management (see Section 2).

The next meetings of the Science Council will concentrate on the development of the White Paper on Science and Technology, due to be released in mid 1992.

Coordination Committee on Science and Technology

Role

To facilitate the sharing of information on science and technology issues and assist the coordination of programs and policies concerned with science and technology.

The Coordination Committee brings together senior officers from all Commonwealth departments with an interest in science and technology and the heads of major research funding and performing agencies.

Recent Achievements

Major topics of discussion by the Committee during the year included the development of the White Paper on Science and Technology, commercialisation of research, costing and pricing of research by public agencies, mobility of researchers, coordination of resource and environmental databases, coordination of international science and technology and Australian genome sequencing activity and funding.

Working parties were set up to investigate the costing and pricing of research by public agencies, to address the coordination of resource and environmental databases, and to coordinate activities in international science and technology collaboration.

A sub-committee of the Coordination Committee was established to discuss preparations for the White Paper on Science and Technology. The Coordination Committee will play a major role in the development of the White Paper.

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 Minister Assisting. It also provides advice, information and administrative support for specific programs in order to maintain and enhance a world class Australian science and engineering infrastructure, and to achieve the effective application of science and technology in the economic and social development of Australia.

The Office of the Chief Scientist:

- provides secretariat services to the Prime Minister's Science 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 Council;
- provides support for the Cooperative Research Centres Committee in its selection of the Cooperative Research Centres, and on behalf of the Committee implements and administers the Program;
- provides advice on issues in science and technology, directly and through the Chief Scientist, to the Prime Minister and other Ministers;
- obtains information about current and emerging developments and issues in science and technology policy;
- maintains close liaison with the Prime Minister's Office, relevant Departments and agencies and within the Department to keep informed of significant developments, consults on policy advice

and facilitates cross-portfolio policy coordination;

- consults broadly with people outside Government, including with research, business, academic communities and the union movement, in order to bring a wide range of views and experience to bear on the development of policy advice;
- advises on the coordination of the work of the Structural Adjustment Committee of Cabinet and other Committees, as appropriate; and
- initiates and develops new policy proposals where appropriate, in cooperation with other Departments.

During the year, major activities of the Office of the Chief Scientist included the organisation of two meetings of the Science Council in October 1990 and May 1991, the organisation of four meetings of the Coordination Committee, and the selection process leading to the announcement of the first 15 Cooperative Research Centres in March 1991.

Recent Achievements and Future Directions

The Cooperative Research Centres Program

The Cooperative Research Centres Program was launched in May 1990. Under the Program, new Government funding, rising to \$100 million annually (1990 dollars) by 1995, will be provided to support up to fifty Centres.

The Program is a direct response to widespread concern that, even in traditional areas of research strengths, it has become increasingly difficult for Australian researchers and research groups to keep up with the pace of scientific and technological developments internationally.

The principal objectives of the Program are:

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

The Program is overseen by an advisory body, the Cooperative Research Centres Committee, which is appointed by the Prime Minister and chaired by the Chief Scientist. The Committee is assisted by two expert advisory panels, with expertise in a wide range of scientific and engineering disciplines. During the selection process, the panels also drew on the expertise of a range of other Australian and overseas assessors.

Selection of Centres

The first selection round attracted 120 applications. They involved higher education institutions (a mandatory requirement) and a wide range of participants from industry, State and Commonwealth Government agencies, and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The selection process was competitive and Centres were assessed using a peer review process on the basis of criteria published in the 'Guidelines for Applicants' issued when the program was launched. The first fifteen Centres were announced in March 1991. These were:

- Aerospace Structures Research Centre
- Centre for Australia's Petroleum Industry
- Centre for Eye Technology and Research
- Centre for Waste Management and Pollution Control
- G. K. Williams CRC for Extractive Metallurgy
- Centre for Intelligent Decision Making Systems
- Centre for Cellular Growth Factors
- Centre for Plant Science
- Centre for Robust and Adaptive Systems
- Centre for Mining Technology and Equipment
- Centre for Tropical Pest Management
- Centre for Soil and Land Management
- Centre for Tissue Growth and Repair
- Centre for Temperate Hardwood Forestry
- Antarctic and Southern Ocean Research Centre

There will be two further selection rounds for Centres under the Program. Applications for the second round closed on 3 July 1991. The third and last round will take place in 1992.

Australian Science and Technology Council

Role

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

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

Recent Achievements

Setting research directions for Australia's future

The Prime Minister has commissioned ASTEC to commence work on the first phase of a new process to set broad directions for Australian research for the 1990s and beyond.

The Prime Minister's request followed advice provided by ASTEC in its report, *Setting Directions for Australian Research* (June 1990). In that report, the Council recommended the preparation of a Government White Paper to provide a robust, national framework for medium to long-term decision making in research and to assist the sound, strategic management of Australia's research resources.

The White Paper will be drafted by the Government's Coordination Committee on Science and Technology. It will be based on the wide ranging "Issues and Options" Paper to be prepared by ASTEC by September 1991. An important aspect of the ASTEC paper, which would perform a role similar to that of a 'green' paper, is that its preparation should follow extensive consultation with key individuals and organisations involved in the funding, performance or use of research throughout Australia.

Review of environment research in Australia.

ASTEC was commissioned by the Prime Minister to undertake a study of environmental research in Australia and to recommend strategies for improving the contribution of research to the conservation and development decision making process. The final report *Environmental Research in Australia - The Issues* was delivered to the Prime Minister in December 1990 and tabled in Parliament in March this year. The Prime

Minister is referring the report to Ministers for a consolidated Government response. The main findings of the report are:

- the Government must develop a Commonwealth Environment Strategy;
- an Environmental Research Strategy must be a subset of the Commonwealth Environment Strategy;
- interdisciplinary research must be supported;
- the Government should fund a system of national long term monitoring and research sites to assess environmental change;
- DEET should support a program to ensure adequate coverage of highly qualified environmental researchers, particularly in taxonomy, soil science, atmospheric science and ecotoxicology;
- the Commonwealth should recognise as a priority the development of environmentally benign technologies for cleaner production; and
- the Commonwealth must ensure the establishment of nationally accessible environment data sets, and develop agreements that will ensure exchange of standardised data.

The final publication from the environmental research study is currently in press. It is titled *Environmental Research in Australia - Case Studies* and consists of seven different Australian environmental resource use case studies which are historically significant in outlining Australia's application of environmental research to natural resource decision making.

ASTEC organised an Environmental Research Seminar to provide an opportunity for the research community, government and industry to discuss the report findings. The Seminar was well attended and the recommendations were strongly supported. The proceedings of the Seminar will be released in September. The Prime Minister has requested the Department of Arts, Sport, the Environment, Tourism and Territories to coordinate comments on ASTEC's Environment study report from relevant portfolios.

An Australian International Gravitational Observatory

ASTEC was asked by the Prime Minister to evaluate the timeliness, scientific promise, technical case and industry flow-on of an Australian International Gravitational Observatory (AIGO) proposed for construction at Wallingup Plain, Western Australia.

ASTEC's report concludes that the project, while being scientifically attractive, does not qualify for Government support as a national project funded entirely by Australia. However if an international partner could be found to meet at least 50% of the cost of \$38 million (1989 prices), the proposal should be reconsidered. Even if such funding were to become available, the cost benefit to Australia would still be dubious, particularly in terms of industrial spin-off.

Funding the fabric: Should competitive research granting schemes contribute more to research infrastructure costs?

This paper arose from ASTEC's work on 'marginal funding' of research. It finds that existing funding arrangements are currently leading to an insufficient provision for research infrastructure needed to support an increase in marginally funded grants, and suggests costing and pricing guidelines for public sector R&D.

TRANSPORT AND COMMUNICATIONS

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).

The budget outlay for 1991-92 for the ARRB will be \$2.2 million. The Budget outlay for FORS will be \$45.3 million (which incorporates \$35 million for the Federal 'Black Spots' Program)

A large number of Government Business Enterprises (GBEs) in this portfolio deal with scientific services and conduct research. Their activities do not appear in the Budget. These include Telecom, which has the largest research effort of the GBEs, Australia Post, the Overseas Telecommunications Commission, Aussat, QANTAS, Australian Airlines, the Federal Airports Corporation and a number of other organisations.

MAJOR RESEARCH ACTIVITIES

Support for the Australian Road Research Board (ARRB)

Role

To provide support for the ARRB which is a non-profit company sponsored jointly by all three levels of government. ARRB's mission is to undertake relevant and timely research and associated services to help the road transport sector in Australia provide safe, sustainable, efficient and effective transport services.

Recent Achievements

Pavement Management Systems for local government

Ageing roads and constrained budgets require the use of systematic approaches to road maintenance such as Pavement Management Systems (PMS). Following release of guidelines designed to promote the adoption of PMS by local government, a series of 22 workshops were held across Australia. The workshops were attended by 450 engineers and 50 senior executives from local government. If widely adopted, PMS will reduce the annual cost of road rehabilitation by many millions of dollars.

Improving truck safety

Under contract to the Australian Road Transport Federation, an industry strategy has been proposed to improve truck safety. A range of immediate and longer term actions and research are proposed to improve roads, vehicles and truck driver performance. The recommendations have the potential to significantly reduce the annual \$500 million cost of truck accidents in Australia.

Exporting technology to China

ARRB is completing a major transfer of Australian road technology to China. During 1990-91, this has involved supply of equipment and software, technical advice, presentation of a seminar and training of local researchers. Commercial benefits have already exceeded the value of the aid funding provided by the Australian International Development Assistance Bureau and further purchases of equipment and advice are expected.

Federal Office of Road Safety (FORS)

Role

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

Recent Achievements

Safety research

Recent research carried out by the Federal Office of Road Safety has provided information on such matters as injury-causing mechanisms in crashes involving passenger cars; causes of heavy vehicle crashes; identification of demographic aspects of drink driving and non-use of seatbelts.

Progressive advances in road safety are made through the translation of results into road traffic legislation, vehicle safety standards or public education and promotion programs of the outcome of research on a number of fronts.

SECTION 4:

TRENDS IN COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION

Summary Data

Commonwealth support for major science and innovation programs has risen from \$2422 million in 1990-91 to an estimated \$2607 million in 1991-92, a real increase of 4.3 per cent. Broadly, there have been significant increases over the whole period since 1980-81, 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 1 present a summary of Commonwealth support for science and innovation at constant price values. They provide a four-way breakdown of the data as follows :

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

Higher Education Research

Support for research in the higher education sector (excluding support from special purpose grant schemes) is estimated to increase to \$1082 million in 1991-92 from \$987 million in 1990-91, representing a real increase of 6.1 per cent.

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

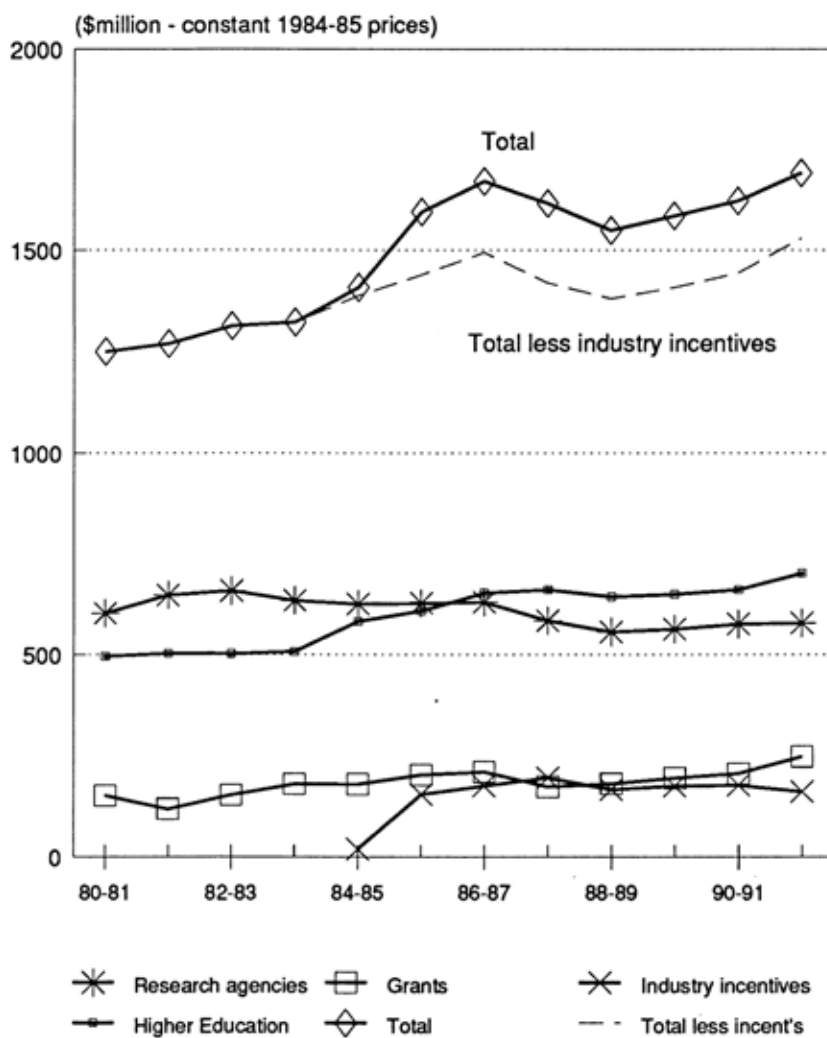
TABLE 1 Constant Price Summary of Major Commonwealth Support for Science and Innovation, Through the Budget and Other Measures (\$m at constant 1984-85 prices)

	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	(est.) 1991-92	
MAJOR SCIENTIFIC RESEARCH AGENCIES													
• Defence	133.4	158.5	157.0	155.2	158.4	155.1	159.5	151.5	155.9	157.5	152.2	143.5	
• Civil	469.3	489.8	501.6	479.6	467.4	472.7	471.1	432.9	400.8	406.1	423.8	435.1	
SUB-TOTAL	602.7	648.2	658.6	634.8	625.8	627.8	630.6	584.4	556.7	563.5	576.0	578.6	
SCIENCE AND INNOVATION GRANTS													
• Health and Medical	28.6	36.0	39.2	47.9	52.0	51.9	55.3	55.3	56.8	61.7	71.2	79.2	
• Industry and space	74.4	34.5	63.7	74.2	67.6	91.0	86.0	64.5	60.2	62.2	63.2	72.5	
• Cooperative Research Centres	-	-	-	-	-	-	-	-	-	-	-	12.7	
• Rural	29.7	30.8	31.1	36.9	41.4	44.8	55.5	44.0	54.2	57.4	55.1	68.0	
• Energy and environment	10.6	14.5	17.0	18.5	16.7	13.5	12.4	9.1	8.7	12.9	16.1	15.4	
• Transport	9.2	3.4	2.8	3.6	2.8	2.4	1.7	1.6	1.5	1.4	1.5	1.5	
SUB-TOTAL	152.6	119.2	153.9	181.1	180.6	203.6	211.0	174.5	181.4	195.6	207.0	249.2	
COSTS OF IR&D & RELATED INCENTIVES		-	-	-	-	20.0	155.1	176.5	196.1	167.2	176.2	178.2	162.2
HIGHER EDUCATION RESEARCH													
• ARC and related grant schemes	38.5	39.9	45.6	49.0	52.8	54.4	56.6	58.4	62.8	87.0	115.5	156.9	
• Specific R&D support	107.7	106.8	106.3	110.1	112.0	110.3	109.6	108.6	105.5	104.9	103.8	103.8	
• Est. general research support	349.7	356.8	350.7	349.2	418.0	443.9	487.0	494.3	475.5	458.0	442.1	441.3	
SUB-TOTAL	495.9	503.5	502.6	508.3	582.8	608.6	653.1	661.3	643.8	649.9	661.4	702.0	
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 84-85 PRICES													
	1251	1271	1315	1324	1409	1595	1671	1616	1549	1585	1623	1692	
EST. REAL % INCREASE/DECREASE		1.6	3.5	0.7	6.4	13.2	4.8	-3.3	4.2	2.3	2.4	4.3	

SOURCE: Based on data in Table 2 and using GDP non-farm deflators.

Figure 4

MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION



Source: See Table 1

Research in Commonwealth Agencies

The largest Commonwealth research agencies are CSIRO, DSTO, ANSTO, BMR, Antarctic Division and AIMS. Support through Budget appropriations to these agencies, and some smaller ones, is expected to be \$891.7 million in 1991-92, at the same real level as in 1990-91 (\$859.9 million). A fall in direct support for defence R&D is offset by a real increase in direct support for the civil research agencies which will increase to \$670.6 million in 1991-92 from \$632.7 million in 1990-91 (a real increase of 2.7 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 1991-92 are expected to amount to \$441 million, but the total budget of the Organisation is expected to be in the region of \$635 million.

Special Purpose Research Grant Schemes

Support for R&D through the special purpose research grant schemes is estimated to increase to \$384.0 million in 1991-92 from \$309.1 million in 1990-91, representing a real increase of 20.4 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 Schemes - Industrial R&D and Innovation

Support for R&D and innovation in the business sector through tax concessions will be \$250 million in 1991-92 (\$266 million in 1990-91), a decrease of 9 per cent in real terms. This overall decrease results from the expiration of the Management Investment Companies (MIC) Program on 30 June 1991. There is an estimated real increase of 4 per cent with respect to the tax concession for industrial R&D. (based on estimates of the amount of revenue foregone by the Commonwealth.)

If the tax concession schemes are included with the industrial component of the special purpose grants, total support for industrial R&D and innovation is expected to be \$362 million in 1991-92, rising from \$360 million in 1990-91, a decrease of about 3 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 1980-81. The slight fall is due to the conclusion of some substantial capital expenditures and recent policy changes to shift the balance towards non-Budget competitive funding. Over the same period, the special purpose schemes have increased significantly. This increase is even more substantial if the industry incentive schemes are included. When this is done support for industrial R&D is seen to have received the largest increases. Support for health and medical research and for rural research has also risen significantly.

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

In the higher education sector there has also been a significant increase in funding since 1980-81. Within the sector, there has been a substantial shift so that the proportion of funds controlled by the ARC is now much higher. Total funds have increased overall and there has been a substantial change in the funding mechanisms.

The 1988-89 dip in total funding levels is traceable mainly to a real fall in the level of Budget funding for Commonwealth research agencies, since offset by increases in external funding. Such non-Commonwealth funding is not shown in Figures 4 and 5.

Detailed Data

Table 2 is the current price summary corresponding to Table 1. It summarises the data from Tables 3, 4 and 5.

For the most part, the data series in Tables 3 and 4 are comprised of well-defined expenditures which can be readily identified from the Budget Papers. However, Table 5 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

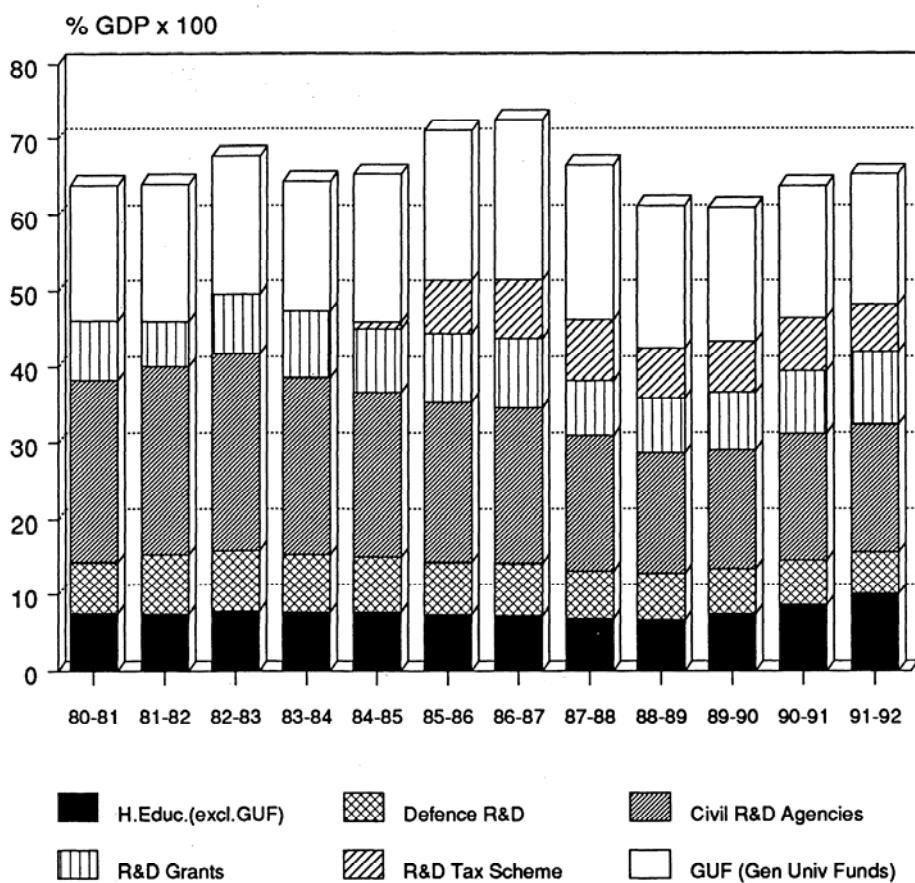
TABLE 2 Summary of Major Commonwealth Support for Science and Innovation, through the Budget and Other Measures (\$m)

	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	(est.) 1991-92
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	95.4	126.1	138.8	146.6	158.4	165.9	183.4	187.0	209.8	225.2	227.2	221.1
• Civil	335.5	389.8	443.4	453.2	467.4	505.8	541.8	534.2	539.5	580.6	632.7	670.6
SUB-TOTAL	430.9	516.0	582.2	599.9	625.8	671.7	725.2	721.2	749.3	805.8	859.9	891.7
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	20.5	28.6	34.7	45.3	52.0	55.5	63.6	68.2	76.4	88.2	106.3	122.1
• Industry and space	53.2	27.5	56.3	70.1	67.6	97.4	98.9	79.6	81.0	89.0	94.4	111.7
• Cooperative Research Centres	-	-	-	-	-	-	-	-	-	-	-	19.5
• Rural	21.3	24.5	27.5	34.9	41.4	47.9	63.8	54.3	73.0	82.0	82.2	104.7
• Energy and environment	7.6	11.5	15.0	17.5	16.7	14.4	14.3	11.3	11.7	18.5	24.0	23.7
• Transport	6.6	2.7	2.5	3.4	2.8	2.6	2.0	2.0	2.0	2.0	2.2	2.3
SUB-TOTAL	109.1	94.9	136.0	171.2	180.6	217.8	242.6	215.3	244.1	279.7	309.1	384.0
COSTS OF IR&D & RELATED INCENTIVES	-	-	-	-	20.0	166.0	203.0	242.0	225.0	252.0	266.0	250.0
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	27.5	31.8	40.3	46.3	52.8	58.3	65.0	72.0	84.5	124.4	172.4	241.8
• Specific R&D support	77.0	85.0	94.0	104.0	112.0	118.0	126.0	134.0	142.0	150.0	155.0	160
• Est. general research support	250.0	284.0	310.0	330.0	418.0	475.0	560.0	610.0	640.0	655.0	660.0	680
SUB-TOTAL	354.5	400.8	444.3	480.3	582.8	651.3	751.0	816.0	866.5	929.4	987.4	1081.8
TOTAL COMMONWEALTH SUPPORT	895	1012	1163	1251	1409	1707	1922	1995	2085	2267	2422	2607
% GDP	0.638	0.640	0.677	0.643	0.652	0.711	0.725	0.665	0.612	0.610	0.637	0.652
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 1984-85 PRICES												
EST. REAL % INCREASE/DECREASE		1.6	3.5	0.7	6.4	13.2	4.8	-3.3	-4.2	2.3	2.4	4.3

SOURCE: See Tables 3, 4 and 5

Figure 5

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



Source: See Table 2 and ABS 5206.0

TABLE 3 Major Commonwealth Research Agencies - Budget Outlays (\$m)

	1980-81	1981-82	1982-83	1983-84	1984-85	Outlays 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	(est.) 1991-92
ARTS, SPORT, THE ENVIRONMENT, TOURISM & TERRITORIES												
Antarctic Division	22.8	21.6	32.0	35.2	37.4	42.2	47.4	49.2	46.3	57.7	62.8	68.2
Bureau of Meteorology												
Research Centre (BMRC) ¹	0.9	1.2	1.7	1.7	1.8	1.8	2.3	2.5	2.2	2.4	2.8	2.9
Supervising Scientist												
Alligator Rivers Research Inst	3.1	4.1	6.1	4.6	4.8	5.5	6.1	6.0	6.6	7.5	6.7	7.2
DEFENCE												
Defence Science and Technology Organisation	95.4	126.1	138.8	146.6	158.4	165.9	183.4	187.0	209.8	225.2	227.2	221.1
EMPLOYMENT, EDUCATION & TRAINING												
Anglo-Aust Telescope	1.5	1.7	1.9	1.8	1.8	1.9	2.0	2.4	2.5	2.7	2.9	3.0
HEALTH, HOUSING & COMMUNITY SERVICES												
Australian Inst of Health (excl. grants)	2.8	3.0	3.4	4.0	4.6	5.1	5.2	3.4	4.2	4.4	4.2	4.9
Commonwealth Serum Labs (Budget component)	3.7	4.9	6.3	6.6	8.8	12.8	15.8	17.3	16.6	9.4	3.0	2.9
INDUSTRY, TECHNOLOGY & COMMERCE												
Aust Nuclear Science & Technology Organisation ²	33.0	37.8	36.4	38.8	41.9	45.4	45.2	50.8	54.3	57.5	62.6	64.9
Australian Institute of Marine Science	5.2	5.7	6.4	6.9	7.4	7.6	8.2	9.5	11.0	11.4	13.6	14.2
CSIRO ²	247.1	290.9	328.2	331.6	324.9	344.3	367.8	347.8	348.1	375.2	414.4	440.7
Kraft Pulp Mill study (CSIRO)	-	-	-	-	-	-	-	-	-	0.5	1.4	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
Bureau of Mineral Resources ³	15.4	18.9	21.1	22.0	30.1	35.2	37.4	40.6	42.9	47.0	52.9	54.2
TOTAL	430.9	516.0	582.2	599.9	625.8	671.7	725.2	721.2	749.3	805.8	859.9	891.7

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

	1980-81	1981-82	1982-83	1983-84	1984-85	Outlays 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	(est.) 1991-92
ARTS, SPORT, THE ENVIRONMENT, TOURISM & TERRITORIES												
Aust Biological Resources Study	0.6	0.8	1.0	1.1	1.2	1.2	1.0	1.1	1.3	1.6	1.2	2.1
Greenhouse research	-	-	-	-	-	-	-	-	0.8	5.7	7.0	9.8
EMPLOYMENT, EDUCATION & TRAINING												
Australian Research Council (ARC) ¹	-	-	-	-	-	-	.	42.7	50.7	35.6	2.8	1.4
ARGS grants/fellowships (including marine R&D grants) ¹	18.4	20.7	22.7	25.5	30.8	34.6	39.8	.	.			
Post-graduate Awards ¹	8.0	8.8	11.5	15.1	16.3	17.8	19.3	20.3	21.7	11.3	-	.
Education R&D Grants	1.2	0.8	0.2	-	-	-	.	-	-	-	-	-
Targetted Institutional Links Program	-	-	-	-	-	-	-	-	-	0.2	1.0	1.9
HEALTH, HOUSING & COMMUNITY SERVICES												
AIDS Research	-	-	-	-	-	0.8	1.5	3.0	3.5	5.0	7.1	9.8
Health and Community Services												
Research Grants	1.5	1.4	1.5	3.2	1.6	1.6	1.8	1.1	1.4	1.7	1.6	1.6
NH&MRC Research Grants	18.7	25.6	30.0	38.5	44.2	51.2	59.4	65.6	72.0	83.0	94.7	103.3
Capital Works for Medical Institutes	0.3	1.6	3.2	3.5	6.3	2.6	1.6	-	-	-	5.0	10.0
INDUSTRY, TECHNOLOGY & COMMERCE												
Industrial R&D support												
- IR&D Incentives Act 1976												
. Commencement grants	9.7	9.7	13.1	14.6	16.3	14.3	16.9	3.1	0.1	-	-	-
. Project grants	36.1	12.1	34.8	43.2	38.1	37.7	17.9	6.4	2.8	0.3	-	-
. Public interest projects	5.0	2.4	4.9	8.1	9.8	6.3	3.5	1.0	0.3	-	-	-
- IR&D Act 1986 (GIRD)	-	-	-	-	-	-	10.8	25.6	31.8	32.0	29.6	32.2
. Biotechnology grants	-	-	-	0.7	2.2	4.3	-	-	-	-	-	-
Advanced Manufacturing Tech Program	-	-	-	-	-	-	-	-	-	-	-	5.0
InterScan support	2.4	2.1	2.2	2.5	-	-	-	-	-	-	-	-
National Space Program	-	-	-	-	-	3.0	5.0	3.2	5.4	2.4	5.5	6.7
Malaria Vaccine Joint Venture	-	-	-	-	-	0.3	0.4	0.8	1.2	0.8	2.3	9.3

TABLE 4 Major R&D Granting Programs and other Support for Science and Innovation through the Budget (\$m) — continued

	1980-81	1981-82	1982-83	1983-84	1984-85	Outlays 1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	(est.) 1991-92
Research associations ²	-	1.2	1.3	1.7	1.9	1.9	2.0	2.0	-	-	-	-
Motor Vehicle R&D	-	-	-	-	-	20.6	22.9	11.6	8.4	8.3	4.7	2.8
Assistance under the Bounty ³ (Computers) Act 1984	-	-	-	-	1.5	13.2	19.4	25.7	31.1	45.0	51.3	53.8
PRIMARY INDUSTRIES & ENERGY⁴												
Wool Research	6.9	7.9	8.6	10.0	11.7	13.0	14.4	12.1	21.7	20.8	11.7	13.6
Meat Research	3.7	4.0	4.6	5.4	4.0	5.5	8.4	8.6	11.9	13.8	13.6	20.7
Fishing Industry Research	1.3	1.5	2.5	3.1	4.3	5.0	6.2	6.2	5.4	8.1	8.5	10.4
Grains	5.8	7.5	6.8	10.8	14.1	15.2	17.9	11.2	11.1	13.3	14.4	17.5
Horticulture Research	-	-	-	-	-	-	-	-	0.6	1.2	3.1	5.0
Energy research	7.0	10.7	14.0	16.4	15.5	13.2	13.3	10.2	9.6	11.2	15.9	11.8
Land & Water research	0.5	0.7	1.2	0.7	1.5	1.8	4.9	7.8	10.4	9.9	13.3	13.3
Special Rural Research Fund	0.2	0.2	0.2	0.1	0.3	0.4	1.5	3.0	4.0	5.0	6.0	8.4
Other rural research	2.8	2.8	3.6	4.6	5.4	7.0	10.6	5.5	8.0	10.1	11.7	15.9
PRIME MINISTER & CABINET												
Cooperative Research Centre Grants	-	-	-	-	-	-	-	-	-	-	-	19.5
TRANSPORT & COMMUNICATIONS												
Payments, to Australian Road Research Board	0.3	1.9	2.0	3.0	2.3	2.0	2.0	2.0	2.0	2.0	2.2	2.3
Railway R&D Organisation	-	0.8	0.5	0.4	0.5	0.6	-	-	-	-	-	-
Transport planning and research	6.3	-	-	-	-	-	-	-	-	-	-	-
TOTAL	130.3	125.9	170.6	211.8	228.5	273.2	306.7	279.9	317.1	328.1	314.1	388.0

FOOTNOTES TO TABLE

4

(1) From 1989-90 most ARC funding has been appropriated through the *Higher Education Funding Act* rather than the Budget. See Table 5. ARC funding now includes post-graduate awards and the grants and fellowships formerly administered under the Australian Research Grants Scheme (ARGS)

FOOTNOTES TO TABLE 4 - *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)

	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92 est.
Wool	7.54	8.77	8.83	9.30	12.32	11.88	15.25	18.31	14.21	19.63	17.11	13.60
Meat	3.30	3.02	4.16	3.61	4.61	5.55 ^a	7.68 ^a	8.65 ^a	11.58 ^a	13.30 ^a	15.17 ^a	23.07 ^a
Grains												
- Grain ^b	0.59	0.77	0.52	1.33	1.30	2.16	2.07	2.35	2.53	3.99	4.27 ^b	5.57 ^b
- Wheat	2.01	1.97	4.65	4.65	5.40	5.48	6.40	5.16	8.35	9.84	8.45	10.12
Coal ^c	4.42	5.16	4.28	2.14	4.17	3.28	4.82	7.07	15.02	17.05	14.95	16.35
Special Rural	-	-	-	-	-	-	-	-	-	0.20	0.30	0.27
Fish	-	-	-	-	-	-	-	-	-	-	0.50	2.25
Horticulture	-	-	-	-	-	-	-	-	-	-	0.92	2.19
Other Rural												
- Chicken Meat	0.24	0.22	0.24	0.23	0.24	0.29	0.38	0.40	0.38	0.46	0.55	0.57
- Cotton	.	0.20	0.25	0.67	1.00	0.89	1.04	0.86	1.55	1.87	2.66	2.79
- Dairying	0.42	0.42	0.54	0.57	0.60	0.67	1.26	1.64	1.57	2.94	4.82	4.99
- Dried Fruit	0.12	0.12	0.12	0.09	0.12	0.16	0.32	0.26	0.29	0.39	0.45	0.73
- Grape & Wine	0.26	0.28	0.37	0.38	0.49	0.52	0.67	0.82	0.94	1.28	1.25	1.00
- Honey	0.02	0.06	0.05	0.05	0.05	0.08	0.09	0.11	0.10	0.12	0.14	0.14
- Pig Industry	0.39	0.42	0.40	0.42	0.60	0.78	1.00	1.43	1.37	1.95	2.58	2.69
- Egg Industry	0.14	0.15	0.15	0.15	0.16	0.22	0.31	0.28	0.37	0.30	0.45	0.60
- Sugar	-	-	-	-	-	-	-	1.28	1.40	1.37	1.48	1.53
- Tobacco	0.38	0.41	0.47	0.55	0.67	0.66	0.69	0.64	0.94	0.77	0.59	0.72
Total	19.81	22.83	22.29	23.71	30.61	32.61	41.98	49.25	60.62	75.47	76.66	89.19

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

	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92 (est)
EMPLOYMENT, EDUCATION & TRAINING*												
Identifiable research support for universities ¹	77.0	85.0	94.0	104.0	112.0	118.0	126.0	134.0	142.0	150.0	155.0	160.0
Higher Education Funding Act: special research assistance ²	-	1.5	5.9	5.7	5.6	5.9	6.0	9.0	12.1	77.3	168.6	238.5
Estimated research component of general university funding for both teaching and research ³	250	284	310	330	418	475	560	610	640	655	660	680
INDUSTRY, TECHNOLOGY & COMMERCE												
150% Tax Concession ⁴ for R&D	-	-	-	-	-	146	183	222	218	233	232	250
100% Tax Deduction for equity subscriptions in Management Investment Companies (MICs) ⁵	-	-	-	-	20.0	20.0	20.0	20.0	7.0	19.0	34.0	-
TOTAL	327	371	410	440	556	765	895	995	1019	1134	1250	1329

* These data are estimates of funding provided for higher education research through the Higher Education Funding Act and predecessor legislation.

- (1) Indicative estimates. The two most recent items are projections based on 1987 identifiable research expenditure data collected by DEET from pre-1986 universities and include funds earmarked for research purposes. They do not include funds spent on research from the operating grants of former advanced education institutions.
- (2) Includes funding for ARC Research Grants, Postgraduate Awards, Fellowships, Overseas Postgraduate Research Scholarships, Special Centres and Infrastructure but excludes funding through Budget sources.
- (3) The data for 1989-90, 1990-91 and 1991-92 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 and 1988-89 are based on ABS R&D Survey data. Estimates for other years are indicative only. Higher education institutions were nominally allocated \$410 million in 1990-91 and \$425 million in 1991-92 for research purposes (including research training) through their operating grants.
- (4) A 150% company tax deduction for eligible industrial R&D expenditure has applied from 1 July 1985. The data series comprise estimates based both on information provided in registrations for the concession and analysis by the Australian Taxation Office (ATO). They do not account for any recoupments arising from the dividend imputation system. The focus of the Table is on the effect of Government actions in the wider community. Hence the series given shows the estimated cost to revenue attributable to business R&D activity in particular years. Because the payment of tax is lagged behind the concessional R&D activity, a separate series estimates the revenue foregone in each year. From 1985-86 to 1991-92 this series is nil, \$105m, \$145m, \$195m, \$215m, \$230m, and \$225m.
- (5) 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.

years shown, the effect of adding this series to others, as in Table 2, is to blur the assessment of overall trends. See the footnotes to Table 5.

A further blurring results from the inclusion of the estimated costs of Commonwealth revenue foregone through the taxation concession scheme for industrial R&D. As already indicated, the amounts shown are estimates. (See footnote (4) to Table 5.) However data presented in Table 5 this year incorporates some improvements to the estimates published previously.

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.

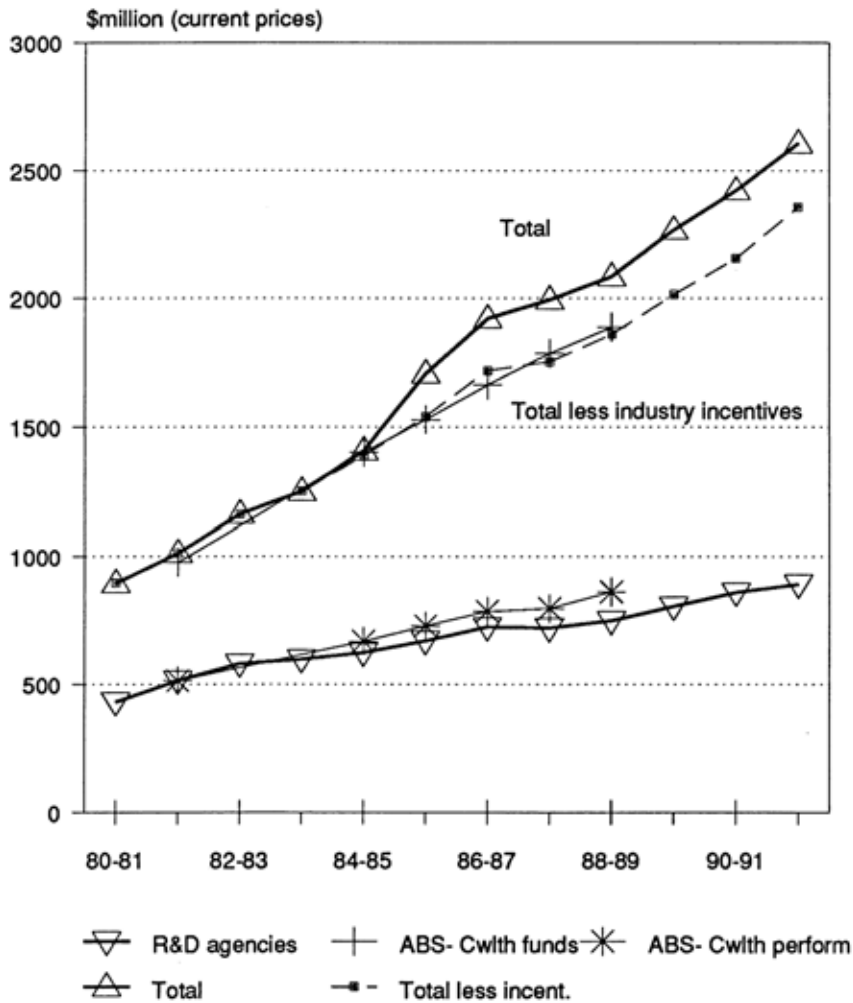
The results from the R&D surveys have been essential in establishing benchmarks and time series in various expenditure and workforce indicators related to the Australian research effort.

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 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



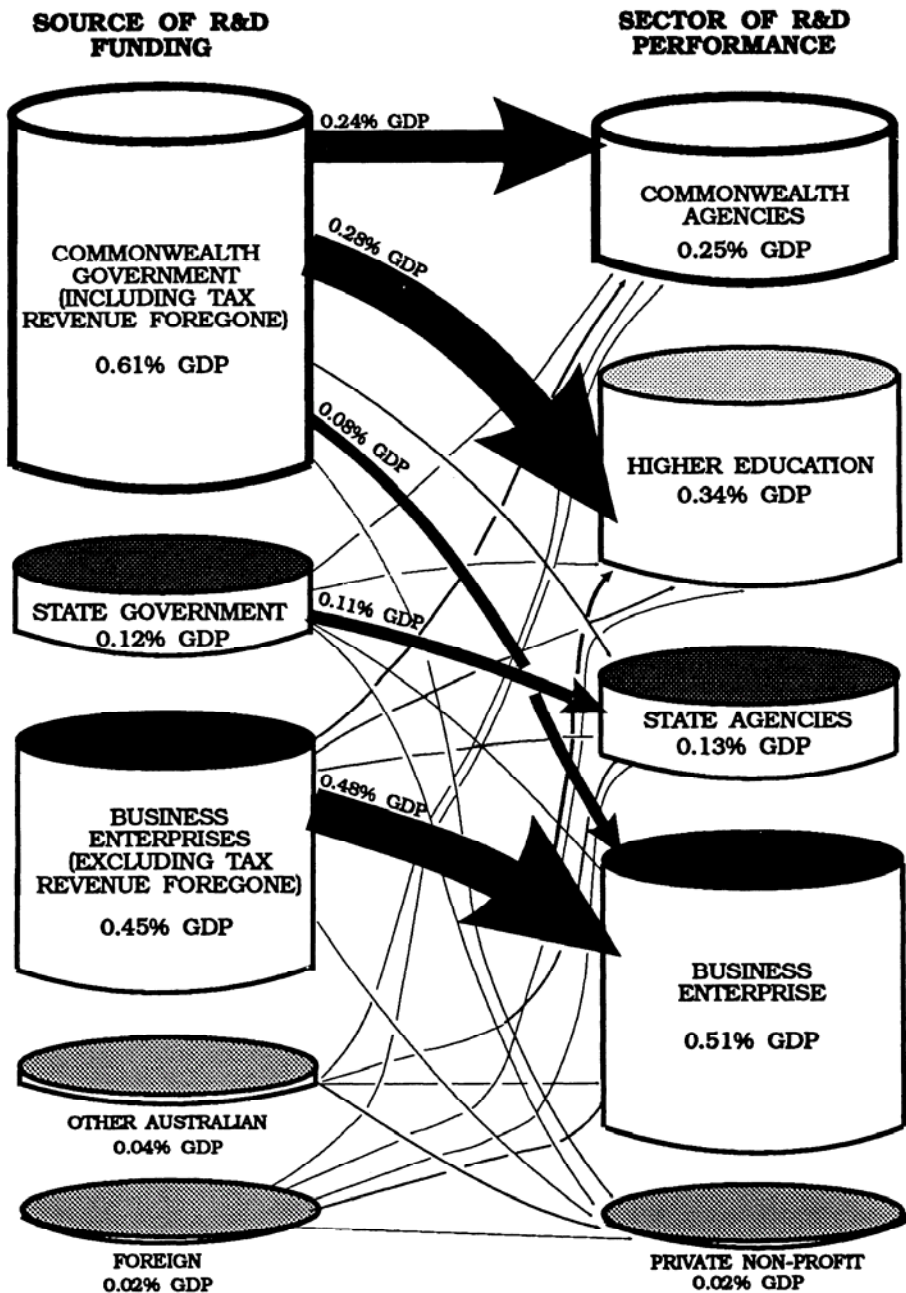
Source: See Table 2 and Australian S&T Data Brief 1989-90

Commonwealth Support in a National Perspective

Figure 7 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 overall R&D system. The Commonwealth is the dominant funder of R&D in Australia and Commonwealth agencies are also significant performers of R&D.

Figure 7

COMMONWEALTH R&D SUPPORT IN A NATIONAL PERSPECTIVE



The figure illustrates major flows of funding support between sectors, based on 1988-89 data. It places Commonwealth funding of R&D in a national perspective.

SECTION 5:

INTERNATIONAL CONTEXT

International Comparisons of R&D Levels

R&D levels in OECD nations are commonly compared by considering the ratio of gross domestic expenditure on R&D (GERD) to gross domestic product (GDP). This ratio of GERD/GDP is the most often quoted R&D indicator and provides a standardised method of comparison between different countries. The major advantage of this ratio is that it removes any need for consideration of exchange rates or inflation. GERD is, however, made up of components from R&D performed in quite different sectors (principally, the business sector, government agencies and universities). Different countries vary widely in the relative contribution of these sectors to total GERD and policy issues are usually focussed primarily at the sectoral level, thus there is advantage in considering them separately. For the same reasons, and because there are flows of funds between all sectors, it is also important to consider separately the major sources of funds for R&D (business and government).

A complication, however, is that institutional structures in the government and academic sectors vary widely between countries. The type of research typically conducted in government agencies in one country may be conducted in universities in another. The reverse also applies. Thus it can also be useful to make comparisons with these two sectors combined.

The upper part of Table 6 provides comparisons of the latest available OECD R&D data dissected both by source of funds and sector of performance. In addition, the funding data from the Table are shown in Figure 8. Sectoral data of this kind can provide useful insights. Table 6 shows that Australia has a relatively low GERD/GDP ratio and that this is due primarily to a relatively low R&D effort by the business sector.

For any country, GERD/GDP and its component ratios can also be compared between different years. Data on Australian trends over recent years are shown in the lower part of Table 6.

International comparisons of R&D/GDP are often made with the implication that the national share of GDP allocated to R&D should change. In that case, inter alia, consideration should also be given to how rapidly change might be effected. These issues require dynamic comparisons (ie, of growth rates) as well as static comparisons of the kind presented in Table 6.

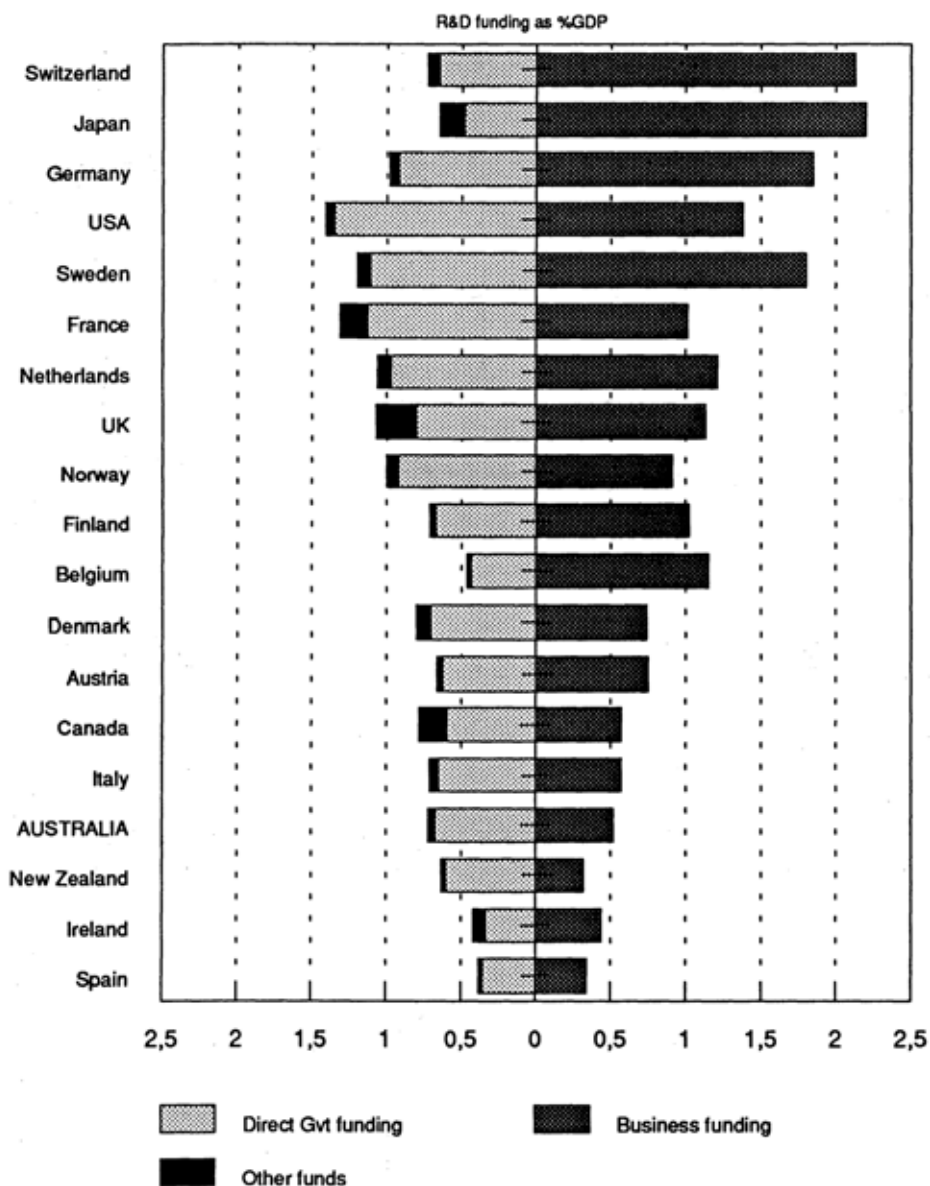
TABLE 6 R&D Expenditure as a Percentage of GDP by Sector - OECD Comparisons, Recent Australian Trends

	Latest %GERD/GDP	Source of Funds for R&D as % GDP			Total Publ =	R&D Performance as % GDP			
		Govt	Business	Other		(Govt + Univs)	Business	Other	
OECD COMPARISONS									
<i>nation (year*)</i>									
Switzerland (1989)	2.86	0.65	2.13	0.08	0.69	(0.12 0.57)	2.14	0.03	
Japan (1989)	2.85	0.48	2.20	0.17	0.60	(0.25 0.36)	2.12	0.13	
Germany (1990)	2.82	0.92	1.85	0.06	0.73	(0.34 0.39)	2.07	0.02	
United States (1990)	2.79	1.35	1.38	0.06	0.78	(0.35 0.44)	1.93	0.08	
Sweden (1989)	2.76	1.11	1.80	0.09	0.93	(0.11 0.82)	1.83	0.00	
France (1990)	2.39	1.13	1.01	0.18	0.91	(0.57 0.34)	1.47	0.02	
Netherlands (1988)	2.26	0.97	1.21	0.09	0.86	(0.39 0.47)	1.32	0.05	
United Kingdom (1988)	2.20	0.80	1.13	0.27	0.65	(0.32 0.33)	1.37	0.09	
Norway (1989)	1.91	0.92	0.91	0.08	0.70	(0.29 0.41)	1.16	0.02	
Finland (1989)	1.83	0.67	1.02	0.04	0.70	(0.34 0.37)	1.11	0.01	
Belgium (1988)	1.61	0.43	1.15	0.03	0.37	(0.07 0.29)	1.18	0.06	
Denmark (1989)	1.53	0.70	0.74	0.10	0.67	(0.29 0.38)	0.84	0.02	
Austria (1989)	1.41	0.62	0.75	0.04	0.55	(0.11 0.44)	0.70	0.03	
Canada (1990)	1.35	0.59	0.57	0.19	0.57	(0.25 0.32)	0.75	0.02	
Italy (1990)	1.28	0.65	0.57	0.06	0.54	(0.31 0.23)	0.74	0.00	
AUSTRALIA (1988-89)	1.23	0.67	0.52	0.05	0.72	(0.39 0.34)	0.51	0.02	
New Zealand (1989)	0.95	0.60	0.32	0.03	0.68	(0.50 0.18)	0.27	0.00	
Ireland (1988)	0.87	0.33	0.44	0.09	0.36	(0.19 0.17)	0.49	0.02	
Spain (1989)	0.72	0.35	0.34	0.03	0.29	(0.18 0.11)	0.42	0.00	
RECENT AUSTRALIAN TRENDS									
<i>year</i>									
1984-85	1.12	0.76	0.32	0.04	0.77	(0.44 0.33)	0.34	0.02	
1985-86	1.16	0.73	0.38	0.05	0.76	(0.44 0.32)	0.39	0.02	
1986-87	1.26	0.75	0.47	0.04	0.78	(0.43 0.35)	0.48	0.02	
1987-88	1.22	0.70	0.48	0.05	0.75	(0.40 0.35)	0.48	0.02	
1988-89	1.23	0.67	0.51	0.05	0.72	(0.39 0.34)	0.51	0.02	
1989-90	na	na	0.52	na	na	na na	0.51	na	

* Year for latest available GERD/GDP. Other data are latest available but may be for different years.

Figure 8

OECD LEVELS OF FUNDING FOR R&D AS A PERCENTAGE OF GDP



Source: See Australian Science and Innovation Resources Brief 1991 (forthcoming)

TABLE 7 Growth in R&D levels and external patenting over the 1980s - comparisons between Australia and OECD nations

	1981 or nearest year (per unit GDP)	1989 or nearest year (per unit GDP)	Average annual real growth (%)	1981 or nearest year (per unit GDP)	1989 or nearest year (per unit GDP)	Average annual real growth (%)
	Average for 19 OECD countries			Australia		
Gross expenditure on R&D	1.55	1.87	+5.7%	1.00	1.23	+6.7%
Government funding of R&D	0.71	0.74	+3.3%	0.73	0.67	+2.2%
Business funding of R&D	0.78	1.05	+8.0%	0.24	0.52	+15.2%
R&D expenditure in Government agencies and universities	0.61	0.65	+3.7%	0.75	0.72	+2.4%
R&D expenditure in business enterprises	0.91	1.18	+7.4%	0.25	0.51	+14.0%
External patent applications by residents*	5.8	8.8	+9.2%	2.7	6.1	+17.5%

* Since the numerator in the ratio is no longer in units of national currency, the GDP values used are expressed in \$US million at constant 1985 prices.

SOURCE: See Australian Science and Innovation Resources Brief 1991 (forthcoming)

Time Series Comparisons of R&D Levels

Consideration of trends in R&D/GDP sometimes overlooks that it is not R&D expenditure itself which is being examined, but a ratio. Since growth in GDP is not always smooth (and consequent effects on R&D, if any, may be lagged), changes in GERD/GDP over a short time span can sometimes be misleading. For a particular country, changes in GERD/GDP (and the similar ratios based on sectoral R&D) are better compared over relatively long periods. For shorter time spans, it is better to consider growth in GERD (and corresponding sectoral R&D expenditures) converted to constant prices. Trends in R&D/GDP and growth data are complementary and a more informative picture is provided by considering both.

Growth in R&D and Innovation over the 1980s

In Table 7, R&D/GDP levels in 1981 are contrasted with 1989, both for Australia and the 19 OECD countries listed in Table 6. R&D data in Table 7 are dissected by the major categories of funding and performance and the ratios to GDP are supplemented by data on average real annual growth rates over the period. In addition, the table provides the corresponding information for external patent applications.

Comparative R&D data, particularly business R&D data, are often used as an indicator or proxy for innovation in the wider sense. National data on external patent applications (ie, patent applications by each country in all other countries) provide an alternative indicator.

The Table shows that for government R&D funding, and for the composite category of R&D expenditure in government agencies and universities, there were relatively small changes over the 1980s. In the OECD, on average, R&D in this category increased by 0.03-0.04 per cent of GDP with a growth rate of about 3.5%. In Australia, the shift expressed as per cent GDP was down, with R&D/GDP moving closer to the average in the composite category. The shift in direct government funding was also down (but in fact was balanced by indirect support for R&D at 0.06 per cent GDP through the tax concession scheme). In fact, over the 1980s there was a degree of convergence towards the average levels in these categories and the shifts and growth rates in Australia have parallels in other OECD countries.

For business funding of R&D, and for R&D expenditure in business enterprises, there were substantial changes. On average in the OECD, R&D increased by 0.27 per cent of GDP in both these categories with an average growth rate in the region of 8%. Australia, from a much lower base than the average, almost exactly matched this increase in R&D/GDP, while the Australian growth rates of 15.2% and 14.0% in the two categories were the highest of the 19 OECD countries in the table.

The data relating to external patenting, being completely independent of the R&D information, provides valuable confirmation. Per unit GDP, the Australian increase in external patent applications has increased by 3.4 compared with the average OECD increase of 3.0. The Australian growth rate of 17.5% is again the highest of the 19 OECD countries (and very substantially exceeds the second highest, Finland at 13.9%).

The ranking of countries by growth in external patent applications correlates well with their ranking by growth in business R&D funding and their ranking by growth in business performance of R&D. All these data confirm the picture of very significant increases in Australian business innovation over the 1980s, over a period in which an extensive range of Commonwealth programs were instigated with the aim of stimulating innovation. Nevertheless, there is no room for complacency. If we wish to reach international levels, the latest data in Tables 6 and 7 clearly show that Australia has substantial ground still to make up.



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