

# SCIENCE AND TECHNOLOGY BUDGET STATEMENT 1989-90

CIRCULATED BY THE HONOURABLE BARRY O. JONES MINISTER FOR SCIENCE, CUSTOMS AND SMALL BUSINESS AND MINISTER ASSISTING THE PRIME MINISTER FOR SCIENCE AND TECHNOLOGY

BUDGET RELATED PAPER No. 10

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- No. 6 Women's Budget Statement 1989-90 An assessment of the impact on women of the 1989-90 Budget.

No. 7 Portfolio Explanatory Notes 19 Volumes—Presents details of 1988-89 expenditure and estimates for 1989-90 on a program basis and relates these figures to program performance.

- No. 8 Towards a Fairer Australia: Social Justice Budget Statement 1989-90 Contains a summary of 1989-90 Budget measures relating to social justice.
- No. 9 Towards Social Justice for Young Australians Contains a summary of 1989-90 Budget social justice measures for young Australians.
- No. 10 Science and Technology Budget Statement 1989-90 Outlines Commonwealth support for science and technology with a particular focus on major Commonwealth research agencies and programs supporting research-related activities.
- Report of the Auditor-General

A report on the Financial Statements prepared by the Minister for Finance for the year ended 30 June 1989.

(This document is to be released in November 1989).

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## SECTION 1: POLICY OVERVIEW

### The Government's Strategy

In May this year the Government released a major strategy statement, *Science and Technology for Australia.* 

That Statement underlined strongly and clearly the Government's understanding of the importance of science and technology to the economic and social well-being of the nation. It confirmed the Government's deep commitment to supporting scientific endeavours across a broad range of activities.

The introduction of a *Science and Technology Budget Statement* further recognises that science and technology are integral and important factors on the economic agenda, including the process of structural change in the economy. The Government has seen such restructuring as crucial to Australia's economic well being and has taken many bold and imaginative initiatives in this direction.

### Science and Technology in the Budget

The Science and Technology Budget Statement replaces the *Science and Technology Statement* which has appeared for several years as a commentary on the Commonwealth's Budget-related expenditures and activities in the science field. The earlier Statement was survey-based and appeared regularly several months after the Budget. Now its successor appears with the Budget documentation and is based directly upon Budget information. These new arrangements recognise the relevance of science and technology in the presentation of overall economic policy in the Budget process. Other publications will cover matters from the earlier Statement not now included in this Budget Statement.

The present document is more sharply focused than its predecessor. It concentrates mainly on Budget issues relating to research conducted in major agencies and research supported through major programs. The recent debate on science policy was mostly concerned with these issues. However, they do not form the totality of current science policy debate. The Government remains concerned about other issues which, whilst they are not directly dependent upon Government funding, are influenced by it.

# *The Need for Better Recognition of Science and Technology*

One such issue is the extent to which science is seen as providing an attractive career, particularly with a view to meeting the needs for a skilled workforce in the 1990s. In the 1980s, the decline in scientific vocations, especially in physics, chemistry, mathematics and engineering has led to reduced morale and an apparent fall in career opportunities.

These problems have been addressed by the Government and there are encouraging signs that confidence is returning. In part, this is one consequence of the recognition now that science and technology are central not just to industrial development, but to understanding of the environment, culturally - and politically as well, when scientific methods are applied in problem solving. The Government attaches a high priority to maintaining the scientific workforce and adapting its capacities to meet the expanding demands of the future.

As well as increasing the number of people following careers in science and mathematics, the Government recognises that a skilled workforce is a crucial component of the economy we are reshaping. We cannot construct a first class economy with second class ingredients. The Government will continue to give skills issues priority attention at all levels of schooling and in higher education, training and retraining.

### **OECD** Review

The Government is meeting the challenges, and providing an environment to create the industries and activities necessary to sustain us in the 21st Century. However, realisation of the important economic role of science and technology has been. In 1984 the OECD was invited to review Australia's science and technology policies. They reported in 1985 that there seemed to us to be less agreement about...the central relationships between technology, science and economic well-being than in any other industrialised countries.' The report noted 'a widespread view of science (and technology) as in some sense external to national life'.

Such attitudes have been matched in some quarters by a feeling that the market should primarily govern the allocation of resources to technology and associated R&D. The OECD examiners had made a prediction in 1985 which subsequent experience has borne out. They said 'Australia also appears to be peculiarly vulnerable in the 1980s to ongoing "exogenous" changes in the structure of world expenditure and world trade, notably the continuing compositional shift away from primary commodities and towards "knowledge intensive" services'. Structural Imbalances and failure to understand the relationship between science, technology and the economy have operated to the detriment of Australia, as our trade figures have shown.

Australia has concentrated on high-volume production, bulk undifferentiated commodities produced at relatively low unit cost (but with relatively high transport costs due to remoteness from markets). It is likely that Australia would have a far stronger economy If the proportion of our trade attributable to manufactures and services was far higher compared to commodities than the present 20:80 ratio. This is not to say that our commodity trade and the greater adding of value to our raw materials will not continue to be vital to Australia's international competitiveness and trade balance.

### The Role of Science and Technology

The Government is strongly committed to an increase in knowledge-based activities. This does not mean that we believe that science alone is the driving force in industrial restructuring: management, marketing, finance and other factors are also crucial. Nevertheless, we can see the important role that science and technology play in the revitalisation of industries and in the achievement and maintenance of competitiveness. The world competitive position of most of our primary resource-based industries is critically dependent upon the quality and relevance of our science. The same can be true of the new and enlarged world-class manufacturing and service sector enterprises which we must seek to develop in order to have a more robust economy.

The Government has been putting this view for some time and further underlined the message in *Science and Technology for Australia*. That statement emphasised the growing realisation that broad attitudinal change is required and further activities are necessary to match and to support macro-economic policies and micro-economic reform. The July Environment Statement, *Our Country Our Future*, again underlined the need for a long-term and very broad-ranging and intelligent approach in order to maintain and increase the real prosperity and quality of life in Australia

Science and Technology for Australia also had philosophical implications in its recognition of the complexity of interactions between fundamental and applied research. CSIRO's funding position was strengthened. It already had the benefit of three-year funding and was now able to retain all outside earnings. These changes provided further encouragement towards seeking closer relations between the CSIRO and users, particularly In industry. At the same time the significance of Greenhouse and ozone layer research has graphically illustrated the importance of maintaining research for wider community benefit and for which there Is no obvious commercial partner.

### Figure 1

# INTERNATIONAL COMPARISON OF LEVELS OF SUPPORT FOR R&D AS A PERCENTAGE OF GDP



(latest available year)

Public funding of R&D in Australia is average when compared with other OECD nations. Private sector support in this area, however, is realatively low.

Source: Science and Technology Indicators Section, Department of Industry, Technology and Commerce, from OECD and national data.

### Policy Mechanisms and Public Awareness

One of the most significant of the several matters announced in May in *Science and Technology for Australia* was the creation of the Prime Minister's Science Council and appointment of a Chief Scientist. The Science Council will meet first in October this year and will provide for the highest level of interaction between Ministers with a key involvement in science-related matters, senior scientists and representatives of industry. The new Council is in addition to the many existing advisory bodies and boards with valuable participatory roles. Its creation is a further reflection of the central place of science in economic and cultural processes and of the need to agree on broad directions and priorities at the very highest levels. The Prime Minister's direct participation as Chairman parallels similar developments in several countries. The outcomes of Council deliberations, both formal and informal, will influence and guide the activities of the many related bodies.

Another important issue receiving continuing attention is public awareness of the nature and role of science and technology and their potential contribution to the resolution of many economic, social and environmental problems. It is important that there is informed participation in decision-making about science and technology and their uses. This Budget-related paper is part of the scientific awareness and accountability processes. The May Policy Statement announced additional amounts of funding for programs to promote awareness and information about science and technology. Considerable contributions to the lifting of Australia's general scientific literacy are already being made by many bodies including research agencies and the Commission for the Future.

### Remaining Concerns

The Government still has a number of concerns about the health and progress of the nation's total scientific and technological enterprise. A key concern relates to the contribution from outside Government. The public sector contribution to research, when Judged against the efforts of comparable countries, is not unreasonable. This is not to say that there is any one objectively correct sum or proportion. However, international comparisons do suggest that the private sector's contribution remains comparatively low. Figure 1 illustrates this point.

The Government has made a number of efforts to encourage greater private sector involvement in research and development. The chief tool has been the 150 per cent tax incentive, now extended in its full effect until June 1993, with a further two years thereafter at 125 per cent. There is evidence that the incentive has contributed to a larger private sector performance of research and development (R&D). The long-term profitability of research and technology-related activities is partly an outcome of the Government's economic policies: measures to alter the balance of public and private sector activity, to free up capital and finance markets, reform taxation and to influence other factors bearing upon the general investment climate. However, profitability of R&D is also affected by micro-economic instruments such as the taxation incentives already mentioned, venture financing measures, export assistance measures, innovation support schemes such as the NIES network and by steps to link Government funded and performed research more closely with the various users and beneficiaries of that research.

The very extent and variety of these matters underlines the importance of seeing science and technology In the context of other economic-related factors. That is a key message yet to be adequately comprehended in Australia. To sum up: science and technology, in addition to their well perceived cultural roles, are an important and integral part of an inter-related set of factors necessary to ensure our total well-being. It is with that understanding and within that context that the Government is acting.

# **SECTION 2: RECENT MAJOR DEVELOPMENTS**

### Reviews and Policy Statements

Over the past year, concerns expressed across a broad front have led to a wide-ranging process of enquiry relating to science and technology. The reviews undertaken have included:

- the Group of Officials' Review of Science Capacity •
- the Review of Research and Development in Primary Industries and • Energy
- the Smith Committee Review of Higher Education Research Policy •
- the Wilson Committee Review of Postgraduate Research Award Levels
- the McKinnon Committee Review of Marine Science and Technology
- ASTEC's Report on The Core Capacity of Australian Science

Major Government statements with implications for science and technology have included:
Science and Technology for Australia (May 1989)

- the Statement on the Environment: Our Country Our Future (July 1989)
- Research, Innovation and Competitiveness Policies for Reshaping Australia's Primary Industries and Energy Portfolio (May 1989)

### New Arrangements for Advice and Co-ordination

A number of new arrangements for advice and co-ordination have been introduced as a result of the review processes. The new arrangements have included the establishment of:

- a Prime Minister's Science Council to consist of senior Ministers, members of the scientific community and leading industrialists a Co-ordination Committee on Science and Technology consisting of
- officials and complementing the Prime Minister's Science Council
- positions of Chief Scientist and Chief Science Adviser within the portfolios of the Prime Minister and the Minister for Industry, Technology and Commerce, respectively

- a Primary Industries and Energy Research Council within the
- Primary Industries and Energy portfolio a National Greenhouse Advisory Committee of eminent scientists to advise on priority areas of research and set objectives for a dedicated research grants scheme to commence in 1990-91

### Major Initiatives for Support of Science and Technology

Also arising out of the reviews and giving effect to the new policies adopted, a number of new measures have been taken to increase support for science and technology. Funding and related initiatives have included:

#### - in industry, science and technology

- extension of the 150 percent tax incentive to June 1993 and a phased reduction to 125 percent from that date to June 1995
- a new program to enhance awareness of the role of science and technology in economic and social development, including:
  - creation of the Australia Prize, an annual \$250 000 international award for achievement In science and technology in promoting
  - human welfare; establishment of an Industry-Science Foundation to alert business leaders to opportunities for long-term patient capital investments in research-based products and services;
  - activities for increased communication about and understanding of science and technology;
  - enhanced and additional awards for journalists and teachers
- additional funds for equipment and priority programs for CSIRO, ANSTO and AIMS
- increased funding to bring marine R&D more in line with industry requirements and for international co-operation in marine science and technology
- new funds for international co-operation in pre-competitive R&D and the human frontiers science program
- in education and research training
- substantially increased funds to be allocated through the ARC, which will in future operate under triennial funding In line with arrangements for higher education institutions
- upgrading of the Commonwealth Postgraduate Research Awards Scheme through the provision of new places and substantial increases in stipends
- a program of direct support to higher education institutions to support research infrastructure

#### - in primary industries and energy

- establishment of two new R&D Corporations to administer R&D for • natural resource management projects and for rural industries R&D additional equipment funding for BMR
- ٠

#### - in environmental issues

- new funding for R&D projects under the National Soil Conservation ٠ Program
- new funding for research into the greenhouse effect

#### - in health and medical research

- significantly increased funding for medical research through the
- NH&MRC an increase in the number and value of postgraduate research awards granted by the NH&MRC •

# 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 1989-90 Budget compared with the expenditure outcome for 1988-89. 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 and the bias is towards brevity of financial discussion. It has not been the intention to be fully comprehensive. It may be useful for some to refer to Statement Number 3 of Budget Paper Number 1, which, for a number of scientific programs, provides a useful discussion of financial trends.

In any exercise of this kind, particularly one undertaken for the first time, there are grey areas where judgements have had to be made to include or exclude certain programs. Advice will be welcomed in cases where readers consider that contrary judgements would be more appropriate.

It should be noted also that no attempt has been made, at this stage, to present a grand total for 'science and technology' across portfolios. There are a number of difficulties in that, which will be addressed by future efforts. In the better-defined area of R&D, however, there is much work which can be built on. Pre-existing R&D data series have been extended 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 2 and 3 are therefore provided as a working guide to the operation of the infrastructure now in place for Commonwealth support of science and technology.

Table 1 presents a summary of many of the new initiatives being funded in 1989-90. These broadly correspond to the initiatives outlined in *Science and Technology for Australia* and summarised in Section 2.

### Figure 2



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



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.

### Table 1

# SIGNIFICANT NEW INITIATIVES FOR SCIENCE AND TECHNOLOGY

	additional funding 1989-90 (\$m)
INDUSTRY AND TECHNOLOGY	14.00
CSIRO equipment, new research	14.00
AINS I O equipment	0.50
Alivis equipment Marina Science and Technology	0.50
National Dragurament Davidorment Draguam	0.70
National Production Development Program	1.00
Australian Building Research Grants Scheme	0.25
Technology Development Program	1.35
International Collaborative Program	4.00
international conadorative i rogram	т.00
EDUCATION AND TRAINING	
Australian Research Council (ARC)	
- Commonwealth Post-Graduate Awards	5.97
- Higher Education Research Infrastructure	10.00
PRIMARY INDUSTRIES AND ENERGY	
BMR Fauinment	1.00
R&D evaluation	0.30
	0.50
ENVIRONMENT	
Greenhouse Research	5.73
National Parks & Wildlife Service	
<ul> <li>Endangered Species Program</li> </ul>	2.00
Great Barrier Reef Marine Park Authority	
- Crown of Thorns Starfish research	0.25
Tropical Rainforest Initiative	0.10
CSIRO industrial waste and sewage treatment	0.20
- Rebuilding program	3.00
- Ship leasing	8.00
I I I I I I I I I I I I I I I I I I I	
HEALTH AND MEDICAL RESEARCH	
NH&MRC	4.40
- Medical and public health research	4.40
- Post-graduate awards	0.80
Australian Institute Of Health	0.50
- Equipment	0.50
PUBLIC AWARENESS	
Prime Minister's Science Council, Office	
of Chief Scientist	0.38
Australia Prize	0.25
Special Projects	0.55

\* This program was to terminate in 1988-89 and has been extended

## **ADMINISTRATIVE SERVICES**

### Science and Technology in the Portfolio Budget

This portfolio includes three organisations dealing with scientific services. These are the Bureau of Meteorology, the Australian Government Analytical Laboratories (AGAL) and the Ionospheric Prediction Service (IPS). In 1989-90 total support for these three organisations comprises \$133 million out of a total portfolio budget of \$1,402 million.

The total budget allocation for the Bureau of Meteorology in 1989-90 is expected to be \$ 117 million (\$111 million in 1988-89). In addition to the Budget allocation through this portfolio, the Bureau will receive additional funding for Greenhouse research through the Greenhouse R&D program (see under the Arts, Sports, Environment, Tourism, Territories portfolio). The Bureau will share an amount of \$5.7 million with CSIRO for research related to the Greenhouse effect.

The Australian Government Analytical Laboratories (AGAL) will receive \$13.6 million in 1989-90, up from \$10.6 million in 1988-89. The Ionospheric Prediction Service will receive \$2.3 million, up from \$2.1 million.

Major research activities within the portfolio are focussed within the Bureau of Meteorology's Scientific Development sub-program. This sub-program's allocation is expected to be \$7.2 million in 1989-90, compared with \$6.9 million in 1988-89.

### **MAJOR RESEARCH ACTIVITIES**

### **Bureau of Meteorology Research Centre**

#### Role

The Bureau of Meteorology Research Centre (BMRC) provides the main organisational framework for carrying out the research responsibilities of the Bureau of Meteorology. The broad objectives of the BMRC are:

- to advance the science of meteorology
- to understand Australian weather and climate
- to solve specific scientific problems in meteorology
- to develop the application of meteorology to the needs of the Australian community
- to contribute to the development and improvement of the operations and services of the Bureau.

#### Recent Achievements

#### **Seasonal Climate Outlooks**

BMRC research into the tropical atmospheric and oceanic processes which have a strong influence on Australia's climate - phenomena known as the Southern oscillation and El Nino - have advanced our understanding to a stage where useful statements can now be made on likely coming seasonal conditions for up to a few months ahead. Regular outlooks are now issued by the Bureau; they relate primarily to expected winter and spring rainfalls over south eastern Australia and the timing and intensity of the monsoon over northern Australia.

#### Monitoring Stratospheric Ozone via Satellite

Using data from instruments flown on the United States National Oceanic and Atmospheric Administration (NOAA) orbiting satellites, BMRC researchers have developed techniques to measure and map the amount of ozone in the southern hemisphere atmosphere. This new capability will complement limited existing surface observation networks and will be especially important in monitoring the 'ozone hole' over the high latitudes of the southern hemisphere.

#### Modelling the Weather and Climate Change

A complex advanced computer model of the global atmosphere has been developed by the BMRC and implemented on the Bureau's supercomputer. Routine weather prediction services will take advantage of the new model when it is introduced into operations later this year and an improvement in forecasting services for periods up to five days is expected. The same modelling capability will also be directed towards studying the impacts of increasing CO2 concentrations on Australia's climate, as part of the Government's recently announced Greenhouse Effect research strategy.

## ARTS, SPORT, THE ENVIRONMENT, TOURISM AND TERRITORIES

### Science and Technology in the Portfolio Budget

There are a number of agencies and programs dealing with scientific services in this portfolio. These include the Australian Biological Resources Survey (ABRS), the Australian National Parks and Wildlife Service (ANPWS), the Great Barrier Reef Marine Park Authority (GBRMPA), the Office of the Supervising Scientist (OSS), the Antarctic Division, the National Science and Technology Centre (NSTC) and the Greenhouse research program.

The budget allocation for the Antarctic Division will be \$59.8 million for 1989-90 (up from \$46.3 million in 1988-89). Major additional items include \$3 million for the Antarctic Rebuilding Program at the three scientific stations, and additional ship leasing costs. The allocation for the Office of the Supervising Scientist will be \$7.5 million in 1989-90, (\$6.6 million in 1988-89).

A number of major new research initiatives to be funded through this portfolio were announced earlier this year and in the Government's Environment Statement. These include: Greenhouse research, which has been allocated \$5.7 million for 1989-90, (\$0.8 million in 1988-89) to fund additional research mainly in CSIRO and the Bureau of Meteorology; the endangered species program in ANPWS (\$2.0 million in 1989-90); and crown of thorns starfish research in GBRMPA (\$0.25 million in 1989-90), Torres Strait Baseline Study (\$0.15 million in 1989-90), Intractable Wastes (\$0.3 million in 1989-90), Environment databases (\$1.8 million in 1989-90), and Coastal Zone Management (0.2 million in 1989-90).

The Australian Biological Resources Survey will receive \$2.1m for 1989-90 (\$1.9m in 1988-89), the Australian National Parks and Wildlife Service will receive \$25.6m in 1989-90 (\$20.2m in 1988-89), the Great Barrier Reef Marine Park Authority will receive \$9.1m in 1989-90 (\$8.6 in 1988-89) and the Office of the Supervising Scientist will receive \$7.7m in 1989-90 (\$6.6m in 1988-89).

### MAJOR RESEARCH ACTIVITIES

### **Australian Antarctic Division**

### Role

To provide scientific knowledge for the effective management of the environment and the living and non-living resources of the Antarctic; and to promote Australia in 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, upper atmosphere physics, cosmic ray physics and medicine as well as providing various support facilities for these programs.

#### Recent Achievements

#### **Dovers Base**

Dovers summer base in the Northern Prince Charles Mountains has been occupied for the first season's work in a five-year research program in the mountains and nearby Lambert Glacier.

#### Law Dome Research

A field research camp on Law Dome was established, east of Casey Station. A long-term deep ice drilling program has begun there, using newly developed mechanical equipment.

#### **Supply Ship Facilities.**

In conjunction with contractors, the Division has refined and implemented the design of science facilities for Australia's new Antarctic research and supply vessel, *Aurora Australis*, due to be commissioned in December 1989.

#### **Environmental Studies**

Environmental studies conducted in Antarctica and the Southern Ocean include monitoring the gas dimethylsulfide (important in predicting climate change), studying population fluctuations among seals and birds and examining the diets, feeding and reproduction and other behaviour of penguins.

### **Australian Biological Resources Study**

### Role

To identify and describe Australia's biodiversity through grants for research.

### Recent Achievements

#### Flora, Fauna and Zoological Catalogue

Ten year's grants under the Australian Biological Resources Study have resulted in a total of 725 books and research reports being published. Summary volumes, usable by all Australians, have been published by the Commonwealth in the Flora of Australia, Fauna of Australia and Zoological Catalogue of Australia. The Fauna volume on the mammals, which was completed last year, has received the Whitley Medal as the best book on the natural history of Australian animals published during the year.

#### **Environmental Resources Information Network**

To enhance the capacity of the Commonwealth Goverment to make informed and speedy environmental decisions, it has established the Environmental Resources Information Network. Research projects to provide data for the Network will be undertaken in co-operation with the States and Territories.

### **Greenhouse Effect Research**

### Role

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

### Recent Achievements

#### National Greenhouse Advisory Committee

A National Greenhouse Advisory Committee has been established to ensure the Government is provided with accurate and timely advice. Comprising up to six experts, a key task for the Advisory Committee will be to provide advice on priority areas for further Greenhouse research and to set objectives for a dedicated research grants scheme.

#### **Greenhouse Research Funding**

The Government will be providing \$7.8m until 30 June 1990 for Greenhouse research and policy support, with the bulk of the funding (\$5.7m) being directed to CSIRO and the Bureau of Meteorology to enable full advantage to be taken of existing expertise and to build on work already done. Other elements of funding will go towards the World Climate Impact Studies Programme being undertaken by the United Nations Environment Program, the Academy of Science to assist with the International Geosphere-Biosphere Program and the World Meteorological Organization's National Climate Program.

### 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

#### **Biology Toxicity Tests**

Release of contaminated water into rivers and streams can only be done safely if the discharge is controlled and a dilution ratio is set by measuring the effect of the effluent on components of the ecosystem. A range of toxicity tests has been developed to test sensitive organisms from the aquatic ecosystem near the Ranger uranium mine. This ensures that any necessary release of contaminated water from the mine can be safely controlled.

#### **Advanced Techniques for Measuring Radioactivity**

High precision techniques, based on gamma-ray and alpha-ray spectroscopy, have been developed for the measurement of radioactive isotopes in the Alligator Rivers Region. These have been used firstly to investigate the origin of past pollution events using present day samples, and secondly to enable a proper assessment of the impact of uranium mining on the traditional foods of local Aboriginal people.

#### **Hillslope Stability**

Because of the long half-life of residual radioactive isotopes in uranium mill tailings, decommissioning procedures for a uranium mine require remaining structures to be stable for a very long period. The stability and integrity of waste-rock dumps and mill tailings containments at the Ranger mine must be maintained under severe climatic conditions. Research has established the important characteristics that contribute to hillslope stability and experimental slopes are now being tested at the Ranger mine site.

## **COMMUNITY SERVICES AND HEALTH**

### Science and Technology in the Portfolio Budget

This portfolio includes four agencies dealing with scientific services. These are the National Health and Medical Research Council (NH&MRC), the Australian Institute of Health (AIH), the National Acoustic Laboratories (NAL) and the Commonwealth Serum Laboratories (CSL). AIDS research and Health research programs are also funded through the portfolio. Support for these agencies and programs in 1989-90 comprises \$123 million out of a total portfolio budget of \$13,065 million.

Medical and public health research funding through the NH&MRC increases to \$80.8 million in 1989-90, (\$72.0 million in 1988-89). The AIDS research program has increased to \$5.0 million in 1989-90 (\$3.5 million in 1988-89). AIDS research is also funded through the NH&MRC. Health research funding has increased to \$1.7 million (\$1.4 million in 1988-89).

The Australian Institute of Health receives an additional \$0.5 million for computer equipment to build key national health databases in 1989-90, but its operating appropriation has dropped to \$3.87 million (\$4.17 million in 1988-89). The Commonwealth Serum Laboratories will receive an additional \$12.8 million, (\$29.4 million in 1989-90 versus \$16.6 million in 1988-89) for the building of a blood fractionation plant. The NAL will receive \$1.7 million in 1989-90, (\$1.8 million in 1988-89).

The Ultrasonics Institute based in Sydney at the NAL site is to be transferred to CSIRO and \$1.6 million is to be transferred from this portfolio to the CSIRO budget for this purpose.

### **MAJOR RESEARCH ACTIVITIES**

### Australian Institute of Health

### Role

To contribute to the production of knowledge which may be used to develop strategies for improving the health of Australians.

### Recent Achievements

#### **Office Pathology Testing**

In 1988-89 a working party of the National Health Technology Advisory Panel (NHTAP) completed a major collaborative study on the use of decentralised pathology tests by 28 general medical practicioners. The result suggests the need for accreditation and training of non-laboratory users of such tests if this application of diagnostic technology is to produce worthwhile benefit to the health care system.

#### **Magnetic Resonance Imaging**

The utilisation, cost and benefits of this high-cost diagnostic imaging technique are being evaluated at five public hospitals in an NHTAP program, co-ordinated by the Australian Institute of Health. Data has been collected on over 16 000 examinations with these machines and provide a major body of information on this technology for consideration by governments, hospitals and professional organisations. This program has provided savings to government health expenditure through enabling the controlled introduction of expensive equipment.

### **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 infection with 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 spread of the infection in the community and to monitor the personal and social impact of HIV infection.

#### Recent Achievements

#### **Identification of ATOS-Related Syndrome**

Researchers in Sydney, funded under the Program, were responsible for the initial description of the acute glandular fever-like syndrome associated with primary HIV infection.

#### **HIV Antibody Testing**

Research in Melbourne has produced a simple and cheap agglutination test for measuring antibodies to HIV. The test has considerable potential for screening blood donations in developing countries or providing rapid results in accident and emergency situations.

#### **Social Aspects of AIDS**

A team of researchers at Macquarie University and the AIDS Council of NSW have undertaken a long-term study on the social aspects of the prevention of infection in homosexual and bisexual men. This has yielded important information of relevance to education strategies.

### **Commonwealth Serum Laboratories**

#### Role

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

#### Recent Achievements

#### **Development of a Q-Fever Vaccine (QVAX)**

Approval has recently been given for the marketing of this vaccine, which will be used to immunise abattoir and meat industry workers against the rickettsial disease Q-Fever. The new product results from six years of field study involving over 4000 volunteers in three Australian states.

#### **Development of Improved Intravenous Immunoglobulin (Intragam)**

Intragam has been developed using licensed technology. It is used as replacement therapy for patients with congenital antibody deficiencies and to treat bleeding due to platelet deficiency. Intravenous immunoglobulin may also prove useful for the treatment of severe infections and in the management of some auto-immune diseases.

#### **Caseous Lymphadenitis Vaccine (CLA)**

Although the basic work on the development of this vaccine, in collaboration with the University of Western Australia, was completed several years ago, continuous improvements have taken place. These have included the incorporation of CLA into various multi-component sheep and cattle vaccines and the extension of clinical studies to maximise the economic benefit of vaccination against cheesy gland disease.

# 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

#### **Teaching the Acquired Deaf to Lip-Read**

This project developed and tested a home video approach to teaching lip-reading. The study showed a significant improvement in the lip-reading skills of students who studied the video cassette compared with a control group who did not. Age and sex did not influence improvement of lip-reading skills. More detailed testing showed generalisation of lip-reading skills to unfamiliar speakers and materials.

#### **Evaluating Demand for Acute Health Care Facilities**

This program forecasts changes in the choice by patients of different hospitals resulting from changes in the provision and location of case-load capacity. Demand from that capacity is expressed in the changing age and sex composition of the population. The effects of these changes on the relative utilisation of hospitals, the size of catchment areas, the relative accessibility of patients to facilities and the relative levels of unsatisfied demand are all evaluated.

#### Women's Health and Instrumental Social Support

This project is extending the analysis of data and associations between the number of roles a woman fulfills and poor health, with a view to developing a measure of instrumental social support.

#### **Interaction With Disabled Persons Scale**

Funding has been provided to complete the development, refining and publication of an instrument designed to measure dimensions underlying community attitudes towards people with disabilities.

### National Health and Medical Research Council

### 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 those standards. The Council is currently funding 862 research projects, as well as providing block funding for several major research centres and institutes.

### Recent Achievements

#### **Protecting Young Children from Rotavirus Infection**

Rotavirus diarrhoea is one of the most common and life-threatening diseases of early childhood, and each year about 8000 children under three-years-old have to be admitted to hospital for treatment of dehydration, caused by rotavirus. Researchers at the Royal Children's Hospital, Melbourne, have identified different varieties of rotavirus that cause disease in children and have measured antibodies that can prevent further disease.

#### **Giardiasis in Aboriginal Communities**

Giardiasis is a common infection of the intestinal tract, and is of particular concern amongst disadvantaged groups in Australia, particularly Aborigines. It may contribute to malnutrition and is thought to be a major cause of failure to thrive in children. Researchers at the Murdoch University School of Veterinary Studies are studying the genetic variation that exists between the disease in humans and domestic animals, in an attempt to understand how people become infected and why they react differently to the parasite.

#### **Alcohol Damage to the Brain**

Alcoholics have been shown to have brain shrinkage in the white matter of the brain that carries the electrical impulses from the nerves' cells to the body. Researchers at the University of Sydney are studying whether the loss of white matter of the brain is due to an alteration of its composition due to alcohol, or as a result of a loss of neurones and subsequent degeneration of their processes.

## DEFENCE

### Science and Technology in the Portfolio Budget

The Defence Science and Technology Organisation (DSTO) will receive \$209.4 million during 1989-90, (\$200.2 million in 1988-89). The Defence Industry Development Program is expected to receive \$10.5 in 1989-90 (\$10.5m in 1988-89). This program is used to foster the development of defence-related technological capacity in industry.

### **MAJOR RESEARCH ACTIVITIES**

### **Defence Science and Technology Organisation**

### Role

DSTO provides scientific and technical advice to the Department of Defence and the Australian Defence Force on defence policy matters and advice on the selection and acquisition of new equipment. It also contributes to the solution of scientific and technological problems of defence agencies and relevant Australian industries and develops and maintains a base of skills and knowledge in defence science and technology.

### Recent Achievements

#### **New Construction Submarine (NCS)**

DSTO has compiled extensive evaluation documentation for the NCS project, addressing sonar performance, the sonar display and the interface between the combat data system and towed array. Support has also included the development of a fracture control philosophy for the submarine pressure hull and R&D support for an Australian industry involvement requirement, to employ locally-produced steels and welding consumables in the submarine pressure hull.

#### Fleet Broadcast Demultiplexer

The RAN Fleet Broadcast is transmitted via RAN high-frequency (HF) communications and also via the US Navy Satellite Fleet Broadcast Sub-system, but suitable receiving equipment for the satellite broadcast is very costly and so is fitted to larger RAN ships only. DSTO has developed a relatively low-cost demultiplexer which offers the potential for all RAN ships to receive the satellite broadcast on their standard-issue radios, thus providing higher communications availability than with HF alone.

#### **Commercial Activity**

DSTO also has an active program of commercial activity through collaboration with industry. It has around 30 commercial licences in place for production and marketing of equipment and systems of civil as well as military significance, and is currently negotiating the formation of several joint ventures for the exploitation of specific technologies. The following are three examples of DSTO's commercialisation acivities:

• DSTO has worked with Austek Microsystems to commercialise a frequency domain processing board, developed within DSTO, which has potential application in the spectral analysis of speech, sonar

and radar, for bandwidth reduction In video and speech transmission, and for studio quality audio processing.

- DSTO has used lasers and ion bombardment to produce highly uniform layers of cadmium mercury telluride (CMT), one of the most sensitive infrared detector materials known. The company CMTEK Pty Ltd was formed as a joint venture between DSTO, BHP Ltd and the Adelaide Innovation Centre, to commercially exploit this CMT production process.
- A joint industry-university-DSTO venture has been formed to develop thin film ceramic coating processes and has attracted a Government Industrial R&D grant of \$300 000.

# **EMPLOYMENT, EDUCATION AND TRAINING**

### Science and Technology in the Portfolio Budget

Support for science and technology in this portfolio is provided primarily through general operating grants to higher education institutions. These grants support the teaching and research activities carried out In institutions across all academic disciplines. Such support is not in general separately identified by discipline.

Further support is provided through the provision of funds via the Australian Research Council (ARC). The ARC recommends on the allocation of research grants and fellowships, Special Research Assistance, Special Research Centres, Key Centres for Teaching and Research, and Assistance to Technological Institutions and also on the additional research infrastructure funding for higher education institutions outlined in the 1989 Science and Technology Statement.

In 1989-90 the ARC'S funding for grants and fellowships will be \$62.4m compared with \$50.7m In 1988-89. Special Research Assistance and additional research Infrastructure funding are estimated to amount to \$38.4m in 1989-90 compared to \$14m In 1988-89.

This portfolio also provides funding for Commonwealth Post-Graduate Awards. Funding for this program is estimated at \$29.6m in 1989-90 compared with \$23.6m in 1988-89 and largely reflects the decision announced in the 1989 Science and Technology Statement to increase the number and value of these Awards. Additional funds will be provided under the Overseas Post-Graduate Research Award Scheme from 1 January 1990 to support overseas post-graduate students, funding for this scheme in 1989-90 Is estimated at \$1.7m. Funds are also provided to the Anglo-Australian Telescope Board to support its operations. In 1989-90, the AATB will receive \$2.7m up from \$2.5m in 1988-89.

### **MAJOR RESEARCH ACTIVITIES**

### 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 for the advancement of scientific knowledge.

### **Recent Achievements**

#### Supernova 1987A

The supernova which exploded in the Large Magellanic Cloud in February 1987 was by far the nearest and brightest of modern times, and has revolutionised our understanding of supernova physics. The AAT has obtained high-resolution spectra which show that the explosion cannot have been spherically symmetrical and that the material in the ejecta has broken up into lumps. In the infrared, the thermonuclear production of radioactive elements has been observed. The supernova has also illuminated clouds of dust and gas along the line of sight, and AAT photographs of the 'light echo' are giving the first three-dimensional picture of these interstellar clouds.

#### Schmidt Telescope

The prototype FLAIR fibre optic system has been used very successfully for the determination of the velocities of large samples of galaxies. A second complete photographic survey of the southern hemisphere has been commenced, which will be particularly useful for finding very nearby dwarf stars.

#### **Coude Echelle Spectrograph**

This major new AAT instrument was commissioned a year ago and since then has won about a third of the time on the telescope, being used for a remarkably wide range of investigations. The new spectrograph has the power to show the spectra of faint stars in much more detail than ever before. One outstanding use has been the study of the absorption lines of distant galaxies seen in the light of even more distant quasars near the limit of the observable universe, allowing us to observe genuinely young galaxies at very early stages of their evolution.

### The Australian Research Council

### Role

To stimulate the development of a dynamic and effective research effort in higher education and to improve the supply of highly skilled and trained people through the ongoing development of programs and policies which are responsive to national needs. Also to support interaction between higher education, government and industry, and to promote efficient and effective management of research activities in higher education.

The Australian Research Council (ARC) programs include:

- research grants to support the ideas of the best researchers
- research scholarships to enable the best students to proceed to PhD level
- research fellowships to enable the most gifted researchers to work for a few years as postdoctoral fellows
- research centre funding to provide a few of the highest fliers with the means to build a concentration of research activity around themselves and their projects
- key centre funding to build on existing teaching and research capabilities.

In 1989 the ARC funded almost 1800 research projects, primarily in higher education institutions. Past ARC projects have produced outstanding research in all fields (except clinical medicine and dentistry, which are funded through the National Health and Medical Research Council).

### Recent Achievements

#### **ARC Initiatives**

In May 1989, the Minister for Employment, Education and Training released a statement entitled *Research for Australia: Higher Education's Contribution*, announcing a series of initiatives to assist research and research training in higher education institutions. These initiatives include the allocation of almost \$lb by the ARC over the next five years, including \$197.5m in new funds, to maintain and improve research infrastructure and to provide extra support for postgraduate students.

The number of new postgraduate research awards offered annually will be Increased to 900 and the scholarships stipend will be raised to the tax-free equivalent of between \$15 000 and \$20 000. In addition there will be 30 new industry research scholarships awarded annually.

#### **Robot Development**

An ARC-funded research group from Monash University has solved three of the basic problems of robot navigation. The team has developed robotic systems to accurately determine position, orientation and where to move without bumping into things. The team is now working at putting the systems together in one integrated system.

#### High Field Nuclear Magnetic Resonance Spectroscopy

With funds provided by the ARC, as well as the National Health and Medical Research Council and CSIRO, the University of Sydney has been able to purchase a 600MHz Nuclear Magnetic Resonance Spectrometer. It is presently the most powerful commercially available, and when installed in 1990 will be part of a network of instruments including two 400MHz Spectrometers (at the University of Sydney) and a 400MHz solid-state instrument at CSIRO. Nuclear Magnetic Resonance spectroscopy can yield information on the structure, conformation and motion of small and large molecules in solution, which is important for biochemists as this solution can be in intact living cells.

#### **Dinosaur Data**

An ARC-funded team from Monash University has made major discoveries about the nature of dinosaurs, particularly Australian dinosaurs. Excavation at Dinosaur Cove on Cape Otway has unearthed previously unknown Australian species of dinosaur and has determined that dinosaurs may have had the capacity to exist at cold temperatures and in partial darkness. This would seem to contradict the presently favoured hypothesis that the dinosaurs became extinct after the blotting out of the sun by dust thrown up when a large meteor collided with the Earth.

#### **Hypervelocity Wind Tunnel**

Researchers at the University of Queensland are building a high-density hypervelocity aerodynamic wind tunnel. The wind tunnel is being used to study a new method of propulsion for orbital launch vehicles of the type which may operate from the Cape York Space Spaceport and NASA have also supporting the project with joint funding.
## **INDUSTRY, TECHNOLOGY AND COMMERCE**

## Science and Technology in the Portfolio Budget

There are three major research organisations dealing with science in this 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). The Department also has responsibility for the 150 per cent tax incentive for Industrial R&D, which has recently been extended.

There are also a number of agencies and programs within the portfolio supporting technological development In industry. These can be categorised as those that provide grants, concessions or services to encourage the development and use of new technology and those where there is the joint involvement of government and industry.

Grants (concessions) to industry include:

- Grants for Industry Research and Development (GIRD). This scheme provides grants for both generic technology (eg biotechnology) and on a discretionary basis, 150 per cent tax concession for industry research and development,
- Management Investment Companies (MIC). The MIC's program operates to increase the availability of venture capital for new, high-growth, export oriented firms using innovative technology. It expires in June 1991,
- National Procurement Developments Program (NPDP). This program provides grants to government purchasing agents to trial new
- high-technology products, Motor Vehicles Components Developments Grants Scheme (MVCDGS). This provides funding for Australian research and design of components and vehicles,
- Computer bounty. This provides assistance for the production of computer hardware, assemblies, electronic microcircuits, systems design and systems software,
- Australian Building Research Grants Scheme (ABRGS). This scheme . provides funds to encourage housing and construction research of long-term benefit to the building industry,

Services to industry and community include:

- National Industry Extension Service (NIES). This scheme provides extension services to small to medium-size firms to increase internal efficiency.
- Vendor Qualification Scheme (VQS). This scheme alms to develop a pool of Australian firms with the relevant international qualifications to supply firms in the Partnerships for Developments Program,

- Patents, Trademarks and Designs Office. This office provides industrial property rights services. The office operates on full cost recovery,
- the Science, Industry and Technology Policy Branch, parts of the International and other Divisons of the Department of Industry, Technology and Commerce,
  the National Space Program. This program aims to promote the
- the National Space Program. This program aims to promote the growth of commercially viable industries based on space technologies and encouraging greater involvement by industry in space R&D,
- Marine Science and Technology Program. This 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,
- the Commission for the Future. The Commission aims to raise community awareness and understanding of the future social and economic impacts of scientific and technological changes.

Joint involvements between government and industry include:

• the Malaria Vaccine Joint Venture (MVJV). The malaria joint venture is a consortium of Commonwealth, state and private research institutions aiming to develop a malaria vaccine. Budget support for these programs is shown below.

Program	or agency	Budget expenditure	Budget estimate				
		1988-89	1989-90				
_		\$m	\$m				
AIMS		11.0	11.1				
ANSTO		54.3	56.9				
CSIRO		348.1	371.6				
GIRD	-Generic	7.4	19.2				
	-Discretionary	13.0	19.2				
	-National interest	11.5	0.0				
NPDP		3.9	6.4				
MVCDGS		8.4	9.5				
Computer Bounty		31.1	35.2				
ABRGS	2	0.25	0.25				
NIES	-Commonwealth	5.3	5.6				
	-States	8.1	8.8				
VQS		-	2.5				
National Space Program		5.4	4.4				
Marine Science & Tech.		0.0	0.7				
Tech Dev	velopment Program	1.1	3.3				
MVJV		1.2	1.0				
Int'l Coll	laborative Program	1.1	5.0				
TOTAL		511.0	561.0				
PORTFC	DLIO TOTAL	\$1,361	\$1,370				

It should be noted that the Patents Office is not included in the above figures as it operates on full cost recovery. Estimated costs for the Patent Office for 1989-90 are \$33.4m (\$29.8m in 1988-89).

CSIRO funding has been the subject of much discussion and Figure 4 is provided to clarify the situation. It is not easy to gain a useful picture of trends in CSIRO's funding simply by looking at aggregate expenditures. There is a lumpiness' introduced by some large capital expenditures for major facilities which can be regarded as a distortion superimposed on a more consistent pattern for other expenditure. Over the period since 1982-83 CSIRO expenditure has included capital works for several major facilities. The figure shows CSIRO's direct budget appropriations split according to capital and non-capital components of expenditure. (A longer, but less detailed, series has been provided in Statement Number 3 of Budget Paper Number 1).

## Figure 4

TOTAL CSIRO EXPENDITURE BY SOURCE OF FUNDS



Funding for CSIRO is supplied directly through the Budget, through funds sought competitively from Commonwealth research funding schemes and by business and other non-government sources. Recent policy has been to diminish reliance on direct Budget funding and to promote more interaction with industry through the active seeking of other funding.

**Source:** Science and Technology Indicators Section, Department of Industry, Technology and Commerce, from CSIRO and Department of Finance data.

## Figure 5





In recent years there have been substantial increases in business investment in  $\ensuremath{\mathsf{R\&D}}$ 

**Source:** Science and Technology Indicators Section, Department of Industry, Technology and Commerce, from ABS Catalogue No. 8104.

Discussion has sometimes been clouded by a failure to consider funds gained by CSIRO outside direct Budget appropriations. These funds include further Commonwealth support (gained in a competitive way from various rural research trust funds, NERDDC, GIRD and other granting schemes), through earned revenue (publications, licencing, disposal of assets etc.), and through contracts from industry and other non-government sources. When the capital fluctuations are ignored, the remainder of total funding was close to constant between 1982-83 and 1987-88. The latter years show the effects of deliberate policy changes to seek a higher proportion of CSIRO's funding from external (non-government) sources and to seek a larger proportion of government funds competitively through general R&D funding schemes (other government sources).

## **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 co-operation between researchers and similar interests.

## Recent Achievements

#### **Environmental Records from Coral Cores**

Coral cores taken from large Forties corals provide records of past climatic conditions which can be traced back hundreds of years, providing information valuable for long-term planning in agriculture and related industries and for creating a baseline against which variations and changes in contemporary climate may be assessed.

#### **Remote Sensing of Marine Environments**

AIMS has developed skilled support for interpreting remote sensing data of nearshore and coastal features. Satellite data can be interpreted to reveal information on ocean fronts, sea surface temperatures and cloud distribution as well as being used for mapping of reefs and mangrove forests.

#### **Ultra-Violet Blocker**

Having discovered naturally occurring chemicals in corals that protect against the harmful effects of ultra-violet light, AIMS researchers are collaborating with ICI Australia in the development of industrial and human UV blockers.

## 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

#### **Accurate Detection of Blood Clots**

A collaborative research project on the use of radiolabelled anti-fibrin monoclonal antibodies was initiated in 1988, following the awarding of a \$300 000 generic technology grant from the Industrial Research and Development Board of the Department of Industry, Technology and Commerce. The research program involves collaborators from AGEN Biomedical Pty Ltd of Brisbane, the Clinical Immunology Research Centre, University of Sydney and the Department of Nuclear Medicine, Royal Prince Alfred Hospital, Sydney. The aim of the project is to derive a suitable radiolabelled antibody for the detection of blood clots in patients. A suitable product has been developed and is in the final stage of animal testing prior to obtaining Health Department approvals for human evaluation.

#### **Erosion and Salinity Soils**

Nuclear techniques were applied in investigating solute concentration and flow processes in Australian catchments suffering excessive salinity problems. These problems have arisen in part through excessive land clearing and have resulted in significant increases in salt export to rivers. Conjunctive use of a range of geochemical and environmental isotope methods (including measurement of minute amounts of naturally occurring radioactivity and uranium series isotopes in groundwaters) has proved invaluable in clarifying the mechanisms controlling salt concentration in surface soils, the significant areas of recharge, and the timescale and flow-path of salt transport to nearby rivers.

#### Synroc for Radwaste Immobilisation

Synroc is an Australian invention to immobilise radioactive waste in a specially designed synthetic rock. It mimics naturally-occuring rocks which have similar properties. ANSTO has a large research and development program on Synroc to make it commercially viable. A non-radioactive fully-automated pilot plant to demonstrate production on a commercial scale has already been commissioned.

## 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.

## **Recent Achievements**

#### **ERS-I** Upgrade

The facilities of the Australian Centre for Remote Sensing (ACRES) are being upgraded to receive high-speed data from the Earth Resources Satellite (ERS-1). This satellite is scheduled for launch into polar orbit by the European Space Agency in October 1990. The principal instrument on ERS-1 is a Synthetic Aperture Radar which will produce highly accurate details of the Earth's surface.

#### **Fast Delivery Processor**

A major component of the ACRES upgrade to receive ERS-1 information is the development of a Fast Delivery Processor which will process this data at one-tenth of realtime, a ten-fold improvement over other available processors. Being funded by the National Space Program, this processor has potential commercial applications as the demand for rapid access to such data grows.

#### Endeavour

The Endeavour payload is an imaging ultra-violet spectrometer that is expected to be flown on the NASA Space Shuttle in April 1990. By detecting ultra-violet light from deep space, beyond the Earth's ozone layer, it will obtain important astrophysical data for the space science community. The payload is currently being refurbished after having been in storage whilst awaiting a flight on the Shuttle.

## Automotive Industry Authority -Motor Vehicles and Components Development Grants Scheme

## Role

The Scheme was established in 1984 as part of the Passenger Motor Vehicle Plan to foster the retention and development of Australian automotive design skills and assist the industry to develop new and improved products in order to enhance its future competitiveness. It provides direct financial assistance, by way of grants, to support local expenditure on design and research and development of passenger motor vehicles and components.

## Recent Achievements

#### **Automotive Brake Caliper**

Brake and Clutch Industries Australia Pty Ltd has developed a unique automotive brake caliper which eliminates conventional guide pins and uses a floating caliper supported only by its pads. The design offers improved performance and quality with reduced costs. It has been successfully marketed overseas.

#### Park Brake Mechanism

Brake and Clutch Industries Australia Pty Ltd has developed a disc brake caliper that incorporates a unique park brake mechanism. The simple design provides for a lock actuator which acts directly on the brake pads. The mechanism offers superior performance, improved quality, lower cost and ease of in-service maintenance and has been successfully marketed overseas.

#### **High-Temperature Plastics**

Vehicle interior plastics are often subject to exposure to very high temperatures, particularly in the harsh Australian environment. Viscount Consolidated Industries has successfully developed a distortion-free plastic component for the crash pad of the EA Falcon, using a plastic material previously considered unsuitable for products of large dimension.

#### **Electric Mirror Actuator**

Until recently the electric actuators used in the exterior rear-view mirrors of Australian cars have been imported from Europe. An actuator designed by the South Australian firm Britax Rainsfords Pty Ltd is now replacing these imports and is planned for export.

## **Commonwealth Scientific and Industrial Research Organisation - CSIRO**

## Role

The main role of CSIRO is to carry out scientific research for the benefit of Australian industry and the community. The emphasis is on strategic research ; that is, on longer-term studies and on achieving results that are potentially widely applicable. A principal objective of CSIRO is the translation of research results into commercial use or other beneficial application.

# **CSIRO Institute of Animal Production and Processing**

### Recent Achievements

#### Vaccine to Control Sexual Behaviour In Cattle

A novel vaccine to control sexual behaviour and fertility in both male and female livestock has been developed in the Division of Tropical Animal Production and the Division of Animal Production. Use of the vaccine is known as immunospaying and immunocastration. Its first application will probably be in northern Australia to delay puberty in young female cattle until an appropriate time for first mating, and to prevent conception and optimise growth of cull females before slaughter. Immunocastration suppresses sexual and aggressive behaviour in bulls and leads to better growth rates than in surgical castrates. The vaccine should be available in 2-3 years, has good commercial prospects in Australia and overseas, and addresses animal welfare issues.

#### **Using Whey Proteins in Food**

A process soon to be commercialised through a collaborative R&D agreement with two Australian dairy companies was developed by the Division of Food Processing for separating the two major proteins from whey, a by-product of cheese manufacture. The separate fractions have functional properties far superior to those of the whey from which they are derived, and should command a premium as tailor-made food ingredients in both domestic and export markets.

#### **Sensory Research Centre**

During 1988-89, the Division of Food Processing took the first steps to establish a Sensory Research Centre, with food industry support, to conduct research into determining and defining, in objective terms, food flavour and texture characteristics preferred in Asian nations. The aim is to help food processors increase Australia's share of the large Asian food export market.

## **CSIRO** Institute of Industrial Technologies

### Recent Achievements

#### Microlab

The Microlab chemical reactor developed in the Division of Chemicals and Polymers was launched by Senator Button in July 1988. The equipment is being commercialised by Industrial Microwave Applications (Australia) Pty Ltd. It could revolutionise the preparation of organic chemicals through the use of microwave technology and can produce certain compounds at rates which are many times faster than conventional processes presently allow.

#### **Biomaterials**

Unique biomaterials developed by the Division of Biotechnology will improve the health of many patients. In association with industrial partner Telectronics Pacing Systems Pty Ltd, the Division has developed and tested several polymeric biomaterials in cell culture which can be used to replace narrow arteries - less than six mm in diameter. The novel polymer biomaterials encourage the growth of endothelial cells on the polymer surface to form a durable cell coverage inhibiting blood clotting, and other undesirable interactions with the blood. Currently the new biomaterial polymers are being tested in animals in association with the University of New South Wales.

#### **Sewage Processing**

A promising new way of treating sewage is being tested in a 100 kL per day pilot plant at Lower Plenty, Victoria. Developed by scientists at the Division of Chemicals and Polymers, the sewage treatment process is a modification of Sirofloc - the successful, CSIRO-designed surface and underground water treatment process based on regenerable magnetic reagent particles. The new technique should result in a reduction in the cost of treating sewage; with the capital cost of a treatment plant being halved and the total treatment cost reduced to two-thirds that of a conventional activated-sludge plant. Use of the technology is being explored by the Sydney Water Board through a two-year research contract with the Division.

## **CSIRO Institute of Information and Communications Technologies**

## Recent Achievements

#### **Gallium Arsenide Technology**

Technology developed at the Division of Radiophysics is being offered as the basis for a new commercial enterprise to manufacture and market gallium arsenide analog devices. Potential seed-capital investors have been presented with the Division's Business Feasibility Report, and their proposals for the project's commercialisation are now being evaluated. The project is aimed at giving Australia a viable share of the world market for these devices, which are designed for microwave and millimetre-wave use in communications, navigation and instrumentation.

#### **Oil Exploration with Fission Tracks**

Fission tracks occur naturally in mineral specimens when trace uranium (238 U) atoms fission spontaneously, and linear regions of damage of 10-20 microns in length, are created. The measured density of spontaneous fission tracks intersecting a mineral surface may be used to determine the age of that mineral and the thermal conditions to which it has been subjected since formation. Fission tracks in the mineral 'apatite' correlate with the temperature range over which oil is generated. Scientists at the CSIRO Division of Mathematics and Statistics and at Melbourne University are working together to use this as a tool for oil exploration.

#### The Australia Telescope - Open for Business

After five years in the making, the Australia Telescope was officially opened by the Prime Minister on 1 September 1988. The first successful observations have been made with two antennas linked together as a simple interferometer, and one antenna of the Telescope has already been linked with others in Australia and overseas for very long baseline interferometry (VLBI) observations. The Telescope was constructed with over 80 per cent Australian content and there was significant involvement of more than twenty Australian companies.

#### **Atmospheric Pressure Scanner**

The CSIRO Division of Atmospheric Research has designed an innovative Atmospheric Pressure Scanner for space-based measurement of the Earth's surface pressure. The CSIRO Office of Space Science and Applications (COSSA) has let a contract through the Space Technology and Applications Fund to Auspace Pty Ltd to build an airborne version of the scanner, for flight on the CSIRO Research Aircraft. The intention is to capitalise on the knowledge thus gained to develop a spaceborne scanner to international standards for launch in the mid-1990s. CSIRO is discussing, with the Bureau of Meteorology and the Australian Space Office, the prospects for joint development of the instrument as an Australian component of the international meteorological satellite system.

## **CSIRO Institute of Minerals, Energy and Construction**

### Recent Achievements

#### **\$100 million HIsmelt Plant**

The results of collaborative research work between the Division of Mineral and Process Engineering and CRA Ltd on a new iron-making technology - HIsmelt - will be incorporated in a \$100 million iron-making plant to be built by a Joint venture company, HIsmelt Corporation Ltd. Partners in the joint venture company, CRA Ltd and Midrex Corporation of the USA, plan to start building the HIsmelt iron-making plant, located south of Perth in Western Australia, in early 1990. The successful operation of the HIsmelt technology will offer the steel industry a more profitable and cleaner method of producing liquid pig iron, the essential first step in the production of steel.

## Proton Magnetic Resonance Thermal Analysis - a new tool to characterise coals

In the rapidly expanding coal export market an understanding of the properties and characteristics of different types of coal is vital in matching Australian coal resources with the requirements of overseas users. The Division of Coal Technology and the Joint Coal Board - the New South Wales coal regulatory authority - have developed a new and sophisticated instrument to test the coking power of coals. Based on proton magnetic resonance thermal analysis (PMRTA), the first such instrument is currently being used at the Joint Coal Board's evaluation laboratory at Cessnock, New South Wales.

#### Remote sensing - thematic mapping for resource assessment

In 1986, scientists at the Division of Exploration Geoscience, in association with the Australian Centre for Remote Sensing (ACRES), initiated a low-cost project to modify the ACRES Landsat facility to receive Thematic Mapper (TM) data. The Thematic Mapper is an advanced scanner with better spatial resolution (30 m instead of 8020 m) and a wider spectral range than earlier Landsat multispectral scanners. Fifty per cent of the project cost was sponsored by members of the Australian Mineral Industries Research Association Limited (AMIRA). TM data have proved especially Important for mineral and petroleum exploration, although it can be used to monitor and map both renewable and non-renewable resources. The first data were received in August 1986 and by May 1989 approximately 55,000 Thematic Mapper images had been acquired.

# **CSIRO Institute of Natural Resources and Environment**

#### Recent Achievements

#### **Climate Change**

During 1989, CSIRO established the most comprehensive multi-disciplinary research program on climate change ever undertaken in Australia. The program involves researchers in the six Divisions of the Institute and aims to provide estimates of climate change for the Australian region. Climate changes are expected over the coming decade as a result of changes In the composition of the Earth's atmosphere due to industrialisation. Two major consequences of these global atmospheric changes are often referred to as the Greenhouse Effect and the depletion of the ozone layer. This program is mainly directed at the Greenhouse Effect but gives consideration to ozone depletion.

#### Wesley Vale

Following a request from the Minister for Industry, Technology and Commerce, CSIRO provided a report to the Government on the environmental guidelines proposed for the Wesley Vale Pulp Mill. The report drew on CSIRO's scientific expertise in the fields of wood pulp technology, oceanography, fisheries, atmospheric research and water treatment. It provided an objective scientific assessment of the guidelines, and this was Invaluable in the midst of the volatile national debate on the subject. This exercise exemplified the value of the Organisation in being able to bring together the range of expertise to provide a clear and balanced perspective on complex issues.

In addition, a CSIRO/Government team has recently reported on a study tour of Sweden and Canada to look at pulp mill technology and environmental guidelines. The team's findings will contribute to the development of new environmental guidelines for future pulp mill development.

#### **Managing Kangaroo Numbers**

In Victoria, South Australia and Western Australia there is increasing interest in developing alternative methods to shooting for the control of kangaroo numbers. In the Division of Wildlife and Ecology, scientists have developed a method which painlessly controls the populations of the common large grey western and eastern kangaroos in southern Australia. Using a new drug which mimics the natural effect of periodic drought or food shortages on the rearing of young grey kangaroos, a natural increase in the kangaroo population can be deferred for one year.

# **CSIRO Institute of Plant Production and Processing**

#### Recent Achievements

#### **Gene Shears**

A world first in genetic engineering has been achieved by the Division of Plant Industry with the discovery of a way of destroying the messages produced by specific targeted genes. Called 'gene shears', the breakthrough has immense implications for all areas of biotechnology, with applications potentially involving the genetic manipulation of micro-organisms, plants and animals.

#### **Controlling Insects in Stored Grain**

The Division of Entomology and the NSW Grain Handling Authority have developed a new method of applying fumigant to stored grain. The technique, known as SIROFLO, applies the fumigant gas phosphine in minute quantities over a period of at least twenty-one days to kill pests at all stages in their life-cycle. Because only small amounts of the gas are used, no pesticide residues are left in the food. The novel technique has given the Australian grain industry a significant marketing edge in the highly competitive international grain trade.

#### **Intercropping Timber and Legumes**

In southern Australia, trials by the Division of Forestry and Forest Products have shown that trees can benefit from intercropping with legumes. Radiata pines have shown an almost 100 per cent increase in growth to year five as a result of being interplanted with nitrogen-fixing lupins.

#### **Controlling the Heliothis Moth**

The Heliothis moth costs Australian agriculture many millions of dollars each year. The Division of Entomology has entered into a joint project with ICI Australia to look at a novel and environmentally safe insecticidal product based on an insect-attacking virus.

## **Government Industrial Research and Development (GIRD) Generic Technology Grants**

## Role

To provide support and directions for the development of nominated areas of generic technology, which are important for the international competitiveness of Australian industry into the 1990s.

## Recent Achievements

#### **Biotechnology - Cattle Vaccine**

A commercial vaccine against the cattle tick under development is showing promising signs of commercial success. An antigen has been purified from ticks, and cattle vaccinated with it were effectively protected against infestation from tick larvae. The vaccine offers great prospects for protecting our northern cattle industry and being exported to south east Asia.

#### **Information Technology - Fast Fourier Transform Chip**

A fast fourier transform (FFT) chip in silicon has been developed. Austek Microsystems Pty Ltd has been granted an exclusive licence to manufacture the FFT chips for sale worldwide, using the name 'Frequency Domain Processor'. The chip is of special interest to those concerned with digital signal processing - the conversion of rapidly acquired data into frequency information.

#### **Communications Technology - Optical Fibres**

A GIRD grant is contributing to the development of the next generation of optical fibres. Not only are new optical fibres being developed, but also new optical fibre manufacturing technologies. Mid-infrared optical fibres will be used in the 1990s and beyond.

#### **New Materials - Ceramic Electrodes**

The Australian Nuclear Science and Technology Organisation has developed and fabricated controlled pore-size ceramic electrode caps. They will have uses in the bio-material field, particularly in heart-pacemaker electrodes. Successful prototypes have been tested and show promise for good commercial returns.

## 150 per cent Tax Concession for R&D

## Role

The 150 per cent tax incentive for research and development is the cornerstone in the Government's commitment to encourage R&D in industry. Its objective 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
- developing a capacity for adoption of foreign technology.

### Recent Achievements

#### **Program Extension**

In the May 1989 statement *Science and Technology for Australia* the Government announced that the tax concession would be extended at 150 per cent until 30 June 1993, and then phased down to 125 per cent for two years until 30 June 1995.

#### Rise in R&D

Since the announcement of the incentive there has been a significant rise in the amount of R&D performed by business enterprises, rising from 0.34 per cent of GDP in 1984-85, to 0.45 per cent of GDP in 1987-88. The annual rate of real increase in private business enterprise R&D was 19 per cent between 1984-85 and 1985-86, 20 per cent between 1985-86 and 1986-87 and six per cent between 1986-87 and 1987-88. Results of surveys conducted as part of the Bureau of Industry Economies' review of the program's effectiveness suggest that the tax incentive has had a positive effect on R&D budgets and on the amount of R&D undertaken. Figure 5 shows the substantial real increases achieved in private business enterprises over the 1980s.

#### **Encouraging Innovation**

A recent study undertaken by a private consultancy, the Centre for Technology and Social Change, on the impact of the R&D scheme on business found that it has helped to establish the right climate for the development of innovative export industries. Significantly, the study found that the incentive had resulted in business R&D strategies being re-evaluated and re-directed with a greater and longer-term commercial focus.

#### **Increasing Public and Private Links**

Another study, by the Australian Industrial Research Group shows that the incentive scheme is increasing links between public organisations and industry, with contracted research in the businesses surveyed having almost doubled in the three years to 1989. Similarly, Australian Bureau of Statistics R&D data show substantial increases in business funding of R&D in public organisations.

# **PRIMARY INDUSTRIES AND ENERGY**

## Science and Technology in the Portfolio Budget

There are a large number of agencies, trust accounts and programs supporting science in this portfolio. Research and development corporations have been set up for the wool, meat and horticulture industries and are being progressively established for other major rural commodities which presently fund research through trust accounts and Research Councils. Corporations/Councils are funded by production levies imposed and collected by the Commonwealth, on the recommendation of the peak industry bodies, and are matched dollar-for-dollar by a Commonwealth contribution up to the amount of the levy or 0.5 per cent of the gross value of production. R&D funds are considered to be part of the portfolio's outlays.

Fisheries research is funded mainly through the Fishing Industry R&D Trust Account to which the Commonwealth contributes by matching State expenditure on fisheries research up to 1 per cent of average value of production. The Australian Special Rural Research Trust Account (ASRRTA) is funded by Commonwealth appropriations and is responsible for the R&D effort into a number of small rural and emerging industries, multi-industry and national interest research.

Payments in support of R&D to these corporations and from trust accounts totals \$141 million in 1989-90 (\$104 million in 1988-89), including the component derived from industry levies.

New portfolio R&D initiatvies announced in May will establish R&D Corporations for a number of the primary and energy industries. A Natural Resources R&D Corporation will integrate water, soil and related forestry R&D. An Energy R&D Corporations will pick up elements of the current National Energy Research, Development and Demonstration Program (NERDDP), while separate coal and Forest Product R&D Corporations will be established to fund R&D in those industries. R&D Corporations will also be established for a range of agricultural industries currently serviced by Research Councils and the ASRRTA functions will be taken over by the Rural Industries Research and Development Corporation.

Other agencies and programs supporting science in the portfolio include the National Energy Research, Development and Demonstration Program (NERDDP), the Federal Water Resources Assistance Program (FWRAP), the National Soil Conservation Program, the Bureau of Mineral Resources, Geology and Geophysics (BMR), the Bureau of Rural Resources (BRR), the Plague Locust Commission (PLC) and the Natural Resources Information Centre (NRIC).

Energy research through the National Energy Research, Development and Demonstration Council (NERDDC) will receive \$33 million in 1989-90 (up from \$25 million in 1988-89) reflecting the Government's increased commitment to the development of energy-conserving technologies and research into new renewable forms of energy, clean coal technology, and domestic and industrial energy efficiency. Funds for NERDDP include \$18.3m for coal research (\$15m in 1988-89), which are obtained from a levy on the coal industry. Under FWRAP, water research will receive \$7.4 million in 1989-90 (\$7.7 million in 1988-89). The National Soil Conservation Program includes a significant scientific services and research component estimated to be \$4.0 million in 1989-90 (\$3.3m in 1988-89).

The BMR, the BRR, the Plague Locust Commission and NRIC will receive for 1989-90 (1988-89 in brackets) \$50 million for 1989-90, (\$43m), \$8.3m (\$7.2m), \$2.0m (\$1.5m) and \$1.9m (\$1.9m) respectively The increase for the BMR mainly reflects the transfer of property costs directly to the agency.

## **MAJOR RESEARCH ACTIVITIES**

# Australian Meat and Livestock Research and Development Corporation

## Role

The objectives of the Corporation are to improve the productivity and market performance of the meat and livestock industry by identifying more precisely areas of meat and livestock research and development relevant to the needs of industry and improving the efficiency and effectiveness of meat and livestock research and development.

## Recent Achievements

#### **Rapid Blood Test for Bovine Tuberculosis**

The development of simple, accurate and rapid blood tests for the diagnosis of bovine tuberculosis have been developed to a stage where extensive field testing of prototype kits developed by a commercial partner can be carried out in the Northern Territory and Queensland. The advantage of these new tests is that they should detect more of the cattle not responding to the conventional skin test and will be applicable to abattoir screening, thereby providing the national Tuberculosis Eradication Campaign with a valuable tool to hasten the eradication of TB in northern herds.

#### Laser Fellmongering

A prototype laser machine has been developed for the process of fellmongering (removing wool and hair from animal skins prior to leather-making). The machine has proven to be feasible with the potential to remove the water pollution problems encountered in traditional fellmongering methods. Overseas processors have been handling the majority of Australian hides because of pollution considerations and most Australian fellmongerers are no longer in business. The next stage is the construction of an industry prototype for meat-works testing.

## **Australian Special Rural Research Fund**

## Role

The Australian Special Rural Research Fund operates under the *Rural Industries Research Act 1985.* The fund provides support for scientific, technical and economic research and development in new rural industries and in existing rural industries that are too small to justify the establishment of their own Rural Industry Research Funds.

## Recent Achievements

#### **Mango Production**

The Australian Special Rural Research Fund, and its predecessor, the Commonwealth Special Research Grant, have financially assisted a range of research projects during the past seven years into mango production and processing in tropical Australia. The results of this research have contributed markedly to the expansion of mango growing from a small industry (1980 value of Australian production \$1.2m) to an established and expanding industry (1987 value of production \$7.9m).

#### **Eradicating Mushroom Disease**

In 1987 the Australian mushroom growing industry requested assistance from the Australian Special Rural Research Fund for a project to investigate a serious viral disease that was affecting the quality of mushrooms for domestic sale and making it impossible to commence exports. The Fund supported a research project which identified the source of the problem and made it possible to introduce changes in production methods. This has resulted in large increases in the 'pack-out' from mushroom farms and has made exports possible.

## **Australian Water Research Advisory Council**

### Role

To maintain a continuing overview of water research in Australia with a view to developing an overall balanced national water research effort; and to advise on proposals for research and demonstration programs and appropriate cost-sharing arrangements.

### Recent Achievements

#### Water Purification by Electro-Coagulation

A simple and effective low-cost water treatment process has been developed by the CSIRO in conjunction with Clearwater Australia Pty Ltd. The process uses an aluminium filter to reduce the levels of turbidity and colour in domestic water supplies and will be of major benefit to farmers and people living in small communities.

#### **Ecological Processes in Saline Ecosystems**

Researchers at the University of Adelaide have used large-scale in-lake enclosures as realistic models to increase scientific understanding of the complex environmental processes occurring in natural saline ecosystems. This work has been a catalyst in the recent formation of an International Consortium for Salt Lake Research.

## **Australian Wool Corporation**

## Role

The Wool Research and Development Council (WRDC) is responsible for planning, funding and co-ordinating the wool research and development program for the Australian Wool Corporation. The Council'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.

## **Recent Achievements**

#### Siroscour

Developed by the CSIRO Division of Wool Technology and designed specifically for Australian wools, Siroscour enables scouring plants to tailor scouring operations to the various types of wools being processed. The principles behind Siroscour can be incorporated into either existing or new plants to achieve optimum scouring of Australian wools. Siroscour, which has been licensed to an Australian company, offers improved quality and efficiency in the scouring process and has numerous advantages over conventional scouring.

#### UV Absorbers for Wool Car Upholstery

Excellent market opportunities exist for wool in automotive upholstery, where its superior comfort properties are becoming increasingly recognised. Two critical performance criteria of car upholstery are resistance to light and heat. New ultra-violet light absorbers developed by the CSIRO Division of Wool Technology are currently being commercialised by a large textile dyestuffs manufacturer to be used in automobile upholstery.

#### **Improved Pasture Plants**

The breeding, selection, development and evaluation of new legume cultivors for Improved pasture quality, are being conducted through co-ordinated national programs. New types of Persian clover and phalaris are due for commercial release and lines of yellow serradella, lucerne and native grasses are progressing towards commercialisation.

# **Bureau of Mineral Resources, Geology and Geophysics (BMR)**

## Role

To develop a comprehensive and Integrated geoscientific knowledge base for the Australian continent, the Australian off-shore area and the Australian Antarctic Territory, as a basis for the provision of the scientific information and technical advice to Government, industry and the public; to encourage and Improve the effectiveness of exploration for petroleum, mineral and groundwater resources; and to contribute to land-use planning and to the resolution of environmental issues including the mitigation of natural hazards.

## Recent Achievements

#### Mineralisation in the Kakadu Conservation Zone

Recent BMR surveys have confirmed that the mineralisation in the Kakadu Conservation Zone occurs in zones of altered rocks associated with major geological structures. Preliminary analysis of data obtained from an airborne geophysical survey reveals extensions of these structures into areas covered by soil and/or thin strata. Zones of alteration which appear similar to those recognised around known ore bodies are extensive and represent potential exploration targets for gold, platinum, palladium and other mineral commodities

# Groundwater Controls on Salinity Problems of the Murray-Darling Basin

A groundwater salinity map of the Murray Basin, at 1:1 000 000 scale, has recently been released. It shows the relationship between groundwater, and land degradation and river salinity. This map is the forerunner to a more comprehensive Murray Basin Hydrological Map Series and database which will form a major knowledge base for future management of the Basin's natural resources. A major publication and maps of the geology of the Murray Basin are due for release in 1990.

#### New Petroleum on Northwest Shelf

In 1986 BMR carried out a marine seismic and geological study of the northern margin of the Exmouth Plateau, a relatively deep water area off the Northwest Shelf. Drill cores collected from the area pointed to a new range of petroleum plays geological features with possible accumulations of petroleum), not previously identified. BMR assessment of this data has identified an undiscovered resource of about 60 million barrels of oil at a probability of 50 per cent.

#### **Monitoring Earthquakes and Nuclear Explosions**

Seismic stations have been operated throughout Australia and Antarctica to rapidly locate earthquakes and monitor nuclear explosions. Satellites and other high-speed communication links are used to transmit recodings from two large seismic arrays (near Alice Springs and Tennant Creek) and other key stations to a dedicated computer system in Canberra. The long-term goals are to locate all earthquakes occurring within the continent down to magnitude three on the Richter scale, so that accurate earthquake risk assessment can be made, and to participate in a global seismic network which could be used to monitor a comprehensive nuclear test ban treaty.

## Fishing Industry Research and Development Trust Fund

## Role

The broad objective of the Fund is to assist R&D which will improve the economic position of the fishing industry consistent with the general needs of the community and within the limits of sustainable economic production.

## Recent Achievements

#### **Artificial Seed Production of Pearl Oysters**

Disease and availability of natural stock limit the Australian pearl oyster fishery, currently valued at \$60m annually. Research assisted by the Fund has investigated the feasibility of artificial seed production as a way of overcoming both problems. Considerable success has been achieved in that 20 000 hatchery-produced pearl oyster spat have been produced and have grown from 20mm to 45mm during the past six months with mortalities of only 9 to 12 per cent. These spat are currently being on-grown by commercial pearl farmers.

#### **Identifying Toxic Algae in Shellfish**

In 1986 high toxic concentrations of a species of algae, new to Tasmania, were detected in commercial Tasmanian shellfish, causing the temporary closure of several shellfish farms. Research sponsored by the Fund described the organism, investigated its life cycle and defined its potential risk to humans. The industry was informed of the research results and shellfish farmers now regularly monitor their farms for the occurrence of such organisms.

## Horticultural Research and Development Corporation

## Role

The Corporation was established in 1988. Through its R&D efforts, it aims to foster the efficiency, competitiveness and adaptability of the horticultural industries with a view to improving their overall performance and the well-being of horticulturalists and the community at large.

## Recent Achievements

#### **R&D** Promotion of Fruit and Vegetables

The establishment of the Corporation in 1988 was itself a major initiative by the Government. This initiative now makes possible research and development initiatives for a very wide range of individual fruit and vegetable industries. Previously, only large industries, such as apple, pear and citrus production could attract government dollar-for-dollar funding for research projects. Under the new Corporation, both these and all the smaller fruit and vegetable products, and their industries, will be able to benefit from government-assisted research projects.

## The National Energy Research, Development and Demonstration Program

## Role

To assist in meeting the energy policy objectives of the Commonwealth Government through selective support of Australian energy research, development and demonstration (RD&D) projects, and also to maximise the technology transfer of the results of projects supported under the Program to potential users and to Australian Industry.

## Recent Achievements

#### **Natural Gas Fuel for Transport**

Australia has an abundance of natural gas but dwindling reserves of indigenous crude oil. Support is being provided for the development of technology to enable the use of natural gas as a substitute for diesel fuel in heavy vehicles. Natural gas powered buses are being supported in Adelaide and Brisbane and systems for trucks should be demonstrated in the near future.

#### Photovoltaic (Solar) Cells

With Program support, a team at the University of New South Wales has developed a non-concentrating silicon photovoltaic cell with the highest energy conversion efficiency yet achieved in the world (22.7 per cent). Efficiencies as high as 19 per cent have been obtained on commercial grade silicon material and the technology has been licensed to a number of companies including the Australian photovoltaic manufacturer, BP Solar Australia.

#### **Solar Water Heating**

Support provided to the University of Melbourne and Siddons Pty Ltd led to the development and commercialisation of a domestic water heater incorporating a solar boosted heat pump. These water heaters use only one-quarter of the electricity required by conventional electric storage water heaters. In 1988 this product was the recipient of the CSIRO medal for outstanding achievement in research and the National Energy Innovation Award for Innovative Energy Production.

## **Special Appropriations for Rural Research**

## Role

Research Councils fund research aimed at improving the efficiency and competitiveness of Australia's barley, chicken meat, cotton, dairying, dried fruits, grain legumes, honey, oilseeds, poultry, pigs, sugar, tobacco, wheat and grape and wine industries.

### Recent Achievements

#### Newcastle Disease Vaccine

Projects on Newcastle disease virus, funded by the Chicken Meat Research Council, have resulted in the development of a bank of monoclonal antibodies for the typing of NDV isolates in Australia and overseas. This has provided the basis for the rapid differentiation of local apathogenic isolates from exotic strains of Newcastle disease virus, should they enter Australia. The V4 Newcastle disease vaccine has given outstanding results in challenge trials in Malaysia after vaccination under commercial conditions in Australia.

#### Lupinseed Pellets for Feeding on Live Sheep Transports

Lupinseed pellets comprising lupin hulls and about 30 per cent lupin kernel are proving an ideal feed supplement for live sheep being transported on board ships. A project funded by the Grain Legume Research Council has found that lupin pellets also have significant advantages over standard shipper pellets in their preparation and handling characteristics as they are dust-free, easy to handle and have high bulk density.

#### **Polyunsaturated Rapeseed Crops**

Western Australian plant breeders, funded by the Oilseeds Research Council, are leading the world in the race to develop better polyunsaturated rapeseed crops. These new rapeseed lines are ideally suited to margarine and cooking oil manufacture and have important implications for the health food industry. Polyunsaturated oil rapeseed, high in linoleic acid and low in linolenic acid, has been keenly sought by breeders in Canada, Europe and China.

#### **Diagnosing Leptospirosis in Piggeries**

Leptospirosis is important both as a disease of pigs and of humans. It is thought to be widespread in Australia but has been difficult to determine whether the presence of the antibody actually reflects the presence of the disease. Research funded by the Pig Research Council and being carried out at the Attwood Veterinary Research Centre and at Monash University has led to the development of new diagnostic technique called IgM enzyme immunoassay, which now allows sera to be examined with a greater certainty of determining if the pigs are currently infected with leptospirosis and thus are active spreaders of the organism to other pigs or to humans.

## **PRIME MINISTER AND CABINET**

## Science and Technology in the Portfolio Budget

Expenditure on Science and Technology policy through the Prime Minister's Science Council and the independent high level advisory body ASTEC is expected to rise to \$1.87 million (\$1.48 million in 1988-89), reflecting the establishment of the Prime Minister's council and associated Office of the Chief Scientist.

The Resources Assessment Commission is expected to receive funding of \$5.2 million in 1989-90 (setup costs of \$0.13 million were incurred in 1988-89) to undertake resource assessment of national forests and coastal resources.

## **MAJOR POLICY ACTIVITIES**

## **Australian Science and Technology Council**

## Role

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

#### **Report on the Profile of Australian Science**

ASTEC has recently completed a major survey of the state of basic research in Australia, based on Australian Bureau of Statistics data, bibliometric measures of research output, and extensive consultation with the basic research community. This material is shortly to be published in a major report entitled the *Profile of Australian Science* which will provide an overview of strengths and weaknesses in Australian research, and a basis for action to address and correct deficiencies in the national research effort.

#### Science and Technology In Australia's Future

A report on the role of science and technology in Australia's economic development to the year 2000 will be published shortly. This report addresses the performance of Australia's services, manufacturing and primary industries, examines their use of technology, and identifies areas of opportunity for Australian industry in these major industry sectors. The report will prescribe the sorts of developments in our science, technology and human resources which will be necessary if Australia is to prosper into the next century.

#### The Core Capacity of Australian Science and Technology

This ASTEC report examines the state of Australian science and technology generally, building on the results of the *Profile of Australian Science* report referred to above. It sets out in some detail the sorts of steps which must be taken to ensure the continued health of our national research effort, and to strengthen the links between that research effort and industrial development. The report was a significant input into the May 1989 Government policy statement *Science and Technology for Australia.* 

## **Office of the Chief Scientist**

## Role

The position of Chief Scientist has been created to enhance advice to the Commonwealth Government on its science and technology effort.

## Rationale

The creation of the position together with the Prime Minister's Science Council and the Co-ordination Committee on Science and Technology was announced in the May Statement *Science and Technology for Australia*.

The Chief Scientist will interact directly with the science and technology communities and advise the Prime Minister on select and important matters. He is the Executive Officer and a member of the Prime Minister's Science Council which will meet at least twice a year to discuss salient science and technology issues. He also chairs the Co-ordination Committee on Science and Technology which comprises senior departmental officials and heads of agencies and meets quarterly.

The Chief Scientist is supported by a small staff which provides secretariat support for the Prime Minister's Science Council and the Science and Technology Co-ordination Committee.

## 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 1989-90 for the ARRB and FORS will be \$2.0 million and \$6.3 million respectively (\$2.0 million and \$5.7 million in 1988-89).

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 (a joint Commonwealth-State body) which undertakes research and provides information to Increase the benefits and to decrease the costs that Australia receives from its present and planned road transport. The ARRB also aims to be Australia's national centre for road research and information capitalising on the advantages which stem from the operation of a centralised research and information.

## Recent Achievements

#### **Bitumous Road Surfacing Anti-oxidants**

Some 80 per cent of the all-weather roads in Australia are surfaced with thin bitumen chip seals. However, such surfacings commonly fail by oxidation hardening of the bitumen. Surfacing's life can be extended by carefully selecting the bitumen, on the basis of a rapid testing procedure developed by ARRB and now included in the Australian Standard. More recently, and in association with the Australian Lead Development Association, it has been shown that lead-based anti-oxidants can extend the life of bitumen chip seals.

#### **Accelerated Loading Facility**

Roads are usually designed to last 20 years or more but eventually fail under a combination of traffic and environmental effects. A full-scale accelerated loading facility has been developed to allow traffic effects to be investigated in three to six month test sequences simulating a 20 year life. This has confirmed and extended the use of both thin traditional crushed rock construction and of cemented base and asphaltic construction for heavy duty pavements. The technology has been exported to the USA and China.

#### **CULWAY**

An unobtrusive weigh-in motion system, CULWAY, has been developed in conjunction with State Road Authorities which weighs trucks at highway speed. This allows unbiased data to be collected for planning and design purposes and has potential for use in selective enforcement applications. Some 60 units have been sold to all States and overseas.

# SECTION 4: BROAD TRENDS

## Introduction

Over about three decades there has been considerable international effort to reach agreed definitions of R&D which have since been applied with a fair degree of rigour in periodic surveys within most OECD countries. This 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. A decade later a compatible survey of R&D support, extended to cover defined categories of scientific and technological activities, was established to form the basis of the then *Science and Technology Statement* 

The survey-based results from the R&D surveys and the *Science and Technology Statement* have been essential in establishing benchmarks and time series in various expenditure and workforce indicators related to the Australian research effort. However, the complexity of classifications necessarily developed for these surveys has sometimes created problems of interpretation. In addition, the rigour of the surveys led to significant delays in the publication of results and this lack of timeliness diminished their value. That particularly applied to the former *Statement* 

In relation to Commonwealth expenditure in support of research, commentators have frequently sought to use data abstracted from the Budget papers to formulate views on the adequacy or otherwise of such support and the implications for scientific and technological policy. The wish to use such an approach is understandable, but these commentaries were often deficient in their scope and difficult to relate to the survey-based data.

## R&D and S&T Surrogates

A more rigorous approach to such a rapid Budget analysis was first taken at Departmental level in a publication known as the *S&T Budget Brief.* That publication aimed to present a post-Budget analysis based soley on published sources. The series of data developed there have formed the basis for those In this first *Science and Technology Budget Statement* It has been possible to demonstrate some correlation between the *S&T Budget Brief* series and the more rigorous survey-based aggregates. Developmental work on the series presented here, which might be taken as surrogate R&D series, will continue. Any improvements will be incorporated in future issues of this paper. In principal it may be possible also to develop a series which might be a surrogate for science and technology activities other than R&D. However, it is questionable whether that would serve a significant purpose in relation to current policy issues. In this paper, a limited approach has been taken, in that scientific services and technology-related programs have been briefly referred to under portfolio headings in section 3.

## The Data

A number of matters should be noted. Firstly, as implied above, the series presented do not purport to represent R&D as defined for the purpose of ABS R&D surveys and international comparisons. The practice of listing whole agencies and programs as defined for administrative and financial purposes inevitably leads to the partial inclusion of non-R&D activities. Secondly, there is in total a significant amount of R&D funded through agencies and programs not listed here. Nevertheless, a high proportion of the aggregates, particularly those in Tables 3 and 4, do comprise R&D in the defined sense.

## The Tables

Table 2 provides a summary of the data from Tables 3, 4 and 5. Overall, this series of major support for science and innovation has risen from an estimated \$2,013m in 1988-89 to \$2,313m in 1989-90 - a real increase of eight per cent. An alternative presentation, this time in a constant price series, is given in Figure 6. Broadly, there have been significant increases over the whole period since 1978-79 - recently stimulated by the tax concession schemes. Omitting those concessions, the rise is due to increased R&D overall in the higher education sector coupled with a steady rise in amounts disbursed through the various granting schemes. The 1988-89 dip in total funding levels is traceable mainly to a real fall in the level of <u>Budget</u> funding for Commonwealth research agencies. See Figure 4 and the accompanying discussion regarding CSIRO in Section 3 for further background.

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 given. 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 research and the latter 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 1988-89 and 1989-90, the effect of adding this series to others, as in Table 2, is to blur the assessment of overall trends. See footnotes (1), (2) and (3) to Table 5.

A further blurring results from the inclusion of the estimated costs of Commonwealth revenue foregone through the 150 per cent taxation concession incentive scheme for industrial R&D. The problem here is that present estimates are based for the most part on registration data for the concession and that data has some deficiencies. It would be much better for estimates to be based on data derived from firms' taxation returns. Work along these lines by the Australian Taxation Office is expected in due course and this will considerably improve these estimates. See footnote (4) to Table 5.

## Figure 6

## MAJOR SUPPORT FOR SCIENCE AND INNOVATION



Through the 1980s there has been a general increase in government support for science and innovation, but the balance between different means of support has changed significantly.

**Source:** Science and Technology Indicators Section, DITAC, from Budget papers and related sources.

		Expenditure									(est.)	
	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90
MAJOR SCIENTIFIC RESEARCH AGENC												
Defence	77.8	85.9	97.8	126.1	138.8	146.6	158.4	165.9	183.4	187.0	200.2	208.7
Civil	243.4	286.5	335.1	391.3	441.4	451.7	465.6	504.0	539.5	531.9	538.3	594.0
SUB-TOTAL	321.2	372.3	432.9	517.4	580.2	598.3	624.0	669.9	722.9	718.8	738.6	802.6
SCIENCE AND INNOVATION GRANTS												
<ul> <li>Health and Medical</li> </ul>	14.4	15.5	20.5	28.6	34.7	45.3	52.0	56.2	64.2	69.8	76.9	87.5
<ul> <li>Industry and space</li> </ul>	25.9	37.7	53.2	27.5	56.3	70.9	69.8	101.7	98.9	79.6	81.0	89.1
Rural	17.2	21.4	25.2	28.6	33.0	36.5	45.2	52.5	67.4	73.4	98.8	127.9
<ul> <li>Energy and environment</li> </ul>	4.2	5.5	7.6	11.5	15.0	17.5	16.7	14.5	14.3	11.2	11.7	20.8
Transport	6.7	7.2	6.6	2.7	2.5	3.4	2.8	2.6	2.0	2.0	2.0	2.0
SUB-TOTAL	68.5	87.2	113.0	98.9	141.5	173.6	186.6	227.5	246.8	235.9	270.5	327.3
COSTS OF IR&D & RELATED INCENTIV	ES						20.0	166.0	190.0	220.0	170.8	221.2
HIGHER EDUCATION RESEARCH												
<ul> <li>ARC and related grant schemes</li> </ul>	22.7	23.3	28.2	30.9	35.2	41.9	48.3	53.7	61.1	65.7	75.7	93.3
<ul> <li>ARC non-Budget</li> </ul>	-	-	-	1.5	5.9	5.7	5.6	5.9	6.0	9.9	14.0	38.4
<ul> <li>Specific R&amp;D support</li> </ul>	64.3	69.0	77.0	85.0	94.0	104.0	112.0	126.0	128.0	135.0	143.0	160.0
<ul> <li>Est. general research support</li> </ul>	213.0	220.0	250.0	284.0	310.0	330.0	418.0	437.0	521.0	549.0	600.0	670.0
SUB-TOTAL	300.0	312.3	355.2	401.4	445.1	481.6	583.9	622.6	716.1	759.6	832.7	961.7
TOTAL COMMONWEALTH SUPPORT 690		772	901	1018	1167	1253	1415	1686	1876	1934	2013	2313
% GDP	0.639	0.630	0.645	0.649	0.683	0.652	0.660	0.707	0.713	0.651	0.600	0.632
TOTAL COMMONWEALTH												
SUPPORT AT ESTIMATED 84-85 PRICES REAL % INCREASE/DECREASE	1173	<b>1195</b> 1.9	<b>1260</b> 5.5	<b>1278</b> 1.4	<b>1320</b> 3.2	<b>1328</b> 0.6	<b>1415</b> 6.5	<b>1576</b> 11.4	<b>1633</b> 3.6	<b>1568</b> 4.0	<b>1492</b> -4.8	<b>1612</b> 8.0

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

SOURCE: See Tables 3, 4 and 5

		Expenditure										(est.)
	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90
ARTS, SPORT, THE ENVIRONMENT. TOURISM & TERRITORIES												
Antarctic Division	12.1	20.8	23.3	21.7	31.7	35.4	37.4	42.2	47.4	49.2	46.3	59.8
Supervising Scientist Alligator Rivers Research Inst	0.8	1.7	3.1	4.1	6.1	4.6	4.8	5.5	6.1	6.0	6.6	7.5
COMMUNITY SERVICES & HEALTH												
Australian Inst. of Health (excl. grants)		2.4	2.8	3.0	3.4	4.0	4.6	5.1	5.2	3.4	4.2	4.4
(Budget component)	2.1	2.9	3.7	4.9	6.3	6.6	8.8	12.8	15.8	17.3	16.6	29.4
DEFENCE												
Defence Science and Technology Organisation	77.8	85.9	97.8	126.1	138.8	146.6	158.4	165.9	183.4	187.0	200.2	208.7
EMPLOYMENT, EDUCATION & TRAININ	NG											
Anglo-Aust Telescope	1.0	1.1	1.5	1.7	1.9	1.8	1.8	1.9	2.0	2.4	2.5	2.7
INDUSTRY, TECHNOLOGY & COMMER	CE											
Aust Nuclear Science & Technology Organisation <sup>1</sup>	27.0	29.2	33.0	37.8	36.4	38.8	41 9	45.4	45.2	51.0	54 3	56.9
Australian Institute of	27.0	27.2	55.0	57.0	50.1	50.0	11.9	15.1	13.2	51.0	51.5	50.7
Marine Science	2.7	3.5	5.2	-5.7	6.4	6.9	7.4	7.6	8.2	9.5	11.0	11.1
CSIROI	184.5	211.3	247.1	293.5	328.2	331.6	324.9	344.3	367.8	347.8	348.1	3/1.6
PRIMARY INDUSTRIES & ENERGY												
for Aust Animal Health Labs							3.9	4.1	4.4	4.7	4.7	4.8
Bureau of Mineral Resources <sup>2</sup>	13.1	13.4	15.3	18.8	21.1	22.0	30.1	35.2	37.4	40.6	44.0	45.7
TOTAL	321.2	3723	432.9	517.4	580.2	5983	624.0.	669.9	722.9	718.8	738.6	802.6

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

(1) CSIRO and ANSTO figures for 1977-78 to 1980-81 were adjusted to include superannuation on the same basis as in subsequent years.(2) BMR figure for 1989-90 was adjusted downwards by \$5.3m to reflect expenditure on the same basis as in previous years.
	Expenditure										(est.)	
	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90
ARTS, SPORT, THE ENVIRONMENT, TO	JRISM & T	ERRITOR	IES									
Greenhouse research											0.8	5.7
Aust Biological Resources Study	0.2	0.2	0.6	0.8	1.0	1.1	1.2	1.2	1.0	1.1	1.3	1.5
COMMUNITY SERVICES & HEALTH												
AIDS Research								0.7	1.3	3.0	3.5	5.0
Health and Community Services												
Research Grants	1.2	1.4	1.5	1.4	1.5	3.2	1.6	1.6	1.5	1.1	1.4	1.7
NH&MRC Research Grants	13.2	14.0	18.7	25.6	30.0	38.5	44.2	51.2	59.8	65.7	72.0	80.8
Payments to Walter & Eliza												
Hall Institute	-	0.1	0.3	1.6	3.2	3.5	6.3	2.6	1.6	-	-	-
EMPLOYMENT, EDUCATION & TRAININ	١G											
Australian Research Council										43.7	52.1	63.7
ARCS grants/fellowships												
(including marine R&D grants)	12.7	13.9	18.3	20.5	22.5	25.4	30.6	34.4	40.3	_	_	_
Post-graduate Awards	9.0	8.5	8.7	9.6	12.6	16.5	17.7	19.3	20.9	22.0	23.6	29.6
Education R&D Grants	1.0	1.0	1.2	0.8	0.2	-	-	-	-	-	-	-
INDUSTRY, TECHNOLOGY & COMMER	CE											
Industrial R&D support												
- IR&D Incentives Act 1976												
. Commencement grants	6.0	7.0	9.7	9.7	13.1	14.6	16.3	14.3	16.9	3.1	0.1	0.0
. Project grants	16.5	23.0	36.1	12.1	34.8	43.2	38.1	37.7	17.9	6.4	2.8	0.7
. Public interest projects	1.2	4.0	5.0	2.4	4.9	8.1	9.8	6.3	3.5	1.0	0.3	0.0
- ER&D Act 1986 (GIRD)	_		_	_		_	_	_	10.8	25.6	31.8	38.3
. Biotechnology grants	-	-	-	-	-	0.7	2.2	4.3	-	-	-	-
InterScan support	2.2	3.7	2.4	2.1	2.2	2.5	-	-	-	-	-	-
National Space Program	-	-	-	-	-	-	-	3.0	5.0	3.2	5.4	4.4
Malaria Vaccine Joint												
Venture	-	-	-	-	-	-	-	0.3	0.4	0.8	1.2	1.0

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

	Expenditure										(est.)	
	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90
Research associations <sup>1</sup>	-	-	-	1.2	1.3	1.7	1.9	1.9	2.0	2.0	0.0	0.0
Motor Vehicle R&D	-	-	-	-	-	-	-	20.6	22.9	11.6	8.4	9.5
Assistance under the Bounty <sup>2</sup>												
(Computers) Act 1984	-	-	-	-	-	-	1.5	13.2	19.4	25.7	31.1	35.1
PRIMARY INDUSTRIES & ENERGY												
Wool Research	3.1	5.0	6.9	7.9	8.6	10.0	11.7	12.0	14.3	12.1	21.7	23.5
Meat & Livestock Research <sup>3</sup>	6.5	6.8	7.0	7.0	8.8	9.0	8.6	11.0	16.1	17.2	23.5	27.8
Fishing Industry Research	0.7	0.9	0.8	2.4	2.1	2.9	4.0	4.9	5.8	4.8	5.2	7.5
Special Rural Research Fund	0.1	0.1	0.2	0.2	0.2	0.1	0.3	0.4	1.5	3.0	4.0	5.0
Other rural research <sup>3</sup>	6.5	8.2	9.8	10.5	12.6	14.1	20.1	23.3	26.4	30.0	36.8	55.6
Energy research <sup>4</sup>	4.0	5.3	7.0	10.7	14.0	16.4	15.5	13.2	13.3	10.2	9.6	13.6
Water research	0.4	0.4	0.5	0.6	0.8	0.3	0.5	0.9	3.3	6.2	7.3	7.4
Horticulture Research											0.3	1.1
TRANSPORT & COMMUNICATIONS												
Payments to Australian Road												
Research Board	0.3	0.3	0.3	1.9	2.0	3.0	2.3	2.0	2.0	2.0	2.0	2.0
Payments to Australian												
Railway R&D Organisation		-	-	0.8	0.5	0.4	0.5	0.6	-	-	-	-
Transport planning and	6.4	6.0	63	0.0								
rescarcii	0.4	0.9	0.5	0.0	-	-	-	-	-	-	-	-
TOTAL	91.2	110.6	141.3	129.8	176.8	215.5	235.0	28L3	308.1	301.7	346.2	420.6

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

### FOOTNOTES TO TABLE 4

(1) Prior to 1981-82, Commonwealth support for Research Associations was provided through CSIRO. Since 1988-89 the Associations are fully funded by industry.

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

#### **FOOTNOTES TO TABLE 4 - continued**

(3) The appropriations include a large component (about 50%) of funds derived from industry levies. Other rural research includes barley, chicken meat, cotton, dairying, dried fruits, grain legumes, honey, oilseeds, poultry, pigs, sugar, tobacco, wheat, and grape and wine. These now come under the Rural Industries Research Act 1985..

	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90 est
Barley	-	-	0.31	0.47	0.29	1.03	0.99	1.37	1.01	0.99	1.10	1.61
Chicken Meat	0.19	0.23	0.24	0.22	0.24	0.23	0.24	0.29	0.38	0.40	0.38	0.48
Cotton	-	-	-	0.20	0.25	0.67	1.00	0.89	1.04	0.86	1.55	1.77
Dairying	0.44	0.46	0.42	0.42	0.54	0.57	0.60	0.67	1.26	1.64	1.57	3.32
Dried Fruit	0.09	0.09	0.12	0.12	0.12	0.09	0.12	0.16	0.32	0.26	0.29	0.46
Grain Legumes	-	-	-	-	-	-	-	0.24	0.66	0.84	0.98	1.34
Grape & Wine	-	0.26	0.26	0.28	0.37	0.38	0.49	0.52	0.67	0.82	0.94	1.02
Honey	-		0.02	0.06	0.05	0.05	0.05	0.08	0.09	0.11	0.10	0.14
Meat	3.20	3.18	3.30	3.02	4.16	3.61	4.61	5.55"	7.68"	8.61'	11.58*	13.11"
Oilseeds	0.35	0.41	0.28	0.30	0.23	0.30	0.31	0.55	0.40	0.52	0.46	0.47
Kg Industry	0.29	0.29	0.39	0.42	0.40	0.42	0.60	0.78	1.00	1.43	1.37	1.91
Poultry	0.14	0.10	0.14	0.15	0.15	0.15	0.16	0.22	0.31	0.28	0.37	0.31
Sugar	-	-	-	-	-	-	-	-	-	1.28	1.40	1.36
Tobacco	0.39	0.39	0.38	0.41	0.47	0.55	0.67	0.66	0.69	0.64	0.94	0.71
Wheat	3.47	3.09	2.01	1.97	4.65	4.65	5.40	5.48	6.40	5.16	8.35	8.90
Total	8.56	8.48	7.85	8.90	9.18	12.27	14.12	17.45	21.91	23.84	31.39	36.89

## INDUSTRY CONTRIBUTION TO RURAL INDUSTRY RESEARCH TRUST ACCOUNTS (estimated proportion of levies attributable to research purposes - \$m)

(a) Industry contributions for meat R&D to the AMLRDC.

(4) Expenditure from appropriations where paid direct to grantees or expenditure from Energy Research Trust Account. Coal research is omitted since it is funded through industry levies: expenditure from the Coal Research Trust Account is estimated to be \$18.3m in 1989-90 compared with \$15.0m in 1988-89.

	Expenditure										(est.)	
	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90
EMPLOYMENT, EDUCATION & TRAINING	3*											
Identifiable research												
support for universities <sup>1</sup>	64.3	69.0	77.0	85.0	94.0	104.0	112.0	126.0	128.0	135.0	143.0	160.0
Australian Research Council <sup>2</sup>												
<ul> <li>Special research assistance</li> </ul>	-	-	-	1.5	5.9	5.7	5.6	5.9	6.0	9.9	14.0	28.4
<ul> <li>Research infrastructure</li> </ul>	-	-	-	-	-	-	-	-	-	-	-	10.0
Estimated research component												
of general university funding												
for both teaching and research <sup>3</sup>	213	220	250	284	310	330	418	437	521	549	600	670
INDUSTRY, TECHNOLOGY & COMMERCE	Ξ											
150% Tax Concession <sup>4</sup>												
for R&D	-	-	-	-	-	-	-	146.0	170.0	200.0	164.0	180.0
100% Tax Deduction for equity												
subscriptions in Management												
Investment Companies (MICs) <sup>5</sup>	-	-	-	-	-	-	20.0	20.0	20.0	20.0	6.8	41.2
TOTAL	277	289	327	371	410	440	556	735	845	914	928	1090

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

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

(1) These are indicative estimates. The two most recent items are projections based on 1987 identifiable research expenditure data collected by DEBT from pre-1986 universities and include funds earmarked for research purposes, they do not include funds spent on research from the operating grants of CAEs

(2) Excludes ARC funding through Budget sources. Special Research Assistance includes funds redirected from university operating grants and funds originally earmarked for Special Research Centres. Infrastructure includes new funds to be distributed to institutions for the maintenance and development of research infrastructure.

- (3) The data for 1988-89 and 1989-90 are projections based on the 1986 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 CAEs. Estimates for 1978-79, 1981-82 and 1984-85 to 1987-88 are based on ABS R&D Survey data. Estimates for other years are indicative only.
- (4) A 150% company tax deduction for eligible industrial R&D expenditure has applied from 1 July 1985. The estimates are based both on information provided in registrations for the concession and preliminary analysis by the Australian Taxation Office(ATO). They do not account for any recoupments arising from the dividend imputation system. It is expected that revised estimates will become available during 1990-91 following further analysis. The focus here 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 1989-90 this series is nil, \$105m, \$137m, \$176m, and \$167m.
- (5) Licensed Management and Investment Companies invest in approved high technology/growth activities. The equity subscription in these companies attracts a 100% income tax deduction in the year that subscriptions are made.

## SECTION 5: INTERNATIONAL CONTEXT

# *Comparing Research and Development 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 comparison between nations.

Table 6 ranks selected nations in descending order of GERD/GDP, as well as showing the latest available values. The left side of the table shows the trends in GERD/GDP for the four year period up to 1988 (the three years up to 1987-88 for Australia) while the right side shows the real annual growth in GERD over the same period. It is useful to consider both sets of data together since fluctuations in one indicator alone may not give an adequate impression. There is sometimes a tendency to overlook the influence of the denominator on the ratio.

An example is Norway's GERD/GDP which has remained constant over the past two years shown. However, the most recent GERD growth rate is negative. Australia shows an opposite pattern with GERD/GDP falling, but a real growth in GERD. The explanation is that in relative terms Norway experienced a decline in real GDP of about the same magnitude as the decline in GERD. In Australia, on the other hand, there was in fact a modest real growth in GERD overall - but in the ratio this is overwhelmed by a very substantial growth in real GDP. Yet consideration of GERD/GDP alone might well lead to the conclusion that Norway's rate of change of R&D levels was the more satisfactory.

Nevertheless, GERD/GDP comparisons remain a useful rapid guide for many purposes. The example above, however, points to some of the problems in comparing particular ratios.

## *The Broad Research and Development Sectors*

Dissections of GERD/GDP provide valuable insights. Table 7 shows changes in the level of R&D expenditures, as a ratio of GDP, in various categories of funding and performing sectors. There are flows of funds between all sectors and it is necessary to consider both who provides the money (ie source of funds) and where the R&D is carried out (ie performance).

For source of funds, the first column shows the business contribution. This includes both private firms and public enterprises (Telecom is an Australian example of a public enterprise). The second column shows Government <u>direct</u> funding. It should be noted that support via indirect means such as tax concessions is excluded. (In fact, indirect support from Government is included in the <u>business</u> contribution. While this is somewhat unsatisfactory there is no ready way of amending the methodology used to derive the data.) 'Other' covers foreign sources and private charitable organisations. It is interesting to note the relatively large size of this sector in some smaller European nations (see also Figure 1 in Section 1) - reflecting a substantial presence of foreign firms conducting R&D.

For the columns under 'performance' the first shows the level of R&D being carried out in business enterprises (both private and public).

The second column shows levels of research performed within government agencies. (It is appropriate to recall here these data do not necessarily constitute funds provided by Government alone. For example, in Australia CSIRO receives some amounts of business funding.) The remaining two columns indicate levels of R&D performed within Institutions of higher education and private non-profit research organisations (other).

The lower part of Table 7 shows the historical trends for Australian R&D, placed on the same basis as the international data. Here it is worth repeating that the indirect support for industrial R&D through the 150 per cent tax concession shows up as <u>business</u> funding rather than government funding. Based on the estimated values in Section 4 Table 5, this is the region of 0.05-0.07 per cent of GDP, but fluctuates somewhat since beginning to have an effect in 1985-86. These levels of indirect support for R&D provided by government to business in many OECD nations.

	Latest	% GERD/GDP trends				Ave	rage annual	growth in G	ERD
	%GERD/GDP	1985	1986	1987	1988	1985	1986	1987	1988
Switzerland	2.88	n.a	2.88	n.a	n.a	n.a	n.a	n.a	n.a
Japan	2.87	2.81	2.79	2.87	n.a	11.1	1.5	7.2	n.a
Sweden	2.82	2.79	n.a	2.82	n.a	9.6	n.a	2.3	n.a
Germany	2.78	2.71	2.69	2.81	2.78	6.2	1.6	6.7	2.5
USA	2.66	2.77	2.74	2.69	2.66	7.2	1.6	1.8	2.8
Netherlands	2.40	2.09	2.22	2.39	2.40	9.4	8.2	n.a	n.a
UK	2.36	2.29	2.36	n.a	n.a	3.5	6.4	n.a	n.a
France	2.29	2.26	2.25	2.27	2.29	4.0	1.8	3.2	4.4
Norway	1.83	1.62	1.83	1.83	n.a	11.4	8.0	-0.4	n.a
Finland	1.64	1.50	1.59	1.60	1.64	9.9	7.9	4.9	6.5
Belgium	1.59	1.65	1.64	1.59	n.a	n.a	1.3	-0.9	n.a.
Denmark	1.37	1.25	1.30	1.37	n.a	6.9	6.8	5.1	n.a
Canada	1.35	1.43	1.43	1.40	1.35	8.6	3.0	1.8	0.4
Austria	1.33	1.27	1.32	1.32	1.33	2.7	4.8	1.5	4.8
Italy	1.30	1.12	1.13	1.27	1.30	14.5	3.8	16.2	5.6
AUSTRALIA	1.20	1.17	1.25	1.20	n.a	8.1	8.9	2.0	n.a.
Ireland	0.99	0.83	0.91	0.96	0.99	11.0	8.4	10.6	4.8
New Zealand	0.97	n.a	n.a	0.97	n.a	n.a	n.a	n.a	n.a
Spain	0.71	0.53	0.59	0.65	0.71	14.7	15.4	15.1	15.4

 TABLE 6
 Trends in Gross Domestic Expenditure on R&D(GERD) - Comparisons of OECD Nations

SOURCE: Science and Technology Indicators Section, Department of Industry, Technology and Commerce based on OECD and nation's data. (OECD/STHD database as at May 1989 and ABS 8122 and 5206.)

	Latest	Source of Fu	nds for R&	D as % GDP	R&D Performance as % GDP					
	%GERD/GDP	Business	Govt	Other	Business	Govt	Univs	Other		
OECD COMPARISONS										
nation (year*)										
Switzerland (1986)	2.88	2.27	0.61	0.00	2.24	0.18	0.37	0.09		
Japan (1987)	2.87	1.96	0.62	0.29	1.89	0.28	0.57	0.13		
Sweden (1987)	2.82	1.77	0.95	0.10	2.03	0.13	0.66	0.00		
Germany (1988)	2.78	1.81	0.92	0.05	2.06	0.36	0.35	0.01		
USA (1988)	2.66	1.26	1.36	0.04	1.87	0.31	0.41	0.07		
Netherlands (1988)	2.40	1.21	1.08	0.11	1.37	0.38	0.49	0.16		
UK (1986)	2.36	1.17	0.92	0.27	1.55	0.37	0.33	0.11		
France (1988)	2.29	0.93	1.20	0.16	1.34	0.57	0.34	0.04		
Norway (1987)	1.83	0.93	0.81	0.09	1.17	0.27	0.40	0.00		
Finland (1988)	1.64	0.73	0.56	0.35	1.02	0.30	0.31	0.01		
Belgium (1987)	1.59	1.10	0.45	0.04	1.14	0.07	0.31	0.07		
Denmark (1987)	1.37	0.62	0.58	0.17	0.80	0.24	0.30	0.03		
Canada (1988)	1.35	0.58	0.60	0.17	0.75	0.26	0.32	0.02		
Austria (1988)	1.33	0.66	0.64	0.03	0.70	0.11	0.44	0.08		
Italy (1988)	1.30	0.53	0.71	0.06	0.73	0.30	0.26	0.01		
AUSTRALIA (1987-88)	1.20	0.45	0.72	0.03	0.45	0.40	0.35	0.00		
Ireland (1988)	0.99	0.43	0.40	0.16	0.63	0.19	0.16	0.01		
New Zealand (1987)	0.97	0.39	0.59	0.00	0.21	0.57	0.18	0.01		
Spain (1988)	0.71	0.30	0.27	0.14	0.43	0.18	0.11	0.00		
RECENT AUSTRALIAN TR	ENDS									
year										
1981-82	1.00	0.23	0.75	0.02	0.24	0.46	0.31	0.01		
1984-85	1.14	0.31	0.78	0.05	0.34	0.45	0.34	0.02		
1985-86	1.17	0.36	0.77	0.04	0.39	0.44	0.34	0.02		
1986-87	1.25	0.45	0.77	0.03	0.46	0.43	0.36	0.02		
1987-88	1.20	0.45	0.72	0.03	0.45	0.40	0.35	0.02		

 TABLE 7
 R&D Expenditure as a Percentage of GDP by Sector - OECD Comparisons, Recent Australian Trends

\* Year for latest available GERD/GDP. Other data are latest available but in some cases are for earlier years.

SOURCE: See Table 6



