#### **1990-91 BUDGET PAPERS**

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Presents an analysis of appropriations, outlays and staffing for each portfolio in program format. It also provides information on running costs and staffing by department and agency.

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- No. 4 Australia's Overseas Aid Program 1990-91 Details Australia's overseas aid programs.
- No. 5 Women's Budget Statement 1990-91 An assessment of the impact on women of the 1990-91 Budget.

No. 6 Portfolio Explanatory Notes 19 Volumes—Presents details of 1989-90 expenditure and estimates for 1990-91 on a program basis and relates these figures to program performance.

No. 7 Science and Technology Budget Statement 1990-91 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 1990.

(This document is to be released in November 1990).

1990-91 BUDGET RELATED PAPER No. 7

# SCIENCE AND TECHNOLOGY BUDGET STATEMENT 1990-91

CIRCULATED BY THE HONOURABLE SIMON CREAN, M.P., MINISTER FOR SCIENCE AND TECHNOLOGY AND MINISTER ASSISTING THE PRIME MINISTER FOR SCIENCE

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# PREFACE

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

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

# **SECTION 1:**

# POLICY OVERVIEW

# The Challenge to Become a Clever Country

The Prime Minister has expressed his vision of Australia as the "clever country". In many ways, Australia is already a "clever country". Our scientific and technical expertise in many areas is second to none. What we are not clever at is applying our considerable stock of scientific and technological expertise, except in the primary industry sector. We need to become cleverer at commercialising that expertise for the benefit of other industry sectors, the sectors in which world trade is growing most rapidly. We also need to become cleverer at applying science and technology to solve our environmental problems and thus contribute to sustainable development, through the development of better solutions.

If Australia is to become the "clever country" we must set clear goals for science and technology policy. These goals can be summed up in three words: excellence, cooperation and application. Excellence is already a feature of Australian science. In many fields we have world class research. However, it is through the application of research findings that wealth is generated and national well-being is enhanced. In order to become the clever country we must put more emphasis on application.

Application will be achieved by increasing cooperation between those doing the research and those making use of the research results. To improve our performance in cooperation, and application, we need to exploit more effectively the scientific resources which we have. This means building a more effective science and technology system which draws on the resources of all sectors. Our impressive store of scientific and technical expertise is a national asset whose potential is yet to be fully utilised.

The Government's approach to realising the benefits of science and technology has been to develop a positive strategic framework which recognises that science and technology are essential elements in addressing two of the major problems facing Australia today, namely:

- the need to develop a more internationally competitive economy based on innovation in order to solve our balance of payments problems;
- the need to integrate economic development with environmental considerations to ensure that development is ecologically sustainable.

Science and technology are critical to providing the understanding required to integrate the demands of economic development with those of the environment. For this reason, scientists are represented in all working groups which have been set up to advise the Government on how the concept of ecologically sustainable development might be given practical effect in major industry sectors.

The wider agenda for science and technology has another benefit: by emphasising the vital role of science and technology to both economic and environmental sustainability we will ensure that we attract the numbers and quality of students we need into scientific and technological careers. Rather than secondary students thinking that a career in science leads only to white coats and a laboratory, they will be attracted to science by its relevance to a wide range of activities.

# The Need for Balance in the Science and Technology System

An important role of science and technology policy is to create and maintain an appropriate balance in the science and technology system, such that the funders, performers and users of research are all working together to maximise economic and social benefits. A balanced system provides opportunities for:

- research responding to both the strategic and immediate needs of users and of the market this places a responsibility on users to articulate their needs to the researchers and should provide a major driving force for the overall system;
- science-driven research, to underpin our scientific capability, to keep abreast of developments at the frontiers of scientific discovery, to develop new opportunities and to advance knowledge as a cultural activity in its own right;
- a pool of appropriately trained people able to carry out research, use research findings and work with new technologies developed here or overseas; and
- a scientifically literate population
  - to understand the role played by science and technology in all aspects of life and especially wealth generation and the creation of a more productive culture, and
  - to encourage informed debate and a proper appreciation of the ways in which we should use the scientific and technological opportunities that arise.

Science and technology policy is also concerned with:

- establishing an economic environment that encourages and facilitates investment in new technologies and the application of research findings; and
- the effectiveness of the technology transfer mechanisms available to gain access to foreign technology.

## Coordination of Science and Technology Policy

The Minister for Science and Technology in the Industry, Technology and Commerce portfolio has been appointed Minister assisting the Prime Minister for Science. In this capacity he has responsibility for the growth and effectiveness of the science and technology system.

However, responsibility for science and technology policy is shared between many government departments in recognition of the contribution they can make to meeting a wide range of national objectives. To complement this approach the Government has put in place mechanisms to enable it to take an overall view of the development of science and technology.

Mechanisms to coordinate science and technology activity among portfolios and to increase the public profile of science were announced in the May 1989 policy statement *Science and Technology for Australia*. A major initiative was the formation of the Prime Minister's Science Council to better develop an overall view of science and technology and to give emphasis to applications. The Council is chaired by the Prime Minister and the Minister Assisting for Science is the deputy chair. The Council is attended by senior Ministers with strong portfolio interests in science and technology (Employment, Education and Training; Primary Industries and Energy; Community Services and Health; the Arts, Sport, the Environment, Tourism and Territories), representatives from the scientific community and leading executives from industry. The Prime Minister's Science Council met twice in 1989-90 and in future plans to meet three times a year. So far the Council has discussed key issues such as the funding of research, global climate change, science and mathematics education and the Cooperative Research Centres program.

The Cooperative Research Centres Program is a major initiative of the Prime Minister's Science Council and a significant development in Australian science and technology. The program is designed to draw together groups of outstanding researchers from higher education and other organisations to create larger, integrated research units. The research groups will be linked with those able and intending to make use of their research findings, whether in industry or in the public sector. The program is built around the threefold approach of excellence, cooperation and application.

The Chief Scientist, a new position announced in the May 1989 policy statement, advises the Prime Minister on matters of science and is the Executive Officer of the Science Council. He also chairs a Coordination Committee on Science and Technology made up of senior officials from the departments whose Ministers attend the Prime Minister's Science Council and the Departments of Defence, Transport and Communications, and Arts, Sport, the Environment, Tourism and Territories. Agencies with responsibility for science and technology such as CSIRO, ANSTO and Telecom are also included. The Chief Science Adviser in the Department of Industry, Technology and Commerce is the deputy chair of the Coordination Committee.

# The Science and Technology System

#### **Cooperation - the Development of Linkages**

The science and technology system is a network of those who fund and perform research and those who use science and technology. It also includes those who teach science and technology. The Government is a major player in this system as a funder, performer and user. Moreover, the Government is concerned to ensure the strength and vitality of the whole system.

There are three major groups in the science and technology system: the private sector, the government sector and the higher education sector. Each has different roles and responsibilities. For the science and technology system to be effective it is important that the private sector, government and higher education sectors work together, making the contribution for which each is uniquely equipped.

The private sector funds, performs and exploits research. Business enterprise research and development is directed towards wealth creation. It concentrates on experimental development to produce new products, processes and services. In doing this, the sector draws on the skills developed in the technical and higher education sector and frequently uses the research know-how and results of both the higher education sector and government laboratories.

The Government recognises the private sector as the main driving force in the application of research findings to economic development. Indeed, a major purpose of the Government strategic framework for science and technology is to enhance and strengthen the private sector in this role. An important element in this framework is the tax concession for expenditure on research and development, which the Government last year extended to 1995. The level of expenditure on research by the private sector has increased in real terms by 50% over the period 1984-85 to 1987-88. The scheme also provides for the contracting of research from the business sector to the public sector to encourage linkages between the different sectors. Investors have also been encouraged to fund research and development through research syndication agreements where the the tax concession reduces the risk involved in large investments in research.

State and Commonwealth governments fund, perform and use research for three main reasons:

• to acquire new knowledge without any immediate application in view and to ensure that Australia keeps abreast of international developments in science and technology. This is an intellectual and cultural activity which contributes to the education and training of scientists and technologists and is largely performed in the higher education sector. In addition to its training and cultural function, this research can develop and follow up scientific opportunities which may be later exploited by industry or other users.

- to meet their own requirements for the effective performance of the government's own responsibilities and functions; eg for environmental management, health and defence.
- in support of research funded to develop our science and technology capability which could have the potential to be exploited by areas within government or in the private sector. Such research is carried out to develop new technologies and new areas of economic activity, and to improve the productivity and importance of existing industries and make them more competitive.

Since taking office in 1983, the Government has implemented a wide range of changes in the research infrastructure in order to give Australians a more effective and more productive research system. The roles of each component of the system have been more clearly defined and the importance of cooperation has been underlined in the design of many programs such as the support for generic technologies and the Cooperative Research Centres Program.

Government laboratories, such as the CSIRO and DSTO, carry out research to meet Government and community needs and for the benefit of Australian industry. The emphasis in such laboratories is often on strategic research and on achieving results that are potentially widely applicable. The Government has taken steps to encourage the laboratories to undertake research work for other funding agencies and for industry by setting external funding targets, allowing retention of earnings and changing their management structures.

The higher education sector is responsible for the communication and advancement of knowledge, carried on through teaching, scholarship and research. A major output is the educated workforce we need to meet the needs of other sectors. The research which is undertaken is an integral part of teaching activity and provides a capability in terms of equipment and technical competence at the forefront of knowledge. This capability should be drawn on by other sectors. Traditionally, the higher education sector has concentrated on basic research and has used its strengths in this field to play a role in the international scientific community. The research results produced in the higher education sector are often applied through cooperation with other parts of the science and technology system.

Teachers and researchers should be attuned to the needs of other non-education sectors for appropriately skilled people and for access to research skills and infrastructure if the education sector is to play an effective role in the science and technology system. Training outside universities, in the TAPE sector and in industry, is also important in transmitting skills.

#### **International Linkages**

Science is essentially international and Australian scientists, especially those involved in basic research, have been active participants in international cooperation. Maintaining high standards of international research in Australia allows our scientists to draw on the international pool of knowledge, thereby enhancing the benefits from Australia's research. Most of our science and technology will continue to come from overseas through the purchase of plant and equipment and the movement of people as well as through scientific publications and licensing agreements.

There is another way in which science and technology can link into our international relationships. Our research capability is an asset which can be used to provide traded services such as education, medical services and engineering consultancies. Our international science and technology agreements provide a means by which bilateral linkages can be developed, resulting in quality relationships built upon our strengths in fundamental and strategic research and the strengths of other countries, such as Japan and Korea, in applications.

The Government is using the International Science and Technology Program to expand the scope of cooperation from that of the individual scientist to larger-scale activities at the institutional or organisational level. On a larger scale, the proposed Multifunction Polls project has the potential to establish in Australia a unique focus for international exchange in science, technology and culture.

Science and technology are now integral to Australia's trade and foreign relations activities with many nations. The potential for further development of cooperative arrangements with other countries, especially in the Asian region, is being actively explored by the Government in cooperation with the private sector.

#### The Scientific Workforce

The future development of our scientific capability is critically dependent on a highly skilled scientific workforce. The demand for highly trained scientific personnel is increasing through the greater demand of the private sector and the expanding higher education sector. This demand will be exacerbated by an expected rise in the retirement rate in the public sector from the mid 1990s which arises from the expansion of the higher education sector and the CSIRO in the 1960s and early 1970s.

The Government is concerned to enhance the teaching of science and mathematics at school level and has increased the number of places for science students in higher education. Programs to increase awareness of the importance of science and the expanding opportunities for scientific careers will be continued.

#### **Public Awareness of Science and Technology**

The Government is concerned to raise the level of understanding of the nature and role of science and technology and their potential contribution to the resolution of many economic and social and environmental problems. It is important that there is informed participation in decision making about science and technology.

To meet this need for greater public awareness of science and technology, the Government included a Science and Technology Awareness Program amongst the measures it introduced in the Science and Technology Statement last year. The program's goal is to increase awareness of the central role of science and technology in achieving economic growth and improved national well-being.

Young people are often uncertain about their feelings towards science and technology. Many of them have the talent and ability to become scientists and technologists of the future. A central task therefore is to ensure that young people fully appreciate the opportunities that exist for challenging and rewarding careers in science and technology. Young people must also be well prepared to live in an increasingly technological society, not just as passive observers, but as active participants.

The take up of scientific and engineering careers can be promoted by emphasising the vital role of science and technology to both economic and environmental sustainability and by developing and promoting appropriate school curricula, particularly for the early years at school. Parents and the wider community are being actively involved in promoting informed discussion and promoting scientific literacy in the schooling process.

Women generally have a low involvement in science and technology in our society. Programs are being offered, in both public and private sectors, to increase participation by women of all age groups in the spectrum of science and technology education and employment.

The Science and Technology Awareness Program conducts two major awards and jointly sponsors other projects. The inaugural award of the Australia Prize for outstanding achievement in the biological sciences relating to agriculture and the environment was made by the Prime Minister to three joint winners in May 1990. The Michael Daley award for excellence in science and technology journalism was presented at the ANZAAS Congress in February 1990.

### The Future

This document describes current programs which have been designed to further the Government's overall objectives for science and technology. The realisation of the vision of the clever country depends critically upon our ability to harness our excellent research capabilities for our greater economic and social well-being. To achieve this objective we need to bring together all elements of the science and technology system and especially those groups which can apply and commercialise research findings. The contribution of the science and technology system is of such significance that the Government must act to ensure that its potential is realised. The Government's strategic framework has been developed to achieve this broad goal.

The 1980s were a seminal decade for Australian science and technology in which a new policy base was laid for the growth of a stronger and more productive science and technology capability in the 1990s and beyond. The process of building on this base presents the Government, industry and the science and technology community with a formidable challenge.

# **SECTION 2:**

# RECENT MAJOR DEVELOPMENTS

# Prime Minister's Science Council

The past year saw the first two meetings of the Prime Minister's Science Council. The Council considered the following matters:

#### - Global climate change and the issues for Australia

The main conclusion reached by the Council was that, despite considerable uncertainties, the balance of scientific opinion was that global warming is likely to occur and may already be underway. Several responses were recommended.

# - Australia's scientific and technological resources and their utilisation

It was noted that even in areas of traditional strengths, Australian researchers and research groups were having difficulties in keeping up with the rapid pace of developments. The Council also discussed the deficiencies of the higher education system in providing sufficient numbers of trained scientists, engineers and technologists for future needs. Other issues included low industry awareness of the need for research and development and difficulties in ensuring the commercialisation of Australian research.

#### - Cooperative Research Centres

There was a presentation of several possible topics for future Centres. Discussion covered the importance of industry and other user group involvement in the Centres' work, as well as the need for cooperative research to add value to the type of research usually performed by such research groups and to develop synergism from interactions between them.

# - Elements of a strategy to advance science and mathematics education

Among other actions, it was suggested that the Commonwealth Government seek cooperation from the States and Territories in a national strategy to strengthen science and mathematics education, and establish a National Standing Committee on Science and Mathematics Education.

# Coordination Committee on Science and Technology

This Committee also held its first meetings over the past year. It brings together senior officers from all Commonwealth Departments and agencies with substantial science and technology interests, as well as heads of major research funding and performing agencies. The Committee facilitates the sharing of information and assists the coordination of programs and policies concerned with science and technology. The Committee is linked to the Prime Minister's Science Council through the Committee Chairman, the Chief Scientist, who is also Executive Officer of the Science Council.

Topics of discussion have included:

- Human resources for R&D and the related question of career structures for scientists and engineers
- Ways of setting directions for Australian research
- Coordination of responsibility for biological collections
- Action following the Government's statement on the environment
- The Committee's role in the provision of advice to the Government on major research projects and facilities

# The Cooperative Research Centres Program

This recent initiative, an outcome of discussions in the Prime Minister's Science Council, is one of the most significant Government decisions aimed at strengthening Australia's scientific and technological capacity. It is based on the recognition that Australia has quite substantial scientific and technological resources which are fragmented and dispersed both geographically and institutionally. It seeks to overcome difficulties for Australia in establishing concentrations and networks of researchers and in meeting the costs of facilities and equipment needed in many research fields to keep up with the rapid pace of international scientific and technological change.

Up to fifty Cooperative Research Centres will be established over the next five years, where possible located on or adjacent to university campuses. Government funding will rise to \$100 million a year over the next five years.

The Centres will have the specific objectives of:

- Improving the quality of Australian research, its relevance and applicability in industry and other sectors of the economy, by strengthening the links between research groups and between performers and users of research, and
- Strengthening undergraduate and graduate education in Australia through the active involvement of non-higher educational staff in educational programs, and the participation of students in the work of the research centres.

# Greenhouse Initiatives

The National Greenhouse Advisory Committee was formed in August 1989 to provide expert scientific advice to government and in particular to advise on priority areas for further greenhouse research, overview the core research and set objectives for a dedicated research grants scheme. The Committee also has the role of promoting public understanding of greenhouse issues.

Recent initiatives include:

- From May 1990, a further \$5.7 million has been provided for greenhouse research for each of the next three years
- Funding to support the Australian contribution towards international climate and environmental programs

# Other Initiatives in Support of Science and Technology

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

#### - in industry, science and technology

- Grants for Industry Research and Development (GIRD) Generic Technologies and Discretionary Grants Schemes have been extended to 1994
- the National Procurement Development Program has been extended to 1992 and expanded to include joint administration and funding by the Commonwealth, State and Territory Governments
- new legislative provisions relating to tax incentives for R&D were introduced including provisions for syndication of R&D by groups of eligible companies undertaking significant R&D projects and removal of the potential for companies to derive unintended tax benefits through syndication
- nomination of Adelaide as the preferred site for the proposed Multifunction Polis (MFP) and moves for further analysis of the feasibility of the proposal at that site
- action through the establishment of a number of working groups, to explore the practical application of the sustainable development concept to the various sectors of industry.

#### - in education and research training

- there have been substantially increased funds made available for allocation through the Australian Research Council (ARC)
- specific funds have been made available to higher education institutions to support research infrastructure
- the ARC Fellowships program has been expanded and has four schemes (Postdoctoral, Australian Research Fellows, Queen Elizabeth II Awards and Senior Research Fellows); stipends have been increased
- in 1990 the Australian Postgraduate Research Awards (APRA)

scheme was expanded to include 150 additional awards, substantially increased stipends and sixty new APRA (Industry) awards; from 1991 an additional 100 APRA and forty APRA (Industry) awards will be provided

#### - in environmental issues

- significant priority has been given to greenhouse effect research
- a ten year Endangered Species Program has been implemented
- a four year environmental study of the Torres Strait has been initiated

#### - in health and medical research

- introduction of New Investigator Awards and Priming Grants to be awarded by the National Health and Medical Research Council (NH&MRC)
- extensions and additions to existing NH&MRC Research Fellowships Scheme
- establishment of a research unit in Health Program Evaluation, a joint venture between Melbourne and Monash Universities.

### - in science and technology awareness

- introduction of a program of activities to increase public understanding of the central role of science and technology in achieving economic growth and improved national well-being
- first award of the Australia Prize, an award for outstanding achievement in science and technology in promoting human welfare

# Significant Reviews and Reports

The past year saw a number of reviews dealing with major issues relating to science and technology, both of a general and specific nature. These included a number of reports by the Australian Science and Technology Council (ASTEC):

- Profile of Australian Science
- Profile of Australian Science, Forum Proceedings: May 1990
- Report on access to major international accelerator and beam facilities. *Small Country Big Science*.
- The Future of Australian Astronomy
- Setting Directions for Australian Research\*
- The first phase of the study *Environmental Research in Australia*\*, and

<sup>\*</sup> To be tabled In Parliament during the Budget Session

• Government funding of academic and related research in Australia: an international comparison (produced in collaboration with the Office of the Chief Scientist)\*

Other published Government reports and documents dealing with science and technology issues, or having implications for future directions in science and technology, included:

- Prime Minister's Science Council, Global Climate Change Issues for Australia
- Prime Minister's Science Council, *Resources for Science and Technology and their Utilisation*
- Bureau of Industry Economics, *Commercial opportunities from public sector research* (Research Report 32)
- Australian Manufacturing Council's *The Global Challenge*, *Australian Manufacturing in the 1990s*
- Prime Minister, *Écologically Sustainable Development, A Common Discussion Paper*
- Australian Research Council statement on *The Matter of Research Priorities*
- Reports prepared by the Centre for Technology and Social Change (University of Wollongong) for the Department of Industry, Technology and Commerce, *Strategic Alliances in the Internationalisation of Australian Industry* and *Technology Strategies in Australian Industry*

# SECTION 3: BUDGET ALLOCATIONS AND PORTFOLIO ACHIEVEMENTS

# Introduction

This Section presents selected Information on science and technology arranged by ministerial portfolio. For each portfolio there is a brief summary of pertinent allocations for the 1990-91 Budget compared with the expenditure outcome for 1989-90. The financial summary for the portfolio is followed by an account of recent research outcomes arranged by program or agency.

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

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

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

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

# Figure 1

### MAIN CHANNELS OF ADVICE FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY



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

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

**Figure 2** FLOW OF FUNDING SUPPORT FOR R&D



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

# **ADMINISTRATIVE SERVICES**

# Science and Technology in the Portfolio Budget

This portfolio includes two organisations providing scientific services: the Australian Government Analytical Laboratories and the Ionospheric Prediction Service. In 1990-91 the total support for these organisations comprises \$19 million out of a portfolio budget of \$921 million. The Bureau of Meteorology has been transferred to the Arts, Sport, Environment, Tourism and Territories portfolio from 1 July 1990.

The Australian Government Analytical Laboratories are now operating under a Trust Account for their commercial activities with budget funding of \$16.5 million in 1990-91, down from a total Appropriation of \$13.6 million in 1989-90.

The Ionospheric Prediction Service will remain fully budget funded in 1990-91 at \$2.4 million.

# MAJOR RESEARCH ACTIVITIES

# **Ionospheric Prediction Service (IPS)**

## Role

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

# Recent Achievements

#### **Advanced Stand Alone Prediction Service**

The IPS Advanced Stand Alone Prediction Service (ASAPS) was successfully released. This is a major upgrade on the earlier IPS Stand Alone Prediction Service and incorporates field strength information. Several IPS clients have purchased ASAPS.

#### **Coronal Hole Study**

Recent studies of coronal hole statistics have revealed an unexpected periodicity in coronal holes in the sun's southern hemisphere. This work may improve medium term solar predictions and could have implications for solar modelling.

# 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 Antarctic Division, the Australian Sports Commission, the Bureau of Meteorology, the Australian National Parks and Wildlife Service, the Great Barrier Reef Marine Park Authority, the Office of the Supervising Scientist and the Greenhouse research program. The portfolio also has a role in science and technology awareness through the National Science and Technology Centre's programs.

The Antarctic Division has been given a 1990-91 budget allocation of \$62.7 million (\$57.7 million in 1989-90). Australia's new Antarctic research and supply vessel, *Aurora Australis*, undertook its maiden research voyage in 1990 in waters surrounding Heard Island.

The Australian Sports Commission has been allocated \$0.6 million for research in the 1990-91 budget. \$0.3 million has been allocated to the Australian Institute of Sport for applied research and \$0.3 million to the National Sports Research Program.

The Australian National Parks and Wildlife Service will receive \$39.1 million in 1990-91 (\$35.7 million in 1989-90), including funding for the Australian Biological Resources Study and other programs. The Great Barrier Reef Marine Park Authority will receive \$10.0 million and the Office of the Supervising Scientist will receive \$6.6 million (\$7.3 million in 1989-90).

Other major research activities being funded through this portfolio include greenhouse effect research. The Government has committed \$5.7m for each of the next three years for greenhouse research. Part of the research includes the development of a global climate model for studies of climate changes associated with an enhanced greenhouse effect by the Bureau of Meteorology.

The budget allocation for the Bureau of Meteorology is \$128.3 million for 1990-91 (\$118.1 million in 1989-90). About \$3.4 million will be directed to research activities, including funding of \$0.6 million for additional studies relating to the Government's Greenhouse Effect research strategy.

# 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 science support facilities under these programs. It also administers research grants under the Antarctic Science Advisory Committee (ASAC) research grants scheme.

# **Recent Achievements**

### **Research Ship Facilities**

Australia's new, state-of-the-art, Antarctic research and resupply vessel *Aurora Australis was* delivered in March 1990 and undertook a successful, maiden research voyage to the waters surrounding Heard Island, following acceptance trials off Tasmania. In addition to a survey of demersal fishes on the shelf around the island, a number of other marine research activities were undertaken, including oceanographic sampling by the CSIRO as part of their global warming experiments.

#### **Other Antarctic Activities**

Continuing work on the Antarctic Continent and Southern Ocean included:

• a range of geological studies of the East Antarctic shield undertaken in the Northern Prince Mountains

- an ice core drilling program at Law Dome, inland from Casey the cores obtained will provide insights into changes in the world's climate over the last 10,000-15,000 years
- studies of the gas dimethylsulphide recent research suggests it acts as an 'anti-greenhouse' gas in that it quickly oxidises in the atmosphere and increases cloud reflection of solar radiation.

# **Bureau of Meteorology Research Centre (BMRC)**

# Role

The Bureau of Meteorology Research Centre 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**

### **Short-range Weather Prediction**

The BMRC regional data assimilation and weather prediction system became operational in October 1989. The system assimilates conventional and satellite data on a 6-hour cycle and produces predictions for the Australian region out to 36 hours ahead. Research versions of the system are being developed for application in the tropics and Antarctica.

#### **Medium-range Weather Prediction**

The BMRC global data assimilation and weather prediction system was implemented routinely in July 1989 on the Bureau's ETA10 supercomputer. The system produces global weather predictions out to 5 days ahead, and its performance is consistently better than that of the present operational system.

### Climate

An empirical study of the relationship between Australian rainfall and the global distribution of sea-surface temperature has been completed. It shows that three major patterns in surface temperature in the Pacific Ocean, Indian Ocean and Tasman Sea influence the seasonal rainfall across Australia.

#### **Greenhouse Modelling**

As part of the core of the national greenhouse research program, the BMRC global climate model Is being developed for studies of climate changes associated with an enhanced greenhouse effect. Initial results have been obtained for a doubled concentration of carbon dioxide with the atmospheric model coupled to a simple ocean model. The atmospheric model has also been involved in an international intercomparison of climate models, sponsored by the USA Department of Energy, to identify the sources of uncertainty in climate models.

#### **Baseline Air Pollution Studies**

The data collected at Cape Grim over the last 13 years now comprise a high quality record of changes in atmospheric composition and show a continuing increase in the concentrations of carbon dioxide, methane and chlorofluorocarbons in the atmosphere.

# **Great Barrier Reef Marine Park Authority (GBRMPA)**

## Role

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

The Authority's research program covers a wide range of disciplines including marine biology, and the physical, chemical and social sciences. Many of these projects are multi-disciplinary to provide a broad appreciation of particular phenomena, sites or issues.

# **Recent Achievements**

#### **Crown-of-Thorns Starfish**

1989-90 was the beginning of a new three year program of investigation into the crown-of-thorns starfish and their impacts on the Great Barrier Reef. In August 1989, the Government guaranteed \$750,000 for 1989-90 rising to \$1 million per annum for each of 1990-91 and 1991-92, subject to a review of the program for 1991-92. A total of 31 projects were funded.

In May 1990, a workshop entitled "A Geological perspective on the *Acanthaster* Phenomenon" was convened to discuss the interpretation of the geological evidence for past outbreaks. The geological evidence is particularly important because of its potential role in indicating whether outbreaks are the result of human influences.

#### **Torres Strait Baseline Study**

In July 1989, the Prime Minister announced in the environment statement Our *Country, Our Future,* that the Government would fund a four year environment study of the Torres Strait. The GBRMPA is supervising the study, which was instigated in response to concerns expressed by Torres Strait islanders as well as commercial fishing interests about the possible effects on the Torres Strait environment of current and proposed mining operations in Papua New Guinea and northern Australia.

# **Greenhouse Effect Research**

## Role

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

# **Recent Initiatives**

#### National Greenhouse Advisory Committee

The National Greenhouse Advisory Committee was formed in August 1989 to provide expert scientific advice to Government generally and, in particular, to advise on priority areas for further greenhouse research, overview the core research and set objectives for a dedicated research grants scheme. The Committee also has the role of promoting public understanding of greenhouse issues.

The National Greenhouse Advisory Committee allocated funds to the following greenhouse related conferences and workshops in 1989-90:

- ANZAAS 59th Conference, focusing on 'Global Change and the Southwest Pacific', and the publication of workshop proceedings;
- Bureau of Meteorology managed workshop for Australian Scientists to assess the Intergovernmental Panel on Climate Change, Working Group 1 recommendations; and
- Bureau of Meteorology Research Centre for its Workshop on the Climate Record of the Southern Hemisphere.

#### **Greenhouse Research Funding**

In April 1989 the Government provided \$7.8 million for research and policy support for 1988-89 and 1989-90. In May 1990, the Government committed a further \$5.7 million for each of the next three years for greenhouse research. This will include the continued funding of a Core Research Program, the commencement of the Dedicated Research Grants Scheme and participation in international greenhouse research.

#### **Core Research Program**

The Commonwealth Government has provided \$3.5 million for continuation of core research on monitoring of greenhouse induced climate change. This research is being undertaken through the agency of the CSIRO, Bureau of Meteorology and the Department of Defence's Permanent Committee on Tides and Mean Sea Level.

#### **Dedicated Greenhouse Research Grants Scheme**

The Government has provided \$1.5 million to establish a national research grants scheme to complement existing greenhouse research, by focusing on research that is ineligible for funding from either the core research or other existing grant schemes.

#### **Other Research**

Funding has been provided to enable Australia to contribute towards the World Climate Impact Studies Program being undertaken by the United Nations Environment Program, the Academy of Science to assist with the International Geosphere-Biosphere Program and the World Meteorological Organisation'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**

#### **Rehabilitation Goals for Ranger Project Area**

Agreement has been reached with the Northern Territory on the broad rehabilitation goal and objectives for the Ranger Project Area. The NT Minister for Mines and Energy has advised the Commonwealth Minister for Primary Industries and Energy that the proposed Commonwealth/NT Goal and Objectives are acceptable. These were developed by OSS in consultation with the Northern Land Council, other Commonwealth agencies and the Northern Territory.

#### **Biological Monitoring**

The Institute has, for the past several years, been in the process of establishing a biological monitoring system, developed from baseline studies of aquatic macroinvertebrates and fish, for the South Alligator River. The sensitivity of the monitoring technique is greatly enhanced if it is possible to distinguish between and recognise the different species of macroinvertebrates. To this end taxonomic studies on four prominent elements of stream benthic macroinvertebrates of the South Alligator River have been carried out and taxonomic keys developed to enable identification of the macroinvertebrates to species level. In the process of developing the key many previously unknown species were found.

#### **Toxicant Identification**

Biological toxicity tests by the Institute have established that during the Wet season, the waters of Retention Pond 4 at the Ranger Uranium Mine become toxic and a program of experiments has been established to enable identification of the dominant toxicant. Extraction experiments carried out so far indicate that the toxicant is a polar organic compound. Further experiments are planned so that the exact identity of the toxic compound may be determined.

# Australian National Parks and Wildlife Service (ANPWS)

## Role

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

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

## **Recent Achievements**

#### Australian Biological Resources Study (ABRS)

The role of the ABRS is to identify and describe Australia's biodiversity through both grants for research and a publications program of high quality. Fifty-seven new grants were awarded under this program during 1989-90. There were 93 scientific books and papers published in which ABRS support was acknowledged for the work achieved. Volume 18 of the Flora of Australia was published and work was completed on the Census of Australian Plants, a complete list of all vascular plant species described from Australia.

#### **Australian National Botanic Gardens**

The in-house database system has been installed and data from 35,000 herbarium specimens have been entered. Sophisticated computer techniques are now being used to establish phylogenetic relationships in various plant genera. A checklist of Australian orchids has been

published and 38 new species of orchids have been described. Major field work on orchids near Australia has been conducted to resolve systematic and evolutionary problems in Australian species. Techniques have been developed for isoenzyme analysis of plant populations.

### **Endangered Species**

The Prime Minister announced in July 1989 a commitment of \$2 million for each of the first two years of a ten year Endangered Species Program. Eighty-two projects directed at research/management of endangered species were funded in 1989-90, including a study of fox control.

# **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 1990-91 comprises \$132 million out of a total portfolio budget of \$14 236 million.

Medical and public health research funding through the NH&MRC increases to \$94.7 million in 1990-91, (\$83.0 million in 1989-90). The AIDS research program has increased to \$7.1 million in 1990-91 (\$5.0 million in 1989-90). AIDS research is also funded through the NH&MRC. Health research funding has increased to \$2.1 million (\$1.7 million in 1989-90).

The Australian Institute of Health operating appropriation has reduced to \$4.2 million (\$4.4 million in 1989-90). The Commonwealth Serum Laboratories will receive \$34.9 million (\$18.4 million in 1989-90) including \$30.0 million for the building of a blood fractionation plant which will ensure the continued supply of therapeutic blood products to the Australian community. The National Acoustic Laboratories' administrative expenses are currently estimated at \$2.3 million in 1989-90).

A new five year program for funding capital works in Medical Research Institutes is to be introduced. This initiative of \$45 million over the period is in response to a large number of requests from medical research institutes over the last year. Funds of \$10 million for 1991 will be allocated following expert assessment. Funding will be highly competitive and restricted to formally constituted medical research institutes which can demonstrate the capacity to contribute to the advancement of medical science.

# MAJOR RESEARCH ACTIVITIES

# Australian Institute of Health (AIH)

Role

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

# **Recent Achievements**

#### **Assessment Activities**

At the request of the Australian Health Minister's Advisory Council, the AIH screening Evaluation Coordination Unit coordinated national evaluations of breast and cervical cancer screening pilot projects and provided technical support for the AHMAC working parties in the development of policy options for the national screening programs.

#### **Gallstone Lithotripsy**

Introduction of a new therapeutic technology, biliary lithotripsy, into Australia is being assisted through a controlled study on the costs and efficacy of this non-invasive technique for removing gallstones. The Australian Institute of Health is assisting with development of protocols and economic analysis.

#### Assessment of Technologies for Assisting the Disabled

Some recent studies have considered the effectiveness and costs of methods for the treatment of people with certain disabilities. These include reports on: the use of dynamometry, a technique for diagnosis and rehabilitation of persons with low back pain; guidelines for acute spinal cord injury services; and the use of tinted lenses in the treatment of the reading disabled. These studies have provided information on approaches to assisting large groups of disabled persons whose difficulties lead to major costs both to the individuals concerned and to society.

# **Commonwealth AIDS Research Grants Program**

# Role

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

# **Recent Achievements**

## **Diagnosis of AIDS Dementia Complex**

Researchers in Melbourne, using the technique of eye movement recording, have developed sensitive methods for assessing the severity of AIDS Dementia and for qualitatively following its progression and response to treatment.

#### **Development of Antiviral Drugs**

Another group of researchers in Melbourne have succeeded in designing and synthesising new compounds with demonstrated activity against HIV. These compounds may lead to the development of new drugs for the treatment of AIDS.

### Vaccine Development

Research conducted at the Australian National University has resulted in the development of recombinant vaccine viruses expressing HIV genes in association with interleukin 2. These viruses have potential for the development of a safe AIDS vaccine.

# **Commonwealth Serum Laboratories (CSL)**

# Role

To be Australia'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 to enhance the overall profitability of the business.
# **Recent Achievements**

#### Malaria

The malaria joint venture Sarmane, has identified three antigens which are proposed vaccine candidates against sporozoite stage of malaria. These antigens are being produced as recombinant proteins and CSL is collaborating in producing these substances for clinical trial. The clinical trial will be managed by a new partner in the project, Roche Pharmaceuticals.

#### **Protein** C

New processes have been developed which allow CSL to isolate Protein C from blood fractions. This process is currently being scaled up to produce product for clinical use. Protein C is an accessory factor in blood coagulation and will be used in patients with genetically determined deficiencies or defects in blood clotting.

#### **Veterinary Diagnostics**

A range of veterinary diagnostics has been developed to facilitate the screening of Australian farm herds for tuberculosis and Johne's disease (paratuberculosis). These tests will enable these diseases to be controlled or removed from the animal population, and now are attracting international interest. Significant export sales are expected.

# 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**

#### Cost Effectiveness of the Cholesterol Check Campaign

This cost-benefit study developed a methodology to determine the direct health benefits resulting from a change in distribution of cardiovascular risk levels. This approach to cost-benefit analysis can be applied to a broad range of health care strategies, both curative and preventative. The methodology was applied to results of the 1987 North Coast Cholesterol Check Campaign. The cost benefit results indicate that community-based screening with brief dietary counselling, referral and follow-up, represents an appropriate use of the community's health dollar. The strategy achieved a significant reduction in a lifestyle risk factor which is known to be a major contributor to high rates of morbidity and mortality.

#### **Primary Medical Care in Community Health Centres**

Four areas of health service functioning in community health centres were examined to identify factors inhibiting and enhancing the development of primary health care. The study confirmed that primary medical care within community health centres represents a viable, alternative model of general practice in Australia.

#### The Nexus Between Child Poverty and Child Health

This study has developed a set of health service and health (including health deficit) indicators for children living in poverty. It has provided a number of recommendations in the context of a social justice strategy.

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

## **Recent Achievements**

#### **Prevention of Osteoporosis**

Bone Fracture following minimal trauma is a serious debilitating problem that affects 26 percent of Australian women at some point in their life. Bone is lost after menopause and there is much evidence that this thinning of bone is related to increased risk of fracture. Researchers in Western Australia have carried out a two year study of the effects of various treatments on bone density and have shown that two approaches to osteoporosis prevention, hormone replacement therapy (HRT) and the lifestyle approach are effective in preventing bone loss. HRT is more effective but has more side effects.

#### **Treatment of Cystic Fibrosis**

Cystic Fibrosis (CF) is an inherited disease affecting one in 2500 live births and characterised by thick secretions in the lungs, pancreas and gut. Up to 40 percent of CF patients develop liver disease (focal biliary cirrhosis) and are at risk from portal hypertension and liver failure. Researchers at the Children's Hospital, Camperdown have determined that the presence of liver disease is associated with a distal common bile duct stricture which potentially is a correctable lesion.

#### **Genetic Markers for Multiple Sclerosis**

Multiple sclerosis (MS) is an inflammatory disease of the central nervous system characterised by myelin destruction, which attacks mostly young adults causing severe disturbance to motor and sensory functions. While the cause remains unknown, pathological, epidemiological and immunological considerations point to MS as a disease of immune origin. As part of their effort to evaluate the complex interplay between immune responsiveness, genetics and infection in the cause of MS, researchers at La Trobe University, have uncovered new genetic markers which correlate with the susceptibility to this disease and have identified an important new pathway by which myelin degradation can occur in MS.

# DEFENCE

# Science and Technology in the Portfolio Budget

The Budget allocation for the Defence Science and Technology Organisation (DSTO) will be \$211.2 million in 1990-91, (\$214.6 million in 1989-90). The Defence Industry Development Program is to receive \$14.2 million in 1990-91 (\$8.7 million in 1989-90)

# MAJOR RESEARCH ACTIVITIES

## **Defence Science and Technology Organisation**

## Role

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

# **Recent Achievements**

#### **Over-the-horizon Radar (OTHR)**

DSTO has provided significant technical assistance on the OTHR site selection and technical evaluation of tenders for the operational radar network. Research to enhance radar target identification and classification is continuing and an enhanced radar freqency management system developed by DSTO has been installed at the experimental OTHR facility near Alice Springs.

#### **Anzac Ship**

The project is a joint venture with New Zealand to build up to twelve surface combatants in Australia. DSTO has provided diverse support for the Anzac ship project including background research and advice on specialised steels and welding techniques for the hull, ship vulnerability estimation, radar selection, and specification of the electronic surveillance, sonar and weapons systems.

#### **Collins Class Submarine**

Support for hull construction, communications, and weapon and sensor systems has been provided for the new submarine project, and research is continuing into more advanced periscope systems, sound-absorbent hull coatings, and air-independent propulsion.

#### Mine Countermeasures

DSTO analysis of data from the shock trials of the Bay Class Minehunter has confirmed that its structural specifications have been met. Portable magnetic/acoustic range technologies developed in DSTO have been demonstrated and the costs and operational benefits quantified. Research into minehunting sonars suitable for use in Australian conditions will continue.

#### **Fighter Aircraft Structural Testing**

Testing equipment has been installed and full-scale fatigue testing of components of the F/A-18 fighter aircraft has commenced in DSTO as part of a collaborative investigation with the Canadian Government. This will facilitate more accurate assessment of the expected service life of the aircraft when operating in Australian conditions and help ensure maximum return from the \$5 billion invested in the aircraft.

#### **Personnel Protection**

Recent developments in DSTO include an insensitive explosive filling to increase safety in the storage and carriage of shells and bombs, an alternative alloy that reduces the cost of protective armour for use in ships and tanks, and a new method of treating clothes with insect repellent which has been proven effective in tropical conditions as part of the Army's anti-malaria measures.

#### **Collaborative Research**

Apart from extensive collaboration with overseas defence research organisations, DSTO spent \$899 000 during the year on collaborative research in Australian universities, and has formal collaborative research agreements with CSIRO and Telecom. A number of research areas have been selected as possible topics for development under the Government's recent Cooperative Research Centre initiative.

#### **Commercial Activities**

DSTO has an active program to commercialise some of its innovations, and around 30 commercial licences resulting from DSTO research are in place. These cover development, production and marketing of equipment and systems of civil as well as defence significance.

A number of joint ventures are also being negotiated. DSTO has signed a substantial contract with a US firm to develop and supply a specialised signal processing chip, and has awarded a market development contract to an Australian company to exploit a marine dye marker system recently developed by DSTO.

# **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 and are paid to institutions through the *Higher Education Funding Act*. The research component of these grants cannot be determined with precision but stands in the region of \$815 million. Of this about \$ 155 million is spent by institutions directly on research activities and includes funding for the Institute of Advanced Studies at the Australian National University. The major part of these funds, estimated at about \$660 million for 1990-91, comprises the estimated research component of general university funding provided for both teaching and research in the universities. Further details on these estimates is provided in footnotes to Table 5 in SECTION 4.

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, postgraduate awards, Special Research Centres, Key Centres for Teaching and Research, and Assistance to Technological Institutions and also on the new program of additional research infrastructure funding for higher education institutions which was outlined in the policy statement *Science and Technology for Australia* in May 1989. In 1990-91 the ARC'S funding for grants and fellowships has notionally been set at \$84.8 million compared with \$68.8 million in 1989-90. Funding for centres, assistance to technological institutions and research infrastructure are estimated to amount to \$51.2 million in 1990-91 compared to \$29.2 million in 1989-90. Funding for postgraduate awards is estimated at \$39.5 million in 1990-91 compared with \$30.4 million in 1989-90.

Funds are also provided under the portfolio for the Overseas Postgraduate Research Awards Scheme from 1 January 1990 to support overseas postgraduate students. Funding for this scheme in 1990-91 is estimated at \$2.7 million. A further \$5.1 million is available for expenditure under this program. Subject to the final negotiation of international agreements this expenditure may be spread over a two year period. Funds are also provided to the Anglo-Australian Telescope Board (AATB) to support its operations. In 1990-91, the AATB will receive \$2.9 million, up from \$2.7 million in 1989-90.

New initiatives were announced by the Government in the document *Research for Australia: Higher Education's Contribution*. These include the provision of \$144.4 million of new resources for research support and training in higher education over the 1990-92 triennium. \$110.6 million of this will be provided to improve infrastructure resources for high quality research. The remainder of the new resources has been used to enhance the Postgraduate Awards scheme.

ARC expenditure on research grants has increased to \$66.4 million in 1990. These expanded resources enabled 2,379 high quality research projects to be funded. Thirteen new Special Research Centres will be established in 1990 with funding for that year of \$8.2 million.

Support for postgraduate research students, now known as the Australian Postgraduate Research Awards (APRA) scheme, has been revised and expanded. 900 new awards were available compared with 745 in 1990. These are predominantly for full-time study but a small proportion of this quota can be converted to 30 part-time awards for candidates who are unable to study full-time for reasons such as family circumstances. The 1989 taxable stipend of \$10 415 has been increased to the range of \$12 734 to \$16 433 and made non-taxable. Funding was also provided for 60 Australian Postgraduate Research Awards (Industry), which are intended to improve links between higher education and industry in postgraduate training. From 1991 the number of awards will rise to 1,100 of which 100 will be APRA (Industry) awards. The Australian Research Fellowships scheme has also been revised and expanded. Five different types and levels of fellowship will be offered from 1991 and, subject to the competitive process, it will be possible for fellows to progress through each of the levels. The fellowships will range from postdoctoral level to senior research fellow. In 1990 fifty new Australian Postdoctoral Research Fellowships (formerly ARC Fellowships) and fifteen Queen Elizabeth II Awards were offered. Australian Research Fellowships (Industry) have also been made available from 1990 to enable academics to work for between three and twelve months on at least a half-time basis in an industrial or commercial environment. The objective of this program is to improve the level and quality of collaboration in research and development between industry, commerce and higher education institutions.

The research infrastructure program has been implemented with new funds (\$25.7 million in 1990, \$38.6 million in 1991 and \$46.3 million in 1992) providing block grants to the pre-1987 universities and infrastructure development grants to the former advanced education institutions. Also funded was AARNet, an important computer-based communications network providing services to the Australian research and academic community. AARNet was set up to assist Australian scholars and researchers to communicate more effectively using leading edge communications technology.

# 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/or the advancement of scientific knowledge.

## **Recent Achievements**

#### **Unveiling Venus**

The dense cloud banks of Venus prevent a view of the planet's surface. The uppermost reflects back sunlight so effectively that we cannot see anything below it on the sunlit side of the planet. Using a technique discovered at the AAT, studies of the planet's lower atmosphere and meteorology have continued. Such studies should eventually lead to improved weather forecasting on Earth.

#### Sextans Dwarf Galaxy

A new companion galaxy to our own was discovered this year from photographs taken by the Schmidt Telescope. Known as the Sextans dwarf spheroidal galaxy, this small star cloud is the eighth of its kind found, increasing the sample for a number of observational programs.

#### **Two Degree Field Project**

Preparation for this project has been underway for several years, and it will be the major instrumentation project for the Observatory over the next four years. The new instrument will give the AAT a wide-angled field of view that is unique among such telescopes. Optical fibres across the two degree field will enable astronomers to observe several hundred stars or galaxies simultaneously, increasing the rate at which they can explore the universe. Equipped with this wide field, the AAT will open up new avenues of astronomical research, and promises to yield fundamental answers on the nature and origin of the universe, as well as on the structure of our own Milky Way Galaxy.

# The Australian Research Council (ARC)

## 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 programs include:

- research grants to support the ideas of the best researchers
- research scholarships to enable the most gifted graduates to undertake research at Doctoral or Masters level
- research fellowships, for the most gifted researchers from postdoctoral to professorial level
- research centre funding to build a concentration of research activity around Australia's best researchers and their projects
- key centre funding to build on existing teaching and research capabilities.

In 1990 the ARC funded almost 2,400 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**

#### **Minerals Processing Boost**

Froth flotation, widely used to separate valuable minerals from associated waste, is an essential part of processing copper, lead, zinc and nickel ores, and other minerals, as well as coal. A new flotation device invented at Newcastle University will lead to significant savings in capital and running costs. World-wide patents have been applied for and an exclusive licence has been granted to a major Australian company to develop and market the machine in Australia and overseas. An ARC grant will allow the invention to be further developed at Newcastle University. The project will greatly assist Australian minerals processing industries to adopt the new technology and so boost their international competitiveness and also the saleability of the technology overseas.

#### **Molecules in Space**

This work by a team from Monash University is in the forefront of research on the structure and vibrational behaviour of small molecules and their extraterrestrial chemistry. The work has been responsible for detecting new small molecules, many of which have interesting properties or are of astrophysical interest because they may occur in other parts of the Milky Way galaxy. This information is vital for the extension of knowledge of interstellar molecules in radioastronomical studies.

#### **Zircon Dating**

The work of agroup at the Australian National University has given Australia a clear lead in developing a highly accurate ion microprobe. This instrument measures uranium/lead ratios in the mineral zircon which enables the geological ages of rocks to be determined. The main capability of the instrument over other techniques is that the size of the area being analysed is very small, so much so that different parts of individual crystals can be analysed accurately. Thus the geological history of individual zircon crystals can be determined, rather than mixing information from many crystals, as other techniques do.

# INDUSTRY, TECHNOLOGY AND COMMERCE

# Science and Technology in the Portfolio Budget

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

There are also a number of agencies and programs supporting technological development in industry through the provision of grants, concessions and services. The Industry Research and Development (IR&D) Board which includes both industry and government representatives is concerned with promoting the development, and improving the efficiency and international competitiveness of Australian industry by encouraging research and development activities. The IR&D Board has responsibility for administration of the 150 percent tax concession, the Discretionary Grants Scheme, the Generic Technology Grants Scheme and the National Procurement Development Program.

Grants or incentives to industry include:

- Grants for Industry Research and Development (GIRD): Generic Technology Grants. These grants provide support for research and development in nominated areas of generic technology which are important for the international competitiveness of Australian industry into the 1990s.
- *Grants for Industry Research and Development: Discretionary Grants.* These grants provide support to companies which have insufficient taxation liability to obtain adequate benefit from the 150% tax concession for research and development but have the potential to fully exploit the results of their research and development projects.
- 150 per cent tax concession for industrial research and development,
- *Management Investment Companies (MIC) Program.* The MIC program operates to increase the availability of venture capital for new, high-growth, export oriented firms using innovative technology. It is to expire 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,
- The National Teaching Company Program creates links between public sector research institutions and companies in the manufacturing and service sectors by providing the opportunity for graduates to work on research projects jointly supervised by participating institutions and companies.

Services to industry and community include:

- *The National Industry Extension Service (NIES)* provides extension services to small to medium-sized firms to increase internal efficiency,
- *The Vendor Qualification Scheme (VQS)* aims to develop a pool of Australian firms with the relevant international qualifications to supply firms in the Partnerships for Developments Program,
- *The Patent, Trade Marks and Designs Offices* provide industrial property rights services. The office operates on full cost recovery,
- *The Science and Technology Awareness Program* aims to raise the profile of Australian science and technology in the community and internationally,
- *Policy advice* for the establishment and delivery of Government services in science and technology is provided through the Science and Technology Policy Branch, the Industry Policy Branch and parts of the International and other Divisions of the Department of Industry, Technology and Commerce,
- *The National Space Program* promotes the growth of commercially viable industries based on space technologies and encourages greater involvement by industry in space R&D,
- The Marine Science and Technology Program aims to align marine R&D more closely with industry requirements and to play a key role in international co-operation in marine science and technology. Closer links between the marine industry, government and research agencies are beingen developed through the Consultative Group on Marine Industries Science and Technology (C-MIST) and the Oceans Australia conference series,
- *The Commission for the Future* aims to raise community awareness and understanding of the future social and economic impacts of scientific and technological changes.

Joint involvement between government and industry includes:

• *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.

Program or agency		Budget expenditure 1989-90 \$m	Budget estimate 1990-91 \$m
AIMS		11.4	13.6
ANSTO		57.5	60.4
CSIRO		375.7	407.0
GIRD	-Generic	16.4	15.9
	-Discretionary	15.7	15.9
NPDP		5.6	7.5
MVCDGS		8.3	7.5
Computer Bounty		45.0	47.2
ABRGS		0.3	0.3
NIES	-Commonwealth	5.6	5.0
	-States	8.8	10.5
VQS		2.1	1.3
National Space Program		2.4	6.2
Marine Science & Technology.		0.5	0.5
Tech Development Program		1.9	3.0
MVJV		0.8	2.6
International Collaborative Prog		am 4.1	5.0
TOTAL		562.1	609.4
PORTFOLIO TOTAL		1286.4	1403.7

Budget support for these programs is shown below.

It should be noted that the Patent, Trade Marks and Designs Offices are not included in the above figures as they operate on full cost recovery. Estimated nett revenue of the Offices for 1990-91 is \$4.4 million (\$6.5 million in 1989-90).

# 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 with similar interests.

## **Recent Achievements**

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

Having discovered naturally occurring chemicals in corals that protect against the harmful effects of ultra-violet light, AIMS researchers have collaborated with ICI Australia in the development of industrial and human UV blockers. The preferred chemical is now in advanced testing for commercial sunscreen application.

#### Explanation of stability of offshore fisheries

Study of the complex ecology of mangrove ecosystems together with the movement of waters in coastal streams and nearshore areas, has resulted in a scientific explanation of the location and stability of offshore fisheries of significant commercial potential, for example, the sports and recreational fishery for billfish (marlin and sailfish) near Cape Bowling Green and other fisheries near Dunk Island and north of Cairns. The methodology of AIMS research on stock recruitment and on interannual variations in replenishment of tropical fisheries, has potential application to the understanding of early life histories of fish in all regions.

#### **Prawn mariculture**

AIMS has established a hatchery and maturation facility for Penaeid prawns, initially concentrating on Penaeus monodon, the giant leader prawn and the species most farmed in tropical Australia. The Institute has concentrated on developing breeding programs to give prawn stock of known genetic characteristics, working closely with northern Australian commercial prawn farmers in providing information and in collaboration in trials of different strains of prawn post-larvae for growth characteristics under different farming conditions.

# 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**

#### Waste conditioning

Synroc is an Australian innovation to immobilise radioactive waste in a specially designed synthetic rock. It mimics naturally occurring 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 successfully processed 4.8 tonnes.

Four major Australian companies (BHP, CRA, ERA and WMC) have agreed to join ANSTO and the Australian National University in investigating the international commercial opportunities for Synroc in nuclear waste management. The agreement covering the current phase of the study involves no technology transfer from ANSTO or ANU to the companies.

The cooperative Synroc program with the Japan Atomic Energy Research Institute (JAERI) has been extended for a further five years.

#### **Extraction of Rare Earth Minerals**

ANSTO was awarded a major contract by Carr Boyd Minerals to carry out laboratory testwork to define the process flowsheet for the Mt Weld rare earth deposit near Laverton in Western Australia. The work involves detailed studies of rare earth extraction, purification, environmental impact and chemical engineering aspects of the process.

There are many similarities between the processes for extraction of uranium and rare earths. This has facilitated technology transfer from ANSTO to meet the renewed interest in rare earth processing in Australia.

#### **Industrial use of Radioisotopes**

A joint venture, Tracerco Australasia, was established to service Australia's manufacturing, processing and chemical industries. ICI Australia Ltd is ANSTO's partner in this venture which will carry out on-site measurements on industrial plants using stable and radioisotope tracers and instruments containing radioactive sources.

#### New radiopharmaceuticals

An important objective of ANSTO's biomedicine and health research is provision of support to its subsidiary, Australian Radioisotopes (ARI), the nation's sole producer of radioisotopes and radiopharmaceuticals.

During the year new products were successfully transferred to ARI for general use. Clinical assessment has started on a new internationally patented method of therapy of swollen joints in patients suffering from chronic rheumatoid arthritis. Clinical assessment is also about to start on a radiolabelled antibody for the detection of blood clots. This product has been developed in collaboration with the Department of Nuclear Medicine, Royal Prince Alfred Hospital, Sydney and the Clinical Immunology Research Centre, University of Sydney. The industrial collaborator is AGEN Biomedical Pty Ltd of Brisbane.

# 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**

#### Space Industry Development Centres (SIDC)

The SIDC Program has been established as an R&D facilitation program aimed at bringing together industry and university researchers (including institutes of technology) to undertake market driven R&D for space related goods and services. There are two elements of fundamental importance to the SIDC concept. Firstly, a high level of private sector commitment to the establishment of the Centres, including support through direct funding, and secondly, a focus on research and product development targeted at identified market opportunities. Funding provided under the program consists of up to \$500 000 per financial year for each of up to four Centres over a three to five year period. Funding by the Australian Space Office is to be matched on a dollar for dollar basis by the SIDC participants. The first two Centres established under the scheme were announced in July 1990.

#### **Tasmanian Earth Resources Satellite Station (TERSS)**

The University of Tasmania and the CSIRO Division of Oceanography have received in principle support from the Australian Space Board for funding of up to \$1 millionO to establish a satellite ground station, TERSS, in Hobart. The station will complement the Australian Centre for Remote Sensing's Alice Springs station. The satellite of most immediate interest is the European ERS-1 which is due to be launched in 1991. From a scientific standpoint the data from ERS-1 will lead to a better understanding of the complex interactions between ocean and atmosphere that drive the world's climate. It will also provide useful information on fishing, commercial shipping and oil rigs, and Antarctic operations.

#### **ASEAN Remote Sensing Projects**

The Australian Space Office has provided funding for three remote sensing projects to be conducted in the ASEAN region. Such funding recognises that Australia's immediate international market opportunities in remote sensing lie in the Asia-Pacific market and that penetration of this market is important in further developing Australia's capabilities. Each of the projects is consequently intended to demonstrate Australia's expertise in a particular area of remote sensing. The total amount allocated to the three projects is \$275 000.

#### Radioastron

A low noise L-band amplifier is being developed and manufactured for the Soviet radioastronomy satellite Radioastron. The satellite will be injected into a very high apogee orbit above the earth in November 1993. It will carry a radiotelescope which, in conjunction with ground-based radiotelescopes, will make observations of radio sources in space through the use of very long baseline interferometry (VLBI). Australian involvement in the project is jointly funded by the Australian Space Office and the CSIRO.

## **Commonwealth Scientific and Industrial Research Organisation** (CSIRO)

## Role

The main role of CSIRO is to carry out research which can be applied by Australian industry, or by government, for the well being of the Australian people. Applications of CSIRO's research cover:

- the development of new technologies to improve the efficiency and the international competitiveness of all sectors of industry,
- *improvements to the management of natural resources, and*
- better ways to protect Australia's unique environment.

While CSIRO is funded primarily by direct appropriations from the Commonwealth, an increasing proportion of the Organisation's funds come from collaborative ventures with industry or from granting schemes jointly funded by industry and government. In 1990-91, it is estimated that more than \$122 million of CSIRO's \$558 million budget will come from these external sources.

The research work of the Organisation is carried out or supported by some 7 000 staff members across Australia. This work is primarily organised into six research Institutes targeting specific national objectives in support of industry or the community interest.

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

## **Recent Achievements**

#### **Developments in Immunospaying of Cattle**

An immunospaying vaccine was previously developed by the CSIRO Divisions of Animal Production and Tropical Animal Production in collaboration with an industry consortium formed by Peptide Technology Ltd and Arthur Webster Pty Ltd. It has now been granted provisional registration for use in Queensland and the Northern Territory for preventing pregnancy in female cattle designed for slaughter. The vaccine, marketed as "Vaxstrate", is the world's first anti-fertility vaccine for livestock. Vaxstrate addresses industry concerns about the use of surgical spaying, which causes trauma and production losses. It has been welcomed by cattle producers and animal welfare groups alike.

#### **New Cattle Breeds**

A joint venture between CSIRO and Australian beef producers has resulted in the arrival of 73 Boran and Tuli calves in Australia in March 1990. It is the first time cattle have been imported from a high risk disease area (Africa).

Crossbreeding could increase productivity by between 5 and 30 per cent, resulting in an increase in value of the beef herd of at least \$100 million a year by 2014. The breeds combine high fertility, a docile temperament and excellent beef characteristics with high levels of resistance to the environmental stresses that exist in many parts of Australia. Both breeds will now be multiplied and undergo studies to assess thier role in commercial beef production.

#### Vaccine to Prevent Lupinosis

CSIRO has developed a new vaccine that controls lupinosis, a poisoning disease of livestock. The lupinosis vaccine developed by the Division of Animal Health is the first of its type in the world. The vaccine is now being commercialised.

Poisoning of livestock by toxins from plants and micro-organisms is responsible for production losses of about \$100 million a year in Australia. Lupinosis results when livestock graze lupin stubble that is infected with a toxin-producing fungus. Use of the new vaccine would enable animals to graze infected but otherwise highly nutritious lupin stubbles and give farmers greater flexibility in managing their flocks and pastures. It would also encourage wider planting of lupins, which are a high-protein cash crop. Australia's lupin seed exports are currently earning over \$120 million a year. The Division is also commercialising a test to detect lupinosis toxins at very low levels to ensure that these exports meet the highest quality and safety standards for both animal and human consumption.

#### SIROCLEAR

A system developed by the Division of Wool Technology for the detection of dark fibre and vegetable matter contamination in white wool yarns has now been successfully commercialised, in collaboration with the International Wool Secretariat. Loepfe Brothers of Switzerland is currently conducting large-scale industrial trials. Once these trials have been successfully completed, Loepfe Brothers will offer SIROCLEAR for incorporation into existing machinery and as part of all new models.

# **CSIRO** Institute of Industrial Technologies

## **Recent Achievements**

#### **Controlled Atmosphere Packaging Film**

Ripening fruit produces ethylene gas which acts in an autocatalytic manner to accelerate the ripening process. If a means of removing the ethylene from packaged fruit could be developed, the ripening process could be slowed and the storage life of fresh produce greatly extended. Scientists at the Division of Materials Science and Technology have developed an additive especially designed for efficient removal of ethylene. When incorporated into a plastic film wrapping it is capable of removing all the ethylene generated by the stored fruit and allows long term storage of items which under conventional storage conditions deteriorate very rapidly. This product is undergoing market trials and should soon be in commercial production. As well as proving a valuable export itself, the film will add to the export potential of the Australian fruit and vegetable growing industry.

#### **Genetic Engineering**

The first recombinant, sub-unit viral vaccine for veterinary applications world-wide, has been developed by the Division of Biomolecular Engineering in collaboration with the Division of Animal Health. The vaccine, which is active against the immunosuppressive pathogen, infectious bursal disease virus, is being commercialised by Arthur Webster Pty Ltd for local and export markets. The potential sales for such a vaccine are in excess of 150 million doses per annum.

#### **Electronic Plasma Torch**

The Electronic Plasma Torch, developed by the Division of Manufacturing Technology, incorporates a new concept of power control to improve the productivity and quality of the plasma spraying process used for spraying ceramic and other powders to produce wear-resistant and thermal barrier coatings. The Torch provides the facility of single gas operation with total solid-state electronic control to improve the efficiency of deposition of powder with fast, accurate and superior control. The Electronic Plasma Spray System is being commercialised in collaboration with Siddons Ramset Limited and Miller Thermal Inc.

#### Ultra-micro Hardness

Researchers in the Division of Applied Physics have developed an ultra micro-indentation system for investigating the plastic and elastic properties of thin films, coatings and near-surface materials. The 'UMIS-2000\* instrument combines the high-resolution of electronic displacement systems with computer technology in order to determine the resistances of these materials. Its reliability and low operating costs have been recognised with sales of a quarter of a million dollars to companies in the field of new products R&D in the United States.

# **CSIRO** Institute of Information Science and Engineering

# **Recent Achievements**

#### Award for Frequency Domain Processor

The Division of Radiophysics and Austek Microsystems Pty Ltd have won a special award for Australian innovation and endeavour for their A41102 Frequency Domain Processor. The A41102 processor is applied in digital signal processing, a powerful technique for handling information in a diversity of areas such as satellite communications, medical imaging, hi-fi sound systems and radar. It is a single-chip processor that gives big advances over traditional processors in the areas of performance, system cost and design complexity. Austek now manufactures and markets it under licence to CSIRO.

#### **Progressive Multi-focal Lenses**

For the last three years scientists from the Division of Mathematics and Statistics have been working with Sola Optical (a spectacle lens manufacturer based in Adelaide) on the design and manufacture of progressive multi-focal lenses. Progressive lenses are an alternative to bifocals. Like bifocals, they have different zones for correcting near and distance vision, but the transition between the zones is continuous. This eliminates many of the optical and cosmetic problems associated with bifocals. The mathematical input to the design was crucial to its success. The work included assisting Sola's R&D staff with quality control and providing training on quality management.

#### Australia Telescope National Facility

The Australia Telescope began full observations during 1990, and proved its worth immediately with a startling image of Supernova Remnant 0540-693, which is one of only two known supernova remnants found to have been energised by a pulsar. The image taken by the Australia Telescope, one of its first, is the clearest yet of this star, which exploded over 1,000 years ago. The faint radio signal emitted by the remnant was gathered by an array of five radio telescopes at Narrabri to create the receiving power of one dish 3km in diameter.

In August 1989 the Parkes radiotelescope played a crucial role in capturing the signals from the Voyager spacecraft as it sped past the planet Neptune. The signals were so weak that NASA's Deep Space Communications Network in the ACT needed to work in harmony with the Parkes Telescope. The Neptune encounter is the latest event in a relationship between CSIRO and NASA that stretches back to the 1960s.

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

## **Recent Achievements**

#### ISASMELT

Two Australian companies, MIM Holdings Ltd and Ausmelt Pty Ltd, have been licenced to market the SIROSMELT bath smelting technology developed by the Division of Mineral and Processing Engineering.

MIM will market world-wide the advanced smelting technology to be known as ISASMELT. The ISASMELT process is based on the SIROSMELT submerged lance technology developed by CSIRO in collaboration with MIM over the past 14 years. ISASMELT sets new standards in the smelting of non-ferrous metals. Its main advantages are:

- simplicity of design with superior metallurgical performance,
- reduced capital costs and lower operating costs compared with available alternatives, and
- greatly improved quality of the working environment.

#### AIRTRAK

AIRTRAK is a high technology tool for monitoring, interpreting and managing photochemical smog. Invented by the CSIRO Division of Coal Technology, AIRTRAK is being marketed internationally by MCI Ltd. The innovation of the system is its ability to measure the totality of smog components present in the atmosphere, and thus to determine smog levels. AIRTRAK can combine this data with information on sunlight and temperature to determine the age of pollution clouds and to predict smog levels for subsequent periods, including later the same day.

#### **Knowledge-based Systems**

In 1989 the Division of Building, Construction & Engineering completed development of the expert system WIND LOADER. Over 100 copies were sold to engineers throughout Australia in the first few months of release. Developed in collaboration with Standards Australia, this is the first expert system in Australia to be sold to a mass market. It is also acknowledged as a world leader in the field of civil engineering. WINDLOADER is used to determine wind loads on structures and helps engineers comply with the Australian Wind Loading Code.

#### **Biological Stimulation of Oil Production**

The Division of Exploration Geoscience, in conjunction with the Microbiology Research Unit, University of Canberra, is working on novel processes for the biological stimulation of oil production to increase the amount of residual oil obtained from reservoirs.

The process, known as BOS, uses a unique injection and dispersion system to introduce relatively small quantities of micro-organisms and nutrients into the oil reservoir. Field tests of the BOS process at the Alton Field in Queensland have shown a 50 per cent increase in oil production which has been sustained for more than 12 months. The field trials also indicated that BOS costs less than \$1 per barrel on top of existing production costs - a significantly lower figure than for existing chemical methods of enhanced oil recovery. BWN Live Oil has a licence from CSIRO to commercialise and market the BOS process.

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

# **Recent Achievements**

#### Managing Australia's Southern Scallop Stocks

Australia's stocks of southern scallops have been over-exploited and there are now no commercially viable scallop beds. Research by the Division of Fisheries has revealed the reasons - a combination of factors relating to the way the scallops have been fished and false assumptions about the way scallop populations develop. The information could help revive the southern scallop industry.

#### Leading-Edge Prediction of Greenhouse-induced Sea Level Rise

As a first step towards meeting our scientific responsibilities to make more reliable Greenhouse predictions, four scientists from the Division of Oceanography have built a simple model of the thermal expansion of the ocean under Greenhouse warming (a major component of the predicted sea level rise). The model gives realistic simulations of sea level rise over the past 100 years.

#### **Rangelands Policy Options**

The Division of Wildlife and Ecology's Report "A Policy for the Future of Australia's Rangelands" suggests policy options for management of rangelands and is based on several decades of scientific research. Its overall aim is to raise awareness of the need to adopt a national policy for the integrated management of Australia's rangelands.

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

# **Recent Achievements**

#### **Gene Shears Commercialisation**

In its biggest commercial joint venture, CSIRO has entered into an agreement with the French-based seed company Groupe Limagrain to develop commercial applications of the Gene Shears discovery made by the Division of Plant Industry. Gene Shears provides a means of stopping the action of unwanted genes and defending plants, animals and bacteria against viruses. Progress is being made with the appointment of a third partner to the Gene Shears company and some 15 projects, in six CSIRO Divisions, are underway to develop commercial applications of the technology.

#### New Genes for Australian Wheat

The Division of Plant Industry, in collaboration with State Departments of Agriculture and universities, is exploring the genetic make-up of 'primitive wheats' in a search for genes conferring resistance to disease and parasites. To date the Division has found resistance to at least six important wheat parasites and diseases in the grass *Triticum tauschii*.

#### **Drought Resistant Crops**

Working in collaboration with the University of Queensland and the Queensland Department of Primary Industries, scientists in the Division of Tropical Crops and Pastures have made a discovery which could lead to more drought-resistant crop varieties. The discovery relates to osmotic adjustment, a property which scientists have found could improve sorghum yields by 30 per cent under water stress. They are now looking at ways of breeding this characteristic into improved varieties.

#### **Colour Imaging Unit for World Market**

CSIRO has signed a licence agreement with Bio-Rad Laboratories Pty Ltd, Australia, to manufacture and market a 'Real Time Colour Imaging Unit for Scanning Electron Microscopes'. Developed by the Division of Forestry and Forest Products, the Unit provides immediate colour images in place of the normal black and white. It significantly increases the scope of electron microscopy.

#### Soil Porosity Imaging System

An imaging system developed by the Division of Soils gives a clear indication of the percentage and type of pore space in the soil profile. This provides vital information about the structure of soils and allows scientists to look at the effects of different soil treatments and conditions, e.g. intensive cultivation, conservation tillage, traffic by heavy machinery, different earthworm populations. The technique will help scientists in research aimed at combating structural deterioration a major form of soil degradation.

## 150 per cent Tax Concession for R&D

# Role

The objective of the 150 per cent tax concession/or research and development is to make Australian companies more innovative and internationally competitive through improving innovative skills in Australian industry by:

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

The 150 per cent tax concession for research and development is a major program in the Government's package of measures to encourage the performance of R&D in industry. The concession will apply at a rate of 150 percent until 30 June 1993 after which a reduced rate of 125 per cent will apply until 30 June 1995.

# **Recent Achievements**

#### Legislative Changes

On 7 September 1989 the Government announced a number of changes to the concession which were incorporated in the *Tax Laws Amendment Act* (35) 1990. These changes include the introduction of: a risk provision for syndicated R&D; new rules giving 100 per cent deductibility for the acquisition of pre-existing 'core technology'; and, changes so that considerations for the disposal of, or use of, technology claimed for the concessional deduction will be considered to be part of assessable income. In addition, legislative amendments to implement the last of the changes to the concession which resulted from the mid-term technical review were included in the *Tax Laws Amendment Act* (167) 1989.

#### Syndicated R&D

Syndication allows groups of eligible companies to form syndicates to undertake significant R&D projects which are beyond the resources of a single company, or too risky for a single entity to undertake. As at July 1990 seven syndicates with a total value of approximately \$120 million had been funded by investors and registered by the Board.

#### Effectiveness

In December 1989 the Bureau of Industry Economics released an interim report on the effectiveness of the R&D tax concession which found that it has had a substantial impact on the level of private sector R&D in Australia. The Bureau's broad conclusions were that the tax

## Figure 3

# PRIVATE BUSINESS EXPENDITURE ON R&D



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

concession has had a positive impact on corporate and collaborative R&D. Also, the level of collaboration between the public and private sectors increased significantly as a result of the availability of the concession. Figure 3 shows the substantial real increases achieved in private business enterprises over the 1980s.

In June 1990 the Industry Research and Development Board commenced an investigation of the effect of dividend imputation on the tax incentive. The study results from expressions of concern from industry that dividend imputation may be reducing both the net cost to revenue of the incentive and its effectiveness.

#### **Registered Research Agencies (RRA)**

During 1989-90 the IR&D Board granted RRA status to 52 organisations. This brought the total registered to 116. RRAs provide scientific or technical services to companies which do not have the necessary expertise or facilities to undertake an R&D project.

# Grants for Industry Research and Development (GIRD)

# **GIRD** Discretionary Grants

# Role

To provide support to companies which have insufficient taxation liability to obtain adequate benefit from the 150 percent tax concession for research and development but have the potential to fully exploit the results of their research and development projects.

# **Recent Achievements**

#### **Mining Industry**

A Tasmanian company has recently developed a large capacity underground load-haul-dump vehicle. The vehicle's maneuverability, high lift arms for truck loading, and performance characteristics make it a world leader in its field. Sales to date are in excess of \$14 million.

#### **Food Industry**

A company has developed a number of modified rice products including stabilized brans, breakfast cereals and snackfoods. A new breakfast cereal has already been marketed and sales are in excess of \$1 million per year.

# **GIRD** Generic Technology Grants

# Role

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

## **Recent Achievements**

#### **Biotechnology - Influenza Protection**

A multidisciplinary approach by four Australian collaborators has made a significant advance towards finding an answer to the scourge of influenza. CSIRO, the Australian National University, the Victorian College of Pharmacy and the biotechnology company Biota Pty Ltd each contributed their special expertise in 3-D protein structure, drug design and synthesis, microbiology and commercialisation of newly developed products and processes. A recent agreement with Glaxo Australia, the Australian arm of the multinational pharmaceutical giant, will ensure the necessary further product development, testing and global marketing.

# National Procurement Development Program (NPDP)

## Role

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

The NPDP was established in 1987. However, the program has effectively been in operation for just over two years. Overall, 136 projects have been considered and 56 projects funded with a total value of \$16.9 million. To date, about 15 or one third of the projects have completed their technical objectives to the satisfaction of the government partner. Of these 15 projects (representing grants of \$3.2 million), 8 have already achieved domestic sales of \$26 million and export sales of \$3.7 million.

An important long term objective of the program is to overcome risk aversion by government purchasing agencies in the purchase of Australian products and services. There are indications that the program is having a positive impact, evidenced by very strong interest from both government and industry. Already, 23 Commonwealth and 33 State Government departments and agencies have participated in the program. Increasingly, government bodies are seeking to use the program to develop Australian products to meet their future procurement needs.

# **Recent Achievements**

#### Mobile Heavy Vehicle Testing Unit

Special Purpose Vehicles Pty Ltd used a \$91,000 NPDP grant to develop a mobile heavy vehicle testing unit after the Roads and Traffic Authority of NSW came up with the original concept and sought a partner to develop a prototype. Traffic authorities in Australia and world wide are showing keen interest in the product.

#### **Document Abstractor**

Computer Power Pty Ltd are using a grant of \$438,000 to trial and demonstrate an Artificially Intelligent Document Abstractor (AIDA) which can 'read' a document and summarise it in point form. After successful trialling with the Parliamentary Information Systems Office in Canberra, the AIDA technology is estimated to be three to four years ahead of its closest rivals.

#### **Teaching Aid for the Blind**

Quantum Technology Pty Ltd developed a highly innovative communications and teaching aid for the blind in association with the NSW Department of Education. NOMAD is a system where special, tactile graphics pages are combined with a software program. When the user touches a page placed on a touch pad, the computer 'speaks' about that area. Educational and creative applications are endless, and Quantum are revising their export projections upwards in response to overseas demand.

#### **Electronic Passport Reader**

With an NPDP grant of \$342,000, Dynjab Research Pty Ltd designed and built a passport reader in association with the Department of Immigration and Ethnic Affairs. The device electronically reads passports and visas faster and more accurately than any other machine of its type. The Digital Vision Reader's near perfect character recognition rate has attracted widespread attention, and it is currently being trialled in a variety of demanding international locations.

# PRIMARY INDUSTRIES AND ENERGY

# Science and Technology in the Portfolio Budget

Science and technology play a significant role towards achieving portfolio objectives to improve the contribution that the agricultural, minerals, energy, fisheries and forestry industries make to the well being of Australians. Specifically, research and development are funded to ensure the competitiveness and sustainability of these industries.

1990-91 will be a major transitional year for R&D funding arrangements in the portfolio. Research Councils established under the *Rural Industries Research Act* 1985 will be replaced by either R&D Corporations or R&D Councils under the *Primary Industries and Energy Act* 1989. New R&D Corporations will also be established for the energy, land and water, and forest industries.

The R&D Corporations for rural industries are funded by production levies imposed and collected by the Commonwealth, on the recommendation of the peak industry bodies. These levies are matched on expenditure by Commonwealth contributions up to the amount of the levy or 0.5 per cent of the gross value of production.

The Land and Water, Energy, and Rural Industry (for small and emerging industries) Research and Development Corporations are predominantly funded by Government appropriations. Fisheries research is funded mainly by Government appropriations to match payments by States up to one per cent of gross value of production.

Agencies supporting science and technology within the portfolio are the Bureau of Mineral Resources, Geology and Geophysics (BMR) and the Bureau of Rural Resources (BRR). The 1990-91 budgets of these agencies are \$50.4 million and \$10.3 million, respectively.

Other expenditure in 1990-91 by the Department and R&D Corporations associated with the portfolio total \$180.1 million of which contributions from industry total \$80.1 million.

# MAJOR RESEARCH ACTIVITIES

# 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 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**

#### National Accord on Geoscience Mapping

Substantial progress has been made towards a National Geoscience Mapping Accord between the Commonwealth and the States through the Bureau and State/NT Geological Surveys. The main purpose of the Accord is to assist in an integrated approach to conservation and sustainable development and, in particular, to help maximise the benefits to the community from the nation's petroleum, mineral, and water resources. The principal goal of the Accord is to produce a new generation of geological maps and datasets for Australia. Work has already commenced on cooperative mapping projects in all mainland states and the Northern Territory.

#### New Understanding of the Mt Isa Mineral Province

The completion of seven year's work in the Mt Isa mineral province has demonstrated that the structure which hosts the mineralisation formed well within the interior of the Australian continent, not at its margin as previously supposed, and that the formation of the copper ore was derived from fluids resulting from the metamorphism of evaporites. These findings have major implications for future exploration for Mt Isa type ore deposits.

# Development of New Petroleum Prospecting Possibilities on Australia's Southern Margin

Recent advances in petroleum development technology which allow production in water depths approaching 1km have opened up possibilities for major prospective areas on Australia's southern margin previously too deep for development. BMR's Continental Margins Program has discovered new exploration plays including folds and uplifted blocks which could be associated with petroleum accumulations. This has renewed impetus for exploration on the southern margin.

#### **Upgraded Petroleum Potential - Clarence-Moreton Basin**

BMR in conjunction with the Geological Surveys of NSW and Queensland has completed a study of the Clarence-Moreton Basin that has resulted in a significantly improved understanding of its geology and petroleum potential. The integrated study of the structure, sedimentology, reservoir potential, geophysics and petroleum geochemistry suggests that the basin may become a new significant source for natural gas in eastern Australia.

# 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. From 2 July 1990, the non-coal elements of the Program became the responsibility of the new Energy Research and Development Corporation.

## **Recent Achievements**

#### **Natural Gas Powered Transport Trials**

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. Demonstrations are underway in bus fleets in Adelaide, Brisbane and Sydney and in a number of truck fleets.

#### **Efficient Use of Energy**

Projects have been undertaken aimed at improving the efficiency of energy use. These have led to the development of energy efficient buildings and novel heat recovery processes and more energy efficient control technologies in industry.

## Australian Meat and Livestock Research and Development Corporation (AMLRDC)

# Role

The objectives of the Corporation are to improve the productivity and market performance of the meat and livestock industry by identifying 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**

#### **Increasing Genetic Improvement in Livestock**

BEEFPLAN and LAMBPLAN are the AMLRDC's two major national commercial genetic improvement programs which aim to increase the rate of genetic improvement and the use of genetic resources. The range of genetic parameters is being expanded to include fertility and carcase traits. Seven cattle ultra-sound scanning operators have been accredited to provide fat depth and eye muscle area measurements on live animals to cattle breeders on a commercial basis. LAMBPLAN is also supported by commercial ultrasound operators accredited to measure weight and fat depth on rams and provide estimated breeding values for growth, leanness or lean growth.

#### **Fututech Meat Processing**

The development of automated slaughtering technology is one of the industry's most important objectives and is the Corporation's largest project. A new system for the slaughter and dressing of beef cattle has been developed. It eliminates many of the arduous repetitive and dangerous tasks associated with slaughter and dressing, and provides a more pleasant working environment. The system is also humane for the animal. This technology, known as Fututech, was launched to industry in November 1989 and is now being commercialised.

# **Wool Research and Development Council**

# 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**

#### **Improved Prediction of Wool Fabric Properties**

A fabric objective measurement system called FAST (fabric assurance by simple testing) has been developed by the CSIRO Division of Wool Technology and currently is being commercialised jointly with AWC. FAST offers simple procedures for predicting the tailorability and appearance retention properties of wool fabrics. It comprises three instruments and a test method for dimensional stability. Tests provided by FAST are of particular importance to fabric manufacturers, finishers and garment makers.

#### Scientific Training in Wool Technology

In recognition of the importance of having a continuing supply of high calibre scientists for its expanding wool textile research activities, the WRDC has implemented the following initiatives in the school of Fibre Science and Technology, University of New South Wales.

- Inclusion of the Textile Technology and Wool and Animal Science courses in the prestigious Co-operative Program which provides undergraduate scholarships.
- Endowment of a chair of Wool Technology.

Additionally, twenty three postgraduate scholarships have been awarded for textile research at the University of New South Wales and other Australian Universities.

# Horticultural Research and Development Corporation

## Role

The Corporation supports R&D which 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 horticulturists and the community at large.

## **Recent Achievements**

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

Funds from this newly established Corporation have been spent predominantly on cultural and harvesting practices, pest and disease management systems, genetic improvement and post-harvest research into a range of commodities including apples, pears, citrus, nursery products, macadamia nuts, potatoes, tomatoes, mushrooms, onions, cut flowers, bananas and pineapples.

# **Rural Industries Research and Development Corporation**

## Role

The Corporation 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 industries research funds. Multi-interest and national interest research funding are also within the Corporation's Charter.

The Rural Industries Research and Development Corporation operates under the *Primary Industries and Energy Research and Development Act* 1989.

## **Recent Achievements**

#### **Regeneration and establishment of trees & shrubs on the New England Tablelands**

A total of 15 000 trees have been planted in a study to examine the natural regeneration of eucalyptus in die back areas and to design and test various methods of re-establishment. Effective methods of establishment have been designed which has led to greater plantings of trees by landholders in the region. Increased tree populations on farms have been shown to reduce stock losses, both by providing protection for stock and increased pasture production.

#### Control of Phytopthera Disease by Phosphorous Acid Treatment

Improved methods for control *of Phytopthera* disease have been developed. *Phytopthera* currently causes losses of around \$154 million and new lower cost treatments are expected to reduce these losses significantly by using phosphorous acid as a preventative treatment. The treatment is having a large impact in the avocado and pineapple industries and work on its potential is being examined for a wide range of horticultural and pastoral crops.

# **Special Appropriations for Rural Research**

## Role

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

# **Recent Achievements**

#### **Inexpensive Treatment for Downy Mildew**

A South Australian Department of Agriculture project funded by the Grape and Wine Research Council has found a new and inexpensive treatment against downy mildew, a disease which afflicts grape vines. The project concluded that tank mixes of phosporous acid with other protectant fungicides are effective and cheaper alternatives to existing formulations of eradicant fungicides.

#### **Barley Capable of Lowering Cholesterol**

Barley and oats are capable of producing a fall in plasma cholesterol when substituted for wheat. The fall is also seen with low density lipoprotein cholesterol, which is elevated in heart disease prone humans. A project funded by the Barley Research Council has found that barley grain offers all the health benefits that oat bran has provided, with the added advantage of a significantly lower fat content. This is consistent with National Heart Foundation objectives to lower fat in the human diet.

#### **Rapeseed Agronomic Packages**

There has been significant progress in research funded by the Oilseeds Research Council into developing a comprehensive agronomic package for rapeseed. Development of this package should enable rapeseed to find a niche in parts of the cereal belt in southern Australia, increasing its role in crop rotation and improving growers' overall productivity.

# **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**

#### Microalgae for Aquaculture

Shellfish hatcheries require large numbers of microalgae to feed bivalve larvae during production and in practice use bacterial contaminated cultures. Technology presently exists to produce small-volume bacterial free cultures. Research is addressing the production of large volume bacterial free nutritional cultures by: the provision of cultures to aquaculture operations throughout Australia; hands on training of industry personnel; and investigation of nutritional value of microalgae.

# PRIME MINISTER AND CABINET

# Science and Technology in the Portfolio Budget

Expenditure on science and technology policy through the independent high level advisory body ASTEC is expected to be \$1.6 million in 1990-91 (\$1.6 million in 1989-90).

Expenditure on science and technology policy and programs through the Office of the Chief Scientist is expected to rise to \$5.4 million (\$0.4 million in 1989-90), reflecting the establishment of the Cooperative Research Centres (CRC) Program, which is administered by the Office. This amount incorporates \$4.0 million as the expected amount of grants towards the establishment of the first CRCs.

Funds for the Resources Assessment Commission will rise to \$6.2 million in 1990-91 (\$4.9 million in 1989-90) to undertake resource assessment of national forests, Kakadu conservation zone and coastal management.

# MAJOR POLICY ACTIVITIES

# **Prime Minister's Science Council**

## Role

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

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

# Recent Achievements and Future Directions

The Science Council has had two meetings since its establishment. Topics of discussion were global climatic change and its significance for Australia, and the scientific and technological resources of the nation and their utilisation. The Council also considered the Cooperative Research Centres program and the teaching of science and mathematics in schools. (See also SECTION 2.) Future meetings of the Council will concentrate on the role of science and technology in improving the competitiveness of sectors of Australian industry, adding value to raw materials, the export of knowledge-based services, and education and skill formation.

# **Coordination Committee on Science and Technology**

# Role

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

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

# **Recent Achievements**

The Committee has met four times and considered issues such as human resources for research and development, career structures for scientists and engineers, and ways of selecting priority areas for research. Other major topics have been coordination of responsibility for biological collections and the Committee's role in the provision of advice to the Government on major research projects and facilities. (See also SECTION 2.)

# **Office of the Chief Scientist**

# Role

The Office supports the Chief Scientist in his roles as the Prime Minister's adviser on science and technology, Executive Officer of the Prime Minister's Science Council, Chairman of the Coordination Committee on Science and Technology, and Chairman of the Cooperative Research Centres Committee.

The Office of the Chief Scientist:

- through the Chief Scientist, provides high quality policy advice and information to the Prime Minister on science and technology
- provides an efficient and effective secretariat to the Prime Minister's Science Council, and to the Coordination Committee on Science and Technology
- coordinates the preparation of material for consideration by the Prime Minister's Science Council
- *ensures the effective coordination of science and technology policy across portfolios*

# **Recent Achievements**

#### The Cooperative Research Centres Program

The program was developed with the aims of strengthening Australia's scientific and technological capacity. Following endorsement of the operational guidelines by the Prime Minister's Science Council, applications were sought from interested parties. The first Centres are expected to be established early in 1991. (See also SECTION 2.)

A Cooperative Research Centres (CRC) Branch has been created within the Office of the Chief Scientist to provide a secretariat to the CRC Committee and to administer the allocation of CRC grants.

### Australian Science and Technology Council

### Role

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

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

# **Recent Achievements**

#### **Setting Directions for Australian Research**

This Report, due to be tabled in the August sitting of Parliament, addresses the question of how to set the broad national directions for research within which departments and agencies may set their own strategic and operational priorities so that Australia's research effort will best support the government's national policy objectives. The Report seeks to define the R&D environment, assess the need for and extent of priority setting here and overseas, and recommend means by which research priorities maybe set, assessed, implemented and evaluated. It recommends that the Prime Minister establish a means by which a White Paper sets national directions in Australian R&D every four years. A mechanism by which this could be achieved is outlined.

#### **Environmental Research in Australia**

*Environmental research in Australia - a Review* is the first phase of ASTEC's study on environmental research in Australia following a reference from the Prime Minister in August 1989. The Report, to be tabled in the August sitting of Parliament, describes the organisation and funding of environmental research in Australia and establishes a basis for the second phase of the ASTEC study which will consider the more complex policy related issues raised in the terms of reference. The Report provides a comprehensive analysis of the funding, human resources and organisation of environmental research and draws attention to the deficiencies in our methods of data collection and management.

#### The Future of Australian Astronomy

This Report reviews the opportunities for Australian astronomy, particularly in the next decade. The Report showed that the quality of Australian astronomy is generally world class, although there is a need to strengthen capabilities in the theoretical area. Recommendations were made in several areas including:

- the level of financial support for research in astronomy, including capital items and operational activities;
- the need to provide access to a very large optical/infrared telescope;
- opportunities for participation by Australian astronomers in international space astronomy projects; and
- the planning and review of Australian astronomy.

#### Access to Major International Accelerator and Beam Facilities

In its report *Small Country - Big Science* ASTEC examined the merits of Australian access to a range of international research facilities which because of their high cost are not available in Australia. The Report focused on three areas of immediate need for Australia, synchrotron light, neutron scattering and high energy physics, where the needs of the scientific community can be met by taking advantage of available opportunities. The report was prepared against the background of the need to support the domestic base from which Australian scientists must operate and the impact that greater access to overseas facilities will have on the development and retention of scientists, skills and technology in Australia.

# Government Funding of Academic and Related Research in Australia: an International Comparison

This Report, due to be tabled in the August sitting of Parliament, was prepared in collaboration with the Office of the Chief Scientist. Existing international data on university research expenditure are limited in several respects, particularly when required to inform debate on funding priorities and mechanisms. The report compared Australian data with that from the UK, FRG, France, the Netherlands , the USA and Japan. The main findings showed: Australian government funding of academic and related research (in per capita terms) was lower than in the other countries; Australia places relatively greater emphasis on general funding and less on separately budgeted research in universities; and levels of Australian investment in engineering and physical sciences appear to be very low.

# 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 1990-91 for the ARRB and FORS will be \$2.1 million and \$10.1 million respectively (\$2.0 million and \$6.3 million in 1989-90).

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

# **MAJOR RESEARCH ACTIVITIES**

## Support for the Australian Road Research Board (ARRB)

### Role

To provide support for the ARRB which is a non-profit company sponsored jointly by all three levels of government. This national body undertakes and sponsors a comprehensive range of road and road transport research aimed at supporting safe and efficient land transport.

ARRB delivers its research results to a wide range of customers and the estimated return to the Australian nation is at least \$14 for each research dollar spent.

### **Recent Achievements**

#### The Accelerated Loading Facility Program

The Accelerated Loading Facility (ALF) is a technique for rapidly and accurately testing different pavements.

ALF has improved understanding of the performance of cement treated bases and sub-bases, the use of non-standard materials by-products (eg slag), and asphalt pavement rehabilitation techniques. The benefits of the ALF trials to date have been estimated at \$30 million per annum against a cost of about \$7 million. The ALF technology has been exported to the USA and China.

#### Local Street Pavement Design

A design guide for residential street pavements has been developed. Workshops have promoted the guide to local authorities throughout Australia and in New Zealand and Indonesia. More than 1000 copies of the guide have been sold. In return for the development cost of \$1.1 million, savings of as much as \$35 million per annum nationally are expected by the year 2000.

# SECTION 4: TRENDS IN COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION

# Summary Data

Commonwealth support for major science and innovation programs has risen from an estimated \$2282 million in 1989-90 to \$2481 million in 1990-91 - a real increase of 2.3 per cent. Broadly, there have been significant increases over the whole period since 1979-80, with the tax concession schemes providing particular stimulus in recent years. Omitting those concessions, the rise in total Commonwealth support results from increased R&D overall in the higher education sector coupled with a steady rise in amounts disbursed through the various granting schemes.

Figure 4 and Table 1 present a summary of Commonwealth support for science and innovation at constant price values. They illustrate a four-way breakdown of the data as follows :

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

#### **Higher Education Research**

Support for research in the higher education sector (excluding support from special purpose grant schemes) is estimated to increase to \$1005.5 million in 1990-91 from \$931.7 million in 1989-90, representing a real increase of 1.6 percent.

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

												(est.)
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
MAJOR SCIENTIFIC RESEARCH AGENCIE	s											
Defence	132.9	136.8	158.5	157.0	155.2	158.4	155.1	159.6	151.7	149.0	156.3	138.1
Civil	444.7	470.0	493.0	501.3	479.8	467.4	472.7	471.5	433.2	401.4	412.5	430.8
SUB-TOTAL	577.7	606.8	651.5	658.3	634.9	625.8	627.8	631.1	584.9	550.4	568.8	568.9
SCIENCE AND INNOVATION GRANTS												
Health and Medical	23.9	28.6	36.0	39.2	47.9	52.0	52.6	55.5	55.5	55.8	60.9	69.2
<ul> <li>Industry and space</li> </ul>	58.3	74.4	34.5	63.7	74.2	67.6	91.0	86.1	64.5	60.3	62.1	62.8
• Rural	41.5	45.7	47.1	47.3	48.9	58.6	62.2	73.2	75.4	85.0	98.5	96.5
<ul> <li>Energy and environment</li> </ul>	8.6	10.6	14.5	17.0	18.5	16.7	13.5	12.5	9.1	8.7	13.6	18.0
Transport	11.1	9.2	3.4	2.8	3.6	2.8	2.4	1.7	1.6	1.5	1.4	1.4
SUB-TOTAL	143.4	168.6	135.4	170.1	193.1	197.8	221.7	229.0	206.2	211.2	236.5	247.9
COSTS OF IR&D & RELATED INCENTIVES	-	-	-	-	-	20.0	155.1	165.4	178.4	127.2	139.2	154.0
HIGHER EDUCATION RESEARCH												
<ul> <li>ARC and related grant schemes</li> </ul>	36.1	38.5	38.0	38.9	43.0	47.2	48.9	51.4	51.1	53.9	32.8	8.4
<ul> <li>ARC non-Budget</li> </ul>	-	-	1.9	6.7	6.0	5.6	5.5	5.2	7.3	9.0	55.8	116.9
<ul> <li>Specific R&amp;D support</li> </ul>	106.8	107.7	106.8	106.3	110.1	112.0	110.3	109.7	108.7	105.7	104.9	102.0
<ul> <li>Est. general research support</li> </ul>	340.6	349.7	356.8	350.7	349.2	418.0	443.9	487.4	494.7	476.2	458.0	434.4
SUB-TOTAL	483.5	495.9	503.5	502.6	508.3	582.8	608.6	653.7	661.8	644.8	651.5	661.8
TOTAL COMMONWEALTH SUPPORT												
AT ESTIMATED 84-85 PRICES	1205	1271	1290	1331	1336	1426	1613	1679	1631	1534	1596	1633
EST. REAL % INCREASE/DECREASE	1.9	5.5	1.5	3.1	0.4	6.7	13.1	4.1	-2.8	-6.0	4.1	2.3

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

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

# Figure 4

# MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION





#### **Research in Commonwealth Agencies**

The largest Commonwealth research agencies are CSIRO, DSTO, ANSTO, BMR, Antarctic Division and AIMS. Support through Budget appropriations to these agencies, and some smaller ones, is expected to be \$864.4 million in 1990-91, at the same real level as in 1989-90 (\$813.4 million). A fall in direct support for defence R&D is offset by a real increase in direct support for the civil research agencies which will increase to \$654.6 million in 1990-91 from \$589.8 million in 1989-90 (a real increase of 4.4 per cent).

It is important to note that the research agenciesreceive funds in addition to those appropriated directly and that these sums are not included in the amounts referred to above. Such external funding has increased significantly in recent years. For example, CSIRO receives business funding, funds from earned revenue (from licencing fees, disposal of assets etc.) and additional Commonwealth support won competitively via the special purpose grant schemes. To encourage CSIRO to improve its links with industry, the Government has set a target for external earnings (ie, funds from other than its direct Budget appropriations) of 30 per cent of total funding in 1990-91. Direct appropriations to CSIRO for 1990-91 are expected to amount to \$407 million, but the total budget of the Organisation is expected to be in the region of \$560 million.

#### **Special Purpose Research Grant Schemes**

Support for R&D through the special purpose research grant schemes is estimated to increase to \$376.6 million in 1990-91 from \$338.3 million in 1989-90, representing a real increase of 4.8 percent.

The Commonwealth has established a number of research grant schemes which are directed to special areas of interest - health and medical research (NH&MRC), rural research (RIRFs and other rural), industrial R&D (GIRD and its predecessors), energy R&D (NERDDC), and some smaller ones.

#### **Tax Incentive Schemes**

Support for R&D and innovation in the business sector through tax concessions is estimated to increase to \$234 million in 1990-91 from \$199 million in 1989-90, representing a real increase of 10.6 per cent.

The two tax incentive schemes (the 150% tax concession for industrial R&D and the 100% concession for investment in MICs) are considered separately from the special purpose schemes because they operate in an indirect manner. Their cost is measured through the amount of revenue foregone by the Commonwealth rather than through direct payments to organisations. However, as the intention is of the same kind as the special purpose grant schemes, it is often useful to consider both kinds

of scheme together and to add the incentives to the industrial component of the special purpose grants. On this basis, total support for industrial R&D and innovation is expected to be \$330 million in 1990-91, rising from \$288 million in 1989-90. This represents a real increase of about 8 per cent.

## Changes in the Balance of Funding

Figure 5, expressed as a percentage of GDP, provides an alternative view to Figure 4. In addition, funding of both civil and defence research agencies is shown and higher education funding is split between specific R&D funding and general university funding of R&D (GUF) which is the estimated research component of support for both teaching and research.

Looking at the broad changes apparent in Figures 4 and 5, Budget funding for the research agencies has remained approximately static in real terms over the period since 1979-80. The slight rise and fall is due to some substantial capital expenditure on building programs. Over the same period, the special purpose schemes have increased significantly. This increase is even more substantial if the industry incentive schemes are included. When this is done support for industrial R&D is seen to have received the largest increases. Support for health and medical research and for rural research has also risen significantly.

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

In the higher education sector there has also been a significant increase in funding since 1979-80. Within the sector, there has been a substantial shift so that the proportion of funds controlled by the ARC is now much higher. Total funds have increased overall and there has been a substantial change in the funding mechanisms.

The 1988-89 dip in total funding levels is traceable mainly to a real fall in the level of Budget funding for Commonwealth research agencies.

# Detailed Data

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

For the most part, the data series in Tables 3 and 4 are comprised of well-defined expenditures which can be readily identified from the Budget Papers. However, Table 5 presents a less clear-cut situation for the two largest items. The first of these is the estimated research component of the general Commonwealth funding for universities. This

												(est.)
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
MAJOD SCIENTIEIC DESEADOU ACENCIE	C											
MAJOR SCIENTIFIC RESEARCH AGENCIE	S 95 0	07.0	100.1	120.0	146.6	150 4	165.0	102 /	107.0	200.2	222.6	200.9
• Defence	85.9	97.8	120.1	138.8	140.0	158.4	105.9	185.4	187.0	200.2	223.0	209.8
	287.3	336.0	392.5	443.1	453.4	467.4	505.8	541.8	534.2	539.5 720.7	589.8	054.0
SUB-IOTAL	373.2	433.9	518.6	581.9	600.0	625.8	6/1./	125.2	/21.2	/39./	813.4	864.4
SCIENCE AND INNOVATION GRANTS												
Health and Medical	15.5	20.5	28.6	34.7	45.3	52.0	56.3	63.8	68.5	74.9	87.1	105.2
<ul> <li>Industry and space</li> </ul>	37.7	53.2	27.5	56.3	70.1	67.6	97.4	98.9	79.6	81.0	88.9	95.5
Rural	26.8	32.7	37.5	41.8	46.2	58.6	66.5	84.1	93.0	114.2	140.8	146.6
<ul> <li>Energy and environment</li> </ul>	5.5	7.6	11.5	15.0	17.5	16.7	14.5	14.3	11.2	11.7	19.5	27.3
Transport	7.2	6.6	2.7	2.5	3.4	2.8	2.6	2.0	2.0	2.0	2.0	2.1
SUB-TOTAL	92.6	120.5	107.8	150.3	182.5	197.8	237.3	263.1	254.2	283.9	338.3	376.6
COSTS OF IR&D & RELATED INCENTIVES	-	-	-	-	-	20.0	166.0	190.0	220.0	171.0	199.0	234.0
HIGHER EDUCATION RESEARCH												
<ul> <li>ARC and related grant schemes</li> </ul>	23.3	27.5	30.3	34.4	40.6	47.2	52.4	59.0	63.0	72.4	46.9	12.8
<ul> <li>ARC non-Budget</li> </ul>	-	-	1.5	5.9	5.7	5.6	5.9	6.0	9.0	12.1	79.8	177.7
<ul> <li>Specific R&amp;D support</li> </ul>	69.0	77.0	85.0	94.0	104.0	112.0	118.0	126.0	134.0	142.0	150.0	155.0
<ul> <li>Est. general research support</li> </ul>	220.0	250.0	284.0	310.0	330.0	418.0	475.0	560.0	610.0	640.0	655.0	660.0
SUB-TOTAL	312.3	354.5	400.8	444.3	480.3	582.8	651.3	751.0	816.0	866.5	931.7	1005.5
TOTAL COMMONWEALTH												
SUPPORT	778	909	1027	1177	1263	1426	1726	1929	2011	2061	2282	2481
% GDP <sup>1</sup>	0.634	0.650	0.656	0.690	0.655	5 0.665	0.721	0.735	0.678	3 0.612	0.612	0.617
TOTAL COMMONWEALTH SUPPORT												
AT ESTIMATED 1984-85 PRICES	1205	1271	1290	1331	1336	1426	1613	1679	1631	1534	1596	1633
EST. REAL % INCREASE/DECREASE	1.9	5.5	1.5	3.1	0.4	6.7	13.1	4.1	-2.8	-6.0	4.1	2.3

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

(1) Based on historical GDP data as in ABS 5206.0 (March Quarter 1990) and using estimates of \$372 00m and \$402 100m for 1989-90 and 1990-91. SOURCE: See Tables 3, 4 and 5

# **Figure 5** MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION AS A PERCENTAGE OF GDP





-		•				Outlays						(est.)
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
ARTS SPORT THE ENVIRONMENT TOURI	SM & TERR	ITORIES										
Antarctic Division	20.8	23.3	21.7	31.7	35.4	37.4	42.2	47.4	49.2	46.3	57.7	62.7
Bureau of Meteorology												
Research Centre (BMRC) <sup>1</sup>	0.8	0.9	1.2	1.7	1.7	1.8	1.8	2.3	2.5	2.2	2.4	2.5
Supervising Scientist												
Alligator Rivers Research Inst	1.7	3.1	4.1	6.1	4.6	4.8	5.5	6.1	6.0	6.6	7.3	6.6
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	4.2
Commonwealth Serum Labs												
(Budget component)	2.9	3.7	4.9	6.3	6.6	8.8	12.8	15.8	17.3	16.6	18.4	34.9
DEFENCE												
Defence Science and												
Technology Organisation	85.9	97.8	126.1	138.8	146.6	158.4	165.9	183.4	187.0	200.2	223.6	209.8
EMPLOYMENT, EDUCATION & TRAINING												
Anglo-Aust Telescope	1.1	1.5	1.7	1.9	1.8	1.8	1.9	2.0	2.4	2.5	2.7	2.9
INDUSTRY, TECHNOLOGY & COMMERCE												
Aust Nuclear Science												
& Technology Organisation <sup>2</sup>	29.2	33.0	37.8	36.4	38.8	41.9	45.4	45.2	50.8	54.3	57.5	60.4
Australian Institute of												
Marine Science	3.5	5.2	5.7	6.4	6.9	7.4	7.6	8.2	9.5	11.0	11.4	13.6
CSIRO <sup>1</sup>	211.3	247.1	293.5	328.2	331.6	324.9	344.3	367.8	347.8	348.1	375.7	407.0
PRIMARY INDUSTRIES & ENERGY												
Contribution to CSIRO												
for Aust Animal Health Labs	-	-	-	-	-	3.9	4.1	4.4	4.7	4.7	4.9	5.2
Bureau of Mineral Resources	13.4	15.3	18.8	21.1	22.0	30.1	35.2	37.4	40.6	42.9	47.4	54.6
TOTAL	373.2	433.9	518.6	581.9	600.0	625.8	671.7	725.2	721.2	739.7	813.4	864.4

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

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

(2) CSIRO and ANSTO figures for 1979-80 and 1980-81 were adjusted to include superannuation on the same basis as in subsequent years.

(3) From 1989-90 onwards BMR became responsible for the payment of its property operating expenses (principally rent) of about \$3m per annum. In this table the amounts have been deducted to reflect expenditure on the same basis over the series.

	1979_80	1080-81	1981_82	1982-83	1983-84	Outlays	1985-86	1986-87	1087-88	1088-80	1989-90	(est)
ARTS SPORT THE ENVIRONMENT TOURIS	M & TERR	ITORIES	1701-02	1702-05	1705-04	1704-05	1705-00	1700-07	1707-00	1700-07	1707-90	1770-71
Aust Biological Resources Study	0.2	0.6	0.8	1.0	1.1	1.2	1.2	1.0	1.1	1.3	1.6	1.6
Greenhouse research	-	-	-	-	-	-	-	-	-	0.8	5.7	8.9
COMMUNITY SERVICES & HEALTH												
AIDS Research	-	-	-	-	-	-	0.7	1.3	3.0	3.5	5.0	7.1
Health and Community Services Research Grants	1.4	1.5	1.4	1.5	3.2	1.6	1.6	1.8	1.1	1.4	1.7	2.1
NH&MRC Research Grants	14.0	18.7	25.6	30.0	38.5	44.2	51.2	59.0	64.4	70.0	80.4	91.0
Payments to Medical Institutes	0.1	0.3	1.6	3.2	3.5	6.3	2.6	1.6	-	-	-	5.0
EMPLOYMENT, EDUCATION & TRAINING												
Australian Research Council (ARC) <sup>1</sup> ARCS grants/fellowships	-	-	-	-	-	-	-	-	42.7	50.7	35.6	12.8
(including marine R&D grants) <sup>1</sup>	13.9	18.4	20.7	22.7	25.5	30.8	34.6	39.8	_	_	_	_
Post-graduate Awards <sup>1</sup>	8.5	8.0	8.8	11.5	15.1	16.3	17.8	19.3	20.3	21.7	11.3	-
Education R&D Grants	1.0	1.2	0.8	0.2	-	-	-	-	-	-	-	-
INDUSTRY, TECHNOLOGY & COMMERCE Industrial R&D support												
- IR&D Incentives Act 1976												
. Commencement grants	7.0	9.7	9.7	13.1	14.6	16.3	14.3	16.9	3.1	0.1	-	-
. Project grants	23.0	36.1	12.1	34.8	43.2	38.1	37.7	17.9	6.4	2.8	0.3	0.1
. Public interest projects	4.0	5.0	2.4	4.9	8.1	9.8	6.3	3.5	1.0	0.3	-	-
- IR&D Act 1986 (GIRD)	-	-	-	-	-	-	-	10.8	25.6	31.8	32.0	31.8
. Biotechnology grants	-	-	-	-	0.7	2.2	4.3	-	-	-	-	-
InterScan support	3.7	2.4	2.1	2.2	2.5	-	-	-	-	-	-	-
National Space Program	-	-	-	-	-	-	3.0	5.0	3.2	5.4	2.4	6.3
Malaria Vaccine Joint Venture	-	-	-	-	-	-	0.3	0.4	0.8	1.2	0.8	2.6

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

						Outlays						(est.)
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
Research associations <sup>2</sup>	-	-	1.2	1.3	1.7	1.9	1.9	2.0	2.0	-	-	-
Motor Vehicle R&D	-	-	-	-	-	-	20.6	22.9	11.6	8.4	8.3	7.5
Assistance under the Bounty <sup>3</sup>												
(Computers) Act 1984	-	-	-	-	-	1.5	13.2	19.4	25.7	31.1	45.0	47.2
PRIMARY INDUSTRIES & ENERGY <sup>4</sup>												
Wool Research	10.4	14.4	16.7	17.4	19.3	24.0	24.9	29.6	30.4	35.9	40.4	34.2
Meat & Livestock Research	6.8	7.0	7.0	8.8	9.0	8.6	11.0	16.1	17.2	23.5	27.1	28.9
Fishing Industry Research	0.9	0.8	2.4	2.1	2.9	4.0	4.9	5.8	4.8	5.2	7.1	9.7
Grains	6.0	5.7	7.5	6.8	10.9	14.1	14.2	15.2	17.9	18.6	22.0	27.1
Horticulture Research	-	-	-	-	-	-	-	-	-	0.3	1.5	4.1
Energy research	5.3	7.0	10.7	14.0	16.4	15.5	13.2	13.3	10.2	9.6	12.1	16.8
Land & Water research	0.4	0.5	0.6	0.8	0.7	1.6	2.0	4.7	7.5	8.5	10.8	11.5
Special Rural Research Fund	0.1	0.2	0.2	0.2	0.1	0.3	0.4	1.5	3.0	4.0	5.2	6.3
Other rural research	2.2	4.1	3.0	5.8	3.2	6.0	9.1	11.2	12.1	18.2	26.8	24.9
PRIME MINISTER & CABINET												
Cooperative Research Centre Grants	-	-	-	-	-	-	-	-	-	-	-	4.0
TRANSPORT & COMMUNICATIONS												
Payments to Australian Road												
Research Board	0.3	0.3	1.9	2.0	3.0	2.3	2.0	2.0	2.0	2.0	2.0	2.1
Payments to Australian												
Railway R&D Organisation	-	-	0.8	0.5	0.4	0.5	0.6	-	-	-	-	-
Transport planning and												
research	6.9	6.3	-	-	-	-	-	-	-	-	-	-
TOTAL	116.0	148.1	138.1	184.7	223.9	247.2	293.9	322.2	3173	356.3	385.1	393.4

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

FOOTNOTES TO TABLE 4

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

#### FOOTNOTES TO TABLE 4 - continued

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

- (3) Assistance is provided for local manufacturers of computer hardware, systems software and electronic microcircuits. It covers design and development costs.
- (4) The expenditure figures for all but Fishing, Energy, Land & Water, and Special Rural Research include a significant component of funds derived from industry levies. The following table identifies that component of all research expenditures which is provided by way of industry levy or contribution.

#### INDUSTRY CONTRIBUTION

(estimated proportion of levies attributable to research purposes - \$m)

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
												est.
Wool	5.40	7.54	8.77	8.83	9.30	12.32	11.88	15.25	18.31	14.21	19.63	17.11
Meat & Livestock	3.18	3.30	3.02	4.16	3.61	4.61	5.55ª	7.68 <sup>a</sup>	8.61 <sup>a</sup>	11.58 <sup>a</sup>	13.30 <sup>a</sup>	14.43 <sup>a</sup>
Grains												
- Barley <sup>b</sup>		0.31	0.47	0.29	1.03	0.99	1.37	1.01	0.99	1.10	1.99	-
- Grain Legumes <sup>b</sup>	-	-	-	-	-	-	0.24	0.66	0.84	0.98	1.32	-
- Oilseeds <sup>b</sup>	0.41	0.28	0.30	0.23	0.30	0.31	0.55	0.40	0.52	0.46	0.68	-
- Grain	-	-	-	-	-	-	-	-	-	-	-	3.77 <sup>b</sup>
-Wheat	3.09	2.01	1.97	4.65	4.65	5.40	5.48	6.40	5.16	8.35	9.84	13.13
Coalc	5.47	4.42	5.16	4.28	2.14	4.17	3.28	4.82	7.07	15.02	17.05	16.62
Special Rural	-	-	-	-	-	-	-	-	-	-	0.20	0.30
Other Rural												
- Chicken Meat	0.23	0.24	0.22	0.24	0.23	0.24	0.29	0.38	0.40	0.38	0.46	0.60
- Cotton		-	0.20	0.25	0.67	1.00	0.89	1.04	0.86	1.55	1.87	2.24
- Dairying	0.46	0.42	0.42	0.54	0.57	0.60	0.67	1.26	1.64	1.57	2.94	5.04
- Dried Fruit	0.09	0.12	0.12	0.12	0.09	0.12	0.16	0.32	0.26	0.29	0.39	0.46
- Grape & Wine	0.26	0.26	0.28	0.37	0.38	0.49	'0.52	0.67	0.82	0.94	1.28	1.12
- Honey	-	0.02	0.06	0.05	0.05	0.05	0.08	0.09	0.11	0.10	0.12	0.14
- Pig Industry	0.29	0.39	0.42	0.40	0.42	0.60	0.78	1.00	1.43	1.37	1.95	2.06
- Poultry	0.10	0.14	0.15	0.15	0.15	0.16	0.22	0.31	0.28	0.37	0.30	0.53
- Sugar	-	-	-	-	-	-	-	-	1.28	1.40	1.37	1.62
- Tobacco	0.39	0.38	0.41	0.47	0.55	0.67	0.66	0.69	0.64	0.94	0.78	0.64
Total	19.35	19.81	22.83	22.29	23.71	30.61	32.61	41.98	49.22	60.62	75.47	79.79

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

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

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

												(est.)
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
EMPLOYMENT, EDUCATION & TRAINI	NG*											
Identifiable research support for universities <sup>1</sup>	69.0	77.0	85.0	94.0	104.0	112.0	118.0	126.0	134.0	142.0	150.0	155.0
Australian Research Council <sup>2</sup>	-	-	1.5	5.9	5.7	5.6	5.9	6.0	9.0	12.1	78.9	175.1
Overseas Postgraduate Awards	-	-	-	-	-	-	-	-	-	-	0.9	2.6
Estimated research component of general university funding for both teaching and research <sup>3</sup>	220	250	284	310	330	418	475	560	610	640	655	660
INDUSTRY, TECHNOLOGY & COMME	RCE											
150% Tax Concession <sup>4</sup> for R&D	-	-	-	-		-	146	170	200	164	180	200
100% Tax Deduction for equity subscriptions in Management Investment Companies (MICs) <sup>5</sup>	-	-	-	-	-	20.0	20.0	20.0	20.0	7.0	19.0	34.0
TOTAL	289	327	371	410	440	556	765	882	973	965	1084	1227

#### 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 expenditiure data collected by DEET from pre-1986 universities and include funds earmarked for research purposes. They do not include funds spent on research from the operating grants of former advanced education institutions.

(2) Excludes ARC funding through Budget sources.

- (3) The data for 1988-89, 1989-90 and 1990-91 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 advanced education institutions. 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 data series comprise estimates 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 1990-91 this series is nil, \$105m, \$137m, \$176m, and \$180m.
- (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.

includes support for teaching activities as well as for 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 the footnotes 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 these data have some deficiencies. It would be much better for estimates to be based on data derived from firms' taxation returns. Work along these lines is being undertaken by the Australian Taxation Office and will considerably improve these estimates. See footnote (4) to Table 5.

### Budget-based Science and Innovation Data and ABS R&D

Over the past three decades there has been considerable international effort to reach agreed definitions of R&D . These have since been applied with some of rigour in periodic surveys conducted within most OECD countries. This so-called "Frascati" methodology has been applied in Australia since 1969 when the national R&D surveys, now conducted regularly by the Australian Bureau of Statistics (ABS), were introduced.

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

At the same time, commentators have frequently sought to use data taken from the Budget papers to formulate views on the adequacy of Commonwealth support for research and the implications of this for science and technology policy. The data series presented in this Section has been developed to meet that need. For this reason, data presented here will not exactly match the R&D aggregates reported in ABS surveys. The practice followed here of listing whole agencies and programs as defined for administrative and financial purposes inevitably leads to the partial inclusion of non-R&D activities. In addition, there is a significant amount of R&D funded through agencies and programs not listed. Nevertheless, there are some broad similarities between trends in what is described here as "science and innovation" and R&D expenditures as reported by ABS.

Figure 6 shows the comparison between the "science and innovation" series presented in this Section and ABS (Frascati) R&D. The total budgets of the research agencies show little deviation from ABS R&D performance data. The discrepancy which does occur can be explained largely in terms of CSIRO external income. (ABS R&D performance data for the agencies includes expenditure from <u>all</u> sources of funds. The series here shows only directly appropriated Commonwealth funding.)

# **Figure 6** BUDGET- BASED DATA AND ABS R&D



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

# Commonwealth Support in a National Perspective

Figure 7 provides a schematic picture of the Commonwealth's activity in the national R&D context and its relative size and interactions compared with other elements of the overall R&D system. The Commonwealth is the dominant funder of R&D in Australia and Commonwealth agencies are also significant performers of R&D.





The figure illustrates major flows of funding support between sectors, based on 1987-88 data. It places Commonwealth funding of R&D in a national perspective.

# 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 one indicator alone may not give an adequate impression. In particular 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 Australia's rate of change in R&D levels was relatively less satisfactory.

Nevertheless, GERD/GDP comparisons remain a useful rapid guide for many purposes. The example above, however, points to some of the problems. As a generalisation, changes in GERD/GDP over a short time frame (five years or less) are a less reliable trend indicator than the rate of change in real GERD.

## 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). Selected funding data from the Table are shown in Figure 8.

For source of funds, the first column of Table 7 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 Figure 8) - 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 note here that 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	%GER	D/GDP tr	ends	Avera	ge annual	growth in	n GERD	
		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
Germany	2.79	2.71	2.69	2.81	2.79	6.2	1.6	6.7	2.7
Sweden	2.76	2.79	n.a	2.91	n.a	9.6	n.a	3.9	n.a
USA	2.60	2.77	2.73	2.71	2.68	7.1	1.6	2.7	2.7
Netherlands	2.40	2.09	2.22	2.32	2.40	9.4	8.2	5.9	n.a
France	2.34	2.25	2.24	2.29	2.31	4.1	1.8	4.1	4.3
UK	2.29	2.29	2.36	2.29	n.a	3.5	n.a	1.2	n.a
Norway	1.91	1.62	1.83	1.83	n.a	11.4	8.0	-0.6	n.a
Finland	1.87	1.55	1.65	1.73	1.77	n.a	9.0	8.6	7.5
Belgium	1.65	1.65	1.64	1.65	n.a	3.8	1.6	3.2	n.a
Denmark	1.43	1.25	1.33	1.43	n.a	6.9	9.4	7.3	n.a
Canada	1.30	1.41	1.44	1.36	1.33	n.a	5.0	-1.8	2.2
Austria	1.32	1.27	1.31	1.32	1.34	2.7	4.5	1.8	5.6
Italy	1.25	1.12	1.14	1.19	1.34	14.5	3.7	8.2	16.8
AUSTRALIA	1.19	1.16	1.24	1.19	n.a	8.1	8.9	2.0	n.a
Ireland	0.99	0.83	0.91	0.95	0.99	11.0	8.4	8.9	4.4
New Zealand	0.98	n.a	n.a	0.98	n.a	n.a	n.a	n.a	n.a
Spain	0.71	0.53	0.59	0.62	0.71	14.7	15.4	10.8	19.9

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

SOURCE: Science and Technology Resource Analysis Section, Department of Industry, Technology and Commerce based on OECD and national data. (OECD/STHD database as at October 1989 and ABS 8122 and 5206.)

	Latest	Source of Fu	Rð	nance as % C	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
Germany (1988)	2.79	1.82	0.93	0.04	2.07	0.36	0.35	0.01
Sweden (1987)	2.76	1.82	1.00	0.00	1.94	0.13	0.74	0.00
USA (1988)	2.60	1.23	1.32	0.05	1.83	0.29	0.40	0.08
Netherlands (1988)	2.40	1.21	1.08	0.11	1.39	0.40	0.49	0.12
France (1988)	2.34	0.99	1.17	0.18	1.38	0.58	0.34	0.04
UK (1986)	2.29	1.14	0.89	0.26	1.53	0.35	0.32	0.09
Norway (1987)	1.91	0.86	0.88	0.17	1.14	0.29	0.41	0.07
Finland (1988)	1.87	1.01	0.67	0.19	1.14	0.34	0.38	0.01
Belgium (1987)	1.65	1.17	0.46	0.02	1.20	0.07	0.31	0.07
Denmark (1987)	1.43	0.70	0.66	0.07	0.80	0.28	0.34	0.01
Canada (1988)	1.30	0.55	0.58	0.17	0.72	0.25	0.30	0.03
Austria (1988)	1.32	0.67	0.61	0.04	0.70	0.11	0.44	0.07
Italy (1988)	1.25	0.55	0.64	0.06	0.71	0.29	0.25	0.00
AUSTRALIA (1987-88)	1.19	0.45	0.71	0.04	0.45	0.40	0.35	0.00
Ireland (1988)	0.99	0.43	0.40	0.16	0.62	0.19	0.16	0.02
New Zealand (1987)	0.98	0.39	0.59	0.00	0.21	0.57	0.18	0.02
Spain (1988)	0.71	0.30	0.27	0.14	0.43	0.18	0.11	0.00
RECENT AUSTRALIAN TRENDS								
year								
1981-82	1.00	0.22	0.74	0.04	0.24	0.46	0.30	0.00
1984-85	1.12	0.31	0.78	0.05	0.34	0.45	0.34	0.00
1985-86	1.16	0.37	0.76	0.04	0.39	0.44	0.34	0.00
1986-87	1.24	0.45	0.76	0.04	0.45	0.43	0.35	0.01
1987-88	1.19	0.45	0.71	0.04	0.45	0.40	0.35	0.00

 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

# Figure 8

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



**Source:** See Australian *S&T Data Brief 1989-90* 





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