Science and Technology Budget Statement 1998–1999

The Honourable John Moore, MP
Minister for Industry, Science and Tourism

SCIENCE AND TECHNOLOGY BUDGET STATEMENT 1998-99

CIRCULATED BY
THE HONOURABLE JOHN MOORE, MP
MINISTER FOR INDUSTRY, SCIENCE AND TOURISM

DEPARTMENT OF INDUSTRY, SCIENCE AND TOURISM
CANBERRA 1998

ISBN 0642 28093 2

DIST 98/036

CONTENTS

WORLD WIDE WEB

AUSTRALIAN SCIENCE & INFORMATION PAGES

Science & Technology

Anglo-Australian Observatory: ... http:/ /www.aao.gov.au/
AusIndustry: ..... http:/ /www.dist.gov.au/
Australian Antarctic Division:..... http:/ /www.antdiv.gov.au/
Australian Broadcasting Corporation, Science Programs: ..... http:/ /www.abc.net.au/rn/science/
Australian Geological Survey Organisation: ..... http:/ /www.agso.gov.au/
Australian Institute of Marine Sciences (AIMS): ..... http:/ /www.aims.gov.au/
Australian Nuclear Science and Technology Organisation:..... http:/ /www.ansto.gov.au/
Australian Research Council: ..... http://www.deetya.gov.au/nbeet/arc/arc.htm
Bureau of Meteorology..... http:/ /www.bom.gov.au/
Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia) .... http: / /www.csiro.au/
Cooperative Research Centres:..... http:/ /www.dist.gov.au/crc/
Defence Science and Technology Organisation: ..... http:/ /www.dsto.defence.gov.au/
Department of Industry, Science and Tourism ..... http:/ /www.dist.gov.au/
Great Barrier Reef Marine Park Authority (GBRMPA):..... http:/ /www.gbrmpa.gov.au/
Industrial Property Australia (IPAustralia)..... http:/ /www.IPAustralia.gov.au/
National Health & Medical Research Council (NHMRC): ..... http:/ /www.health.gov.au/nhmrc/
Primary Industries and Energy R&D Corporations: ..... http:/ /www.dpie.gov.au/dpie/statutory-authorities.html
Science and Technology Advisory Bodies:..... http:/ /www.dist.gov.au/science/bodies/bodies.html

General Information on Australia

Australian Bureau of Statistics: ..... http:/ /www.abs.gov.au/
Australian Federal Government Entry Point:..... http:/ /www.fed.gov.au/
Australian Universities:..... http:/ /www.deetya.gov.au/divisions/hed/unis.htm
Major Australian Newspapers:
Australian Financial Review. ..... http:/ /www.afr.com.au/
Sydney Morning Herald:..... http: / /www.smh.com.au/
The Age: ..... http:/ /www.theage.com.au/
The Australian: ..... http:/ /www.australian.aust.com/

HIGHLIGHTS

Commonwealth support for major programs of science and innovation in 1998-99 is estimated to be over $3.7 billion, an increase in dollar terms of $90 million. Allowing for the completion of some major capital works, there is a real increase in Commonwealth support of 0.4%.

Other financial highlights include real increases of:

- 13% in total support for innovation in industry, to $627 million; and
- 9% in funds for the National Health and Medical Research Council, to $176 million.

Increases such as these are a substantial achievement in a period of tight fiscal restraint.

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

- A world first "nanomachine", a sensor so sensitive that it could detect sugar from a sugar cube dissolved in Sydney Harbour, will be commercialised in Australia as a result of research at the Cooperative Research Centre for Molecular Engineering and Technology.
- Genes responsible for glaucoma which inhibits the eyesight of 3% of Australians over 40 have been identified by the Universities of Melbourne and Tasmania.
- Five cotton varieties developed by CSIRO and superior to US varieties are to go on sale to US farmers in a market worth $A200 million a year.
- Human brain cells containing tiny magnetic crystals that may have roles in interaction with environmental magnetic fields and in diseases such as epilepsy have been discovered at the University of Western Australia.
- A more sensitive and faster test for the chlorine resistant parasite Cryptosporidium parvum, which contaminated Australian swimming pools last summer, has been developed and patented by Murdoch University.
- Land mine explosion shock on the leg is likely to be better understood and defended against through research using a new instrumented leg developed and patented by the Defence Science and Technology Organisation.
- Up to 55 yachts (each worth $A500,000) are expected to be built based on a design from the Australian Maritime Engineering Cooperative Research Centre.
- Plants that produce seed without pollination may dramatically lift world grain output — with CSIRO discovering a gene that bypasses pollination.
- Antarctic sea ice has contracted 25% between 1931 and 1987, according to Australian Antarctic Division analysis of whaling vessel records.

SUMMARY NOTES

SUPPORT FOR SCIENCE AND INNOVATION IN 1998-99

- In 1998-99, Commonwealth support for major science and innovation programs is expected to rise to $3733m from $3643m in 1997-98, a dollar increase of $90m. Allowing for completion of some major capital works, there is a real increase of 0.4% overall.

- Targeted research in universities (mostly funded on the advice of the Australian Research Council) will receive $445m, a real increase of 1% ($429m in 1997-98). Total funds for university R&D are estimated to decrease by about 1.9% in real terms.

- Total support for industrial R&D and innovation, including both direct support through appropriations and the estimated effects of tax revenue forgone, is expected to be $627m in 1998-99. This is a real increase of 13%, resulting from a substantial real increase of 30% in direct support for innovation coupled with an estimated increase of 6% through the industrial R&D tax concession.

- Support for R&D through the Cooperative Research Centres Program, aimed at promoting more effective interaction between researchers in industry, government agencies and universities, will be $138m in 1998-99, a decrease of 9% in real terms. The Government has announced it will maintain funding for the program. A selection round will occur in 1998-99 for new centres that will commence in 1999-2000

- Funds for specific purpose R&D grant schemes (rural R&D, National Health and Medical Research Council grants, other health R&D and some smaller R&D grant schemes) together rise to $370m (up 2% in real terms), with NHMRC increasing 9% in real terms to $176m.

- A total of $955m will be provided to the major research agencies in 1998-99 ($976m in 1997-98), which includes $236m on defence R&D ($239m in 1997-98). Budget support for CSIRO will be $482m (a small decrease of 1%), and the Organisation's external earnings will bring its total income to around $720m. Relative to GDP, appropriations for research in Government agencies in Australia are among the highest in the OECD.

- In common with trends in many countries with high levels of Government R&D, policy in recent years has sought to encourage greater reliance on external earnings, particularly those resulting from productive interactions with industry.

- Budget support is provided in the expectation of useful outcomes and applications, including the development of the national skills base. The *Science and Technology Budget Statement* provides many impressive examples of the discoveries, advances in understanding and steps in commercialisation resulting from Government support for science and technology.

SUMMARY TABLE

COMMONWEALTH SUPPORT FOR MAJOR PROGRAMS OF SCIENCE & INNOVATION

	1997-98 $m est	1998-99 $m est	Real change
TARGETED HIGHER EDUCATION R&D[1]	428.6	445.0	+ 1%
OTHER HIGHER EDUC. R&D	1200.7	1200.3	- 3%
CO-OPERATIVE RESEARCH CENTRES	146.9	137.9	- 9%
R&D Start, etc	157.6	209.8	+ 30%
IR&D TAX CONCESSION	382.0	417.0	+ 6%
RURAL R&D	153.0	158.8	+ 1%
NH&MRC	156.4	176.0	+ 9%
OTHER HEALTH R&D	14.7	20.9	+38%
OTHER R&D GRANTS[2]	27.2	12.5	- 55%
CSIRO[3]	472.9	481.5	- 1%
DSTO[4]	239.2	236.4	- 4%
OTHER R&D AGENCIES	263.9	236.6	- 13%
TOTAL	**3643**	**3733**	**- 0.5%**

NOTE: Estimated outlays and expenditure are at current prices, the real changes shown are based on constant price estimates.

1 Represents the total of Budget and HEF Act funding and incorporates funds allocated on the advice of the Australian Research Council (ARC).

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

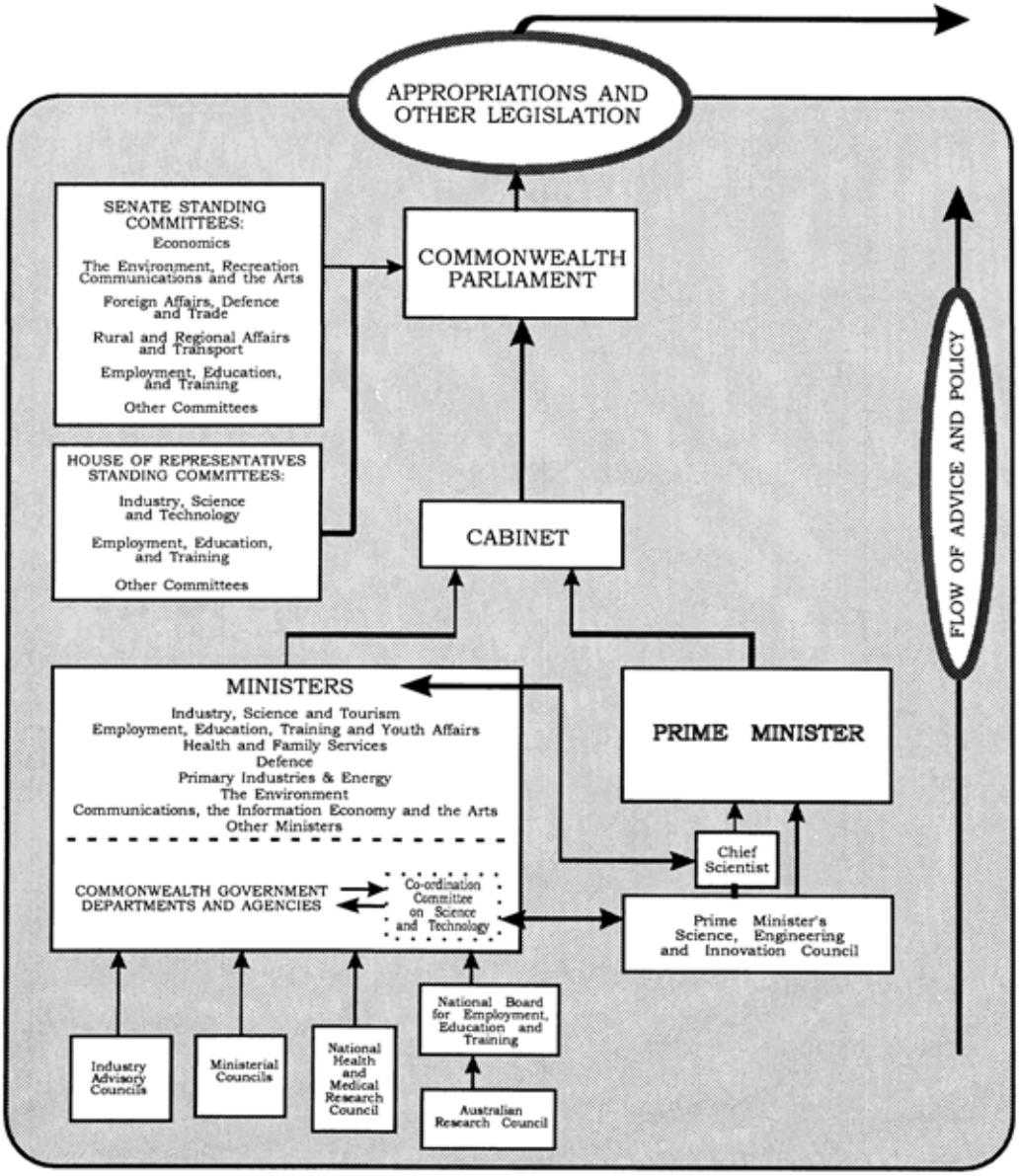
3 Includes funding through DPIE for the Australian Animal Health Laboratories. In addition to the budget funding shown, CSIRO expects to earn about $255 million from external sources in 1998-99.

4 These figures include DSTO overheads that are funded through appropriations to other parts of the Defence Portfolio. (See note 1 to Table 4.) They also include capital works appropriations principally attributable to DSTO.

For more detailed information see Tables 2 to 6

Figure 1

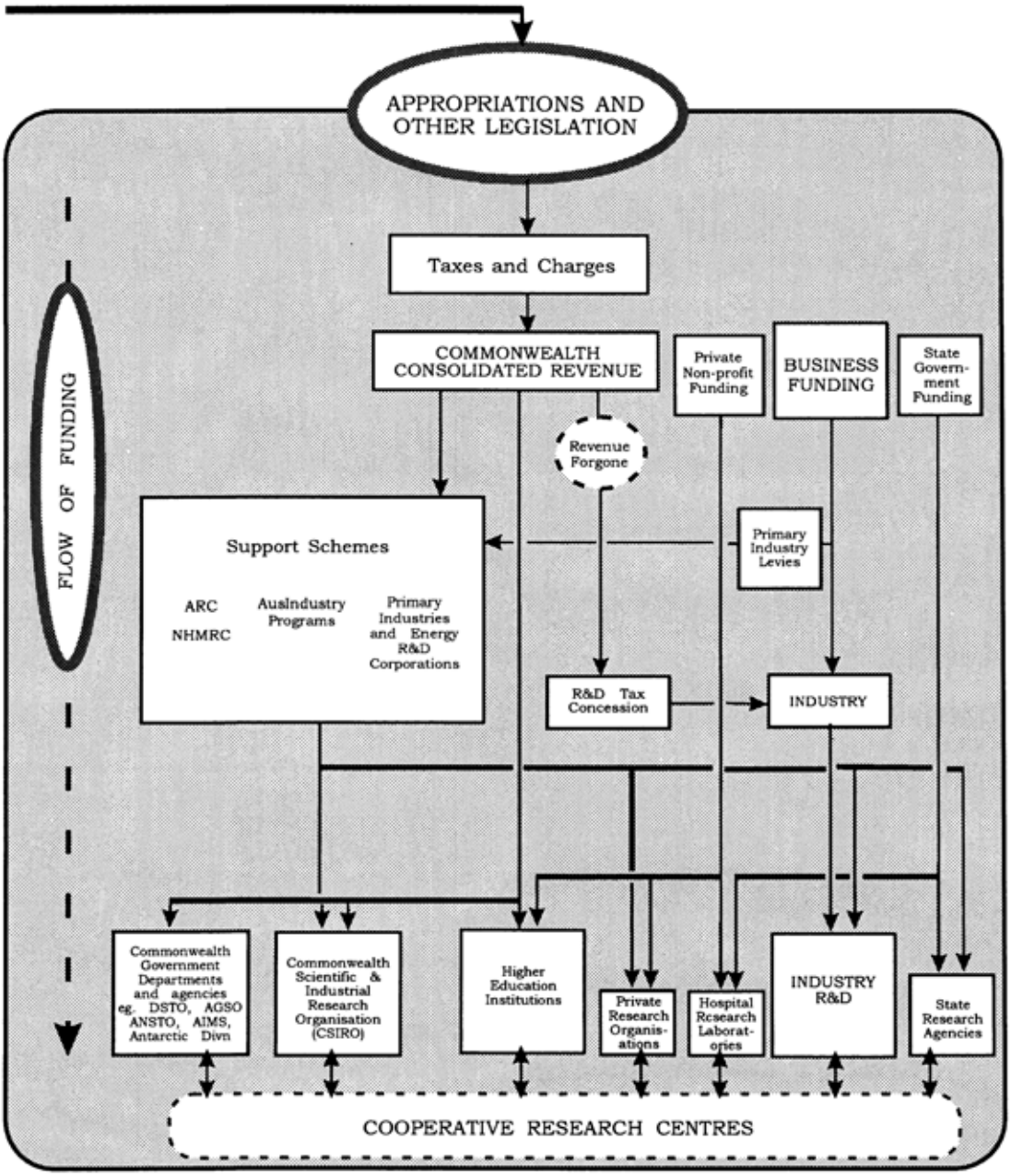
MAIN CHANNELS OF ADVICE
FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY



The figure is indicative of major bodies and principal channels for the flow of policy advice leading to Parliamentary and Cabinet decisions on science and technology issues. It does not purport to be other than illustrative.
Of course, there are a host of influential forces, including professional organisations and other non-government groups, and there are many cross-links and productive interactions between them.

Figure 2

FLOW OF FUNDING SUPPORT FOR R&D



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

Fostering Commercialisation of Research

This section discusses issues associated with the commercialisation of research in Australia, including the initiatives taken by the Government to ensure that opportunities for commercialisation are more fully realized

Introduction

The 1998-99 Budget provides for the expenditure of $3.73 billion on a broad range of research related programs supporting science and innovation. The Government's aim is to create an environment in which the return on this public investment will be maximised.

There are a wide range of benefits from public investment in research, many of which are intangible. It improves our quality of life, our health, the environment, social infrastructure, and national security. Today's Australians benefit from advanced diagnostic and therapeutic medical procedures; future generations of Australians will benefit from environmental management practices implemented on the basis of sound ecological research; while Australia's political, legal and economic life can continually adjust to the improved understanding that results from many research studies.

Australia's investment in science and technology also underpins Australia's capacity for innovation — the development and commercialisation of new products, processes and services. It can be an important factor in attracting overseas investment for industry development, and in enabling Australia to exert influence in furthering our global economic interests. In turn, this determines our ability to generate sustainable economic growth and to create new jobs and improve living standards.

CSIRO has a long history of achievement of commercial outcomes from its research programs. Traditionally, the emphasis was in the rural based industries, but more recently CSIRO as well as universities and other research institutions have placed a strong emphasis on manufacturing and service industries.

More recently, the Cooperative Research Centres (CRC) program has played a significant role in linking researchers and research organisations with the commercial users of the research.

Some examples of successful Australian research commercialisation are illustrated in the boxes overleaf.

What is research commercialisation?

Research commercialisation is a key aspect of innovation.

Research commercialisation is a complex and heterogeneous concept, requiring complicated interactions between the researcher providers, the companies wishing to exploit the research, and — in many cases — the investment sector.

In its most obvious form, the commercialisation process involves taking laboratory scale research results and completing the considerable further experimental development, production and marketing that is needed to deliver new products and services to consumers. Equally, it may involve incremental changes in materials, products and processes leading to improved efficiency and competitiveness.

CASE STUDIES

Anti-flu drug

CSIRO research on a surface protein of the influenza virus has produced a novel anti-flu drug. The research was commercialised in conjunction with pharmaceutical companies Biota Holdings and Glaxo Wellcome Australia. It was the culmination of 20 years of Australian research in CSIRO and the Victorian College of Pharrnacy. The drug has passed its most demanding clinical trial. Australians are likely to be the first in the world to have access to this new drug which is destined for world-wide release.

World lead in high-speed ferries

Australia is the world: leader in design and construction of high-speed ferries and catamarans, building some 40 per cent of the total world production. An ocean leveller, designed by the Cooperative Research Centre for Australian Maritime Engineering delivers far smoother rides for high speed ferries and has already generated $300 million in export income.

Mineral exploration

CSIRO discoveries of geochemical traces of hidden ore bodies in overlying laterites has led to new techniques in mineral exploration. Industry backing was partly through a consortium based on the Australian Minerals Industry Research Association (AMIRA). The use of so-called "lateritic haloes" in exploration in deeply weathered terrain is now an industry norm in Australia and is widely established overseas. The techniques have slashed exploration costs and dramatically sped up the process of mineral discovery. They were used in the discovery of the world class Plutonic and Bronzewing deposits in Western Australia, a combined resource of over 10 million ounces of gold and a value of over $2.8 billion.

Energy from the sun

Energy from the sun can be harnessed in solar cells to meet many electrical power requirements. The University of New South Wales in playing a leading role in developing solar cells. This world leading research is demonstrated by more records set this year for silicon solar cell performance. Earlier improvements have already been applied by BP Solar to produce about 8 per cent of the world’s silicon solar cells. Similarly, an Australian company has acquired an option to purchase the rights to commercialise one of the biggest advances ever in solar cell technology, the Australian National University’s "Epilift" process. This process is expected to halve the cost of solar photovoltaic electricity.

Adding value to minerals — light weight metals

CSIRO research has led to electrolytic processes for the production of magnesium metal in Australia that increase the value of the magnesite ore mined by Queensland Metals Corporation by up to a factor of ten. Light weight alloys of magnesium and aluminium (another Australian resource) are increasingly replacing steel in the manufacture of cars. For example, the aXcess Australia Concept Car features 18 inch magnesium wheels made by Castalloy in South Australia. CSIRO research has resulted in the development of lighter, stronger magnesium alloy automotive components.

Saving Australia's pine industry

Tiny parasitic worms are saving Australia's pine-wood industry at least $50 million each year and providing a safe alternative to chemical pesticides. This is the return on a CSIRO investment in scientific research of only half a million dollars. The worms home in on Sirex wasps that are the scourge of pine plantations when they burrow into trees and deposit eggs. The process eventually kills the trees. The introduced parasitic worms bring about sterility in the female wasps in a complex biological series of steps. Their population then dwindles to a very low level.

Welding

The costs of welding high pressure gas pipelines currently being laid across Australia will be reduced by at least $110 million. This is the result of new technology developed by the Cooperative Research Centre for Materials Welding and Joining.

Sun protection

Skin damage from the sun's ultraviolet light is very well recognised these days but there is growing evidence that ultraviolet light also suppresses the immune system. Conventional sunscreen products do not provide protection for the immune system. After a decade of research, helped by Industry R&D Board support, a new sunscreen has been developed by Hamilton Pharmaceuticals collaborating with researchers at Flinders' University. Hamilton's "Superblock" was released in time for the recent Australian summer.

Sustaining Australian grain exports

The bulk storage of grains requires careful control against pest infestation and grain spoilage to maintain Australia's profile of a clean and green food producer A range of CSIRO research on stored grain technologies has been commercialised. It has been estimated that for every dollar invested by CSIRO in stored grains research, between $3 and $9 extra sales income occurs to the industry. Consumers benefit from higher quality grain and the environment benefits from reduced pesticide use.

The economic benefits from commercialisation may arise in a number of ways. For example, there are many instances in the mining industry, (as illustrated in the case studies), where the final outcome can be a major enhancement of wealth generation, without a specific commercial "product" appearing. Even more diffuse outcomes, but economically significant ones, occur in areas such as environmental management. For example, actions which improve the management of river catchments enhance the efficiency and sustainability of the farming and other industries that depend on the river system. These economic benefits may arise from the production and investment decisions of only a few firms or of many small producers or users.

The most effective strategy for capturing the benefits of commercialisation may also vary significantly between industry sectors. For example, in the area of biotechnology, patent protection is a key issue and increasingly multinational companies are dominating the market. In other areas, such as electronics, speed to market may be critical, with smaller companies more able to carve out sustainable competitive niches. But, the time scale from development to application to economic returns may span a few years or be measured in decades.

Commercial outcomes may derive from research conducted by businesses themselves, or the licensing of intellectual property from overseas or from public sector researchers, such as CSIRO or the universities. The Cooperative Research Centres (CRC) program attempts to strengthen the "pull-through" effect, by requiring strategic linkages between the researchers and the commercial participants, to ensure that the research is streamed towards specific requirements of those users.

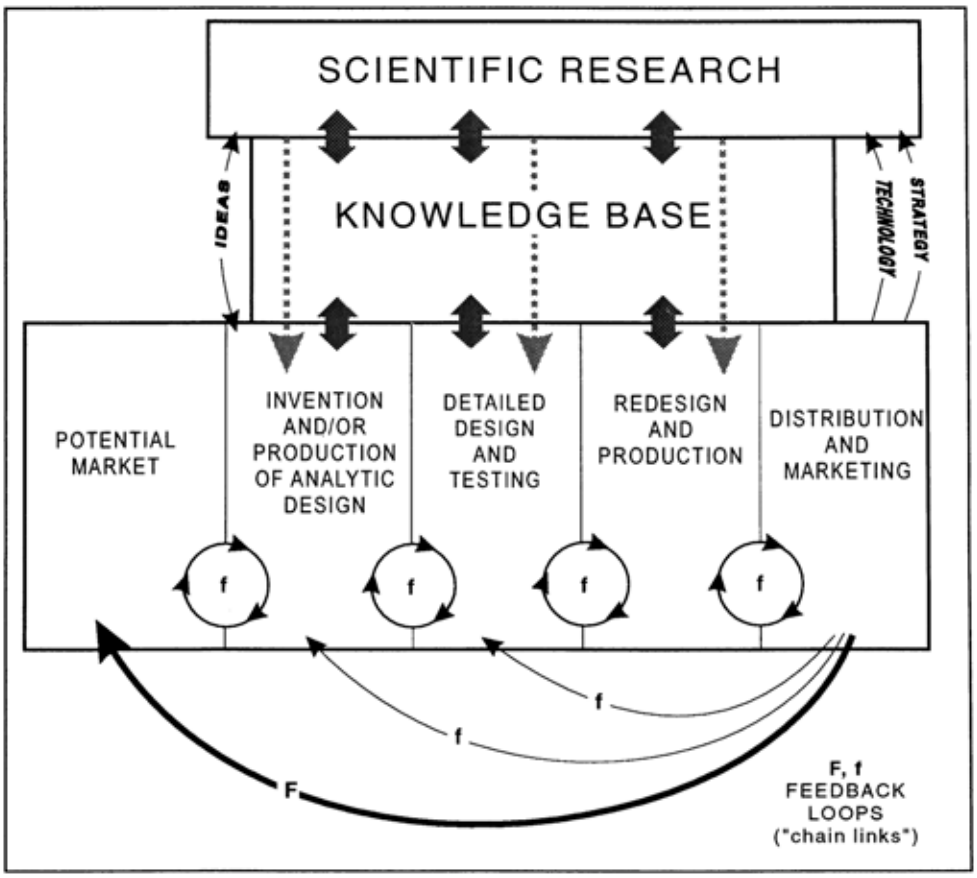
While it can generate substantial economic benefits, research commercialisation is a complex and costly process. For every dollar that leads to a promising research outcome, anything up to 100 dollars or more of further investment may be required for successful commercialisation. Moreover, promising research outcomes are not always as promising in commercial terms as they may seem at first sight. Experience both overseas and in Australia indicates that only one in one hundred of prospective research outcomes investigated for investment purposes can be successfully commercialised.

The steps involved in research, development, production and marketing are not linear, but are highly interactive and have many linkages. Following a direct path to market from an initial laboratory discovery or invention is highly unusual. Producing a fully marketable product usually requires a substantial design and testing effort involving many incremental changes additional and unrelated to the original discovery. And for newly developed processes, carrying out production efficiently on a large scale may involve a range of challenges not encountered under laboratory conditions. All these interactive processes must draw heavily on the accumulated knowledge base that resides in the scientific, technological and skilled trades workforce.

Figure 3 provides what has become a well-accepted view of commercial innovation that outlines the various processes — the activities, interactions and feedbacks involved in the processes of commercialisation. The originators of this model emphasise the non-linearity of these processes that

"... must be viewed as a series of changes in a complete system not only of hardware, but also of market environment, production facilities and knowledge, and the social contexts of the innovation organization."

Figure 3 The "chain-link" model of commercial innovation



Source: Adapted from Kline and Rosenberg (1986)

The Figure indicates that ideas flow in both directions — from science to technology and from technological effort to science. Technology may provide useful devices that enhance scientific research, and market signals may point to specific strategic directions where research is needed to back up commercially viable technology development. There are extensive feedback loops between all stages of the innovation and commercialisation processes — these are the "chain links" in the model.

What are the key ingredients for successful commercialisation and how does Australia rate?

While the strategies for successful commercialisation will vary greatly, there are a number of factors concerning the broad environment in which commercialisation is taking place which can influence a country's performance in commercialising research. These include:

- the quality of a country's own research base, and the maintenance of S&T skills;
- the availability of companies willing and able to take up the results of research;
- the strength of links between the research base and industry;
- access to technology invented overseas;
- availability of venture capital;
- the quality of management skills;
- an appropriate regulatory environment; and
- a competitive business environment.

Underpinning all these, and addressed under the last point, is an economic environment which is conducive to business growth. Achieving this has been a central focus of the Government. Through sound macroeconomic management, interest rates and inflation are now at levels not seen for decades. And business competitiveness and flexibility has been enhanced through further deregulation of financial markets, labour market reform, more efficient and competitive infrastructure services and reductions in red tape.

These policies complement and underpin the more specific actions the Government has taken to improve the environment for commercialisation of research.

An indicative rating of Australia's performance against each of these commercialisation factors is provided in Figure 4 opposite. These factors are discussed in turn under the headings below.

- **The Australian research base — public and private**

Australia has a large scientific effort of internationally recognised quality.

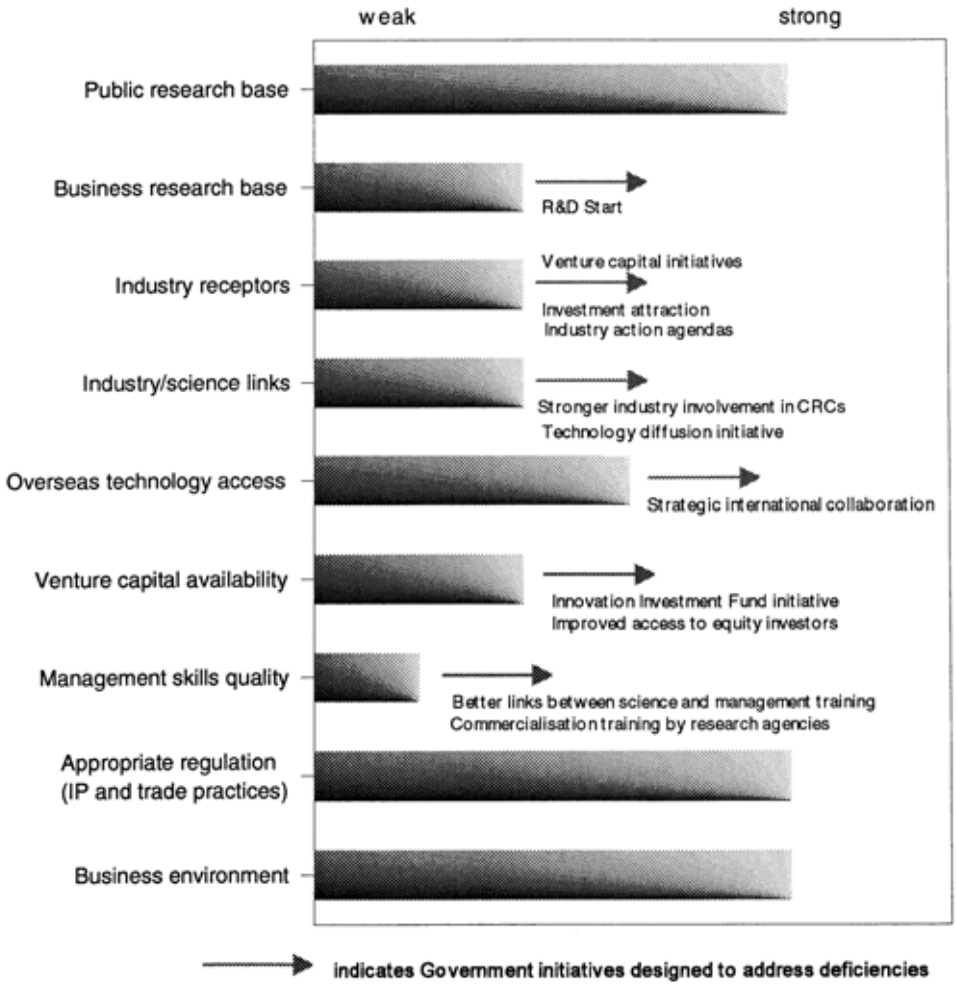
Relative to our GDP, our expenditure on scientific research outside the business sector is the fifth largest in the world. But even the scale of our effort is relatively large - in absolute terms we are thirteenth among all countries and one or two places higher if purely engineering research and development (R&D) is excluded.

Moreover, the diversity of our scientific effort and the evenness of its high quality is unusual in world terms. Our physical size and length of coastline, the arid nature of our country, its dry and highly variable climate, its vast biological diversity, its extensive mineral resources, and geographical location, together raise a great number of scientific problems and opportunities, many of which are not duplicated in other parts of the world.

This research strength provides a rich stream of discoveries which may have the potential for commercialisation. In addition, Australia's research capability and infrastructure also helps us access leading edge science and technology overseas.

Despite difficult Budgetary circumstances in recent years, the Government has continued its high level of support for public sector research.

Figure 4 A scorecard on Australia's framework for research commercialization

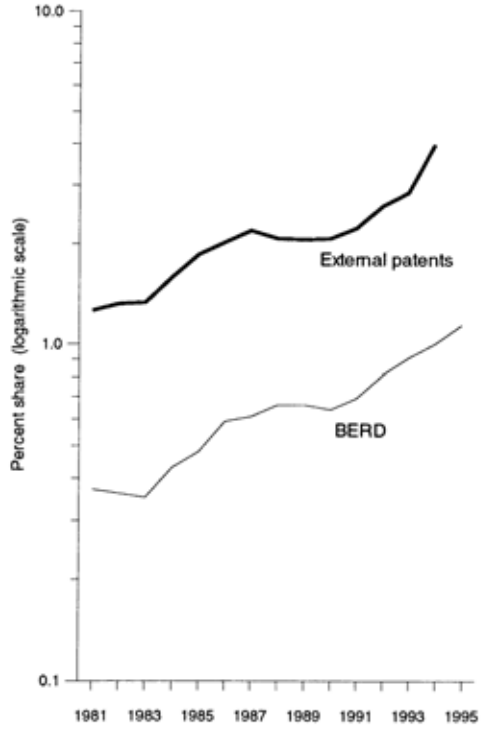


Source: Summary by Department of Industry, Science and Tourism, based on various indicators

Turning to business expenditure on R&D (BERD), as is indicated in Section 4 of this *Statement*, growth has been among the fastest in the OECD over the past decade and a half. Along with this growth, there has been an increase in commercialisation activity. Figure 5, for example, not only shows a substantial improvement in Australia's level of business R&D expenditure, but also indicates that this R&D has resulted in a substantial increase in patenting applications from Australia to other countries.

The Government is seeking to ensure that this strong growth continues and has recently introduced a number of changes to Government programs supporting business R&D to improve their effectiveness. For example, R&D Start, the competitive grants program for industry R&D, has been significantly extended and expanded with an additional $556 million of funding being announced in the Government's *Investing for Growth* Statement. The expanded R&D Start program targets high quality R&D with high expected returns and complements the 125% R&D tax concession. Reforms to the tax concession are also being made to maximise its effectiveness.

Figure 5 Australia's external patent applications and business R&D expenditure as shares of OECD totals



Source: Updated from Australian Science and Technology — At a Glance, 1997

- **Industry receptors**

It is not the role of universities and science agencies to commercialise their research outcomes by themselves. Ideally, at an early stage in the research project, or before the project commences, an appropriate commercialisation vehicle needs to be thought through and built into forward planning. In addition, companies need to think more strategically about their research needs with a view to developing collaborative arrangements with public sector researchers, and putting in place appropriate internal processes so that research results can be progressed through the commercialisation chain.

A complaint often made by researchers is that it is difficult to find an Australian company to take up a new piece of technology which, in contrast, may be eagerly sought overseas. Similarly, it is claimed that too few companies are prepared to take full advantage of Australia's high quality public sector research base — for example through entering into collaborative research partnerships. There may be a number of reasons for this apparent lack of interest by Australian companies. Difficulties in accessing the financial resources to make the relatively large and long term investments required, a small domestic market and relatively weak or specialised market networks, limited in house capability to develop and refine a product for market, and, for larger companies, incompatibility with existing global technology strategies, could be factors in varying degrees.

Without sufficient numbers of capable Australia-based firms, Australian public sector research agencies may be forced to seek an international partner. For some technologies, this will sometimes be necessary to tap the marketing and financial resources that are required for successful commercialisation. Where this occurs, it is important that the intellectual property is managed in such a way as to maximise ongoing benefits for Australian taxpayers, including opportunities for Australian industry to participate and/or for Australian consumers to benefit from the resulting products.

The Government has been active in fostering a stronger Australian industry receptor base. For example:

- new industry investment is being attracted through sound macroeconomic management, microeconomic reform and active investment attraction;
- support for industry research and development is being made more effective - for example through the introduction of R&D Start;
- new strategies have been announced for industries with a heavy reliance on R&D, such as pharmaceuticals;
- forward looking legislation is being introduced to encourage the establishment of an Australian space industry; and
- new programs, which are discussed further below, and changes to business regulations, have made it easier for companies to raise long term equity capital.

In addition, the Government announced in *Investing for Growth* that Action Agendas would be developed to address impediments to growth in specific industry sectors. These are to include information industries, textiles, clothing and footwear, chemicals and plastics, tourism, renewable energy, liquified natural gas and passenger motor vehicles. Issues of research and its commercialisation will be addressed where appropriate in these Action Agendas.

- **Linkages between the research base and industry**

For public research, research commercialisation depends on bringing science and business together. Partnerships between science and business have worked well for many years in the US and some other leading nations, and linkages of this kind are now beginning to work well in Australia.

Australia's universities and public science agencies can be the source for much valuable knowledge. They can provide specialist advice and significant technological advances — often having their origin in their own scientific needs for improved research tools. In addition, they provide the scientists, engineers and managers to fill key positions concerned with business innovation. Business managers need to be prepared to look to the public research sector as a source for potentially valuable innovative developments.

However, there are substantial cultural and motivational differences between researchers in scientific institutions and those who operate within a commercial environment. For example, achievement is recognised differently, through different reward structures. These differences can inhibit the development of effective linkages between the research base and industry.

In science, individuals tend to have a strong, almost independent role within the institution. In a university, scholarship and scientific research is directed towards gaining fundamental understanding. The reward system in science is based largely on priority of discovery — this encourages early disclosure and exchange of information leading to an enhanced reputation for the researcher. The reward system in business derives directly from commercial profits or their expectation. This financial success will usually require monopoly rights to information regarding new technological developments — thus disclosure or exchange of information usually needs to be discouraged or strictly controlled.

In addition, standards of commercial practice such as approaches to confidentiality, management of intellectual property, and research time frames and responsiveness may differ substantially between public sector researchers and industry.

To redress the lack of natural interactions between science and business, the Government is seeking to improve links between public sector researchers, businesses and other research users, and between Australia and the international scientific community. From the research end, the science authorities are actively pursuing opportunities to collaborate with Australian industry in commercialisation activities, through, for example,

licensing intellectual property, and encouraging the establishment of spin-off companies. CSIRO, for example, now sets its research priorities according to the needs of the 22 sectors of the Australian economy with which it works. Sector Advisory Committees provide guidance on strategic issues for each industry sector and long-term research needs. Performance indicators in the science authorities' triennium agreements provide information on linkages with industry and other research users. All the science authorities have substantially increased external earnings and currently exceed their targets.

Universities have been encouraged to make stronger linkages with industry through, for example, the Strategic Partnerships with Industry Research and Training (SPIRT) Scheme, and the provision of 50 additional industry Australian Postgraduate Awards announced in *Investing for Growth* last year. A review of the effectiveness of university-industry linkage programs is currently under way to see where further improvements can be made. The West Review of Higher Education and Funding also makes recommendations in this area.

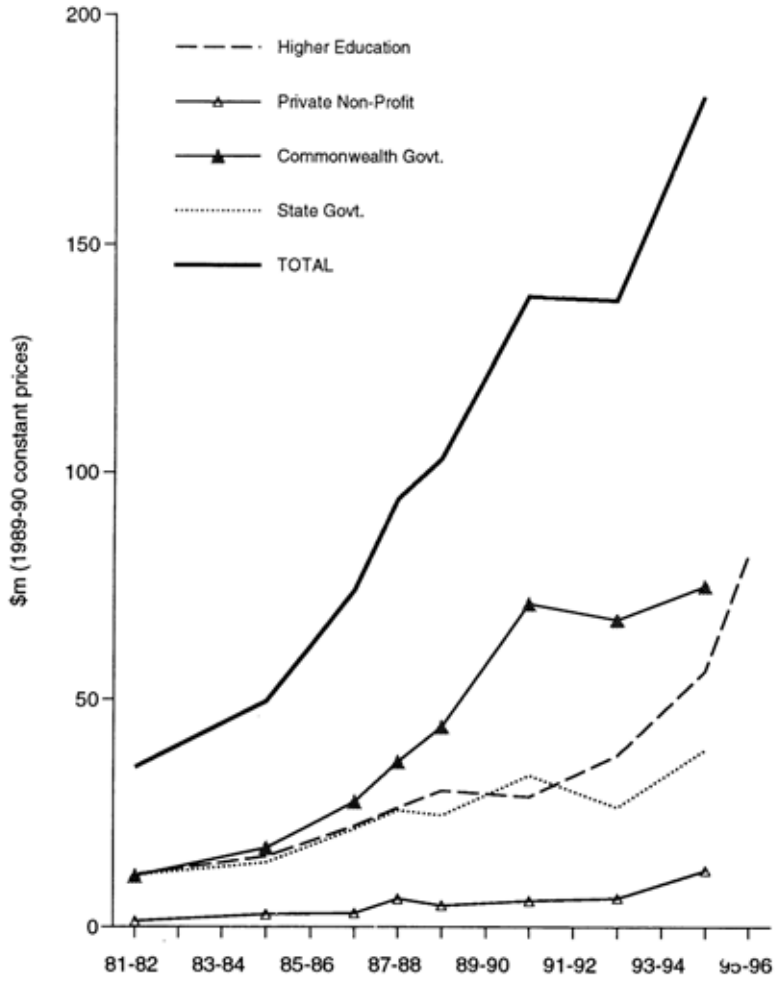
At the same time, a number of universities have established commercialisation arms to facilitate the process of commercialising their research. The activities of these organisations' which are represented by the Australasian Tertiary Institutions Commercial Companies Association Incorporated, are outlined in the box below.

ATICCA, Australasian Tertiary Institutions Commercial Companies Association Inc.

ATICCA is a group of organisations which aim to promote effective interaction between tertiary institutions and commerce, industry and Government. Over the past two decades, growth in the number of ATICCA organisations has been substantial — many are now strong companies and earn substantial incomes for the benefit of their parent institutions.

In bridging the gap between academia and industry, ATICCA organisations provide a mechanism for tertiary institutes to commercialise their research, transfer technology, and provide consulting and other services to industry and other outside bodies. Their services also include; intellectual property development and marketing; commercial market planning and research; product testing; continuing education; and exports of educational services.

Figure 6 Australia's flow of R&D funds from business to other sectors



Source: Derived from Australian Bureau of Statistics Catalogue 8112.0 (various years)

The CRC program promotes long term collaboration between industry, universities and government agencies in order to obtain a better return from Australia's investment in research and development. The Government has recently reviewed the program and will be making changes to the management arrangements to ensure industry is more closely involved and that, where relevant, the results of CRC research have a clear path to commercialisation.

In addition, the Government recently announced that an additional $72 million will be provided to encourage Australian industry to access and implement technology diffusion initiatives. Under the new Technology Diffusion program, a total of $108 million will be provided to industry, universities and research agencies over the next four years. The program will increase industry's ability to absorb new technology and strengthen alliances nationally and internationally between Australian science, engineering and technology. It will focus particularly on small and medium enterprises.

There is evidence of significant improvements in linkages between industry and public sector researchers. These linkages have grown at a faster rate than most other OECD nations and are illustrated by the growth in funding flows from the business sector in support of public sector research (Figure 6).

Figure 6, adjusted for inflation, shows a sharply rising trend in total R&D funds received by the public sector from business. The rate of increase is marginally faster than that for overall business R&D expenditure over the same period. Overall, nearly 6 per cent of business R&D funding now flows to fund research outside the business sector. The increase of business R&D funding in the higher education sector since 1990-91 is particularly notable.

- **Access to technology invented overseas**

Another important source of technology for commercialisation is that which is invented overseas. Like most countries, Australia produces only a fraction of the science and technology that it needs. And with the increasing cost of major research facilities, and globalisation of industrial production, effective international collaboration is becoming increasingly important.

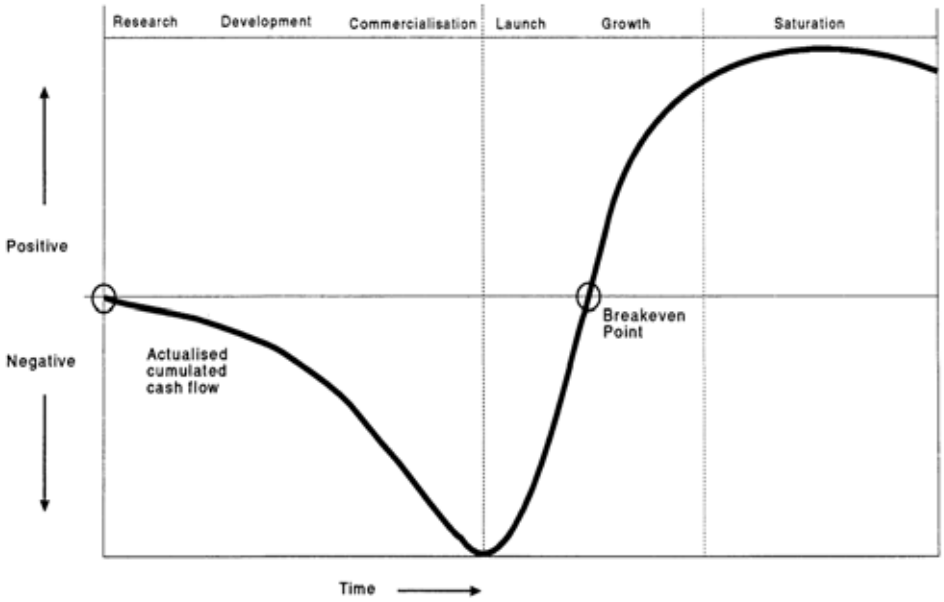
Australia's strong regime for protecting intellectual property rights, and its openness to foreign investment and trade, play an important role in facilitating technology transfer.

Within this positive environment, the Government recently announced increases in funding to improve access by business to technologies developed overseas. In addition, the new Technology Diffusion program will focus on linking Australia with leading edge science and technology capabilities overseas and in developing new strategic alliances between Australian industry and high technology industries in other countries.

- **Venture capital**

The costs involved in commercialisation of a new product can be modelled as in Figure 7. As time proceeds, the accumulating costs of investment grow steeply. This includes expenditure on such things as the costs of building a prototype, industrial design, production engineering, and marketing. The accumulated costs may mean that it is some time before a breakeven point is reached and investors begin to see a return. The longer this takes, the higher the probability that rivals will try to copy, improve or bring a competing innovation into the marketplace. However, especially with very innovative developments, a "first mover" advantage may help bring about a successful return on the investment.

Figure 7 Net cash outflow and return during R&D and its commercialisation



Source: Adapted from OECD sources

Availability of "patient" capital is therefore a key requirement for successful commercialisation. Australia's level of venture capital funding is less than 0.08 per cent of gross domestic product, compared to Canadian levels which are estimated at around 0.1 per cent. This suggests a need to lift performance to a level appropriate for the economic circumstances in Australia.

A number of initiatives have been taken in the past to address this issue. Pooled Development Funds (PDFs) were established to increase the supply of patient equity capital for small business. PDFs qualify for concessional tax treatment on realised profits for investors. In addition, the Australian Technology Group was established with a Government capital base to improve the supply of equity capital and management expertise to companies at the start up and early stage of their development.

A major new initiative introduced by the Government early last year as part of its *More Time for Business Statement* was the Innovation Investment Fund (IIF) program. The program is expected to greatly assist the commercialisation of research outcomes in Australia. Together with private sector funding, the $173 million announced by the Government for this program will create an overall investment pool of about $260 million. In addition, recent changes to business regulations will make it easier for small companies to raise equity capital through the stock market.

Matching Service on the Internet – the enterprise market (e.m™).

e.m is a new Internet-based market available to any non-listed entity wishing to raise capital and is an initiative of the Australian Stock Exchange.

The mission of **e.m** is to produce a single, national capital market for non-listed businesses. It will enable capital raisers to be brought together with capital providers. A seller seeking capitalor seeking to sell an existing invetment will display a certain amount of mandatory information on the system. Key aspects of this information will be validated and an opinion about the seller's docoument provided through a system of 'sponsors'. These are accountants, lawyers, stockbrokers etc who can scrutinize the document and offer prospective investors professional advice on the business.

Buyers will also have a profile on the system, outlining the type of investment they are looking for. The computer program underlying **e.m** will sort through the new information from sellers every night, and then automatically generate an e-mail message to every buyer whose profile indicates an interest in such an investment. Buyers can use investor advisors (eg a merchant bank) for this, and subsequently for conducting fast and detailed investigations through the e.m of the information published about a business.

Besides investing in a business that suits their interests and expertise, a buyer may have the opportunity to influence the directions of the business and personally help to increase its value. If the business wants the buyer to form a key part of the management team this will be indicated.

As the Internet knows no national boundaries, the market for investors is worldwide.

Web site: www.asx.com.au/e.m

There has also been a growth of private sector activities to help companies identify potential equity investors, such as a new matching service provided by the Australian Stock Exchange through the internet. (See box above)

- **Management skills**

Human skills are central to the process of research commercialisation. Effective management is critical for the day to day operation of the business, implementation of research, development and marketing programs, securing funding, and intellectual property strategies.

A concern often stated is that Australia has a shortage of skills and experience in these areas — comparisons frequently being made to a more entrepreneurial culture in some other countries, such as the United States. The magnitude of this problem is difficult to gauge, but may require longer term efforts to develop a stronger business culture and skills through the education system and to encourage greater awareness of the importance of science and technology at senior management and Board level in companies.

In recent years, Australian universities have expanded the courses available to embrace not only research but other important areas of innovation, such as management skills. In addition, there are a number of mechanisms which are designed to assist in this area - to help bridge the gap between a technological development and the creation of an interesting commercial proposition. As noted above, some of the universities have commercialisation arms which assist in this area. CSIRO and CRCs are also placing particular emphasis on strengthening the commercialisation skills of senior management. In addition, arrangements exist and are developing which facilitate experienced business people providing guidance to managers of new start up companies.

- **Business regulation**

Australia has an advanced, well developed system for protecting intellectual property. This system provides a strong incentive for Australian businesses to innovate, it facilitates trade in innovative products and services, and encourages the transfer of new technologies from overseas. Our competition policies encourage vigorous competition and strong rivalry between firms to differentiate their products and position in the market.

Recent changes to the patents system introduced by the Government will build on this favourable regulatory regime. These include the reduction of patent fees and simplification of fee schedules, amendments to the Patents Act to allow extensions of up to five years on 20 year patents for standard pharmaceutical products, and the introduction of an "innovation patent" to replace the petty patent. The innovation patent will provide a lower entry threshold to the patent system with simple procedures and low costs. It is expected that this form of intellectual property protection will be particularly valuable for small and medium sized business.

- **Competitive Business Environment**

Since coming to office, the Government has vastly improved Australia's economic fundamentals. Strong economic growth is being achieved while interest rates have been reduced to levels not seen for many years and inflation is now at historically low levels.

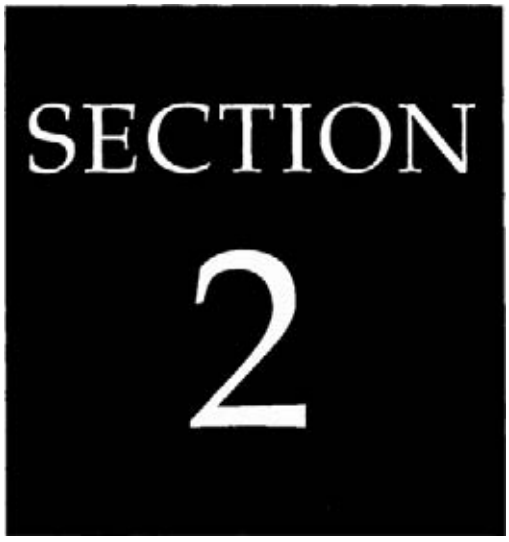
At the same time, the Government has vigorously pursued a range of microeconomic reforms, including changes to Australia's industrial relations system, a major program of privatisation which has enhanced efficiency, competition and choice, reforms to Australia's communications industry and our financial sector, and a major package of measures for small business which has cut red tape, reduced regulation and expanded opportunity.

This provides a very positive environment for new investment and the development of new businesses. In addition, through increased competition, it provides added incentive for the follow-up research, re-design and incremental improvement at the heart of the processes of commercialisation.

Next Steps

The mix of incentives and concessions available to Australian industry for R&D makes Australia one of the most attractive countries in the world in which to do research. At the same time, considerable progress has been made by the Government in improving the environment for commercialisation of research. This will continue to be a key focus of science and innovation policy.

Over the next 12 months, the Government will be exploring whether there are further impediments which need to be addressed. For example, the goal of increasing investment in new industries will be an important consideration in shaping reforms to the Australian taxation system. These reforms are a central element of the Government's forward policy agenda.



Recent Major Developments

This section outlines the major developments of the past year and initiatives to be taken in science and technology across all Government portfolios

Science and Technology Advice

Formation of the Prime Minister's Science, Engineering and Innovation Council (PMSEIC)

In December 1997, the Prime Minister announced the formation of a new Prime Minister's Science, Engineering and Innovation Council to replace the former Prime Minister's Science and Engineering Council and the Australian Science and Technology Council (ASTEC). PMSEIC is to be the Government's principal source of advice on issues in science, engineering and technology, relevant aspects of education and training, and the national system of innovation. It will meet in full session, generally twice a year, to discuss major national issues in science, engineering and technology and their contribution to the economic and social development of Australia.

The new Council will be chaired by the Prime Minister, and will retain the existing membership of the Prime Minister's Science and Engineering Council. The new membership will be supplemented by other key representatives of the business and scientific community. The Minister for Industry, Science and Tourism, the Hon John Moore, MP, will be Deputy Chair of the Council, and the Chief Scientist will be its Executive Officer.

The terms of reference of PMSEIC are:

- to advise on important issues in science, technology, engineering and relevant aspects of education and training, including as they relate to economic growth, employment creation, the development of new industries and the sustainable development of new resources;
- to examine the contribution of science, technology and engineering to the innovative capacity and economic and social development of Australia;
- to enhance awareness in the community of the importance of science, technology and engineering for Australia's economic and social development;
- to examine Australia's science and engineering resources and the effectiveness of their organisation and utilisation; and
- to examine Australia's science and engineering infrastructure and the effectiveness with which it achieves the application of science and technology in the economic and social development of Australia.

The non-ministerial members of the Council will constitute a Standing Committee of the Council, and will oversee and contribute to studies and research aimed at improved understanding on major science, technology, engineering and innovation issues. The Standing Committee will have the power to invite other experts to join in this work. It will take over major responsibilities of the Australian Science, Technology and Engineering Council (ASTEC). The Standing Committee will be a strong source of independent advice on issues in science and technology, and will retain

ASTEC's capacity to undertake work on its own initiative, as well as work requested by the Government.

The decisions on the new Council build upon recommendations made by the Chief Scientist, Professor John Stocker, in his report *Priority Matters*, and are a response to that part of his report that dealt with cross-portfolio advisory arrangements.

Government response to the review of science and technology arrangements

In March 1998, the Minister for Industry, Science and Tourism released the Government's response to those aspects of the Stocker report not covered in the Prime Minister's announcement of the formation of the new Prime Minister's Science, Engineering and Innovation Council. The main points of the Government response are:

- the adoption of the thrust of the Stocker proposals on cross-portfolio advisory arrangements, through the formation of PMSEIC and the absorption of ASTEC into its work;
- decisions on the Coordination Committee on Science and Technology (CCST), including that it should be chaired by the relevant Deputy Chief Executive Officer in the Department of Industry, Science and Tourism(DIST), rather than by the Chief Scientist, as recommended by Professor Stocker;
- responses to Professor Stocker's recommendations on within-portfolio advisory arrangements, where the importance of chief science advisers or their equivalents, and coordination arrangements involving the portfolio department and agencies, are stressed;
- a role for PMSEIC in identifying national science and technology priority areas, based on the contribution of science and technology to broad (and generally non-prescriptive) national structural goals; and
- responses to Professor Stocker's views on a number of identified gaps and overlaps in the Australian science and technology system.

Higher education issues were addressed by the West Committee while the Stocker Report's comments on the Cooperative Research Centre (CRC) Program have been addressed in the Government's consideration of the recent review of commercial aspects of the Program. Copies of Professor Stocker's report and the Government's response are on the Department of Industry, Science and Tourism Web site at http://www.dist.gov.au/science/cs/index.html

Australian Science and Technology Council (ASTEC)

This year has marked the last year of the operation of ASTEC. Its functions are now to be incorporated into the new Prime Minister's Science, Engineering and Innovation Council (see above).

ASTEC conducted two major studies in 1997-98. These focused on the Effects of Competition Policy on R&D, and the Ethics of Research in Environmentally Sensitive Areas. ASTEC also prepared a submission to the

Parliamentary Joint Committee of Public Accounts' inquiry into Internet Commerce.

Competition Policy and Research and Development
ASTEC examined the implications for research and development of competition policy reform within the Australian utility sector, particularly unintended or unforeseen consequences of the corporatisation or privatisation of the utilities for their R&D. The issue was raised by the Chief Scientist in his report to the Commonwealth on its science and technology advisory arrangements, *Priority Matters.* The report referred to the potential for a loss of spillover benefits from R&D which has a public good component and which maybe reduced as reformed authorities focus increasingly on core business activities. The ASTEC study has identified a number of concerns that need to be taken into account by Governments considering privatisation programs. ASTEC provided a submission to the House of Representatives Standing Committee on Industry, Science and Technology for their inquiry into competition policy. It also prepared a more formal report on its findings, in the form of an Occasional Paper.

Ethics and the Conduct of Research in Protected and Environmentally Sensitive Areas
The study on Ethics was undertaken in response to community concern that there are no structures in place to guide scientists on best practice in conducting research in areas that may suffer damage as a result of that research. ASTEC worked closely with the Great Barrier Reef Marine Park Authority and the Australia and New Zealand Environment and Conservation Council (ANZECC) to develop these guidelines. The study involved extensive consultation with interest groups around the nation to take into account a diversity of views in developing the guidelines. ASTEC provided part sponsorship for a Fenner Conference on the Environment, held in November 1997, to provide a public forum to discuss the issues and the debate and revise the draft guidelines. It is expected that the report will be presented to the ANZECC Ministerial Council at its meeting in June 1998.

Submission to the Joint Committee of Public Accounts Inquiry into Internet Commerce
ASTEC provided a submission to this parliamentary inquiry, alerting the Committee to important science and technology issues that underpin Internet commerce. The Committee subsequently sought further assistance from ASTEC relating to matters raised in other submissions.

ASTEC's final year of operation
The Prime Minister announced in December 1997 changes to the science and technology advisory structures in the Commonwealth Government. This involves the incorporation of the functions of ASTEC and the Prime Minister's Science and Engineering Council into a new high level policy advice body, the Prime Minister's Science, Engineering and Innovation Council. The new body will continue ASTEC's work. The Minister for Industry, Science and Tourism requested that current ASTEC studies be carried to completion by the present Council and its Working Groups.

Coordination Committee on Science and Technology (CCST)

The Committee's major role as a forum for exchange of information among departments and agencies has continued. In its recent activities, the Committee has:

- considered the Chief Scientist's Report *Priority Matters* on arrangements for Commonwealth Science and Technology;
- considered the implications for science and technology of the Government's industry statement *Investing for Growth*;
- been developing a website on the Internet that will help coordinate arrangements for Australia's international science and technology activities;
- examined a paper on supply and demand of scientists in Australia;
- discussed the implications for research of the proposed World Intellectual Property Organisation (WIPO) Database Treaty; and
- discussed possible topics for the PMSEC/PMSEIC agendas.

Innovation in Industry

Investing for Growth

In December 1997, the Government released a major statement of industry policy, *Investing for Growth.* This statement provided a range of initiatives aimed at supporting the Government's extensive agenda of economic reform — with the over-riding aim of achieving an average annual growth rate of over four percent for the decade up to 2010.

The package of measures in this major statement deal with: the encouragement of innovation; boosting investment; improving Australia's trade performance; enhancing Australia's attractiveness as a financial centre; ensuring that the benefits of the "information age" are captured; and establishing a series of "Action Agendas" to address impediments to growth in specific industry sectors.

In aggregate, the budgetary impact of the *Investing for Growth* initiatives is $1.26 billion over the four years to 2001-02. Within this amount $1 billion is in support of innovation, including some renewable energy initiatives announced in the Prime Minister's November 1997 Statement *Safeguarding the Future: Australia's Response to Climate Change.*

Within the innovation component of *Investing for Growth,* major changes were announced to the R&D Start Program, additional support was announced for the Innovation Investment Fund and new initiatives were undertaken to improve technology diffusion in Australia. These measures are described below.

Enhancement of the R&D Start Program

The Government's Industry Statement *Investing for Growth* announced a significant expansion of the R&D Start program. An additional $556 million will be provided over four years — bringing total expenditure under this program until June 2002 up to $739 million. The program will now be available to all non-tax-exempt companies incorporated in Australia. A competitive outlays program, the objectives of R&D Start are to:

- stimulate business innovation and R&D in Australia;
- provide direct support via competitive grants for outstanding business R&D projects; and
- complement the broad-based indirect support provided by the R&D tax concession program.

The expanded *R&D Start* program will have three components. The first component is a core grants element which provides similar benefits to the existing program. Grants of up to 50% of an eligible R&D project's cost are available to firms with a group turnover of less than $50 million in each of the previous three years. The two new components are:

- **R&D Start Plus,** which will provide grants of up to 20% of the project cost to companies which are ineligible for the general R&D Start program, that is, companies with a group turnover of more than $50 million; and
- **R&D Start Premium,** which allows the Industry Research and Development Board to provide an additional amount of repayable assistance over and above the level of assistance provided under the general R&D Start and R&D Start Plus elements of the program. The R&D Start Premium component will be for projects of high merit and bring total assistance up to 56.25 cents in the dollar.

Innovation Investment Fund (IIF)

Introduced early in 1997 as part of the *More Time for Business* statement, the IIF provides assistance to small, technology-based companies seeking access to equity finance (venture capital). A further $43 million announced in *Investing for Growth* brings the total funding announced for the IIF to $173 million. As these amounts are to be provided on a 2:1 basis with private capital, an overall investment pool of about $260 million has been created. This allows for the creation of early-stage investment funds in the range of $30 million to $50 million. These funds are to be managed by expert private sector fund managers and will be restricted to investing in technology companies with an annual revenue of $4 million or less, averaged over the previous two years. These companies offer a dynamic source of economic growth, employment, the development of highly innovative products and services, and exports.

Technology Diffusion Program

As part of the December 1997 *Investing for Growth* statement, the Prime Minister announced that $108 million would be provided over four years for technology diffusion initiatives. These will be delivered through the new Technology Diffusion Program (TDP) to commence on 1 July 1998.

The Program comprises three integrated components representing a substantial shift from the current approach, especially in relation to international science and technology (IS&T) collaboration, which will be strategically focused on select industry sectors and countries to provide the best opportunities for industry innovation. Elements include:

- **Technology Alliances** — a package of international science and technology collaboration initiatives designed to access leading edge technologies for industry innovation;
- **Technology Transfer**— national initiatives to provide access by industry (particularly SMEs) to leading edge, affordable, quality sources of knowledge, advice and equipment; and
- **Online Business** — national initiative to encourage industry and business to adopt electronic commerce.

The existing International Science and Technology Program and the Technology Support Centres Program will be wound up and funding rolled into the new TDP to commence from 1 July 1998.

National Office for the Information Economy (NOIE)

In September 1997, the Prime Minister announced the appointment of Senator Alston as Minister for the Information Economy, and the establishment of the National Office for the Information Economy as a separate organisation within the Communications and Arts portfolio. NOIE will develop, coordinate and overview broad policy relating to the regulatory, legal and physical infrastructure environment for online services, including facilitating electronic commerce. The Office also ensures that Australia has a consistent international position on these issues and oversees policies for applying new technology to government administration and information and service provision.

NOIE will help ensure an integrated approach to delivery of online policy, and guarantees that Australia will be well placed to take advantage of the opportunities arising from the Information Economy.

Higher Education Research

West Review of Higher Education Financing and Policy

The Government announced the details of a broad ranging, independent review of higher education financing and policy in January 1997. The Committee chair was Mr Roderick West.

The Review Committee's task was to develop a policy framework including financing options to ensure that Australia's higher education system is responsive to long term environmental challenges while meeting the Government's broad goals for higher education. The focus was on the following themes:

- the role of higher education in Australia's society and economy over the next 10-20 years;
- factors affecting demand for and provision of higher education over the next two decades;
- the regulatory and administrative framework for higher education;
- financing of higher education teaching and research training; and
- funding of higher education research.

The Review Committee undertook an extensive program of visits and consultations. The Committee visited 42 Australian higher education institutions and met with representatives of higher education peak bodies and business. Over 330 submissions were received.

The Review Committee released a policy discussion paper in November 1997. The paper identified several strengths of the higher education research and research training system. It also noted that there are several areas in which action could be taken to get greater value from Australia's public investment in university research and research training. These include:

- no explicit, transparent and open means of setting broad, national priorities for publicly funded university research currently exists;
- there is room for improvement in the processes of transferring knowledge and skills between the higher education sector and industry;
- funding available for research infrastructure is out of step with the levels of research activity currently undertaken and the processes for its allocation are less than optimal; and
- there is a need to increase the mobility of funds for research training between institutions to increase students' options and the responsiveness of institutions, and to provide incentives for improvements in the quality of research training supervision.

There have been over 170 responses to the policy discussion paper. The final report of the West Committee, *Learning for Life*, was received by the

Government in April 1998 and its recommendations are currently under consideration.

Program reviews of higher education targeted research

The Department of Employment, Education, Training and Youth Affairs (DEETYA) and the Australian Research Council (ARC) have continued to implement a monitoring and evaluation strategy for the higher education targeted research program. In the past year the following reviews have been completed:

Evaluation of ARC/DEETYA industry-linked research schemes
This evaluation was conducted by a team from the Centre for Research Policy, University of Wollongong. It found that targeted support for industry-linked research, through the ARC Collaborative Grants scheme, Australian Postgraduate Awards (Industry) scheme and the Key Centres of Teaching and Research scheme, has grown significantly in recent years but is still a relatively modest proportion of total targeted research funding.

Both academic and industry participants in the schemes are generally positive about their experiences with the schemes and consider that they have served to build closer alliances. In general the different expectations and needs of the participants have been successfully accommodated.

The evaluation found that ARC/DEETYA schemes complement other industry-linked schemes by supporting collaborative research across a wider research spectrum and building links in different sectoral niches. In particular ARC/DEETYA schemes appear to be facilitating collaborative research activity that would not otherwise occur.

The "Future Directions" recommendations of the evaluation include: improving the marketing of the schemes, increasing the level of industry-linked research as a proportion of ARC grants funding, adding a second annual applicant round, and establishing a closer relationship with the managers of the Cooperative Research Centres scheme. The ARC and DEETYA are currently considering these recommendations. Publication of the report is expected in the near future.

Study of ARC/DEETYA grant allocation processes
This study was conducted by KPMG Management Consulting. The study produced a comprehensive mapping of grant allocation processes for researchers, institutions, DEETYA and the ARC. It also estimated the cost of direct administrative and indirect opportunity costs for the processes. This information is currently being used by DEETYA and the ARC to refine the processes to enhance their effectiveness and efficiency. Phase one of the study was published in October 1997.

Discipline Research Strategies
Discipline Research Strategies have been completed for management, information technology, the humanities and the social sciences. The strategies are developed by the various learned academies and other peak

organisations with the assistance of grants from the Commonwealth. They provide information on the current state of the disciplines, the opportunities and challenges they face and propose strategies to advance the disciplines over the next 10 to 15 years.

Review of the ARC Small Grants Scheme
This review was conducted by a team from the Centre for Continuing Education at the Australian National University. The review found that the scheme is effective in assisting institutions to support early career researchers and lower cost research. It recommended some refinement of the current objectives and administrative processes. The review outcomes are currently being considered by DEETYA and the ARC. Publication of the report is expected in the near future.

Two other major reviews are nearing completion:

- evaluation of the ARC Large Grants Scheme: this review, scheduled for completion in August/September 1998, will review the distinctiveness of the scheme in relation to other sources and types of funding for research, assess its effectiveness and efficiency in meeting current objectives, provide advice on outcomes/impacts, grant assessment processes, administration, institutional and disciplinary issues and future directions for the scheme; and
- a Review of Biological Sciences Research funded by ARC /DEETYA Targeted Research Schemes: this review, scheduled for completion in June 1998, will assess the quality and quantity of outcomes in biological research produced by ARC/DEETYA schemes in relation to the Government objectives for research and research training and the needs of the biological research community and research users and the efficiency and effectiveness of ARC/DEETYA support.

Special Research Centres Program, 1999 selection round

The Special Research Centres (SRC) Program funds special units of researchers and resources in Australian higher education institutions. The program aims to encourage the pursuit of excellent, internationally competitive research which contributes to national objectives and provides undergraduate and postgraduate education and postdoctoral training. The Centres are funded as a recognised source of expertise that promote cooperative links with government and industry or the relevant communities. They also make a significant contribution to the commercialisation of research.

Government funding for individual SRCs is generally provided for six years, with a maximum of nine years subject to a successful review every three years. The last selection round occurred in 1996, and on the advice of the ARC, the Minister for Employment, Education, Training and Youth Affairs recommended eight new centres. The 1997 cohort of SRCs is:

- Centre for Integrated Dynamics and Control (University of Newcastle);
- Centre for Multiphase Processes (University of Newcastle);

- Centre for Ecological Impact of Coastal Cities (University of Sydney);
- Tectonics Research Centre (University of Western Australia);
- Centre for Offshore Foundations Systems (University of Western Australia);
- Centre for Subatomic Structure of Matter (University of Adelaide);
- Centre for Ore Deposit Research (University of Tasmania); and
- SRC for Cross Cultural Research (Australian National University).

The eight SRCs funded in 1997 will be subject to review in 1999. A new selection round for Centres will also be conducted in 1999.

Australian Research Council key developments

The Gemini project

Australia's partnership in the Gemini project was announced by Dr Kemp, Minister for Employment, Education, Training and Youth Affairs on 18 February 1998. Under the Gemini project, the ARC, representing the Australian astronomical community, will join with partner agencies in the United States of America, the United Kingdom, Canada, Chile, Argentina and Brazil to fund the construction and operation of two new generation optical telescopes — one in Chile and one in Hawaii. The telescopes will provide coverage of the entire sky in both visible and infrared wavelengths with infrared images providing a suitable window to see through dust to the cooler star-forming regions and into early galaxies.

The ARC played a leading role in coordinating the Australian bid to participate in Gemini and in securing Australian funding. A total of A$13.5 million, which includes funding from the Council's Research Infrastructure (Equipment and Facilities) program, will be provided over the next five years. Total funding from all partner nations for the construction of the project is expected to be US$193 million.

Participation in the Gemini project will enable Australian researchers to maintain and enhance their position at the forefront of international astronomical research. In particular, it will give Australian researchers access to world class facilities, leading technologies and knowledge, global innovation networks and internationally competitive research opportunities. It will also provide opportunities for high quality research training of the next generation of researchers in this field.

Research on topics of interest to Aboriginal and Torres Strait Islander people

Since 1995, the ARC has been working on a reference to advise the Minister on the level of research on topics of interest to Aboriginal and Torres Strait Islander people. The study, which was developed to inform the Council's advice on this reference, consists of two stages. Stage 1 was designed to discover the extent of current research and sources of funding for research of interest to Aboriginal and Torres Strait Islander people and included

development of a database of relevant research. The database showed that by far the greatest part of this research is in the social sciences and humanities, with research projects concentrated in the disciplines of anthropology and sociology, history and prehistory, linguistics and archaeology.

Stage 2 of the project, which is nearing completion, aims to discover, in consultations and discussions with reference to the findings and the database arising from Stage 1, whether there are any significant gaps, discrepancies and anomalies in research of interest to indigenous Australians. The second stage will also include the development of options on how the ARC may raise awareness within the research community of the impact of research on indigenous Australians, and the need to involve indigenous Australians in research of interest to them. It is expected that the advice on this reference will be provided to the Minister in the first half of 1998.

Australian Research Council innovative projects

The peer review process
The use of peer review in selecting projects for funding under competitive research schemes is widely used by the ARC and other funding agencies. This report, published by the ARC in January 1997, provides an overview of the operation of peer review at a particular point in time, both in Australia and in agencies overseas. An important component of the study concerned a workshop on peer review which involved key players in the process.

The report identified a number of issues relating to the ARC's current processes which were subsequently considered by Council and its program committees. This action is part of an ongoing effort by the ARC to improve the quality, effectiveness and efficiency of the selection procedures used in its programs.

Evaluating university research: the British Research Assessment Exercise and Australian practice
This study was commissioned jointly by the ARC and HEC to consider possible alternatives to the Australian Research Quantum Publications Collection and, in particular, to examine the British experience with the Research Assessment Exercise which focuses on the quality rather than the quantity of research produced by institutions. The final report of the study, published in July 1997, was circulated within the higher education sector to stimulate further discussion and debate about possible changes to the process currently utilised in Australia.

Federal Sector Science Programs

Nuclear science and technology

New nuclear research reactor
In September 1997, the Government announced a major upgrade to Australia's nuclear science infrastructure with the decision for the construction of a replacement nuclear research reactor at a cost of $306 million. The replacement reactor will provide Australian stakeholders with access to a state-of-the-art facility of purpose-driven design, which provides the high degree of research and isotope production flexibility necessary to meet Australia's requirements for the 21st century. This facility will ensure a reliable supply, both in volume and in range, of diagnostic and therapeutic radiopharmaceuticals needed to satisfy Australia's future requirements well into the next century. The replacement reactor will enable a national centre to be established for world class research in neutron science, and will enhance and expand the wide range of other activities presently supported by HIFAR (High Flux Australian Reactor) in areas such as new materials, life sciences and environment protection.

In a related decision, the Government has decided that there will be no reprocessing facility for spent nuclear fuel at ANSTO's Lucas Heights site or anywhere else in Australia. Instead, $88 million has been set aside to remove spent fuel rods from Lucas Heights and meet the costs of reprocessing overseas.

Technical Advisory Committee
A Technical Advisory Committee (TAC) was established to review ANSTO's program of strategic research to advise the ANSTO board independently of management. This committee, consisting of science and technology leaders within the academic, industrial and scientific communities from both within Australia and abroad, advises the board on:

- whether the topics being researched are relevant, given the mission and core science businesses of ANSTO;
- whether the projects being undertaken are nationally or internationally important and are realistic, given the resources of ANSTO; and
- whether the results of the research work are of world standing, timely, relevant and cost effective.

Major geophysical initiatives

Law of the Sea
In May 1998, the Australian Geological Survey Organisation (AGSO) completed the data collection phase of the Law of the Sea element of the Australian Ocean Territory Mapping Program (AOTMP). Eight areas were surveyed and over 30,000 kilometres of deep seismic data collected. The Government provided supplementary funding for the AOTMP of $16.7

million in 1996. This funding aims to document Australia's claims to marine jurisdiction under the United Nations Convention on the Law of the Sea (UNCLOS). AGSO is providing information to maximise and sustain Australia's claims to extensions of the legally defined continental shelf beyond a 200 nautical mile exclusive economic zone. These claims must be lodged by 2004 with the UN Commission on the Limits of the Continental Shelf. Post-survey phases of AGSO's Law of the Sea project will involve the compilation and interpretation of all relevant data, the delineation of the outer limits of the continental shelf and the final preparation and presentation of Australia's case to the UN.

AGSO new building
The new AGSO Canberra headquarters was officially opened in January 1998. Construction of the new AGSO complex began in April 1996 and was completed about four months ahead of schedule and within the approved budget of $109.5 million. The purpose-built geoscience research facility brings together for the first time in AGSO's history its 500 scientific, technical, and support staff, and various functional elements, including 30 laboratories and associated equipment, mapping library and information systems, rock fossil and mineral collections, and project facilities. AGSO is the largest geoscience organisation in Australia.

Australian National Seismic Imaging Resource (ANSIR)
The identification of and a tender process to acquire the equipment for ANSIR was completed in February 1998 and orders placed in March/April 1998. The facility will provide a significant expansion of the capability for geophysical research in Australia and create a centre of excellence for pursuing world class research and training in the field of seismic imaging. ANSIR has already developed a scientific program with experiments begun or planned for the Hamersley Basin region in NW Australia, near Broken Hill and at Orange, NSW. International interest is high with enquiries for collaborative experiments coming from a number of countries.

Strategic directions for CSIRO research

CSIRO is implementing its Strategic Research Plan 1997-98 to 1999-2000, which reflects a focus on sectors. This is a new approach to the way CSIRO is structured and manages its business. The Plan resulted from extensive work by staff throughout the Organisation in consultation with the members of the CSIRO's Sector Advisory Committees. Divisions are developing and enhancing links across the organisation to focus on outcomes of benefit to the sectors, reinforcing the value of CSIRO as a single entity whose diverse skills can be coordinated and harnessed to meet particular economic, environmental, societal or scientific needs.

In addition, many CSIRO Sector Advisory Committees have sponsored Industry/Stakeholder Forums. These have been attended by a broad range of users or potential users of CSIRO's research, and other stakeholders. They provide a means to ensure that existing and potential needs and CSIRO capabilities are understood. The Forums are also designed to challenge

current research priorities. Sector Advisory Committees will use the results of the Forums in their discussions on strategic directions for CSIRO's research.

Gene technology legislation

In October 1997, the Government announced that it would seek agreement with the States and Territories on the introduction of measures to provide comprehensive national regulation of gene technology. The decision follows consideration of the advice of a February 1992 report by the House of Representative Standing Committee on Industry, Science and Technology and consultation with the States and Territories in the period 1992-1995.

For the purposes of consultation with the State and Territory Governments, the Federal Government has developed a package of measures which include:

- use of existing legislation, amended where appropriate, to regulate the planned release of genetically modified organisms (GMOs) and GMO products where the regulation is consistent with the original intent of the legislation;
- enactment of new legislation to provide coverage of GMOs and relevant GMO products not covered by existing legislation and to regulate contained research in gene technology; and
- establishment of a non-statutory Gene Technology Office to administer the new legislation and to harmonise the regulatory activities of other bodies in the field of gene technology.

Further consultations with the States and Territories commenced in December 1997.

Review of the Cooperative Research Centre (CRC) Program

In August 1997, following discussion of the CRC Program in the 1997-98 Budget context, the Minister for Industry, Science and Tourism established a review of aspects of the Program. The review focused on the scope for greater commercialisation and self funding in the Program. Mr Don Mercer, formerly Chief Executive Officer of the Australia and New Zealand Banking Group, and Professor John Stocker, the Chief Scientist, formed an External Steering Committee to the review. The review consulted widely among relevant research, government and business organisations. The review examined:

- the means for improved commercialisation of CRC research outcomes; and
- opportunities for CRCs to achieve a higher degree of self funding.

The final report of the review was presented to the Minister in February 1998 and its recommendations are currently being implemented. The Mercer

recommendations are consistent with steps which have been under consideration for some time, partly following from the 1995 Myers Review, as well as appearing as natural consequences of the maturation of the Program.

Drug and chemical testing facilities

Australian Sports Drug Testing Laboratory
The Australian Government Analytical Laboratories (AGAL) operate the Australian Sports Drug Testing Laboratory (ASDTL) at the Pymble (NSW) laboratory complex. ASDTL is one of 25 laboratories around the world accredited by the International Olympic Committee for providing testing of drugs in sport.

ASDTL has commenced a major research program to improve its technical capabilities in readiness for the Sydney 2000 Olympics. The research program includes:

- baseline studies aimed at statistical profiling of analytical results to develop a database for levels of endogenous substances;
- production of steroid standards as reference materials;
- carbon isotope ratio mass spectrometry to determine administered testosterone; and
- the application of techniques of immunoaffinity liquid chromatography, immunoassay and high resolution mass spectrometry for the detection of previously undetectable drugs.

A centre for chemical metrology
The National Analytical Reference Laboratory (NARL) within AGAL is working in collaboration with the National Standards Commission, the National Measurement Laboratory and the National Association of Testing Authorities as part of a program to provide Australia and the Asia-Pacific region with a primary centre of reference for the accuracy and validity of chemical measurements. Under the umbrella of NARL, current activities undertaken through the Curator of Standards and the Australian Chemical Standards Laboratory will be enhanced to provide a centre for chemical metrology.

Radiofrequency electromagnetic energy program

In October 1996, the Government announced a $4.5 million research and information program over 4.5 years to address community concerns about exposure to electromagnetic energy (EME) occurring in the radiofrequency range of the spectrum. This includes exposure to mobile phones, mobile phone towers, broadcast towers etc.

The program consists of:

- a public information dissemination strategy;

- continuing participation in the World Health Organisation's project to assess the health and environmental effects of EME exposure; and
- an independent Australian research program to be managed by the National Health and Medical Research Council.

Major Antarctic review

Senator Ian Macdonald, Parliamentary Secretary for the Antarctic, has released for public comment a major report to the Federal Government on possible future directions for Australia's Antarctic Program. The report, *Australia's Antarctic Program beyond 2000: a framework for the future*, was undertaken by the Antarctic Science Advisory Committee (ASAC) and contains recommendations with significant ramifications for Australia's Antarctic activities in the first part of the next century. The Government is currently considering its response.

Weather forecasting

Capturing opportunities in the provision of meteorological services

The Government responded in December 1997 to the report of the Slatyer Study into the scope for enhancing revenue generation in the Bureau of Meteorology.

The Government accepted 17 of the 18 recommendations of the report including the two key recommendations that:

- the Bureau be funded on a rolling triennial or quintennial basis; and
- the organisational arrangements that the Bureau remain as a statutory agency in a Commonwealth Government Department be reaffirmed.

The Slatyer Study concluded that enhancing the level of services would require modifications to the Bureau's charging principles and its operational practices, and that any enhancements would need to be consistent with the Government's Competition Policy rules for fair competition and with existing agreements on the international exchange of meteorological information and made recommendations to this effect. In its response, the Government has accepted the recommendations relating to policies and practices for the provision of free, cost recovered and commercial meteorological services and expects that the Bureau will continue to make the best use of new technologies to improve all types of services.

Upgrade to marine weather services

The Bureau has strengthened and extended its commitment to the provision of marine weather services through advances in network management, data collection, product range and service delivery. A Marine Observations Unit has been established in the Bureau's Head Office with responsibility for the operational implementation of the national sub-surface ocean temperature observing program. This program, formerly operated by CSIRO, produces

Bureau's existing drifting buoy and voluntary observing ships programs, as well as the newly established waverider buoy program which will see a number of moored buoys installed by the Bureau at critical locations around the Australian coast to provide on-line data on surface wind and wave characteristics.

The Bureau has also expanded the range of cost recoverable marine services products available to users, based on integrating meteorological observations, forecast charts, satellite imagery and tide information in both textual and graphical formats. Products are being introduced for specific locations including Bass Strait, Port Phillip Bay/Westernport and Sydney waters.

Improved access to meteorological services

The Bureau has implemented a project to enable integrated access by users to its wide range of meteorological and hydrological services, made possible by the funding support provided by Government in response to the Slatyer report. As well as providing an integrated framework for the delivery of facsimile and voice products through the popular Weather By Fax service and the WeatherCall and Dial-It telephone services, the project uses the Bureau's established national communications network to channel information from all States and Territories to a public access server to facilitate on-line computer access. Using the Internet or direct connections, the general public and individual clients can view or download text, graphics and data, much of which is updated in real-time as meteorological observations and forecasts are prepared. The system under development already includes over 3000 pages of information on the World Wide Web, hits on which more than doubled in 1997, peaking at over 1.5 million hits per week in January 1998.

A special-purpose Internet site at http:/ /www.bom.gov.au/silo has been established to provide a diverse and easily accessible source of agrometeorological information to meet the specific needs of the rural community. The Website, which blends the expertise of meteorologists and agricultural scientists, was developed in a collaborative project between the Bureau and the Queensland Departments of Natural Resources and Primary Industry.

Environmental protection

Management of hazardous pollutants and wastes

A valuable outcome from limiting options for the export of persistent organochlorine wastes from Australia and establishment of national management plans for polychlorinated biphenyls (PCBs) and hexachlorobenzenes (HCBs), has been the development of new commercial treatment facilities. In 1991, Australia had no capability to treat PCBs, organochlorine pesticides or HCB waste, and export or continued storage were the only options. In 1997, four commercial facilities were operating in Australia treating a range of persistent organochlorine wastes.

With the finalisation of the National Pollutant Inventory better information can now be provided to the community on emissions. The National Pollutant Inventory was given legislative effect by the National Environment Protection Council on 27 February 1998. The Inventory will provide information on the emissions of hazardous chemicals to the environment from industry and community activity.

Information on emissions is available from the National Pollutant Inventory via the Internet at http:/ /www.environment.gov.au/net/npi.html. In addition, the National Pollutant Inventory has been undertaking a range of trials during 1997 and 1998. These trials include: full implementation of the Inventory in the South-East Region of Queensland; testing of the Inventory with respect to mining in the Kalgoorlie region of Western Australia; and development of industry handbooks, designed to provide advice to industry on how to report their emissions to the Inventory. This information will progressively become available on the Internet site.

Refining the National Greenhouse Gas Inventory
Astrong emphasis has been placed on reducing the level of uncertainty in the National Greenhouse Gas Inventory especially in those sectors where uncertainties are relatively high, such as the Land Use Change and Forestry Sector. This is to ensure that the Inventory is a reliable technical document and credible policy instrument for the development of mitigation strategies based on continually improving emission estimates. This emphasis has resulted in planning a keenly focused program of inventory research/development projects specifically aimed at the short to medium term with results directly applicable to the inventory.

Marine research and strategic planning

Australia's Oceans Policy
A draft of the Oceans Policy for Australia is scheduled for release for public comment in the near future. The policy will promote ecologically sustainable development of our oceans and their resources through better knowledge and understanding and more effective planning and management arrangements that build on the strengths of current sectoral and jurisdictional frameworks.

The Government is developing a Marine Science and Technology Plan to provide a foundation for the conservation and resource development efforts encompassed by the Oceans Policy. The Plan identifies priorities for scientific, technological and industrial development to increase the capacity to care for, use and understand our marine resources. A draft of the Plan is scheduled for release for public comment in conjunction with the draft Oceans Policy.

Australian Institute of Marine Science (AIMS) — refurbishment
The 1998-99 Budget provides $11.5 million for the capital refurbishment program for AIMS. The funds will be used to:

The 1998-99 Budget provides $11.5 million for the capital refurbishment program for AIMS. The funds will be used to:

- construct a new building to house research programs and equipment in an environment that will increase the efficiency and effectiveness of research activity and that provides high standards for occupational health and safety;
- refurbish the AIMS *Research Vessel Lady Basten*, to ensure its capabilities as a modern research platform that is responsive to current and future needs;
- replace the *RV Harry Messel* with a new vessel to service the Institute's ongoing at-sea research activities; and
- commence the repair and refurbishment of the existing buildings.

The repair and refurbishment program will ensure that AIMS continues to fulfil its statutory obligations to undertake high quality scientific research and to develop new technology for use in the marine environment. The new facilities will improve the effectiveness of research programs by permitting the optimal function of modern equipment in adequate and controlled environments; and permit the Institute to bid for a wider range of commercially contracted research.

International Science and Technology Links

APEC

The Government supports participation by the Australian research community in APEC science and technology activities. These activities are coordinated through APEC's Industrial Science and Technology Working Group (ISTWG).

APEC member economies are actively encouraging improved flow of science and technology information, networking and partnerships. The APEC Science and Technology Web (ASTWeb), which is at URL http://www.apecst.org/astweb.html has been developed by Australia as part of a larger project on facilitating the flow of science and technology information.

ASTWeb includes a web-based directory of links toscience and technology sites throughout APEC, information on science and technology policy and infrastructure, APEC projects, discussion forums, and a calendar of APEC science and technology events.

OECD

Over three decades, the OECD has had a substantial focus in studying and discussing policy issues in science, technology and innovation. These activities, through the OECD Committee for Scientific and Technological Policy (CSTP) and its various working groups, have greatly facilitated the

the CSTP over the years have had a major influence on the directions of science and technology policy in all developed countries.

Australia continues to be very active within the CSTP and its subgroups and has taken a leading role in some areas. The focus of the CSTP covers work in the following areas:

- **Science and technology indicators and their analysis,** focusing on a consistent international approach to the measurement of science and technology activity — inputs such as R&D and human resources, and outputs such as patents and high technology exports. This work provides an empirical base for comparing member countries' performance in science and technology.
- **Innovation and technology policy,** which includes the exploration of new policy approaches, covers studies on technology, productivity and job creation, national innovation systems, and issues such as the promotion of technology diffusion.
- **The science system,** which focuses on the dynamics and organisation of scientific activities. OECD work in this area has dealt with trends affecting university research and education, public understanding of science and technology and how results of the science system contribute to economic growth and employment, and technology transfer mechanisms.
- **International cooperation in relation to large facilities and projects,** focusing on areas such as radio astronomy, neutron sources, removing obstacles to international megascience cooperation, biological informatics and nuclear physics with a clear desire to deliver practical policy outcomes for the countries involved. Australia has been particularly active in relation to biological informatics and radio astronomy, where this work has also been exploring the need for new large-scale facilities and projects in science. Environment Australia participated in a Megascience Forum Workshop on Global Scale Issues which was held in Stockholm in March 1998. The Workshop had a particular focus on oceans, biodiversity, and land use and food production.
- **Biotechnology studies** related to human health, intellectual property, technology transfer and genetic resources, water use and conservation, and food safety.

Australia has offered to host a meeting of the OECD Working Group on Technology and Innovation Policy (TIP) late in 1998. In association with this meeting, it is intended to arrange associated workshops that will also involve participation from APEC member economies and some other countries.

Bilateral activities

- CER/MERCOSUR

- Bilateral science and technology collaboration with New Zealand and the South American countries that form the MERCOSUR group, is to be included under the current dialogue towards the development of a CER/MERCOSUR Agreement.

- China

- The Chief Scientist, Professor John Stocker, led an Australian delegation to a successful Third Joint Science and Technology Commission (JSTC) meeting in Beijing in October 1997. The JSTC held talks on the bilateral science and technology relationship and agreed on cooperation in six joint projects.

- Europe

- Under the 1994 EU-Australia Science andTechnology Agreement, some 30 collaborative projects have been established with Australians as partners in R&D consortia supported by the European Union's Fourth Framework Program for Research and Technological Development. Many other less formal cooperative links have also been formed.
- Scientific cooperation with individual EU Member States has also been strengthened as a result of the EU-Australia Science and Technology Agreement. The European Commission has indicated support for Australia's request that the scope for cooperation be broadened to include multi-disciplinary projects across all thematic programs of the EU's forthcoming Fifth Framework program for Research and Technological Development (1998-2002).

- France

- The Australian Minister for Industry, Science and Tourism, the Hon John Moore, met with French Minister for National Education, Research and Technology on 2 February 1998 to sign the revised Arrangement for the French Australian Industrial Research (FAIR) program. The French side hosted a workshop on Food Processing Technologies for Packaging, Transport and Storage with an emphasis on Food Safety. The Joint Steering Committee Meeting, held in Paris, discussed strategies for future bilateral collaboration under the FAIR Arrangement.

- India

- $94,000 was awarded to Australian and Indian scientists to support exploratory visits between the countries during the 1997-98 financial year. This program is a joint initiative between DIST and the Indian Department of Science and Technology, and aims to promote development of bilateral research projects.

  Fields of science selected as being priority areas for this program are:

  – Medical science and human nutrition;
  – Food technology;
  – Energy (including renewable energy); and
  – Environmental management.

- Indonesia

- Activities under the Collaboration on Science and Technology Australia - Indonesia (COSTAI) agreement included a broad advertising campaign for new proposals and a workshop on

Biotechnology in conjunction with the annual Joint Steering Committee meeting in Jakarta.

- Supported by AusAID's Government Sector Linkages Program a Pre-Feasibility Study of the Potential for Aquaculture Development in Eastern Indonesia was undertaken.
- CSIRO interactions with Indonesia have included:
  - Development of the Australia-Indonesia Mineral Resources Research Network designed to link science and technology experts in government research laboratories in Australia and Indonesia.
  - A CSIRO joint program between the Division of Human Nutrition and the University of Indonesia to reduce anaemia of female adolescents in eastern Indonesia.
  - The Division of Animal Health and BALITVET, the Indonesian Research Institute for Veterinary Science, working to strengthen the Indonesian livestock sector by improving the diagnostic capability of BALITVET.
  - Participation in a meeting of climate scientists from around the world called together by the Indonesian Minister for Research and Technology, Dr B J Habibie, to assess the El Niño effect.

- Japan

- Activities under the Joint Science and Technology Consultative Committee continue to progress. Proposals have been developed for joint workshops in greenhouse gases, mariculture and drug design.
- A delegation from the Japanese Research Institute of Innovative Technology for the Earth (RITE) met with senior Australian officials to discuss collaborative project proposals in CO_2 fixation and greenhouse gases. The Department of Industry, Science and Tourism will canvass potential Australian interest.

- Korea

- Following the visit of the Korean Science and Technology Minister during 1997-98, two project proposals by Australian researchers in polymer sensors and laser thermometry have been funded and workshops on biotechnology and environmental technology are proposed.
- A text of proposed Australia: Korea Science and Technology Agreement was initialled and is expected to be formally signed in 1998.

- Malaysia

- In February 1998, the CSIRO signed a Memorandum of Understanding with the Government of Sarawak covering applied research and development in the field of plantation forestry and related forest products. The CSIRO also entered into a more specifically commercial arrangement through a Heads of Agreement with Borneo Tree Seeds and Seedlings Supplies Sdn Bhd. Activities covered by these arrangements complement work the CSIRO Division

of Forestry and Forest Products have been carrying out in neighbouring Indonesia.

- Also in February 1998, Telekom Malaysia and the Australian Photonics CRC signed a Memorandum of Understanding covering research collaboration.

- Mexico

- At a bilateral meeting between the Australian Department of Industry, Science and Tourism and the Mexican Ministry for Foreign Affairs it was agreed that Mexico and Australia would develop a strategy for bilateral science and technology cooperation. On the Australian side, the bilateral science and technology relationship will be supported under the Technology Diffusion Program.

- United Kingdom

- An action plan for bilateral cooperation between the UK and Australia has been announced. As part of that plan, the Department of Industry, Science and Tourism in consultation with the British Council is developing a strategy for bilateral science and technology cooperation with the UK under Australia's Technology Diffusion Program.
- Australia will send a delegation and provide a keynote address to the UK Technology Transfer and Innovation Conference to be held in June 1998.

Other initiatives in support of science and technology

- in industry, science and technology

- **R&D Scoreboard'97** was released by the IR&D Board and Auslndustry. This is the third in a series of reports on business expenditure on R&D at the firm level. The Scoreboard aims to raise awareness of the importance and benefits of R&D. It shows that a select group of Australian companies have a strong commitment to R&D and to playing a major role in determining Australia's technological progress, thus ensuring the future prosperity of Australian business. In contrast to most studies on R&D, the R&D Scoreboard series provides R&D data on individual firms. This can provide unique insights for investors, policy makers and firms.
- Since 1992-93 **CSIRO has more than doubled its interactions with small and medium sized enterprises (SME)s**, undertaking more than 700 collaborative and contract research projects in 1996-97 in addition to more than 2,000 testing, calibration, diagnostic and accreditation services. CSIRO improved both its Information Network Service and its focused support for SMEs through a network of Industry Liaison Managers and outreach programs in quality improvement, electronic systems and food processing.

- **Visionary science projects:** In December 1997 CSIRO announced a series of demonstration projects to be undertaken by large research teams with the goal of building a better future for Australia. More than $20 million generated from the sale of CSIRO assets and internal savings has been allocated to major projects. They include a new hybrid energy system, next generation telecommunications technologies, a concept car, sustainable city water systems, feral pest control and leading-edge gene technologies.
- **CSIRO's healthy profile of basic research:** The Research Evaluation and Policy Project of the Australian National University has undertaken for CSIRO a bibliometric profile of the Organisation's research output and a comparison of its research publications output and performance in different fields of research with that of other Australian research sectors. The results of this survey are encouraging in that they show citation rates for CSIRO research publications have broadly stayed high and in some areas are well above the Australian average.
- A joint venture agreement was signed by CSIRO and the Australian Food Industry Science Centre in October 1997. Under that agreement, CSIRO's Division of Food Science and Technology and the Centre will operate as a single organisation under the name **"Food Science Australia"**. The new venture will provide the $40 billion food industry with a fully integrated service from research and development to commercial application and manufacture.
- Upgraded facilities for CSIRO:
  - Construction for the **upgrade of the Australia Telescope National Facility** commenced on 31 March 1998.
  - The Queensland Government has provided CSIRO with over $24 million to build **additional accommodation at the Queensland Centre for Advanced Technologies** at Pinjarra Hills, Brisbane.
  - **A national centre will be established for R&D on petroleum and mineral exploration and extraction** in Perth. The government of Western Australia will provide the land on a 99 year lease and contribute over $26 million towards the cost of the building, up to $5 million to help relocate staff and equipment, $1 million to establish a high performance computing centre and $2 million towards project funding.
  - CSIRO has cooperated with the Bureau of Meteorology in the **establishment of the High Performance Computing and Communications Centre,** located in Melbourne. This Centre provides scientific computing resources and mass storage facilities for the Bureau and CSIRO, for operational and research needs.
- The ARC/DEETYA **Strategic Partnerships with Industry in Research and Training (SPIRT) Scheme** operated for the first time in the 1998 funding round and attracted over 700 applications for funding. The 340 successful projects involve industry funding commitments in 1998 of approximately $9 million in cash and over $16 million in in-kind contributions.

- In addition to support for collaborative projects and Australian Postgraduate Awards (Industry)(APA(I)), the SPIRT Scheme also provides **funding for Australian Postdoctoral Research Fellowships Industry**. In the 1998 funding round, these awards attracted over 50 quality applications from recent graduates with limited research experience to act as project leaders on collaborative projects. The 21 Fellows appointed will develop their research skills and experience, and gain an appreciation of the challenges of economic and social change through the activities of the industrial partners.
- Late in 1997 the Government announced that it would fund 50 **additional APA(I)s targeted to the fields of information, computers and communication technologies**. This initiative is part of the package of measures announced in the *Investing for Growth* industry statement. The selection process for the additional 50 awards, available each year from 1999 to 2001, will be undertaken by the ARC's University-Industry Research Collaboration Committee as part of the larger selection process for the SPIRT Scheme grants.
- In November 1997 the ARC endorsed the amalgamation of the International Research Fellowships and International Projects schemes to form a new program entitled the International Research Exchange program (IREX) which will provide **more flexibility in supporting international collaborative links.**
- Beginning with the 1997 grants round, DEETYA, with the cooperation of the ARC, have begun **implementing an electronic grants processing platform** to assist in the allocation of targeted research grants to universities, researchers and other bodies. The platform allows university research offices to electronically submit key parts of research grants applications via on-screen forms. It also gives the Panels and Committees of the ARC access to a large database of peer review assessors and the ability to establish electronic links to them. The platform is allowing a large reduction in paper-based processing and handling, resulting in significant time and cost savings and quality improvements. It is expected that much of the process will be handled electronically by the 1999 grants round.

- in science and technology awareness:

- **The 1998 Australia Prize** was awarded in the field of molecular genetics to four scientists — Professor Elizabeth Blackman, Professor Suzanne Cory, Professor Sir Alec Jeffreys and Professor Grant Sutherland — for their contributions to advancing our knowledge of molecular genetics.
- **The Michael Daley Awards for Science, Engineering and Technology Journalism** have been outsourced to the Australia Museum to be presented in conjunction with the Eureka Awards. The four 1997 winners were: Associate Professor Michael Tyler (Promotion of Science); James Woodford (Print Journalism); Justin Murphy (Television Journalism); and Tom Morton (Radio Journalism).
- In 1998-99, the Science and Technology Awareness Program will be providing financial support totalling $1 million to **projects that aim to increase awareness of the role of S&T in national development.** The projects will target regional and country areas of Australia; industry

or industry groups; or emphasise increased awareness of engineering or mathematics.

- In May 1997 the Commonwealth supported a highly successful pilot **National Science Week** featuring activities coordinated and arranged by the Australian Broadcasting Corporation (ABC), the Australian Science Teachers Association and the Australian Science Festival. National Science Week 1998 featured over 410 events involving schools, businesses, museums, science centres and industry.
- The Government is funding **a major science broadcasting development project** at the ABC. The Lab website, launched in July 1997, has generated intense interest and is receiving 45,000 content page accesses a week. The companion site, Labnotes, extends ABC's science output to Australia's classrooms with specific curriculum contents. The website has gained two awards: The Atom Award for Best Online Multimedia Production; and AIMIA Award for the Best Multimedia/Online Producer of the Year. NOVA, the website of the Australian Academy of Science, won the Best Science Site.
- The Government will continue to be a major sponsor of the **Australian Science Olympiads** providing funding of $750,000 over three years.
- **Australia's Cultural Network was launched** in April 1998 by the Minister for Communications, Information Economy and the Arts. It has two main objectives: to improve and develop online access to and participation in Australian cultural endeavour, activities and events, and to improve the productivity of Australian cultural organisations, commerce and cultural workers.
  - Users are able to access specific scientific sites through the Cultural website finder. The website finder is unique to Australia's Cultural Network and enables the user to get straight to the desired website without having to sift through thousands of search results. Pre-sorted lists are also available.
  - Additionally, the network's powerful search engine facilitates access to hundreds of sites with a scientific theme. All query interfaces have comprehensive help screens.
  - Australia's Cultural Network aims to promote the use of the new medium and has a range of resources for those who want to learn more about how to use the Internet. This includes a set of interactive Internet Development Guides. It can be found at: http:/ /www.acn.net.au/.
- The **Australia on CD program** brings together Australia's emerging multimedia industry, national cultural institutions, content creators and multimedia professionals. Establishing these partnerships has become essential with the growth of the on-line economy.

  Two titles have been released with specific scientific themes:
  - *Tales from the Kangaroo's Crypt* was launched by the Minister for the Environment, Senator Robert Hill, in August 1997. This title investigates the prehistory of Australia. The user can discover unique Australian fossils from a variety of important sites, while learning how Australia's land and wildlife originated.

– *Ingenious* was completed recently. This CD-ROM asks the viewer to solve unique Australian scientific problems while they learn about the role of science in Australian culture.

- in international science and technology collaboration

- The Organisation for Economic Cooperation and Development's Nuclear Energy Agency Analogue Studies in the Alligator Rivers Region project was completed. This international project managed by ANSTO included collaborators from Australia, Germany, Japan, Korea and the USA. The project involved a study of the Koongarra uranium ore body as a natural analogue for a nuclear waste repository. The overall aim of this project was to build confidence in the scientific procedures for assessing the likely performance of radioactive waste repositories over the very long periods of time that are of regulatory interest.
- In June 1997 the Office of Atomic Energy for Peace in Thailand signed a prime contract with General Atomics of the USA for the **design, construction and commissioning of a nuclear research complex at Ongkharak** 60 km north east of Bangkok. The complex will comprise a 10 MW TRIGA research reactor, an isotope production facility and a waste processing and storage facility. ANSTO is part of the General Atomics team and, under a sub-contract with General Atomics, is responsible for the design, construction and commissioning of the Isotope Production Facilities. The contract was won by tender against competition from all the major international research reactor suppliers.
- ANSTO staff have established collaborative **research programs using small angle neutron scattering to study the properties or advanced materials** with colleagues in France (Saclay Laboratory of the French Atomic Energy Commission), Germany (Hahn-Meitner Institute in Berlin), and the USA (Oak Ridge National Laboratory and the National Institute of Standards and Technology). The current focus of the research is on the development of improved ceramic powders for use in coatings and films, and on cements for encapsulation of low-level radioactive wastes.
- **International Agreements signed by CSIRO:**
  - An agreement between CSIRO and the State Government of Sarawak, Malaysia, under which CSIRO expertise will assist the provision of quality seed, seedlings and clonal trees for the establishment of quality forestry plantations in a rapidly expanding industry.
  - An agreement between the CSIRO Division of Exploration and Mining and the Indonesian Directorate General of Geology and Mineral Resources, to promote sharing of information and the establishment of research and development projects and consultancies of interest to both.
  - A major mining research agreement by CSIRO and the Coal Mining Research Centre Japan. CSIRO will represent the Australian coal mining industry and coordinate research funding from mining industry groups, for cooperation based on a series of 3-5 year projects each having a budget of $5-10 million.

- International cooperation in meteorological science and technology was strengthened during the year with the **updating of the Exchange of Notes between the Australian and Japanese Governments on the Geostationary Meteorological Satellite (GMS) System.** The Exchange of Notes was first signed in 1977 but updated in 1997 to cover GMS-5, with an associated Implementing Arrangement with the Japan Meteorological Agency.
- In 1997-98, $5.6 million was allocated under the International Science and Technology Program (ISTP) to **develop and strengthen relationships between Australian and overseas researchers** through a variety of funded programs.
- Elements of the new Technology Diffusion Program (TDP) will provide **increased support for Australian researchers to travel to overseas facilities** to conduct their research. This will include DIST's annual contribution towards the operating costs of the Gemini project, allowing Australian astronomers to be involved in this major international project.
- The Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering will receive **funding to enable continued support for focused international S&T collaboration** and related projects, missions, workshops, fellowships and exchanges.

- in environment

- ANSTO has launched a $9 million **three-year project on Managing Mine Wastes**. This project is targeting acid mine drainage, one of the major environmental issues facing the mining industry not only in Australia but worldwide. This project will provide the sound scientific basis and tools for decision-making in the management of sulphidic mine wastes by: identifying the key parameters that influence pollutant generation and transport processes within waste rock heaps; developing physico-chemical measurement techniques for quantifying these parameters and evaluating the effectiveness of remediation options; identifying key biological indicators for assessing ecological risks and impacts; and developing associated computational tools for modelling the processes, impacts and risks. A prototype of a novel instrument to determine oxygen fluxes into waste dumps (a key factor affecting the pollution generation process) has been constructed and tested.
- Australian scientists made an important contribution to the International Atomic Energy Agency (IAEA) **study of the radiological situation at the former French nuclear sites at Mururoa and Fangataufa atolls.** Scientists from ANSTO and the Australian Radiation Laboratory (ARL) took part in the independent monitoring of radioactivity on the atolls, important to the validation of the models for predicting possible migration of radioactivity from the nuclear test cavities into the marine environment.
- ANSTO is involved in a **collaborative project in Global Climate Change research**. The project is entitled "The Use of Long-lived Radionuclides in Antarctic Ice as Tracers and Chronometers in Global Climate Change Studies" and will help forecast what significant changes are likely to occur over the next 100 years. This project also

involves the Division of Atmospheric Research, CSIRO, the Antarctic Division and the Antarctic CRC for the Law Dome site in Antarctica and is funded under a National Greenhouse Advisory Committee Grant.

- ANSTO has a leading role in **global measurements of radon gas for tracing large-scale air mass transport**. The network of radon measurement stations operated by ANSTO has now been extended to the Antartic. An ANSTO-designed radon detector was installed and commissioned at Mawson base in February 1998. Measurements with this detector will provide climate modellers with improved data to verify the accuracy of their transport model calculations in a region, which is known to have a strong influence on global climate change.
- Environment Australia **improved coordination of its science and technology interests** and activities in 1997-98 through establishment of the office of Chief Science Adviser.
- The Environment Protection Group continues to provide **funding for climate change research** through the National Greenhouse Research Program, currently funded at around $4 million per year. The Program is aimed at providing understanding of climate change, through provision or funds for basic and applied scientific research, and at improving confidence levels in predictions of climate change for the Australian region. It consists of a core component, supporting greenhouse-related science through provision of funding provided to the CSIRO, Bureau of Meteorology and National Tidal Facility; and a non-core component, supporting research projects on the science and impacts of climate change undertaken by a wide range of institutions.
- The Environment Minister has established the Greenhouse Science Advisory Committee to provide him with **independent advice on key developments and issues in greenhouse science;** an overview of greenhouse science research in Australia and advice on links between greenhouse science and greenhouse policy.
- The National Wetlands Research and Development Program, a joint initiative between the Biodiversity Group (BG) of Environment Australia and the Land and Water Resources Research and Development Corporation (LWRRDC), is **funding management oriented research designed to encourage application of the wise use of wetland principles** championed by the Ramsar Convention on Wetlands. The National Wetlands R&D Program Management Agreement covers a three year period, from 1996-97 to 1998-1999, with BG and LWRRDC each contributing around $350,000 per annum.
- A number of research projects in native vegetation research were completed as part of a program funded by BG and LWRRDC, and managed by LWRRDC. The aim of the program is to **assist government agencies, community groups and landholders to better manage and protect remnant native vegetation** through the application of improved knowledge and understanding gained from research.
- The Portfolio Marine Group is providing funding of $1 million from the Introduced Marine Pests program to the Australian Quarantine and Inspection Service to support a range of **ballast water research and development** contracts under their Strategic Ballast Water Research and Development Program.

- in meteorology

- In order to improve the speed and flexibility with which the Bureau of Meteorology can respond to users' real-time data needs, the Bureau's Regional Offices (initially three with the rest to follow) have been given **access to a number of portable automatic weather stations** (AWS) which can be set up in temporary locations to provide data for specific purposes, including support for forecasting in emergency situations such as bush fires, or at other outdoor events potentially affected by weather.
- The Bureau of Meteorology developed a powerful and award-winning technique combining a simple set of measurements and a **mathematical algorithm to accurately calibrate pyranometers that measure solar radiation.** The technique halves the uncertainty in routine global solar radiation measurements and has been adopted as international standard practice.
- Government funding support for the recommendations of the 1996 Review of the Operation of the Bureau of Meteorology allowed continuation of the program commenced in 1996 to **restore meteorological observing networks to accepted benchmark levels.** About forty new rainfall recording sites were established in 1997-98, about half of which were tilting bucket rain gauges to record rainfall intensity in addition to rainfall totals. Eleven new automatic weather stations were added to the Reference Climate Station (RCS) network for climate change detection. A subset of the RCS network has been selected to form part of the Global Climate Observing System Surface Network which is designed to provide data from sufficient stations to support analysis of temperature and atmospheric circulation up to global scale. The establishment of the National Benchmark Network for Agrometeorology is nearing completion.
- The Bureau of Meteorology's Australian Integrated Forecast System (AIFS), which is the centrepiece of its **program to modernise weather forecasting services** to the Australian community by the implementation of a modern open systems computing and communications infrastructure in Regional Forecasting Centres, was awarded a Technology Productivity Award from the Technology in Government Committee. Recent major achievements include the operational implementation of AIFS at Sydney Airport, Canberra Meteorological Off ice and at the Fiji Regional Specialised Meteorological Centre in Nadi as part of a Japanese Government Aid project. The AIFS is now operational in Victoria and New South Wales and implementation for remaining Bureau offices is scheduled for the next 12 to 18 months.
- The **Joint Bureau of Meteorology-CSIRO High Performance Computing and Communications Centre** (HPCCC) was officially opened in October 1997 and since 18 December 1997 has been operationally running the Bureau's numerical weather prediction models.

- in defence

- In September 1997, the Minister for Defence formally opened the **new Knowledge Systems Building at DSTO Salisbury,** SA, which accommodates several research and development Divisions. The new building also facilitates the operation of Research Hubs, each

covering an area of science and technology vital to the Australian Defence Force's research needs. These Hubs currently cover: Radio Frequency; Optoelectronics; and Human Factors. DSTO has established these Research Hubs to improve its effectiveness as well as enhance competency development in staff and prevent duplication of R&D between Divisions.

- Defence is accelerating the rate at which new technology can be integrated into military capability by the **introduction of the Capability and Technology Demonstrator (CTD) Program.** CTDs demonstrate how new technology may be operationally exploited to enhance capability in a previously unexplored manner. Three new CTDs were approved in 1997-98. These incorporate advances in technologies such as sonar and radar. A CTD can be initiated by DSTO, the Australian Defence Force or industry.
- Defence, through DSTO, has sponsored the creation of the Command, Control, Communications and Intelligence Research Forum (C^3IRF) as part of its commitment to industry involvement in Defence research. The C^3IRF is industry-led and aims to bring together key stakeholders from industry, other institutions (such as universities) and the Australian Defence Organisation to determine areas for collaborative research best suited to Defence's C^3I needs. The C^3IRF will bring **closer alignment between industry and defence research and development,** allowing early identification of key technologies and trends.
- Australia and the United States have signed a **collaborative program of research on Electronic Warfare Self-Protection**. It will involve Australia (primarily DSTO and Industry) participating in a joint six year program with United States (with the US Army as lead Service) in various activities related to Electronic Warfare Self-Protection for aircraft. The collaboration has been set up under the auspices of the Agreement on Cooperative and Collaborative Research, Development and Engineering (the Deutch-Ayers Agreement).
- DSTO has developed a **sophisticated radio frequency scene generator** which is part of the DSTO Systems Simulation Centre at Salisbury, SA, and can be used systematically to investigate the performance of radio frequency sensors without the need for expensive field trials.
- During the year, DSTO signed a **further four industry alliances** in the following focus areas: Combat Systems Research; Command, Control, Communications and Intelligence (C^3I) Engineering; Gun Systems; and Electronic Warfare. These bring the total number of alliances between industry and DSTO to twenty one. As the result of an internal review, DSTO is progressively shifting the focus of its alliance arrangements from bilateral and technology based agreements, to multilateral (including Defence users in some instances) and capability based agreements.

- in health

- In 1997, it was announced that nine nominated "centres of excellence" located at hospitals in Sydney, Melbourne, Perth, Darwin and Adelaide will receive a total of nearly $5 million over three years, fulfilling a Federal Government pre election **commitment to support centres of excellence in hospital based research.** These funds are to

help foster and train clinical researchers, support innovative clinical research and successfully translate research into clinical practice.

These centres link hospitals and other health care delivery units with universities and similar research services and will focus their research on a range of important health areas, such as Aboriginal health, cancer, cardiovascular disease, epilepsy and stroke, pain management, neurological disorders and midwifery research and practice. Examples of the centres funded include the Sydney midwifery research and practice team, at St George Hospital, who are to research the management of high risk pregnancies, and the Darwin team researching important health areas for Aboriginal communities, such as childhood diarrhoea, adult respiratory diseases and sexually transmitted diseases.

- In 1998, NHMRC introduced an **overseas fellowship** in public health research, The Sidney Sax Fellowships. These are equivalent to Fellowships offered in the biomedical areas.
- In 1998, block-funding was offered for the first time to the **Queensland Institute of Medical Research** (QIMR).
- In commemoration of the centenary of the birth of Howard Florey, discoverer of penicillin, five **Howard Florey Centenary Fellowships** were awarded. These awards were for Australian researchers based overseas to return to Australia to continue their research.
- Support for the work of Professor Grant Sutherland of Adelaide, in **mapping the human genome,** was provided through the Ellen Craig bequest to the NHMRC. Ellen Craig, who passed away in 1997, was a Melbourne doctor with a lifelong interest in medical research, particularly genetic mechanisms.

Significant statements, reviews and reports

Over the past year, a number of statements, reviews and reports dealing with major issues relating to innovation, science and technology have been published. These are listed below. Annual reports are not included in the list.

Industry Science and Tourism Portfolio

- Minister for Industry, Science and Technology
  - *Science and Technology Budget Statements* 1997-98 and 1998-99.
- Prime Minister's Science and Engineering Council
  - *Connecting Australians: Opportunities for a New Wireless Age,* May 1997.
- Australian Science and Technology Council(ASTEC)
  - *An International Comparison of High Level Science, Technology and Engineering Advisory Arrangements,* November 1997.
  - *Competition Policy and Research and Developmen*t, May 1998.
  - *Ethics and the Conduct of Research in Protected and Environmentally Sensitive Areas,* June 1998
- Department of Industry, Science and Tourism
  - *Investing for Growth: The Howard Government's Plan for Australian Industry,* 1997.
  - *Australian Science and Technology at a Glance 1997.*
  - *Review of Greater Commercialisation and Self Funding in the Cooperative Research Centres Program,* (forthcoming).
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
  - *CSIRO Operational Plan 1997-98.*
- Australian Institute of Marine Science
  - *Research Plan, 1997-2000,* Australian Institute of Marine Science 1997.
  - *Long-Term Monitoring of the Great Barrier Reef – Status Report Number 2,* Australian Institute of Marine Science 1998.
  - Cappo, M. (1998). *A Review and Synthesis of Australian Fisheries Habitat Research.* Australian Institute of Marine Science 1998. The report is available at URL: http://www.aims.gov.au/pages/ research/afhr/afhr-00.html.
- Genetic Manipulation Advisory Committee (GMAC)
  - *Guidelines for Small Scale Genetic Manipulation Work.*
  - *Guidelines for the Deliberate Release oj Genetically Manipulated Organisms* (which replace the Guidelines for the Planned Release of Genetically Manipulated Organisms).
  - *Guidelines for Activities with the Potential for Unintended Release of Genetically Manipulated Organisms*
  - *Safety Practices in PC2 Laboratories* booklet.
  - *Biotechnology Information Series,* a reprint of the series produced by Iowa State University of Science and Technology.

Employment, Education, Training and Youth Affairs Portfolio

- Department of Employment, Education, Training and Youth Affairs
  - *Higher Education Funding Report for the 1998- 2000 Triennium,* DEETYA Canberra 1998 (forthcoming)

- *Selected Higher Education Research Expenditure Statistics 1994,* AGPS Canberra 1997
- K Trigwell, T Shannon, R Maurizi, *Research-coursework Doctoral programs in Australian Universities,* DEETYA, Canberra, 1997
- *The Australian Research Council: A Guide to Research Centres Scheme,* DEETYA Canberra 1997
- *The Australian Research Council: Report on Research Funding Schemes,* DEETYA Canberra 1997
- *Learning for Life - Final Report: Review of Higher Education Financing and Policy,* DEETYA Canberra 1998

- National Board of Employment, Education and Training
  - *Discipline Research Strategies: Language and Literacy: Australia's Fundamental Resource*, ARC, June 1997.
  - *Comments on Discipline Research Strategies: Language and Literacy: Australia's Fundamental Resource,* ARC, June 1997.
  - *Reviews of Grants Outcomes No. 21: Response by the Australian Research Council to Report No. 21, Plant Physiology 1989-1993,* ARC, June 1997.
  - *Evaluating University Research: The British Research Assessment Exercise and Australian Practice* (Commissioned Report No. 56), ARC-HEC, July 1997.
  - *Reviews of Grants Outcomes No. 22: Response by the Australian Research Council to Report No. 22, Atmospheric and Oceanographic Sciences 1989-1993,* ARC, October 1997.
  - *Reviews of Grants Outcomes No. 23: Response by the Australian Research Council to Report No. 23, Marine Biology 1989-1993,* ARC, October 1997.
  - *Reviews of Grants Outcomes No. 24: Response by the Australian Research Council to Report No. 24, Education 1989-1993,* ARC, October 1997.
  - *Discipline Research Strategies: Management Research in Australia,* ARC, November 1997.
  - *Comments on Discipline Research Strategies: Management Research in Australia,* ARC, February 1998.

Environment Portfolio

- Australian Antarctic Division
  - *Australia's Antarctic Program beyond 2000: a framework for the future.* Antarctic Science Advisory Committee 1997, Australian Antarctic Division, Hobart.

- Bureau of Meteorology
  - *Research in BMRC.* Bureau of Meteorology 1997, Melbourne.
  - *Improving short range forecasting: abstracts of presentations at the Ninth Annual BMRC Modelling Workshop* 8-10 October 1997, BMRC Research Report 64. BOM, Melbourne.
  - *Some observutionally-identified meteorological features of East Antarctica,* Meteorological Study 42, BOM, Melbourne 1997.
  - *Climate Activities in Australia,* Bureau of Meteorology 1997, Melbourne.
  - *Severe weather and flooding, North Queensland* January 1998. BOM, Melbourne.

- Great Barrier Reef Marine Park Authority
  - *Norman Reef Great Adventures Pontoon: 1997 biological survey and summary of damage from Cyclone Justin, 1998* Research Publication 46.
  - *Heavy metals in commercial prawn and crayfish species in Torres Strait,* Commonwealth Coastal Action Program Report Series 5b.

- *Seagrass communities in the Shoalwater Bay Region, Queensland : Spring (September) 1995 and Autumn (April) 1996*, Research Publication 44.
- *An investigation of optimum methods and unit sizes for the visual estimation of abundances of some coral reef organisms*, Research Publication 47.
- *Habitat, cross shelf and regional patterns in the distributions and abundances of some coral reef organisms on the Northern Great Barrier Reef, with comment on the implications for future monitoring*, Research Publication 48.
- *Scales and magnitudes of variation in population densities of some coral reef organisms: implications for the design of sampling and monitoring procedures*, Research Publication 49.
- *Standard operational procedure: video-monitoring of sessile benthic communities*, Research Publication 42.
- *State of the Great Barrier Reef World Heritage Workshop: proceedings of a technical workshop held in Townsville, Queensland, Australia, 27-29 November 1995*, Workshop Series 23.
- *Development of trap and drop-line sampling techniques for reef fishes*, Research Publication 43.

- Environment Protection Group
  - *Appropriate Technologies for the Treatment of Scheduled Wastes.* Review Report 4. Canberra, 1997.
  - National Greenhouse Gas Inventory Committee 1997, *National Greenhouse Gas Inventory - Land Use Change and Forestry Sector 1988 -1995*.
  - National Greenhouse Gas Inventory Committee 1997. *National Greenhouse Gas Inventory - 1995*.
  - National Greenhouse Gas Inventory Committee 1997, *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks, Land Use Change and Forestry, Workbookfor Carbon Dioxide from the Biosphere*. Workbook 4.2. Revision.
- Biodiversity Group
  - *Mollusca: the southern synthesis*, Fauna of Australia Vol 5, CSIRO Publishing, Melbourne, 1998.
  - *Motivating people: using management agreements to conserve remnant vegetation*, National Research and Development Program on Rehabilitation, Management and Conservation of Remnant Vegetation Paper 1/97. Environment Australia Biodiversity Group, Canberra 1997.
  - *More than just the odd tree: report on incentives and barriers to rural conservation using Grassy White Box woodlands as a model*, National Research and Development Program on Rehabilitation, Management and Conservation of Remnant Vegetation Paper.
  - *The effects of artificial sources of water on rangeland biodiversity*. Environment Australia and CSIRO, Canberra, 1997.
  - *An evaluation of the effectiveness of environmental surrogates and modelling techniques in predicting the distribution of biological diversity*, Environment Australia, Canberra, 1997.
  - Environment Australia and the National Museum of Natural History, Smithsonian Institution, *The Darwin Declaration*, Australian Biological Resources Study, Environment Australia, Canberra, 1998
- Supervising Scientist Group
  - *Vulnerability assessment of predicted climate change and sea level rise in the Alligator Rivers Region, Northern Territory, Australia*, Supervising Scientist Report 123,1998.

- *Science for environment - policy for environmental science*, Review of Australia's Environmental Science Priorities.
- *State of the Derwent Estuary*, Supervising Scientist Report 129, 1998.
- *Final report. Mount Lyell Remediation Research and Demonstration Program*, Supervising Scientist Report 126, 1997.
- *Investigation of metal toxicity to tropical biota: Recommendations for revision of the Australian water quality guidelines*, Supervising Scientist Report 127, 1997.
- *State of the Tamar Estuary*, Supervising Scientist Report 128,1998.

Primary Industries and Energy Portfolio

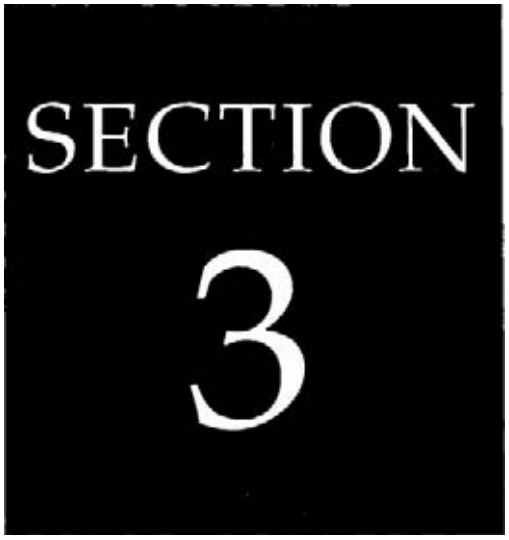
- Bureau of Resource Sciences
  - *Managing Vertebrate Pests: Feral Pigs*, the sixth in a series of national 'best practice' pest management guidelines, 1996.
  - *Australia's Identified Mineral Resources*, 1997.
  - *Oil and Gas Resources of Australia*, 1996.
  - *National Plantation Inventory of Australia*, 1997.
  - *Commercialisation of transgenic crops: risk, benefit and trade considerations*, 1997.
  - *Managing cadmium in agriculture and food: the issues for government*, 1997.
  - *Report on the National Residue Survey Results*, 1997.
  - *Fisheries Status Reports: resource assessments of Australian Commonwealth fisheries*, 1997.
  - *Indicators of drought exceptional circumstances: proceedings of a workshop held in Canberra on 1 October 1997* .
  - *Multiple and sequential land use: Proceedings of a technical symposium.*

Health and Family Services Portfolio

- National Health and Medical Research Council
  - *The Australian Code of Practice for the Care and Use of Animals for Scientific Purposes*, 6th Edition
  - *Policy on the use of non-human primates in medical research*, NHMRC
  - *Policy on the Care of Dogs Used for Scientific Purposes*, NHMRC
  - *Guidelines on the Use of Animals for Training Surgeons and Demonstrating New Surgical Techniques*, NHMRC
  - *Statement and Guidelines on Research Practice*, Joint NHMRC/AVCC
  - *NHMRC Grants 1997*

Treasury Portfolio

- Australian Bureau of Statistics (ABS)
  - *Research and Experimental Development, Business Enterprises, Australia 1995-96*, Bulletin 8104.0,16 May 1997
  - *Research and Experimental Development, Higher Education, Australia 1996*, Bulletin 8111.0,8 May 1998



Science and Innovation in the Budget

Australia's national R&D expenditure

Table 1 provides a broad outline of recent data on R&D expenditure in Australia, based on surveys by the Australian Bureau of Statistics (ABS). The most recent data showed that Australia's gross expenditure on R&D (GERD) stood at $7427 million in 1994-95, corresponding to 1.61 per cent of gross domestic product (GDP). Broadly, about 47 per cent of Australia's R&D expenditure, corresponding to 0.76 per cent of GDP, was undertaken within business enterprises in that year.

TABLE 1 Australia's expenditure on R&D, by sector of performance, 1991-92 to 1995-%*

	1991-92			1992-93			1993-94			1994-95			1995-96		
Sector of performance	$m	%GDP	%rea1 annual increase	$m	%GDP	%rea1 annual increase	$m	%GDP	%rea1 annual increase	$m	%GDP	%rea1 annual increase	$m	%GDP	%rea1 annual increase
Business	2365	0.61	10.1	2863	0.70	17.5	3120	0.72	6.5	3489	0.76	11.2	4243	0.86	18.7
- private	2148	0.55	10.7	2618	0.64	18.1	2887	0.67	7.6	3153	0.69	8.4	4063	0.83	26.2
- public	216	0.06	3.8	245	0.06	11.4	233	0.05	-5.8	336	0.07	45.6	180	0.04	-49.8
Government	na	na		1819	0.45	-0.9	na	na		1965	0.43	2.7	na	na	
- Cwlth	na	na		1151	0.28	0.6	na	na		1178	0.26	0.0	na	na	
- State	na	na		668	0.16	-3.3	na	na		786	0.17	7.3	na	na	
Higher educ.*	na	na		1695	0.43	8.9	na	na		1830	0.41	1.8	2039	0.43	8.3
Priv non prof.	na	na		101	0.02	5.0	na	na		144	0.03	18.7	na	na	
TOTAL	na	na		6478	1.59	7.8	na	na		7427	1.61	5.5	na	na	

Source: DIST based on ABS data.

** ABS R&D data for 1996-97 will become available progressively during 1998. Higher education data for 1996 became available as the Statement was going to press. In 1996, higher education expenditure on R&D was $2308 million, corresponding to 0.46 per cent of GDP. The real annual increase in expenditure over 1995 was 11 per cent.*

The other principal R&D sectors include higher education, where 25 per cent of R&D expenditure (0.41 per cent of GDP) was undertaken, and Commonwealth agencies, which accounted for 16 per cent of R&D expenditure and 0.26 per cent of GDP.

At 1.61 per cent of GDP, GERD in 1994-95 stood at an all time high and had increased dramatically from 1.38 per cent in 1990-91 and 1.26 per cent in 1988-89. The substantial increases in GERD since 1988-89 mainly reflect substantial increases in the level of R&D in the business sector. Business sector R&D expenditure increased sharply from 0.76 per cent of GDP in 1994-95 to 0.86 per cent in 1995-96. This implies that GERD in 1995-96 had increased to about 1.7 per cent of GDP.

Further background on Australian science and technology is provided in the box of "key facts" on page 4.2.

Commonwealth support for R&D in a national perspective

As is seen from Table 1, Commonwealth agencies are significant performers of R&D, but undertake only 16 per cent of total R&D expenditure. As a funding source, however, the Commonwealth Government provides about 40 per cent of R&D funds directly, and has provided another 12 per cent through the indirect means of the R&D tax concession. Derived from ABS survey data, Figure 8 provides a schematic picture of the Commonwealth's activity in the national R&D context and its relative size and interactions compared with other elements of the system.

While the ABS surveys provide the definitive data on Australian R&D expenditure, they cannot be directly related to Government programs. However, a data series has been derived which draws on Budget and other information relating to major Commonwealth research agencies and programs supporting research-related activities. These "science and innovation" data (named so as to distinguish them from ABS R&D data) are described below.

Commonwealth support for science and innovation through major programs

Commonwealth support for major science and innovation programs has increased from $3643 million in 1997-98 to an estimated $3734 million in 1998-99, a decrease in real terms of 0.5 per cent. Broadly, support generally increased over the period from 1986-87 to 1995-96, with revenue forgone from the Industrial R&D Tax Concession Scheme providing particular stimulus from the mid-1980s. Omitting this, the rise in total Commonwealth support results from increased R&D support to the higher education sector coupled with a steady rise in amounts disbursed through the various granting schemes, including the introduction of the Cooperative Research Centres Program.

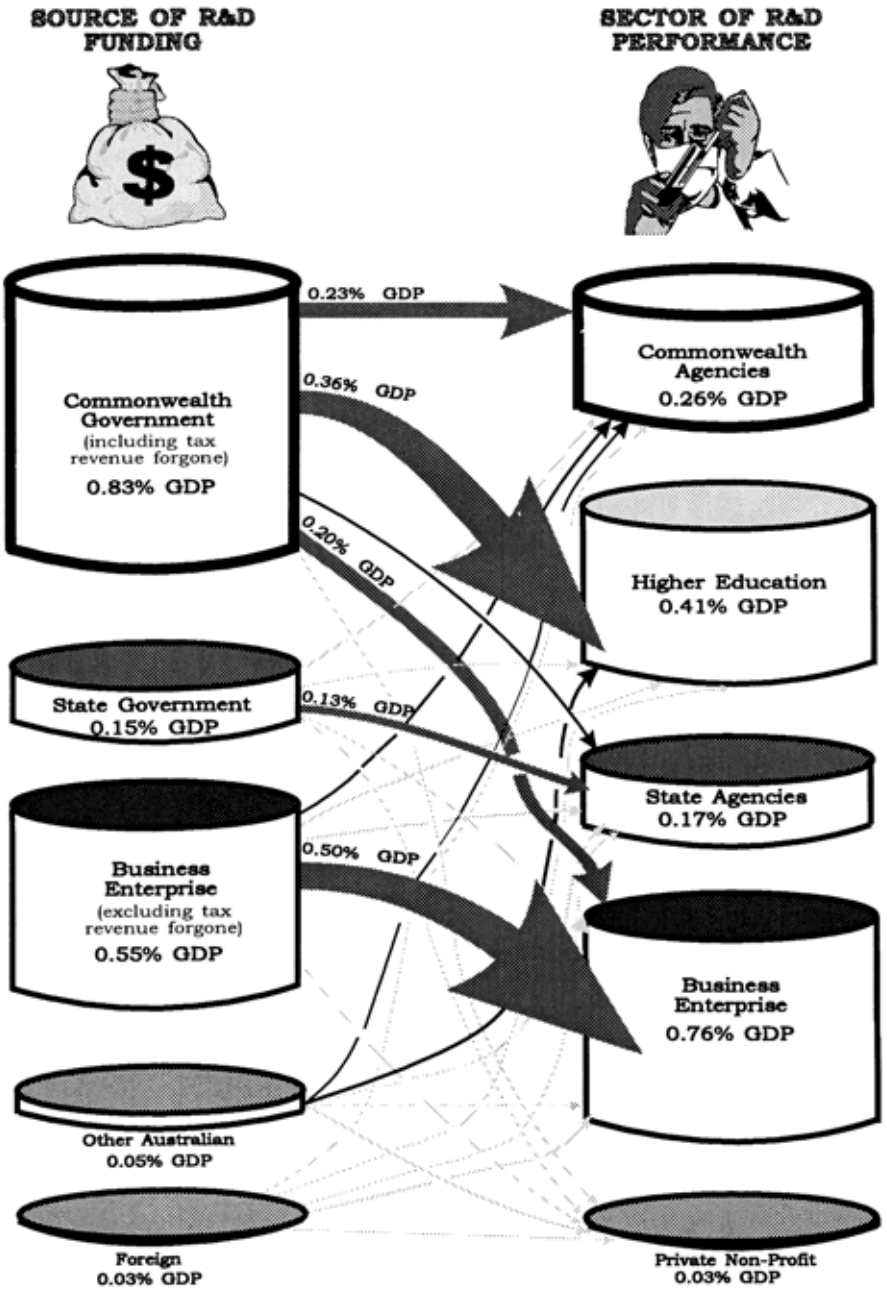
The small real decrease in 1998-99 results from the conclusion of a major capital works program for the Australian Geological Survey Organisation (AGSO). If those capital works are omitted there is a small real increase of 0.4 per cent overall.

Figure 9 and Table 2 present a summary of Commonwealth support for science and innovation at constant price values. They provide a four-way breakdown of the data as follows :

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

Figure 8

COMMONWEALTH R&D SUPPORT IN A NATIONAL PERSPECTIVE



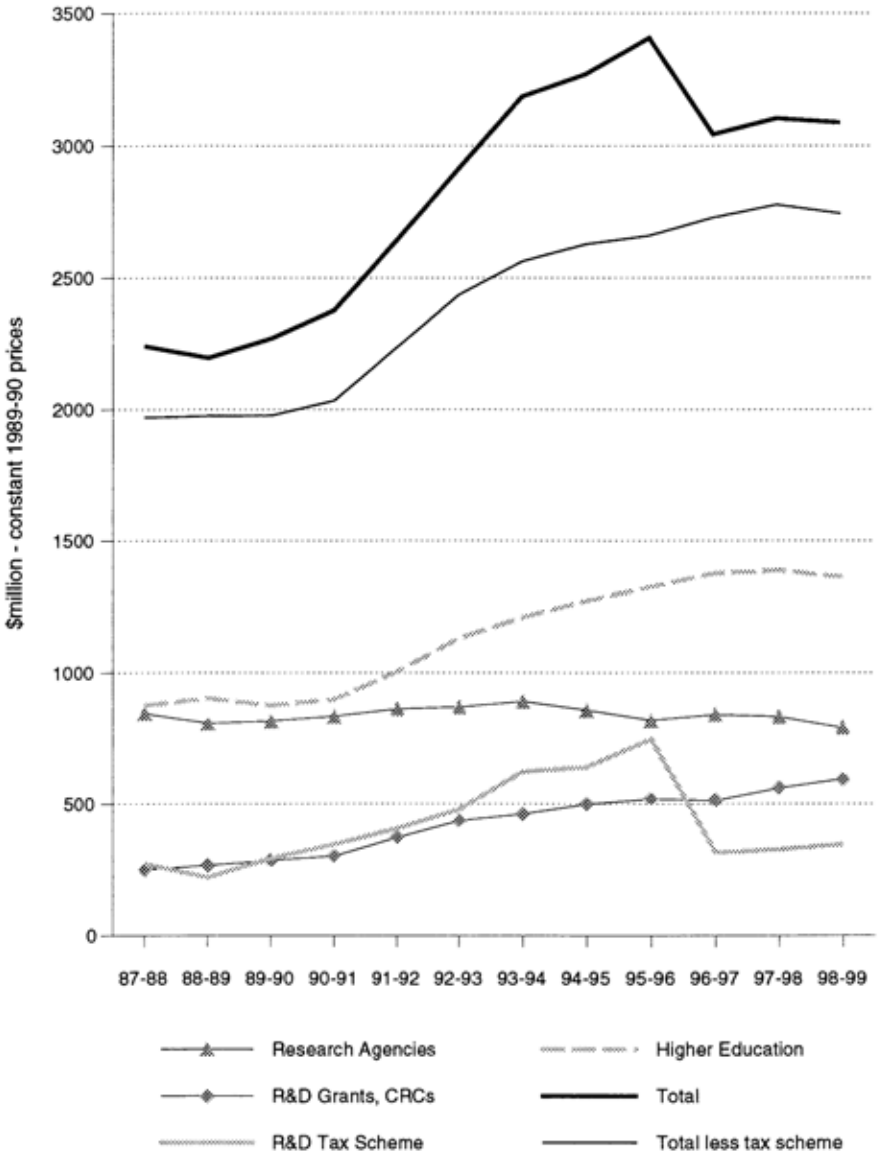
The figure illustrates major flows of funding support between sectors, based on updated 1994-95 data. It places Commonwealth funding of R&D in a national perspective.

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

	1987-88	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*(est) 1997-98*	*(est) 1998-99*
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	225.9	232.9	235.0	227.1	228.0	224.0	247.0	225.4	236.6	220.1	203.7	195.6
• Civil	618.2	573.9	580.7	606.0	633.4	644.4	643.3	631.7	580.9	620.2	627.6	594.2
SUB-TOTAL	844.1	806.8	815.7	833.1	861.4	868.4	890.4	857.0	817.5	840.3	831.3	789.8
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	80.7	81.8	89.9	104.0	118.5	123.1	131.0	138.3	144.2	143.4	145.7	162.9
• R&D Start, etc	90.8	91.4	92.8	94.0	126.7	147.7	118.9	126.4	125.0	124.6	134.3	173.5
• Cooperative Research Centres	-	-	-	-	17.2	42.1	83.4	94.4	117.4	123.6	125.1	114.1
• Rural	62.8	77.6	82.0	78.7	88.9	102.5	107.6	118.9	111.9	108.8	130.3	131.4
• Energy and environment	13.1	12.4	18.5	21.8	18.8	18.5	17.6	17.3	17.4	9.8	21.5	8.7
• Transport	2.3	2.1	2.0	2.1	2.1	2.0	2.0	2.0	1.9	1.7	1.7	1.7
SUB-TOTAL	249.7	265.4	285.2	300.7	372.0	435.9	460.4	497.4	517.6	512.0	558.6	592.2
IR&D TAX CONCESSION	272.0	221.3	293.0	344.8	406.4	478.7	623.7	641.2	747.1	314.3	325.4	344.9
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	83.4	89.9	124.4	174.8	229.9	244.1	271.8	282.1	308.9	344.7	367.3	370.0
• Specific R&D support	115.7	114.9	122.0	128.4	140.4	150.1	150.2	149.9	148.5	146.9	130.3	124.1
• Est. general research support	675.9	697.9	629.0	595.8	633.1	736.5	789.3	841.5	867.4	883.4	890.1	866.8
SUB-TOTAL	875.0	902.7	875.4	898.9	1003.3	1130.7	1211.3	1273.5	1324.7	1375.0	1387.8	1360.9
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 89-90 PRICES	**2241**	**2196**	**2269**	**2378**	**2643**	**2914**	**3186**	**3269**	**3407**	**3042**	**3103**	**3088**
EST. REAL % INCREASE/DECREASE		-2.0	3.3	4.8	11.2	10.2	9.3	2.6	4.2	-10.7	2.0	-0.5

SOURCE: Based on data in Table 3 and using GDP non-farm deflators.

Figure 9 MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION



Source: see Table 2

– *Higher Education Research*

Support for research in the higher education sector (excluding support from special purpose grant schemes) is estimated to increase to $1645 million in 1998-99 from $1629 million in 1997-98, a small real decrease of about 2 per cent.

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

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

– *Research in Commonwealth Agencies*

The largest Commonwealth research agencies are CSIRO, DSTO, ANSTO, AGSO, Antarctic Division and AIMS. Support through Budget appropriations to these agencies, and some smaller ones, is expected to be $955 million in 1998-99, compared with $976 million in 1997-98, a real decrease of 5 per cent associated with the completion of capital works for a new AGSO building.

It is important to note that the research agencies receive funds in addition to those appropriated directly and that these sums are not included in the amounts referred to above. Such external funding has increased significantly in recent years. For example, CSIRO receives business funding, funds from earned revenue (from licencing fees, disposal of assets etc.) and additional Commonwealth support won competitively via the special purpose grant schemes. To encourage improved links with industry, the Government has set a target for external earnings (ie, funds from other than its direct Budget appropriations) of 30 per cent of total funding. Direct appropriations to CSIRO for 1998-99 are expected to amount to $475 million (with a further $6 million through DPIE, see Table 4), but the total income of the Organisation is expected to be in the region of $720 million.

– *Special Purpose Research Grant Schemes*

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 (R&D Start and its predecessors), energy R&D, and some smaller ones. The Cooperative Research Centres, established for the purpose of promoting linkages, are also included in this category.

Support for R&D through the special purpose research grant schemes is estimated to increase to $717 million in 1998-99 from $656 million in 1997-98, representing a real increase of 6 per cent.

– *Tax Incentive Scheme - Industrial R&D and Innovation*
Support for R&D and innovation in the business sector through the industrial R&D tax concession is estimated to be $417 million in 1998-99 ($382 million in 1997-98), an increase of 6 per cent in real terms.

The industrial component of special purpose grants will increase substantially to $210 million from $157 million in 1997-98, a large real increase of 30 per cent in direct support for R&D and innovation in the business sector.

Changes in the balance of funding

Figure 10, expressed as a percentage of GDP, provides an alternative view to Figure 9. In addition, funding of both civil and defence research agencies is shown and higher education funding is split between specific R&D funding and the research and research training component of the general operating grant for universities.

Looking at the broad changes apparent in Figures 9 and 10, Budget funding for the research agencies has remained approximately static in real terms over the period from 1987-88 to 1998-99. (But note that their external earnings — not shown in the figure — have increased over the same period.) Over the same period, the special purpose schemes have increased significantly.

The significant increases in funding in the higher education sector have been accompanied by a substantial change in arrangements so that the proportion of funds allocated on the advice of the ARC is now much higher than in the mid-1980s. Total funds have increased overall in parallel with this substantial change in the funding mechanisms.

The 1988-89 dip in total funding levels is partly due to a real fall in the level of Budget funding for Commonwealth research agencies, since offset by increases in external funding. Such non-Commonwealth funding is not shown in Figures 9 and 10. As a proportion of GDP, overall support was relatively steady between 1992-93 and 1995-96 (Figure 10). The noticeable decline between 1995-96 and 1996-97 was due to the change in the rate of the tax concession from 150 to 125 per cent and other changes concerning the concession.

Detailed data

Table 3 is the current price version of Table 2 and summarises Tables 4, 5 and 6. It estimates total annual support for science and innovation.

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

A further blurring results from the inclusion of data relating to the taxation concession scheme for industrial R&D. The amounts shown in Table 6 are *estimates* only (see footnote (7) to Table 6) and relate to the year in which companies undertake the R&D for which they subsequently claim the concession. (Footnote (7) provides the amounts of tax revenue forgone relating to years in which tax claims are lodged.) There are revisions to some historical data and further revision may be necessary as new data become available, and as the outcomes of the recent changes to the concession are seen.

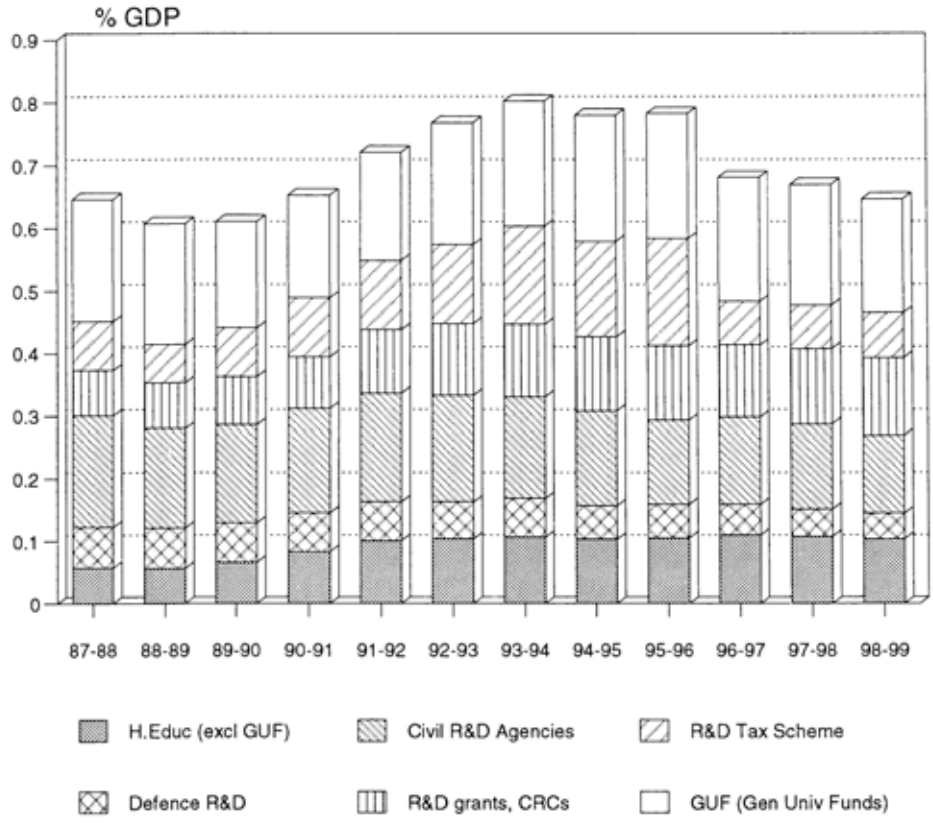
Budget-based science and innovation data and ABS R&D

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

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

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

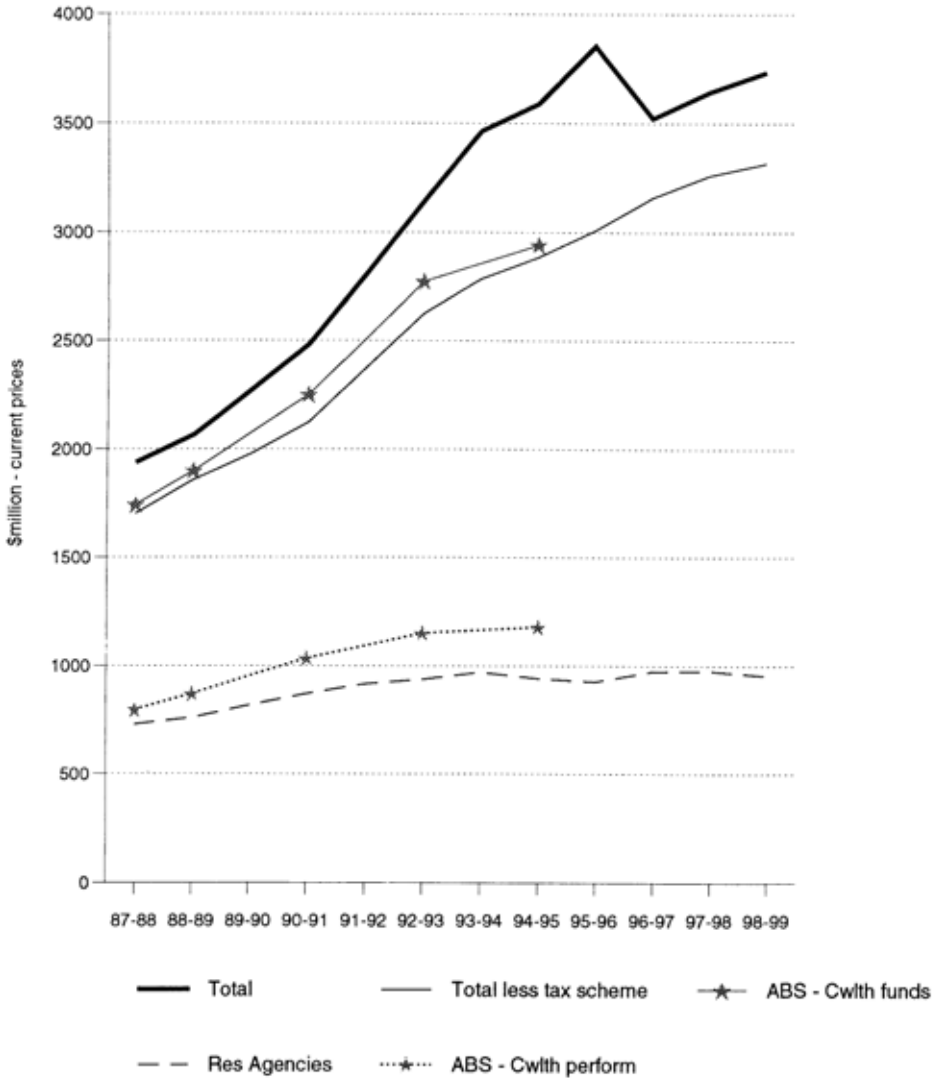
Figure 10 MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION AS A PERCENTAGE OF GDP



Source: *See Table 2 and ABS 5206.0*

Figure 6 shows the comparison between the "science and innovation" series presented in this Section and ABS (Frascati) R&D. The total appropriation income of the research agencies shows a small but increasing deviation from ABS R&D performance data. The discrepancy which occurs can be explained largely in terms of CSIRO's external income. (ABS R&D performance data for the agencies includes expenditure from all sources of funds. The series based on Table 3 shows only directly appropriated Commonwealth funding.)

Figure 11 BUDGET-BASED DATA AND ABS R&D



Source: DIST and ABS

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

	1987-88	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*(est) 1997-98*	*(est) 1998-99*
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	195.1	219.0	235.0	237.1	242.4	241.5	268.5	247.4	267.6	254.9	239.2	236.4
• Civil	534.1	539.5	580.7	632.7	673.3	694.6	699.3	693.6	657.0	718.2	736.8	718.4
SUB-TOTAL	729.3	758.4	815.7	869.8	915.7	936.1	967.8	941.0	924.6	973.1	976.0	954.8
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	69.7	76.9	89.9	108.6	125.9	132.7	142.4	151.8	163.0	166.1	171.1	196.9
• R&D Start, etc	78.4	85.9	92.8	98.2	134.7	159.2	129.2	138.8	141.3	144.3	157.6	209.8
• Cooperative Research Centres					18.2	45.3	90.6	103.7	132.7	143.1	146.9	137.9
• Rural	54.3	73.0	82.0	82.2	94.5	110.5	117.0	130.5	126.5	126.0	153.0	158.8
• Energy and environment	11.3	11.7	18.5	22.8	19.9	19.9	19.1	19.1	19.6	11.4	25.2	10.5
• Transport	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.0	2.0	2.0
SUB-TOTAL	215.7	249.4	285.2	313.9	395.4	469.8	500.5	546.1	585.5	592.9	655.8	715.9
IR&D TAX CONCESSION	235	208	293	360	432	516	678	704	845	364	382	417
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	72.0	84.5	124.4	182.5	244.3	263.1	295.4	309.8	349.3	399.2	431.3	447.3
• Specific R&D support	100	108	122	134	149	162	163	165	168	170	153	150
• Est. general research support	584	656	629	622	673	794	858	924	981	1023	1045	1048
SUB-TOTAL	756.0	848.5	875.4	938.5	1066.5	1218.9	1316.7	1398.3	1498.2	1592.3	1629.3	1645.3
TOTAL COMMONWEALTH SUPPORT	**1936**	**2064**	**2269**	**2482**	**2810**	**3141**	**3463**	**3589**	**3853**	**3522**	**3643**	**3733**
% GDP	0.646	0.608	0.611	0.653	0.721	0.768	0.802	0.780	0.783	0.681	0.670	0.646
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 1989-90 PRICES	2241	2196	2269	2378	2643	2914	3186	3269	3407	3042	3103	3088
EST. REAL % INCREASE/DECREASE		-2.0	3.3	4.8	11.2	10.2	9.3	2.6	4.2	-10.7	2.0	-0.5

SOURCE: See Tables 4, *5* and 6

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

	1987-88	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*Outlays 1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*(est.) 1997-98*	*(est.) 1998-99*
ENVIRONMENT												
Antarctic Division	49.2	46.3	57.7	62.8	67.3	65.4	61.0	61.3	63.1	59.4	61.9	63.1
Bureau of Meteorology Research Centre (BMRC)	2.5	2.2	2.4	2.8	3.3	3.3	3.6	3.6	4.0	4.4	4.5	4.3
Supervising Scientist - including ERISS	6.0	6.6	7.6	6.7	7.5	7.6	6.6	6.5	6.0	5.4	4.3	4.2
DEFENCE												
Defence Science and Technology Organisation[1]	195.1	219.0	235.0	237.1	242.4	241.5	268.5	247.4	267.6	254.9	239.2	236.4
EMPLOYMENT, EDUCATION, TRAINING & YOUTH AFFAIRS												
Anglo-Aust Telescope	2.4	2.5	2.7	2.9	3.0	3.1	3.1	3.0	3.2	3.3	3.5	3.6
HEALTH & FAMILY SERVICES												
Australian Institute of Health & Welfare (excl. grants)	3.4	4.2	4.4	4.2	5.0	6.8	7.2	8.1	7.1	7.6	7.7	7.7
CSL[2]	17.3	16.6	9.4	3.0	1.3	6.9	16.7	-	-	-	-	-
Nuclear Safety Bureau	-	-	-	-	-	0.8	0.8	0.8	0.9	0.9	0.9	0.9
INDUSTRY, SCIENCE & TOURISM												
Aust Nuclear Science & Technology Organisation	50.8	54.3	57.5	62.6	64.3	68.2	64.2	66.2	65.6	63.7	76.7	80.0
Australian Institute of Marine Science	9.5	11.0	11.4	13.6	14.2	14.2	16.9	16.5	16.6	16.4	16.4	18.5
CSIRO	347.8	348.1	375.2	414.4	446.3	456.2	460.4	460.8	416.7	433.9	466.8	475.4
Kraft Pulp Mill study (CSIRO)	-	-	0.5	1.4	1.9	1.9	1.9	-	-	-	-	-
PRIMARY INDUSTRIES & ENERGY												
Contribution to CSIRO for Aust Animal Health Labs	4.7	4.7	4.9	5.3	5.5	6.0	5.9	6.2	5.8	6.0	6.1	6.1
AGSO *(note capital works in 96-97 & 97-98)*	40.6	42.9	47.0	52.9	52.9	54.2	50.9	60.5	68.0	117.1	88.0	54.5
TOTAL	**729.3**	**758.4**	**815.7**	**869.8**	**915.7**	**936.1**	**967.8**	**941.0**	**924.6**	**973.1**	**976.0**	**954.8**

(1) DSTO expenditure shown here includes overhead components funded under other Defence programs, such as salaries for service personnel, FBT, superannuation and some administative support costs. These have been added to the DSTO figures published in the Budget Papers. For 1996-97 and 1997-98, DSTO funding included additional one-off provisions to cover the costs of voluntary redundancy and a redirection of administrative savings.

(2) Excludes Budget funding for CSL Reference Centre, which has been mainly for production of antivenom rather than R&D.

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

						Outlays					*(est.)*	*(est.)*
	1987-88	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*
ENVIRONMENT												
Aust Biological Resources Study	1.1	1.3	1.6	1.2	2.0	2.3	2.3	2.0	1.8	1.3	1.0	1.0
Greenhouse research (NGRP)	-	0.8	5.7	5.7	6.1	6.0	5.8	6.0	6.0	3.5	3.6	3.5
EMPLOYMENT, EDUCATION, TRAINING & YOUTH AFFAIRS												
Research evaluation and Academies	-	-	-	1.6	2.0	2.0	2.0	2.1	2.1	2.2	2.2	2.3
ARGS & ARC grants/fellowships (including marine R&D grants) [1]	42.7	50.7	35.6	1.2	-	-	-	-	-	-	-	-
Post-graduate Awards[1]	20.3	21.7	11.3	-	-	-	-	-	-	-	-	-
Targeted Institutional Links Program	-	-	0.2	1.0	2.0	1.1	1.4	1.4	0.8	0.5	0.5	-
HEALTH & FAMILY SERVICES												
AIDS Research	3.0	3.5	5.0	7.1	10.8	10.5	11.6	12.1	12.1	11.7	12.0	12.0
NH&MRC Research Grants[2]	66.7	73.4	84.9	96.5	105.1	112.2	120.8	126.7	141.3	152.4	156.4	176.0
Capital Works for Medical Institutes	-	-	-	5.0	10.0	10.0	10.0	13.0	9.6	2.0	2.7	8.9
INDUSTRY, SCIENCE & TOURISM												
Industry Innovation (incl. R&D Start)	-	-	-	-	-	-	-	-	-	56.4	91.2	128.1
Renewable Energy Grants	-	-	-	-	-	-	-	-	-	-	-	4.4
Industry Innovation Program grants	-	-	-	-	-	43.5	40.3	46.9	52.4	-	-	-
Innovation Investment Fund	-	-	-	-	-	-	-	-	-	-	-	14.0
Advanced Manufacturing Tech Program	-	-	-	-	0.1	-	-	-	-	-	-	-
Technology Development Program	1.4	1.1	1.9	3.0	3.2	-	-	-	-	-	-	-
National Procurement Development Program (NPDP)	0.7	3.9	5.6	4.2	4.4	-	-	-	-	-	-	-
IR&D Act 1986 (GIRD)	25.6	31.8	32.0	29.6	32.2	-	-	-	-	-	-	-
IR&D Incentives Act 1976												
. Commencement grants	3.1	0.1	-	-	-	-	-	-	-	-	-	-
. Project grants	6.4	2.8	0.3	-	-	-	-	-	-	-	-	-
. Public interest projects	1.0	0.3	-	-	-	-	-	-	-	-	-	-
Technology Diffusion Program	-	-	-	-	-	-	-	-	-	-	-	18.0
Technology Support Centres	-	-	-	-	-	-	-	3.9	12.2	7.2	19.2	-
International S&T Programies	-	-	-	-	5.1	5.3	5.4	5.5	5.6	5.6	5.6	-

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

	1987-88	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*Outlays 1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*(est.) 1997-98*	*(est.) 1998-98*
Malaria Vaccine Joint Venture	0.8	1.2	0.8	2.3	9.4	-	-	-	-	-	-	-
Research associations[3]	2.0	-	-	-	-	-	-	-	-	-	-	-
Motor Vehicle R&D	8.4	8.3	4.7	2.3	-	-	-	-	-	-	-	-
Australian Technology Group Pty Ltd	-	-	-	-	-	30.0	-	-	-	-	-	-
National Research Facilities	-	-	-	-	-	-	-	-	6.4	17.0	21.4	9.6
Cooperative Research Centre Grants	-	-	-	-	18.2	45.3	90.6	103.7	132.7	143.1	146.9	137.9
Assistance under the Bounty[4] (Computers) Act 1984	25.7	31.1	45.0	51.3	74.5	75.0	78.0	74.8	64.1	56.5	19.5	40.0
National Space Program	3.2	5.4	2.4	5.5	5.7	5.4	5.4	9.0	2.7	1.7	0.5	-
PRIMARY INDUSTRIES & ENERGY[5]												
Wool Research	12.1	21.7	20.8	11.7	13.8	13.2	12.0	15.1	11.7	10.4	13.0	14.3
Meat Research	8.6	11.9	13.8	13.6	20.8	22.9	22.1	25.1	22.6	21.1	26.2	25.1
Fishing Industry Research	6.2	5.4	8.1	8.4	6.6	7.5	8.5	9.2	10.4	11.3	7.8	11.4
Grains	11.2	11.1	13.3	14.4	14.8	15.7	21.2	23.3	21.3	29.1	33.8	34.4
Horticulture Research	-	0.6	1.2	3.1	4.4	8.3	9.6	10.7	11.4	12.0	15.6	16.5
Energy research	10.2	9.6	11.2	15.9	11.8	11.6	11.0	11.1	11.8	6.6	20.6	1.5
Land & Water research	7.8	10.4	9.9	13.3	13.3	13.7	11.8	11.3	10.6	9.8	10.9	11.1
Rural Industries R&D Corporation	3.0	4.0	5.0	6.0	8.4	10.5	10.5	10.5	10.5	5.6	10.8	11.0
Other rural research	5.5	8.0	10.1	11.7	12.4	18.8	21.3	25.5	28.0	26.7	34.9	35.0
Payments to Austroads/ ARRB Transport Research Ltd	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.0	2.0	2.0
TOTAL	**278.8**	**321.9**	**332.2**	**317.7**	**399.5**	**473.0**	**503.9**	**549.6**	**588.4**	**595.6**	**658.5**	**718.2**

FOOTNOTES TO TABLE 5

(1) From 1989-90 most ARC funding has been appropriated through the *Higher Education Funding Act* rather than the Budget. See Table 6.

(2) Includes funding for health and health services research grants.

(3) Since 1988-89 the Associations have been fully funded by industry.

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

FOOTNOTES TO TABLE 5 - *continued*

(5) For consistency, the expenditure figures for Wool, Meat, Other Rural Research, Fish, Horticulture and Grains exclude that component of Commonwealth outlays funded from industry levies. The component of outlays provided by way of industry levy or contribution is given in the following table .

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

	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	est 1997-98	est 1998-99
Wool	18.31	14.21	19.63	17.11	14.05	12.32	12.45	19.50	10.94	12.79	14.47	15.08
Meat	8.65[a]	11.58[a]	13.30[a]	15.17[a]	25.60[a]	25.55	24.65	23.52	22.40	23.13	22.91	21.41
Grains												
- Grain[b]	2.35	2.53	3.99	4.27[b]	5.31[b]	9.36	12.61	8.51	17.18	19.48	16.51	18.88
-Wheat	5.16	8.35	9.84	8.45	12.92	18.35	19.95	16.28	33.65	35.17	31.63	30.00
Coal[c]	7.07	15.02	17.05	14.95	13.88	16.10	1.48	-	-	-	-	-
Special Rural	-	-	0.20	0.30	0.15	0.99	1.03	1.32	1.57	1.39	1.73	1.71
Fish	-	-	-	0.50	1.12	1.01	2.01	2.41	2.46	2.52	3.00	3.30
Horticulture	-	0.20	1.62	3.26	4.94	7.24	3.12	3.61	4.28	8.04	8.56	8.98
Other Rural												
- Chicken Meat	0.40	0.38	0.46	0.55	0.78	0.65	0.67	0.71	0.71	0.79	0.81	0.82
- Cotton	0.86	1.55	1.87	2.66	3.87	3.89	2.57	2.13	2.90	4.30	4.90	5.08
- Dairying	1.64	1.57	2.94	4.82	5.21	5.65	6.20	6.13	5.75	8.36	11.39	11.61
- Dried Fruit	0.26	0.29	0.39	0.45	0.78	0.92	0.46	0.49	0.39	0.79	0.46	0.64
- Grape & Wine	0.82	0.94	1.28	1.25	0.96	1.60	1.70	2.08	1.91	2.62	2.38	2.76
- Honey	0.11	0.10	0.12	0.14	0.07	0.12	0.15	0.15	0.15	0.20	0.16	0.18
- Pig Industry	1.43	1.37	1.95	2.58	2.68	2.88	3.61	3.75	3.57	3.42	3.37	3.42
- Egg Industry	0.28	0.37	0.30	0.45	0.57	0.68	0.67	0.63	0.68	0.76	0.69	0.68
- Sugar	1.28	1.40	1.37	1.48	1.28	3.40	4.48	4.89	5.46	5.99	6.14	6.16
- Tobacco	0.64	0.94	0.77	0.59	0.59	0.92	0.64	0.33	0.49	0.57	0.76	0.72
- Forestry	-	-	-	-	-	-	-	0.38	1.00	1.72	2.30	2.50
Total	49.25	60.82	77.09	79.00	94.86	111.62	96.97	96.84	115.49	132.05	132.17	133.91

(a) Industry contributions for meat R&D to the Australian Meat Research Corporation.
(b) From 1990-91 barley, grain legumes, and oilseeds are covered by a single outlay to the Grains R&D Corporation.
(c) Coal research was funded entirely through industry levies. As there is no Commonwealth contribution it is omitted from Table 4.

TABLE 6 Estimated Costs of Programs and Incentives providing support for Research and Innovation outside the Budget ($m)

	1987-88	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98 (est)*	*1998-99 (est)*
EMPLOYMENT, EDUCATION, TRAINING & YOUTH AFFAIRS												
Higher Education Funding Act: special research assistance [1,2]	9.0	12.1	77.3	178.7	240.3	260.0	292.0	306.3	346.4	396.5	428.6	445.0
Funding for ANU Institute of Advanced Studies[3]	100	108	122	134	141	145	146	147	150	152	153	150
Estimated research & research training component sourced in the operating grant[4,5,6]	584	656	629	622	673	794	858	924	981	1023	1045	1048
INDUSTRY, SCIENCE & TOURISM												
Tax Concession[7] for industrial R&D	215	201	274	326	432	516	678	704	845	364	382	417
Tax Deduction for equity subscriptions in Management Investment Companies (MICs)[8]	20	7	19	34	-	-	-	-	-	-	-	-
TOTAL	**928**	**984**	**1121**	**1295**	**1495**	**1732**	**1991**	**2099**	**2340**	**1954**	**2009**	**2060**

* These data are estimates of funding provided for higher education research through the *Higher Education Funding Act* and predecessor legislation. About 70% of these funds cover research in the natural sciences and engineering, with the balance going to support social sciences and humanities research.

(1) Includes ARC/DEETYA funding for research grants, fellowships, centres, postgraduate awards and infrastructure.

(2) In 1996, the funding of Advanced Engineering Centres was transferred from HEFA to the university operating grant. In order to maintain consistency, that funding from the operating grant since 1996-97 has been added to the Budget appropriation figures appearing in the Budget Papers. In 1998-99, such funding is estimated to be $1.6 million, pending a current review of this programme.

(3) This is an estimate of funds for research and research training provided to the Institute of Advanced Studies (IAS) of the Australian National University (ANU) through the operating grant. Funding for the John Curtin School of Medical Research (JCSMR) of the ANU was transferred to the Health Portfolio in 1992 and is not included from 1992-93 to 1996-97. JCSMR funding returned to EETYA portfolio in 1997-98 and is included in the 1997-98 estimate (JCSMR funding made up $18.7 million of the total IAS funding of $153 million in 1997-98). For 1998-99 the IAS block grant is estimated to be $150million. This amount includes some $104 million which is allocated by the University to the annual budget of the Research Schools (including the John Curtin School of Medical Research) and Centres of the Institute of Advanced Studies (IAS). In addition, the University estimates that a further $40-45 million can be regarded as being attributable to the IAS in respect of University overheads, major equipment and such campus-wide costs as the library, information technology and central administrative activities. The total direct and indirect funding devoted by the University to the IAS is therefore in the order of $150 million.

(4) The sum of the estimates in the previous row and this row of figures is an estimate of the research and research training component of the university operating grant. It does not include funds spent on research by the former advanced education sector institutions prior to the 1989 amalgamations.

(5) A new methodology of estimating research and research training is used for 1993-94 onwards due to changes in ABS data collection introduced in *1994 Research and Experimental Development - Higher Education Organisations* (8111.0). The methodology prior to 1993-94 uses estimates for 1984-85, 1986-88, 1988-89, 1990-91 and 1992-93 based on ABS R&D surveys in the calendar year in which each of these financial years commences. From 1993-94 onwards, the estimate is based on the ABS survey of research expenditure of universities by source of funds. One of the sources identified by the ABS is General University Funds (GUF), a term that covers all university expenditure attributable to Commonwealth funding excluding funds provided through competitive granting schemes and other funding mechanisms identifiable in the ABS R&D Survey. The ABS estimates GUF for 1994 as $1166 million. The operating grant component is the major part of GUF, and can be estimated by using the operating revenue figures from *DEETYA Selected Higher Education Finance Statistics*. A research and research training component of the operating grant can then be calculated by multiplying the proportion of GUF attributable to the operating grant, by the R&D funds sourced from GUF (this latter is obtainable from ABS Higher Education R&D surveys for 1994, 1995 and any subsequent years). The estimate for 1993-94 is based is based on 1994 data; with adjustment for 1993. The estimate for 1994-95 is the most accurate, as it is based on existing 1994 and 1995 data. Estimates for 1995-96 and beyond are based on the 1995 data, using forward projections of the non-capital unified system operating grant for subsequent years.

(6) Data prior to 1993-94, as presented in the *Science and Technology Budget Statement 1996-97* and previous *Statements*, have been adjusted downwards (pro rata) to minimise any break in the data series due to the introduction of the new methodology.

(7) A 150% company tax deduction for eligible industrial R&D expenditure applied from 1 July 1985 to 20 August 1996, when the rate was reduced to 125%. The data series in Table 6 comprise estimates by the Department of Industry Science and Tourism based both on information provided in registrations for the concession and from the Treasury. They do not account for any recoupments arising from the dividend imputation system. Since the policy rationale for the tax concession scheme is to increase business expenditure on R&D, the data in the table are estimates relating to the year when companies undertake the R&D for which they subsequently claim the concession — that is, they are the estimated cost to revenue that would have occurred if companies had claimed the tax concession in the same financial year in which the R&D expenditure was incurred. In fact, some claims are not made until subsequent years (not necessarily in the next financial year). The estimated revenue forgone for the years when claims for the concession are lodged with the Australian Taxation Office is, from 1987-88 to (estimated) 1998-99, as follows: $160m, $195m, $200m, $275m, $305m, $400m, $465m, $685m, $675m $800m, $350m and $410m. Figures published here are revised over those published previously. While these data represent best estimates at the time of publication, they may require further revision as more information becomes available.

(8) Licensed Management and Investment Companies invested in approved high technology/growth activities. The equity subscription in these companies attracted a 100% income tax deduction in the year that subscriptions were made. The scheme concluded in June 1991.

TABLE 7 Thematic priorities of Commonwealth Support for Science and Innovation – Budget and other measures

THEMATIC PRIORITIES	*1988-89*	*1989-90*	*1990-91*	*1991-92*	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*%Total*	*%GDP*
Primary products	183.8	191.5	207.9	232.1	254.3	277.6	287.0	280.0	278.4	312.5	**320.6**	*8.6*	*0.055*
Industrial development	394.2	476.5	542.4	654.7	757.0	879.1	902.3	1016.2	638.2	674.3	**761.9**	*20.4*	*0.132*
Energy	54.3	61.7	73.3	77.7	87.3	108.6	109.0	123.6	80.3	100.9	**89.3**	*2.4*	*0.015*
Transport & telecommunications	30.2	34.4	38.5	42.1	39.0	34.7	35.5	49.7	36.5	38.7	**40.3**	*1.1*	*0.007*
Urban and rural planning	0.4	0.5	0.6	0.8	0.5	0.5	0.9	1.4	0.6	0.6	**0.7**	*0.0*	*0.000*
Prevention of pollution	30.5	40.3	49.9	59.6	60.5	61.8	68.9	56.8	52.5	57.2	**58.8**	*1.6*	*0.010*
Identification & treatment of pollution	18.4	21.3	22.3	28.5	27.6	32.6	36.6	38.0	31.2	33.4	**35.1**	*0.9*	*0.006*
Health	115.0	122.0	136.6	159.9	181.2	212.4	210.0	230.5	220.5	231.2	**260.5**	*7.0*	*0.045*
Social development & services	5.1	5.1	12.3	13.3	13.1	12.0	14.4	12.0	10.1	10.8	**11.1**	*0.3*	*0.002*
Mining, earth & atmosphere	72.6	92.7	100.2	100.1	117.9	118.9	130.1	129.1	187.6	163.1	**127.6**	*3.4*	*0.022*
Advancement of Knowledge													
- targeted research funding	278.2	347.6	426.0	510.8	541.6	573.8	591.9	641.9	696.1	723.1	**728.5**	*19.5*	*0.126*
- general university funding	656.0	629.0	622.0	673.0	794.0	858.0	924.0	981.0	1023.0	1045.0	**1048.0**	*28.1*	*0.181*
Defence	225.7	246.7	250.1	257.2	267.1	293.0	278.7	292.9	267.2	252.1	**250.4**	*6.7*	*0.043*
TOTAL	**2064**	**2269**	**2482**	**2810**	**3141**	**3463**	**3589**	**3853**	**3522**	**3643**	**3733**	*100.0*	*0.646*

Note: Table 7 represents the aggregate data from Table 3 re-arranged by broad socio-economic objective (SEO) categories in accordance with general OECD practice for "government budget appropriations on R&D" (GBAORD). The categories are consistent with aggregated groups of the Australian Standard Research Classification (1993 edition). It should be noted that Budget items cannot be allocated to SEO categories with precision corresponding to that achieved through the R&D surveys of the Australian Bureau of Statistics. In general, single Budget lines are allocated to a single broad category in the derivation of the Table. The outlays of CSIRO and those for the CRC Program are, however, split between a number of categories according to available information.

Thematic Priorities

Table 7 presents a re-arrangement of aggregate outlays from Table 3 according to "thematic priorities". Presentation of these data follows a recommendation from the Chief Scientist in his June 1997 Report, *Priority Matters*.

The Table shows that support for "advancement of knowledge" is the dominant category, representing almost 48 per cent of the total - mostly via general university funding. "Targeted research funding" within this category is also mostly in support of university research, though small components are expended through Government programs.

Industrial development, for which the tax concession and the R&D Start Program are the major components, accounts for 20 per cent of total support. Support for activities relating to primary products (mostly agriculture) account for almost 9 per cent, while health research and defence R&D are the other substantial categories, each at around 7 per cent of the aggregate.

Australia in an International Context

AUSTRALIAN SCIENCE & TECHNOLOGY
- KEY FACTS -

In 1994-95, Australia's total R&D expenditure stood at Aus$7.4 billion. This corresponds to 1.61% of GDP. It is estimated to be around 1.7% of GDP in 1995-96.

In 1994-95, the annual investment of Australian business in R&D was 0.76% of GDP, but increased to 0.86% in 1995-96. Though still low compared with other developed countries, it has increased markedly since the early 1980s. Over 1988 to 1995, Australia's growth rate in business R&D expenditure was the second highest in the OECD.

Comparing Australian business R&D expenditure and external patenting applications, each as a share of total activity within the OECD, shows a good correlation between R&D and Australian patent applications to other countries. This indicates an international orientation in Australia's industrial R&D and confirms the reliability of data on R&D expenditure in the business sector.

In 1994-95, R&D expenditure in Australian public sectors (government agencies and universities) was 0.84% of GDP, the fifth highest in the OECD.

Australia has about 86,200 people in its R&D workforce. These include 40,100 in universities (including 22,000 postgraduate research students), 25,200 in the business sector and 19,100 working in Federal and State Government laboratories.

In 1995, Australian universities graduated some 14,600 students with bachelor degrees in science, and 5,900 with bachelor degrees in engineering. Some 37 universities awarded these degrees. In the same year, 840 science and 310 engineering PhDs graduated.

Australia's net gain in scientists, engineers and academics through migration has been considerable — over a nine year period totalling about 30,700, of whom 22,000 were engineers. On average, the annual gain in scientists and engineers is equivalent to the graduate output from 6 universities. The high volume of this "brain gain" should dispel concerns of any overall loss of high level skills.

Professor Peter Doherty shared the Nobel Prize for medicine in 1996. Over the years, seven Australian scientists have received this prestigious international prize in science.

Australia ranks eleventh in international scientific effort normalised by population - by publishing some 830 scientific papers per million population per year.

As measured by use of the Internet, Australia has a high capability and readiness to take up new technology. In January 1997, Australia had the sixth highest number of host computer connections to the Internet and, normalised by population, ranked fourth.

This information is an update of information from *Australian Science and Technology at a Glance 1997*. A new edition will be released later in 1998. See also Table 1 (p. 3.3), Figure 8 (p. 3.5) and the associated text.

Broad international comparison of R&D levels

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

Table 8 shows the latest available GERD/GDP data for nineteen OECD and five Asian economies. Since it is also useful to know the relative scales of R&D effort, the list is ranked by the total R&D expenditure level (in US

TABLE 8 Gross expenditure on R&D (GERD), GERD as a proportion of GDP, and change and growth rates - international comparisons

			Period 1981 to 1988			Period 1988 to 1995		
	GERD (est. 1995 US$m)	GERD/GDP	Change	Average annual real increase in GERD	Average annual real increase in GDP	Change	Average annual real increase in GERD	Average annual real increase in GDP
United States (1995)	179126	2.55	0.36	5.5	3.4	-0.23	0.5	2.0
Japan (1995)	75636	2.77	0.54	7.1	3.7	0.11	2.0	2.2
Germany (1995)	38412	2.30	0.43	4.6	2.0	-0.57	0.3	4.0
China (1995)	33469	0.49	na	na	5.4	-0.15	5.6	10.9
France (1995)	27044	2.33	0.30	4.1	2.0	0.06	1.8	1.4
United Kingdom (1995)	21375	2.05	-0.19	2.4	3.6	-0.08	0.4	0.9
South Korea (1995)	15132	2.68	1.22	28.6	9.9	0.92	12.7	7.4
Italy (1995)	12693	1.14	0.34	7.9	2.5	-0.08	-0.3	1.2
Canada (1995)	10240	1.65	0.14	5.3	3.8	0.25	4.0	1.1
India (1992)	7550	0.74	0.26	11.1	5.4	-0.11	-0.1	3.9
Netherlands (1995)	6376	2.09	0.37	5.1	2.2	-0.13	1.5	2.6
Sweden (1995)	5939	3.60	0.69	7.2	2.5	0.66	4.2	0.3
AUSTRALIA (1994)	**5693**	**1.61**	**0.26**	**7.4**	**3.9**	**0.35**	**6.2**	**2.7**
Spain (1995)	4720	0.85	0.29	10.4	3.0	0.13	4.3	1.8
Chinese Taipei (1995)	4618	1.85	0.32	13.7	8.9	0.57	12.0	6.6
Switzerland (1992)	4429	2.66	0.57	6.8	2.1	-0.17	-1.6	0.5
Belgium (1995)	3391	1.61	0.02	2.3	1.5	-0.02	1.1	1.7
Austria (1995)	2553	1.54	0.18	3.8	1.5	0.19	4.5	2.4
Finland (1995)	2150	2.37	0.61	9.7	3.3	0.56	3.6	-0.7
Denmark (1995)	2149	1.92	0.40	7.5	3.0	0.43	5.3	1.6
Norway (1995)	1697	1.71	0.53	8.4	1.6	0.02	2.9	2.3
Ireland (1995)	867	1.40	0.14	6.2	2.5	0.58	15.2	5.6
Singapore (1993)	606	1.20	0.60	25.7	5.3	0.33	14.7	6.9
New Zealand (1995)	589	0.98	-0.14	-2.1	1.9	0.10	3.7	2.2
Average (24 economies)		**1.84**	**0.36**	**8.2**	**3.5**	**0.16**	**4.4**	**3.0**
Average (19 OECD only)		**1.95**	**0.31**	**5.8**	**2.6**	**0.11**	**3.1**	**1.9**

Source: DIST based on ABS, OECD and national sources.

dollars at 1995 prices). The Table also shows the change in the GERD/GDP ratio between 1981 and 1988, and between 1988 and 1995 (or nearest years), and the average annual real growth rates over each period both for GERD and GDP.

The Table shows that the scale of Australia's total R&D expenditure is about one thirtyfifth that of the largest national effort (USA) and about eleven times that of the smallest. In terms of the relative share of national wealth devoted to R&D (GERD/GDP), Australia lies in the middle range. Australia's relative R&D effort is about half that of Sweden (the highest in relative terms) and is about three times that of the lowest. In almost all economies, real growth rates in GERD over the second period were substantially lower than in the first - with Ireland being the striking exception. In the period 1988 to 1995, many economies showed slower growth in GERD than in GDP, particularly compared to the period 1981 to 1988. Australia was one of the exceptions in this case. The three "dynamic Asian economies" shown (Singapore, South Korea and Chinese Taipei) have dramatically increased their total level of R&D effort and show exceptionally high growth rates in GERD and GDP.

GERD is, however, made up of R&D expenditure undertaken in quite different sectors (principally, the business sector, government agencies and universities). There are wide international differences in the relative contribution of these sectors to GERD and policy issues may differ substantially between research sectors. Figure 12 indicates the relative sizes of the research sectors for the economies listed in Table 8, but re-orders the list according to level of GERD/GDP.

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

(i) R&D in government agencies and universities combined; and

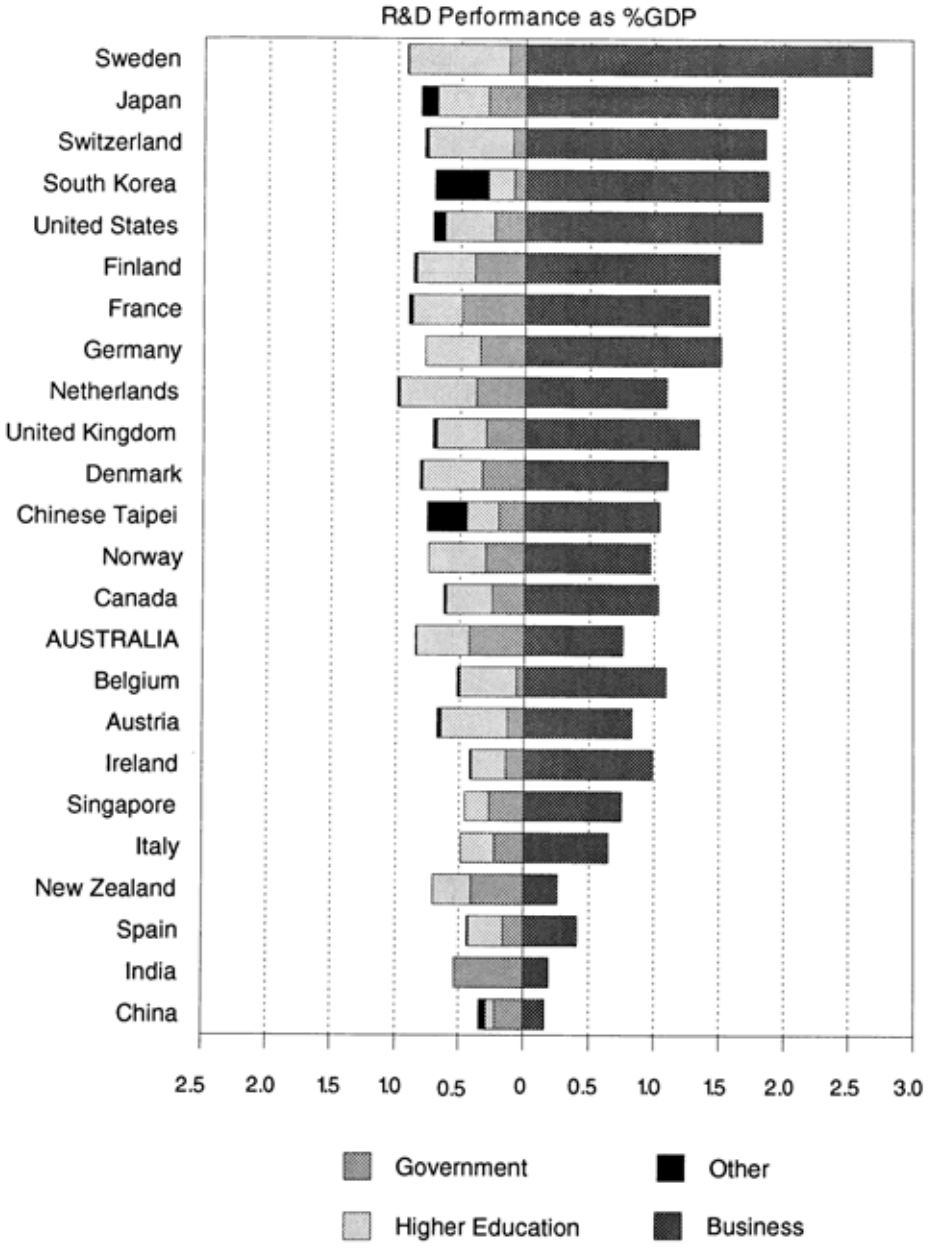
(ii) R&D in the business sector.

R&D expenditure in government agencies and universities

Table 9 shows comparative international data for combined R&D expenditure within government agencies and universities. In this list, the arrangement is in order of R&D expenditure as a percentage of GDP. The Table also shows shows changes in this ratio for the periods 1981 to 1988 and 1988 to 1995, as well as the average annual real growth rates.

In terms of the share of national wealth expended on R&D within government agencies and universities (R&D expenditure as a per cent of GDP), Australia has a high ranking of 0.84% compared with an average of

Figure 12 R&D EXPENDITURE AS A PERCENTAGE OF GDP - INTERNATIONAL COMPARISONS



Source: DIST based on ABS, OECD and national sources.

0.65% for all twentyfour economies listed. The change in this ratio for Australia was negative between 1981 and 1988, but over the period since 1988 was twice the OECD average increase. Among all countries, there was some convergence towards the mean over the whole period since 1981.

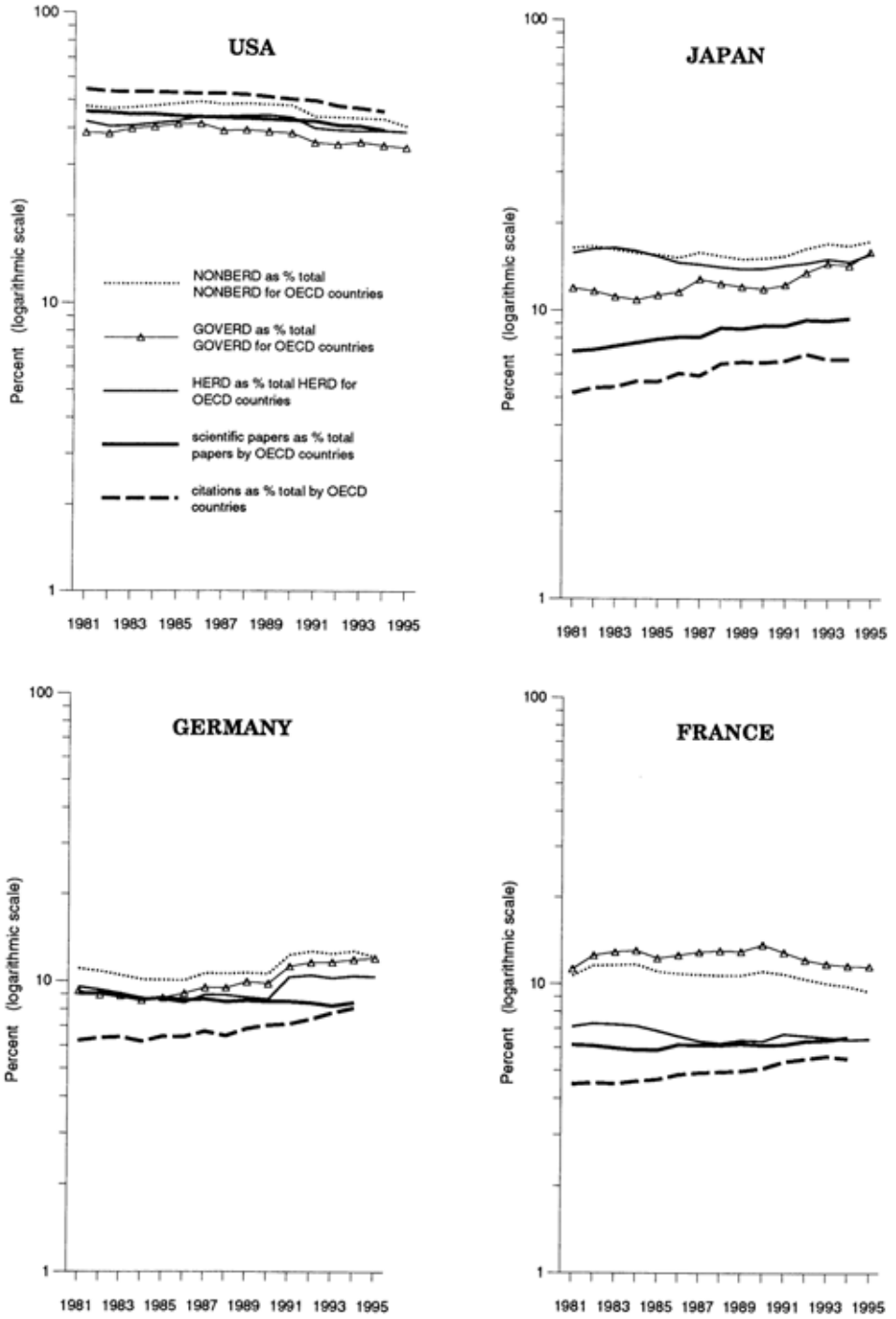
Australia's level of effort in basic research has been a matter of some interest. In fact, comparative data are available for only eleven countries. These are shown in Table 8. (The data also include small amounts of basic research conducted in the business and private non-profit sectors.) Australia has increased its level of effort in basic research from 0.33% of GDP in 1978-79, to

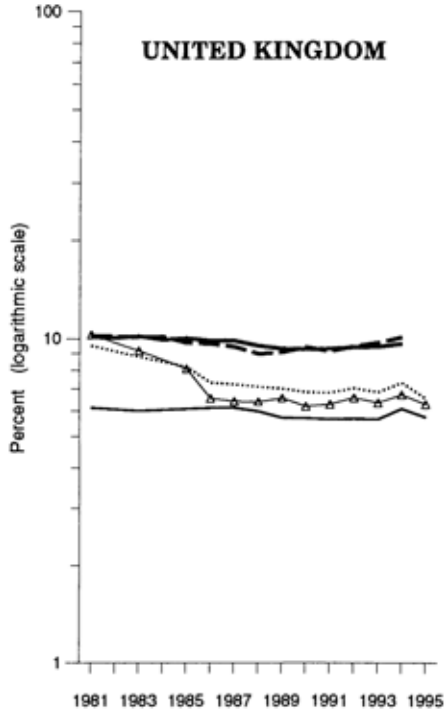
TABLE 9 Expenditure on R&D in government agencies and universities as a proportion of GDP, change and growth rates, and basic R&D as a proportion of GDP- international comparisons

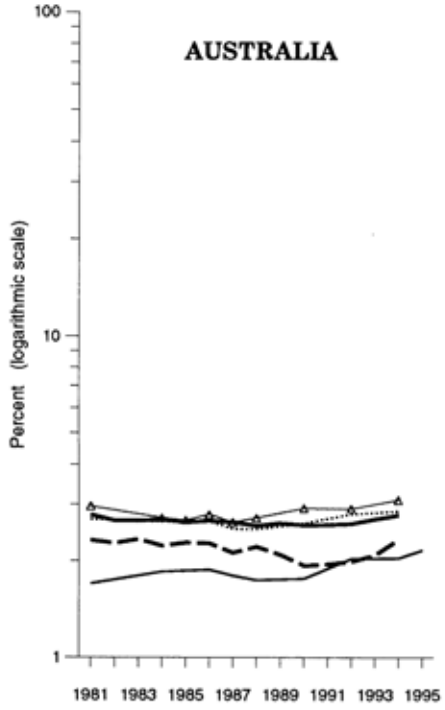
		Period 1981 to 1988		Period 1988 to 1995		
	R&D expend. in govt and universities as % GDP	Change	Average annual % real increase in R&D	Change	Average annual % real increase in R&D	Basic R&D as %GDP (most recent year)
Netherlands (1995)	0.98	0.03	2.3	0.14	4.8	na
Sweden (1995)	0.92	0.16	5.3	-0.10	-0.7	0.53
France (1995)	0.88	0.11	3.7	-0.02	0.8	0.50
Finland (1995)	0.86	0.18	7.9	0.14	3.1	na
AUSTRALIA (1994)	**0.85**	**-0.02**	**3.0**	**0.11**	**4.5**	**0.44**
Denmark (1995)	0.80	0.11	5.6	0.15	4.2	na
Germany (1995)	0.79	0.07	3.5	0.01	4.3	0.49
Norway (1995)	0.74	0.07	3.7	0.01	2.9	0.28
New Zealand (1995)	0.71	-0.18	-4.5	0.12	4.4	na
Japan (1995)	0.69	-0.02	3.3	0.09	4.3	na
United Kingdom (1995)	0.68	-0.18	-0.4	0.06	2.6	na
South Korea (1995)	0.67	0.11	17.3	0.04	10.2	na
Austria (1993)	0.65	0.06	4.9	0.11	7.2	na
Switzerland (1994	0.65	0.10	2.0	0.09	3.0	na
Canada (1995)	0.63	-0.03	2.4	0.02	1.8	na
United States (1995)	0.63	0.07	5.1	-0.09	-0.1	0.42
India (1992)	0.54	0.23	12.4	-0.11	-1.2	na
Belgium (1995)	0.50	-0.03	0.4	0.13	4.4	na
Italy (1995)	0.49	0.13	7.3	-0.02	0.6	0.24
Chinese Taipei (1995)	0.46	0.16	10.6	0.04	9.8	0.29
Singapore (1993)	0.46	0.23	22.8	0.10	10.8	na
Spain (1995)	0.43	0.07	6.4	0.12	8.0	0.15
Ireland (1995)	0.41	-0.03	2.1	0.05	8.9	0.07
China (1995)	0.28	na	0.0	-0.10	4.2	0.03
Average (24 economies)	**0.65**	**0.06**	**5.5**	**0.04**	**4.3**	
Average (19 OECD only)	**0.70**	**0.04**	**3.4**	**0.06**	**3.6**	**0.35**

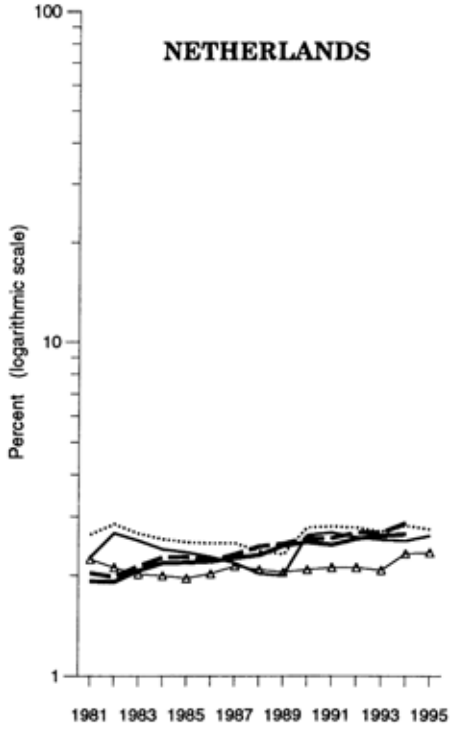
Source.: DIST based on ABS, OECD and national sources.

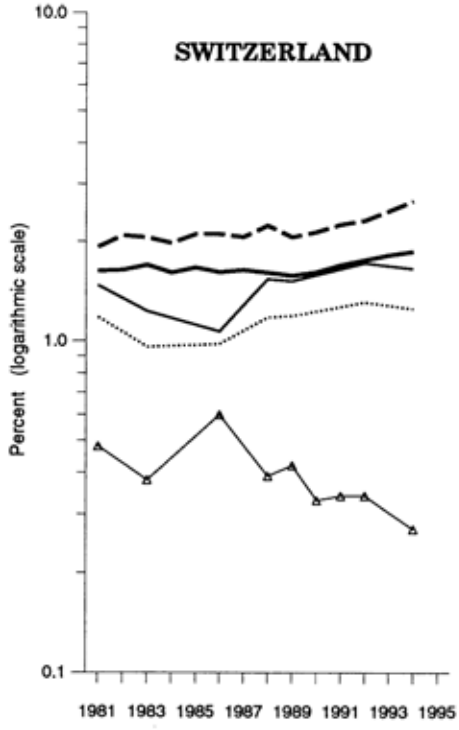
Figure 13 TRENDS IN NONBERD AND SCIENTIFIC PAPERS

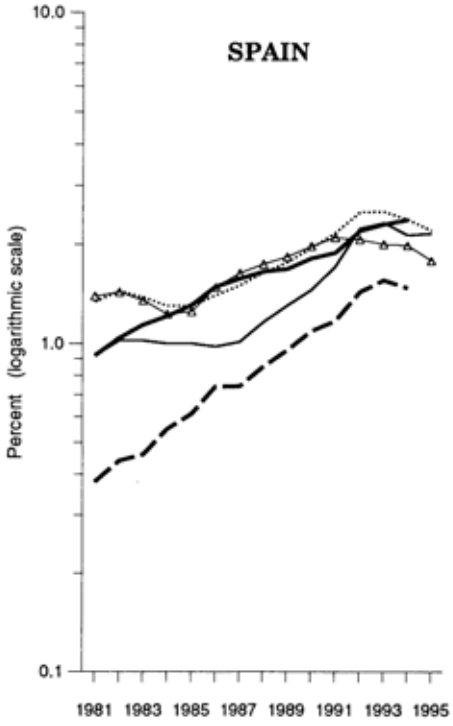


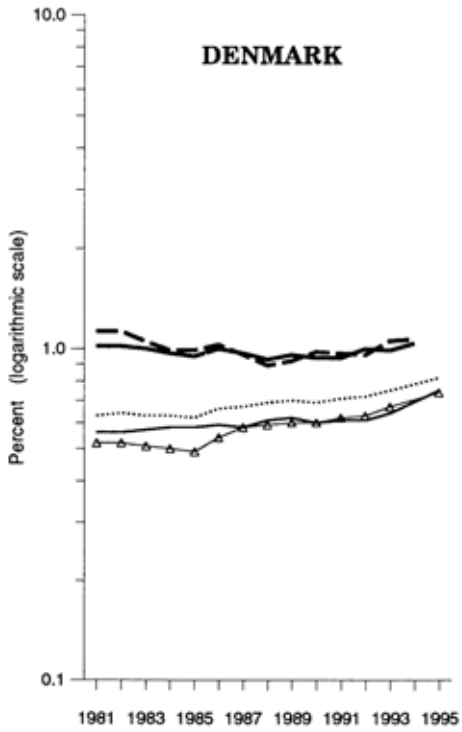

UNITED KINGDOM
100
10
1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995

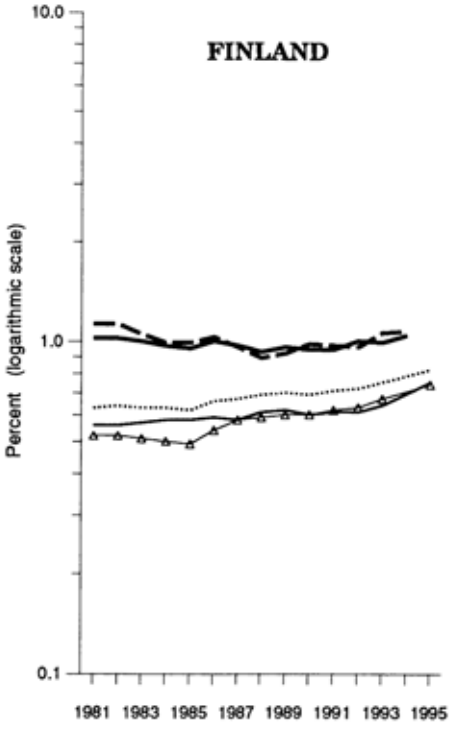

AUSTRALIA
100
10
1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995

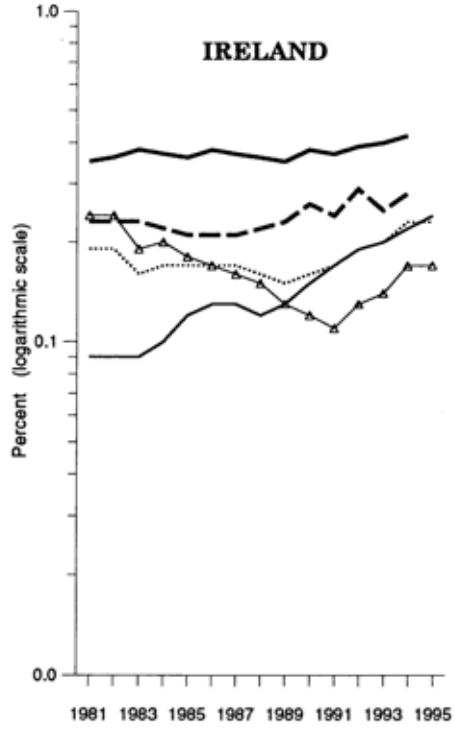

NETHERLANDS
100
10
1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


SWITZERLAND
10.0
1.0
0.1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


SPAIN
10.0
1.0
0.1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


DENMARK
10.0
1.0
0.1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


FINLAND
10.0
1.0
0.1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


IRELAND
1.0
0.1
0.0
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995

0.35% in 1984-85 to the most recent level (1994-95) of 0.44%. This compares well on the limited comparisons that are available.

One alternative to making international comparisons as a fraction of GDP is to compare national levels as a proportion of aggregate OECD levels. International trends on this basis are shown in Figure 13 for "nonBERD" (all R&D expenditure other than in the business sector). An advantage of comparing national performance in this way is that comparisons can also be made on the same basis with national outputs of scientific research papers (the principal measurable output of the non-business sector), and with the impacts of those papers. Figure 13 shows levels and trend on this basis for twelve OECD countries. As well as shares in total nonBERD, Figure 13 also shows trends in shares of its dominant components — higher education expenditure on R&D (HERD) and expenditure on R&D in government agencies (GOVERD).

For a number of reasons (caveats on publication data, particularly, have been well discussed in many recent reports) these comparisons should be treated with some caution. Nevertheless, there are a number of interesting features. For Australia, a recovery in share of expenditure on nonBERD from about 1990 appears to have improved shares in the output of scientific papers and, more markedly, the relative impact of those papers. Among other countries, the improvement in Spanish shares in all quantities is very striking.

For most countries, universities produce a greater share of scientific papers than government agencies. However, the Figure shows that trends in share of total nonBERD correlate better with trends in shares of scientific papers or citations than shares in HERD alone. This confirms the usefulness of considering indicators that aggregate data for research in universities and government agencies.

Business expenditure on R&D

Table 10 shows comparative international data for business expenditure on R&D (BERD) arranged in order of BERD as a percentage of GDP. The Table also shows changes in this ratio in parallel with those of Table 9.

There were substantial increases in levels of BERD in most countries over the 1980s and much higher growth rates than for the composite category of R&D expenditure in government agencies and universities. However, changes in BERD and in growth rates were much lower for the period 1988 to 1995 than for 1981 to 1988. As in most other economies beginning with relatively low levels of BERD, Australia achieved increases in BERD/GDP and growth rates well above OECD averages - the highest OECD rate of growth for the period up to 1988, and the second highest for the period since then. Nevertheless, growth rates in OECD nations were all much lower than for the three dynamic Asian economies in the Table - Singapore, with a real annual growth rate of about 18 per cent, Chinese Taipei on 16 per cent, and South Korea on 13 per cent - but Ireland, with the leading OECD growth rate (19 per cent), is now ahead of all these.

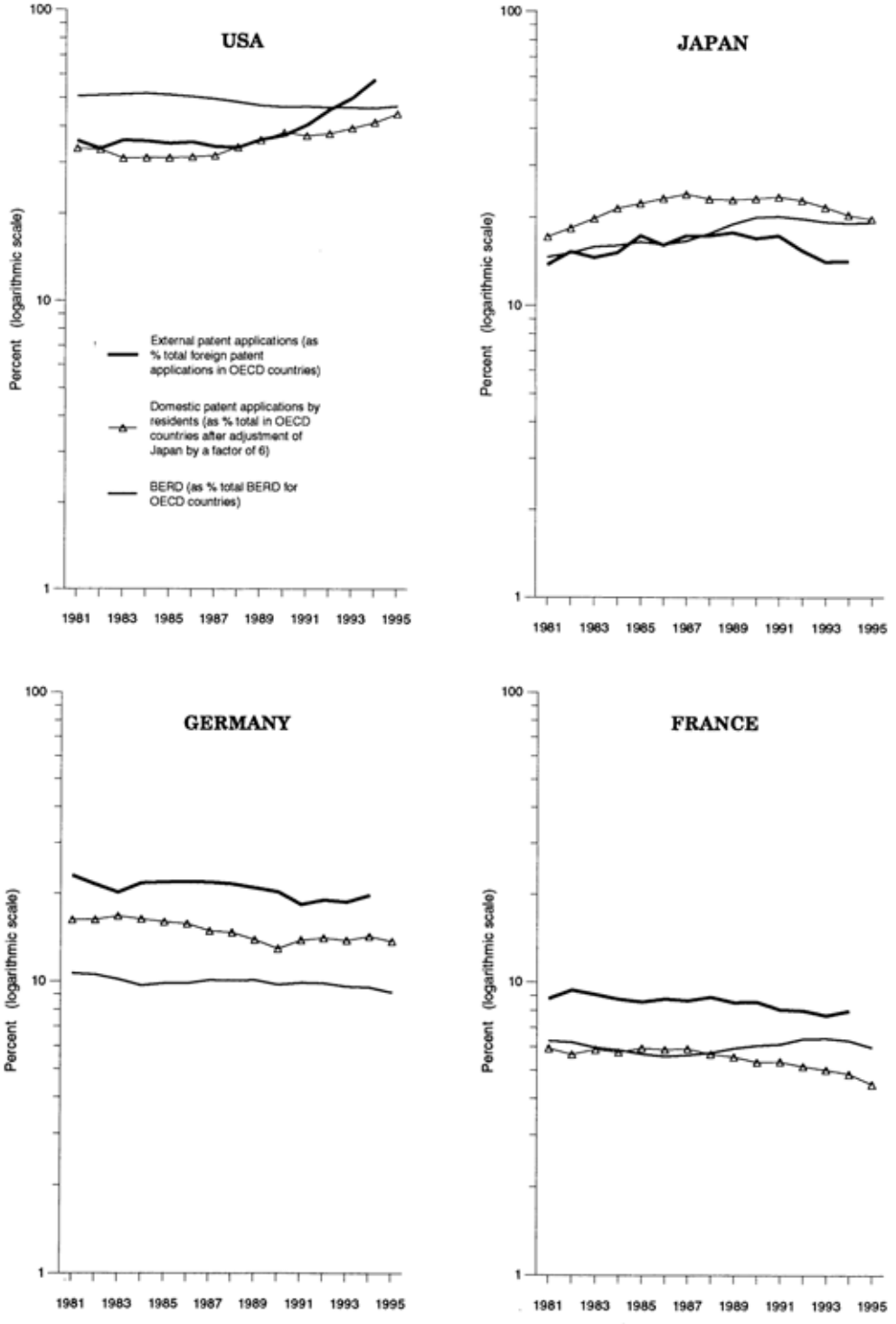
Figure 14 provides OECD comparisons for the business sectors in 12 OECD economies on a parallel basis to Figure 13. However, output here should be assessed on the basis of the share in external patent applications (domestic patent applications in most cases have less relevance). For smaller countries in particular, changing patterns in the share of R&D expenditures are reflected (with a small lag) in similar patterns in the share of external patenting. The similarities are particularly striking for Australia - and verify the reality of increased R&D expenditures reported since the early 1980s. However, improvements for Spain, Finland, Denmark and Ireland should be noted. These might be regarded as indicating the "dynamic European economies" — to a degree, counterparts to those in Asia.

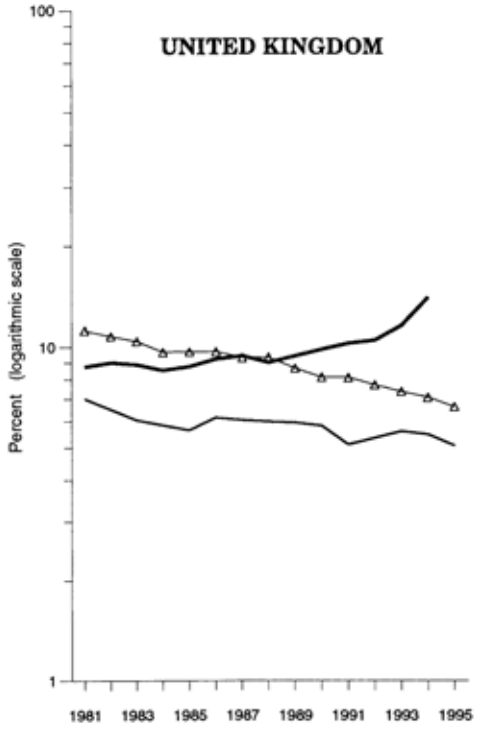
TABLE 10 Business expenditure on R&D (BERD) as a proportion of GDP, change and growth rates in BERD - international comparisons

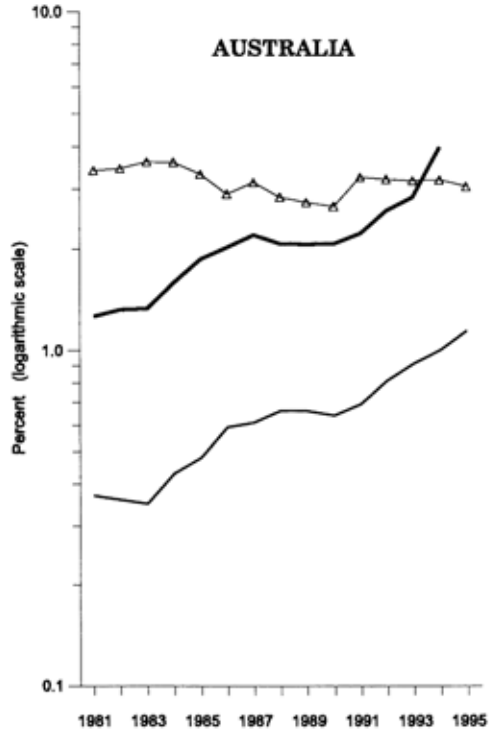
		Period 1981 to 1988		Period 1988 to 1994	
	%BERD/GDP (latest)	Change	Average annual real increase in BERD	Change	Average annual real increase in BERD
Sweden (1995)	2.68	0.54	8.3	0.75	6.3
South Korea (1995)	1.98	1.02	37.9	0.65	13.7
Japan (1995)	1.95	0.54	8.5	0.02	1.2
Switzerland (1992)	1.86	0.44	7.9	-0.26	-3.8
United States (1995)	1.83	0.29	5.7	-0.16	0.5
Germany (1995)	1.51	0.36	5.0	-0.56	-1.2
Finland (1995)	1.50	0.43	11.2	0.42	3.9
France (1995)	1.42	0.19	4.4	0.07	2.2
United Kingdom (1995)	1.34	-0.02	4.1	-0.13	-0.4
Denmark (1995)	1.10	0.28	9.1	0.28	6.0
Netherlands (1995)	1.09	0.35	7.5	-0.24	-0.8
Belgium (1993)	1.09	0.16	3.7	-0.11	0.1
Chinese Taipei (1995)	1.08	0.08	14.1	0.45	15.6
Canada (1995)	1.00	0.17	8.0	0.23	5.6
Ireland (1995)	0.99	0.16	10.4	0.53	19.2
Norway (1995)	0.97	0.45	11.7	0.01	2.8
AUSTRALIA (1995)	**0.86**	**0.28**	**17.7**	**0.33**	**9.6**
Austria (1995)	0.83	0.15	3.5	0.03	3.5
Singapore (1993)	0.75	0.36	28.1	0.24	17.6
Italy (1995)	0.65	0.21	8.2	-0.05	-0.9
Spain (1995)	0.41	0.21	13.9	0.00	0.9
New Zealand (1995)	0.26	0.06	-0.6	-0.02	2.0
India (1992)	0.19	0.03	7.0	0.01	3.7
China (1995)	0.18	na	0.0	-0.03	-1.6
Average (24 economies)	**1.15**	**0.29**	**10.2**	**0.10**	**4.4**
Average (19 OECD only)	**1.23**	**0.28**	**7.8**	**0.06**	**3.0**

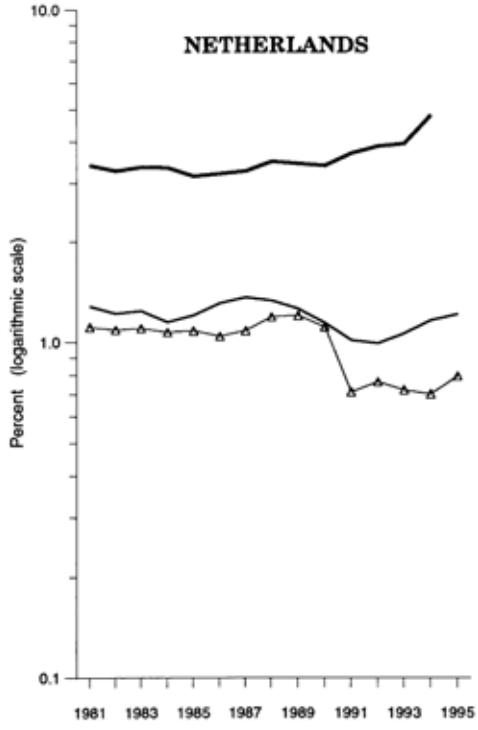
Source: DIST based on ABS, OECD and national sources.

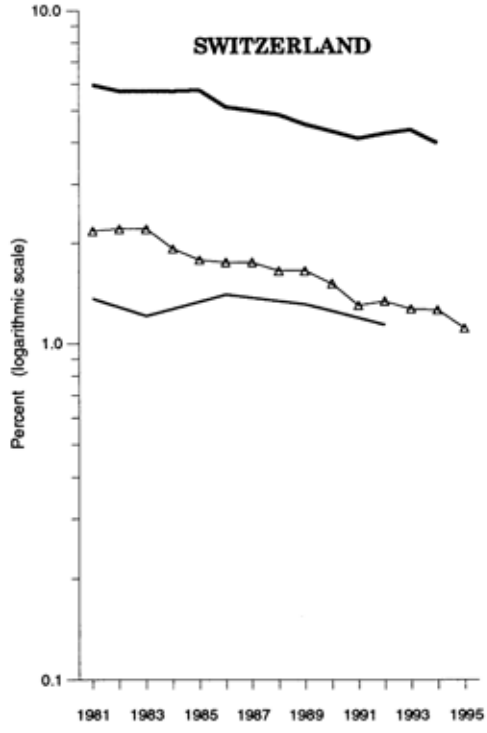
Figure 14 TRENDS IN BERD AND PATENT PERFORMANCE

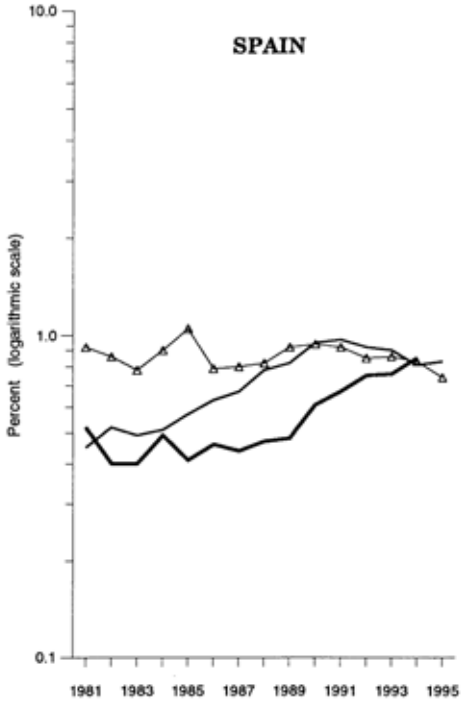


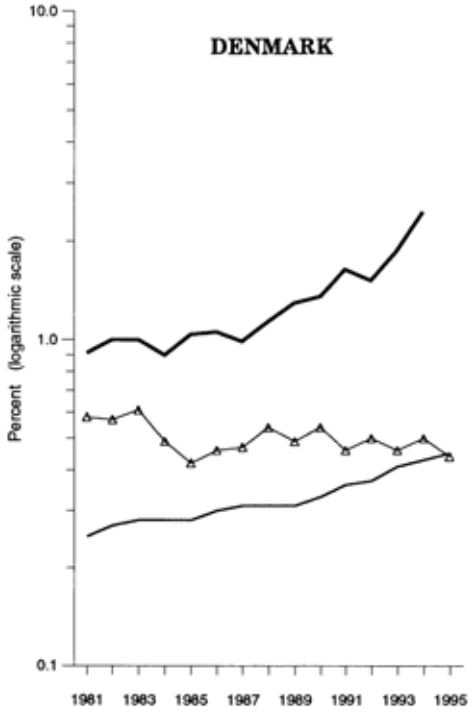

UNITED KINGDOM
Percent (logarithmic scale)
100
10
1
1981 1983 1985 1987 1989 1991 1993 1995

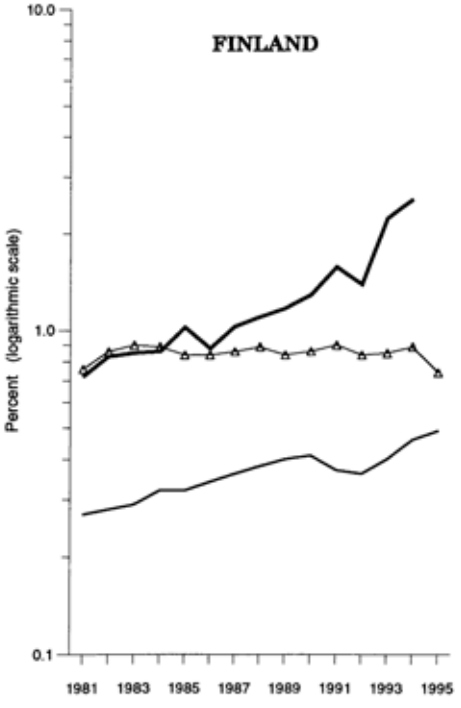

AUSTRALIA
Percent (logarithmic scale)
10.0
1.0
0.1
1981 1983 1985 1987 1989 1991 1993 1995

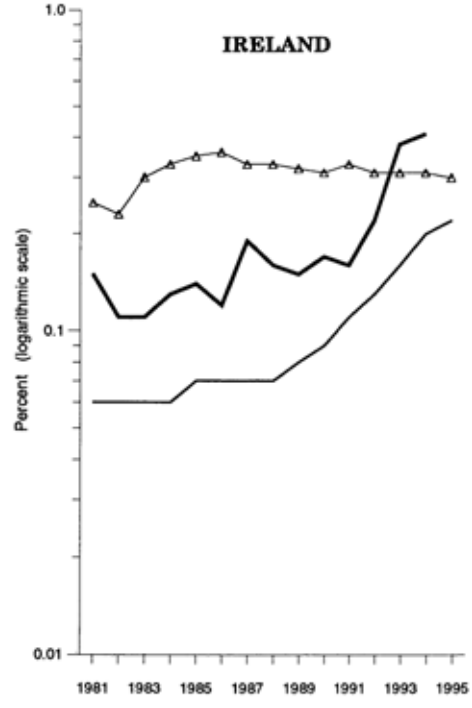

NETHERLANDS
Percent (logarithmic scale)
10.0
1.0
0.1
1981 1983 1985 1987 1989 1991 1993 1995


SWITZERLAND
Percent (logarithmic scale)
10.0
1.0
0.1
1981 1983 1985 1987 1989 1991 1993 1995


SPAIN
10.0
1.0
0.1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


DENMARK
10.0
1.0
0.1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


FINLAND
10.0
1.0
0.1
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995


IRELAND
1.0
0.1
0.01
Percent (logarithmic scale)
1981 1983 1985 1987 1989 1991 1993 1995

A regional perspective

Internationally, while there has been increasing attention paid to *national* "systems of innovation", this work has also pointed to the importance of *regional* systems. This is particularly pertinent to the situation of Australia's States and Territories, where the geographical dispersion of centres of economic activity point to the value of considering indicators relating to individual regions as well as those of the nation as a whole. Taken as a whole, Australia shares some features in common with the five Nordic countries - another set of geographically dispersed centres of activity with a degree of economic integration and having, in total, similar levels of GDP and population. This approach can be carried one step further by considering combined indicators for both signatories to the Closer Economic Relationship (CER) Agreement. Table 10 then presents a range of indicators along these lines - with a range of developed countries included that are comparable to Australia's States and Territories in terms of GDP and population. The various economies listed are ranked by scale of total R&D activity.

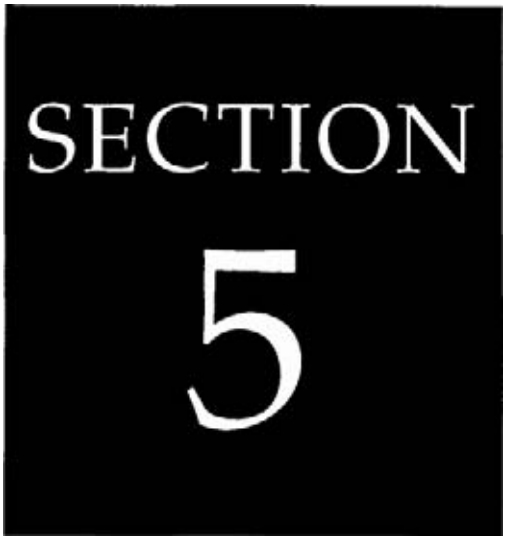
TABLE 11 R&D in Australia's regions - an international perspective

	GERD (US$m 1995)	% GERD/GDP	change since 1981	BBRD (US$m 1995)	% BERD/GDP	change since 1981	GDP (US$m 1995)	Population (thousands)
Nordic Countries	11711	2.48	0.92	7999	1.69	0.79	472873	23798
CER (Aust. & NZ)	6282	1.48	0.48	3306	0.78	0.53	425304	21629
AUSTRALIA (1994*)	**5693**	**1.61**	**0.62**	**3147**	**0.86**	**0.61**	**365004**	**18049**
Sweden (1995)	5939	3.60	1.35	4415	2.68	1.29	164960	8847
Switzerland (1992)	4429	2.66	0.40	3134	1.86	0.19	176860	7062
Austria (1995**)	2553	1.54	0.38	1336	0.83	0.18	165254	8047
Finland (1995)	2150	2.37	1.17	1359	1.50	0.84	90833	5108
Denmark (1995)	2149	1.92	0.82	1233	1.10	0.55	112164	5228
Norway (1995)	1697	1.71	0.55	962	0.97	0.46	99110	4348
New South Wales (1994*)	**1138**	**1.46**	**0.63**	**1156**	**0.91**	**0.69**	**126311**	**6205**
Victoria (1994*)	**1064**	**1.80**	**0.72**	**1070**	**1.12**	**0.72**	**95241**	**4560**
Ireland (1995)	867	1.40	0.72	611	0.99	0.69	61692	3598
Singapore (1993)	606	1.20	0.93	376	0.75	0.60	37256	3200
New Zealand (1995)	589	0.98	-0.04	159	0.26	0.04	60300	3580
Queensland (1994*)	**412**	**1.12**	**0.40**	**328**	**0.56**	**0.41**	**58352**	**3339**
Western Australia (1994*)	**318**	**1.36**	**0.68**	**325**	**0.82**	**0.70**	**39365**	**1765**
South Australia (1994*)	**289**	**1.76**	**0.52**	**178**	**0.67**	**0.47**	**26477**	**1474**
Australian Capital Territory (1994)	**250**	**5.23**	**-1.15**	**13**	**0.26**	**0.24**	**7808**	**308**
Iceland (1995)	89	1.54	0.91	29	0.37	0.43	5806	267
Tasmania (1994)	**81**	**1.68**	**0.73**	**18**	**0.36**	**0.10**	**7762**	**474**
Northern Territory (1994)	**35**	**1.47**	**1.07**	**2**	**0.08**	**0.08**	**3687**	**182**

GERD data relate to 1994, but BERD and other data are for 1995.
GERD, GDP and population data relate to 1995, but BERD data are for 1993.

Since the end of the 1970s, measures to stimulate R&D activity in the business sector have been taken in a wide range of countries, and have proved successful. The results can be seen in the table, with most economies exhibiting substantial increases. In Australia's case, measures taken at a Federal level have had substantial effects in increasing business R&D expenditures in the States and Territories.

Table 11 provides a different comparative view than that usually seen at a purely national level. For example, Victoria's levels of business R&D activity are seen to be equivalent to those of Denmark, and clearly exceeding those of Ireland, Norway, Austria and Singapore. While the R&D levels for the ACT seem remarkably high, these are essentially for the city of Canberra. Even higher levels would be seen if it were possible to obtain comparable indicators for cities such as Cambridge, Berkeley, etc. where there are also high concentrations of academic and other research within relatively small cities.



Portfolio
Budgets and Priorities

Introduction

This Section presents summaries of 1998-99 budget allocations and priority goals relevant to science and innovation. This information is arranged by Ministerial portfolio, with a particular focus on agencies engaged in R&D and on programs funding R&D.

For each portfolio, there is a brief summary of pertinent allocations for the 1998-99 Budget. Where possible this is compared with the expenditure outcome for 1997-98. Discussion of financial aspects is deliberately brief. 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 research".

The financial summary for each portfolio is followed by an outline of priorities for 1998-99. Priority goals are drawn from 1998-99 performance forecasts published in the *Portfolio Budget Statements* (Budget Initiatives and Explanations of Appropriations 1998-99). These statements provide detailed information on the purpose and nature of portfolio budget measures. *Portfolio Budget Statements* are available from individual departments after the Budget each year.

COMMUNICATIONS, THE INFORMATION ECONOMY AND THE ARTS

Science and Innovation in the Portfolio Budget

The Government has recognised that science and technology is part of the cultural mainstream of Australian society. Through the Department of Communications and the Arts and its cultural policy, the Government has sought to fully develop the synergies between communications and information technology and the creative industries sector.

The Communications, the Information Economy and the Arts portfolio has a diverse range of science and technology responsibilities and activities. It includes agencies such as the National Office for the Information Economy, the National Science and Technology Centre, the National Film and Sound Archive and the Australian Film Commission.

The National Science and Technology Centre hasbeen allocated $7.76 million for 1998-99 to stimulate public awareness, understanding, and interest in science and technology ($3.13 million will be used for works and exhibitions). The Centre's interactive exhibitions and education programs reach about a million people throughout Australia and the Asia Pacific region each year.

A major portfolio achievement in 1997-98 was the creation of the National Office for the Information Economy (NOIE). NOIE:

- provides support for the Commonwealth Ministerial Council for the Information Economy, a high level forum responsible for a whole-of-government action agenda, including development of a legal and regulatory framework for electronic commerce, and a National Information and Online Services Strategy;
- provides support for the Online Council, a Commonwealth/State Ministerial Council established to coordinate all three tiers of government activities relating to online services; and
- administers an Online Awareness Program, designed to raise business and community awareness of the uses and benefits of new communications and information technologies.

The Department of Communications and the Arts is a major stakeholder in the Heritage Collections Committee of the Cultural Ministers Council. The Committee, a collaborative partnership involving the Commonwealth, State

and Territory Governments and the museums sector, is responsible for increasing access to museums, including natural science collections both in-situ and online.

The Department also provides policy advice to the Minister on matters relating to film, licensed broadcasting, multimedia and broadband services. Changes to legislation concerning telecommunications came into effect from 1 July 1997, establishing a new fully liberalised, pro-competitive telecommunications regime.

1998-99 Science and Innovation Priorities

National Film and Sound Archive

In 1998-99, the Archive will:

- commission its new laboratory facilities;
- acquire audiovisual items of cultural significance (e.g. sound recordings and films) and negotiate agreements with commercial producers to allow the Archive to acquire such material;
- remove from the collection duplicate items and items not considered to be of cultural significance;
- improve standards of collection description and the availability of access guidelines and catalogues;
- update the collections' database and reduce the accessioning backlog;
- improve preservation and safe storage of collection material review preservation and storage practices; and
- contribute to the development of audiovisual archiving nationally and internationally.

The National Science and Technology Centre

In 1998-99, its tenth birthday year, the Centre will continue to provide a national focus for popularising science and technology through the touring of interactive exhibitions and the conduct of a range of educational programs aimed at increasing awareness and creating positive attitudes towards science and technology.

The Centre will continue to explore and use innovative technologies to enhance access to the Centre's programs and services, and to provide a diverse range of exhibitions and programs. For example, the Centre is developing a new exhibition aimed at increasing awareness of aspects of modern communications technology. It is also working with the Government of Japan to present an exhibition on space and Japan's efforts in developing an automatic landing space flight vehicle. In the coming year the Centre will present further programs in the Pacific and work cooperatively with other science and technology centres both in Australia and in the Asia Pacific region.

DEFENCE

Science and Innovation in the Portfolio Budget

The Budget allocation for the Defence science and technology function will be $236.4 million in 1998-99 ($232.8 million expected outcome in 1997-98).

1998-99 Science and Innovation Priorities

Defence Science and Technology Organisation (DSTO)

DSTO's activities planned for 1998-99, and the expected outcomes, are grouped below in the broad areas corresponding to DSTO's client groups.

Policy and Command Priorities

Research in support of policy and command focuses on command and control, communications, intelligence, information technology, wide-area surveillance, joint operations, and defence against nuclear, biological abd chemical weapons. Priorities include:

Operational Command:

- providing scientific advice to assist Defence in the acquisition of a military payload on board the Optus Cl /D spacecraft;
- establishing an experimental distributed command, control, communication and information (C^3I) environment. This will be used to demonstrate candidate solutions to interoperability of distributed C^3I systems including the United States Global Command and Control System. Network management infrastructures will also be provided. This activity also contributes to Strategic Intelligence;
- establishing a group in HQAST to assist in researching, defining, developing and evaluating command and control support systems for theatre-level operations. This activity also contributes to Strategic Intelligence;
- completing a command and control study which will identify capability shortfalls and policy trade-offs to aid high-level decision making on future command and control capability development; and
- demonstrating the application of the Australian Membrane and Biotechnical Research Institute ion channel sensor technology for Defence purposes by the fabrication of a biosensor for the detection of ricin.

Maritime Force Capabilities Priorities

Capability for Major Surface Combatant Operations:

- improving the survivability of surface combatants against radar homing anti-ship missiles through further development of the Nulka system; and
- enhancing the survivability of naval platforms through the development of a suite of software tools for damage assessment, damage control, operational planning and training for surface vessels and submarines. A key deliverable in the reporting period will be a damage control command decision aid for use on board FFG-7 frigates. This activity also contributes to the Capability for Submarine Operations;

Capability for Submarine Operations:

- investigating the acoustic signature of Collins class submarines to develop means to manage the acoustic signature and so increase the operational capability of the submarines; and
- providing the Navy, DSTO and industry with a laboratory environment for the rapid prototyping and evaluation of combat system concepts for the Collins class submarine, surface combatants and possibly airborne platforms. This will provide a significant contribution to the evolution of the naval combat systems. This activity also contributes to the Capability for Major Surface Combatant Operations.

Capability for Major Surface Combatant Operations and Capability for Submarine Operations:

- providing advice and technical assistance on the integration of weapon systems into the Anzac class ships and Collins class submarines, including collaboration with Australian industry to maintain a capability to support weapons systems/maritime platform combinations unique to Australia.

Capability for Mine Countermeasures and Defensive Mining:

- providing advice and technical assistance to ensure that appropriate quantitative data is obtained from the shock testing of the Minehunter Coastal, including development of ultrasonic inspection methods for the composites hull. This will assist in assessing the vulnerability of the vessel to underwater blasts.

Land Force Capabilities Priorities

Capability for Land Task Forces Operations:

- developing the initial capability and technology demonstrator to demonstrate the utility of a broad-area aerial surveillance capability in support of land operations in the Restructuring the Army trials. This activity also contributes to Military Geographic Information;

- conducting analysis of the Restructuring the Army Task Force structures and operations to assess the effectiveness of the Task Force in conducting operations in the Top End. This activity also contributes to the Capability for Special Forces Operations;
- developing a "synthetic environment" for linking simulations for the assessment of capability options. To demonstrate this concept, the "environment" will be used to evaluate some specific cases of high priority to the Land Force. This activity also contributes to Operational Command;
- producing and evaluating demonstrations of improved aggregation and presentation of information on the battle situation on the computer screens of Land Force commanders (Situation Awareness) to enable better decision making. This activity also contributes to the Capability for Special Forces Operations; and
- providing advice to the Army on the performance of night-vision goggles. This will lead to greater safety and awareness of the limitations imposed by the goggles in aviation operations. This activity also contributes to the Capability for Special Forces Operations.

Air Force Capabilities Priorities

Capability for Air Strike/Reconnaissance:

- conducting simulated fatigue loading of a full-scale F-111 wing and carry-through box, followed by a teardown inspection to identify potential failure locations and crack growth rates at these locations. This will help ensure safe operation of the F-111 fleet to its planned withdrawal date of 2020; and
- improving self-protection for the F-111 in reconnaissance and strategic roles through support to the RAAF for full-scale engineering development of the ALR 2002 radar warning receiver and its integration into the F-111's new electronic warfare self-protection suite.

Capability for Air Strike/Reconnaissance and Capability for Tactical Fighter Operations:

- improving aircraft electronic warfare self-protection capabilities through a joint research, development and engineering program with the US by exchange of data, joint demonstration of aircraft electronic warfare using cockpit simulators, and commencement of a number of joint R&D technology programs. This activity also contributes to the Capability for Airlift and other aircraft-related Defence outputs.

Capability for Tactical Fighter Operations:

- developing models of pilots' tactical reasoning using artificial intelligence technology to contribute to more reliable evaluations of Australia's air defence system. This activity also contributes to the Capability for Strategic Surveillance.

Capability for Strategic Surveillance:

- contributing to the evaluation of responses to the Airborne Early Warning and Control aircraft tender by providing advice on scientific issues.

All Defence Outputs Involving Aircraft:

- developing a sensor that has the capability to detect and measure rates or corrosion, thereby reducing the costly (in terms of dollars and aircraft availability) unscheduled maintenance that results from corrosion; and
- completing the fatigue testing on PC-9/A and providing Support Command Australia with advice for extending the structural airworthiness clearance of PC-9/A from 6,000 hours to 10,000 hours, and information on airframe modifications, fleet usage management and life extension options.

Defence S&T Research Priorities

This research comprises those elements of forward-looking (or enabling) research which are initiated by the Science and Technology Program itself, rather than by one of the client groups. Enabling research involves the development and maintenance of skills and expertise to position DSTO to exploit new and developing science and technologies which show promise for application to Australia's defence needs. Priorities include:

- developing new methods, based on thermal excitation and emission, for identifying defects and stress fields in structural components to reduce cost ofownership of ADF aircraft;
- investigating the sonar reflectivity of the inhomogeneous sea bed and refractive properties of the sea, so that the maritime environment may be better used to the advantage of the ADF; and
- research to improve the capability to develop guidance software for air defence, point defence and other missile systems.

Industry and External Relations

The main aims of DSTO's industry and external relations activities are:

- helping Australian industry and other R&D organisations to become better able to support defence;
- contributing through industry to national wealth creation; and
- improving the understanding by the Defence community, Australian industry, the scientific community and the general public of the role of advanced technology in the defence of Australia, and DSTO's part in this.

Activities which will be pursued during 1998-99 include placing R&D contracts and licence arrangements with industry, universities and other research organisations; developing existing and new industry alliances and other collaborative arrangements in a variety of areas; and developing beneficial affiliations with other research institutions.

International Cooperation and Regional Engagement

Extensive interaction and cooperation with the United States, the United Kingdom, Canada and New Zealand will continue under the auspices of The Technical Cooperation Program and bilateral agreements. Longstanding defence research and development arrangements with Sweden and France will continue. DSTO will also continue to provide technical support to Australia's United Nations and global security activities. Initiatives in international activities for 1998-99 include:

- revising the MOU on Defence Science and Technology with Canada; and
- increasing collaboration with France and Sweden.

Cooperation in our region in defence science and technology will continue through a range of collaborative activities conducted under existing bilateral defence, and science and technology, cooperation arrangements with Indonesia, Malaysia, Singapore and Thailand.

DSTO Corporate Planning and Support Priorities

- implementing a new classification structure for DSTO staff working in R&D which will remove unnecessary barriers to career advancement and allow a more flexible approach to working arrangements that will enhance DSTO's ability to achieve its outcomes;
- finalising approval of the property rationalisation in Melbourne; progressing planning and approvals for the relocation of elements of Maritime Operations Division from Pyrmont, Sydney; and obtaining approval for facilities needed to accommodate additional staff and equipment resulting from the increase in DSTO's Five Year Defence Program allocation; and
- initiating an executive leadership development program to enhance the leadership and management skills of senior R&D staff.

EMPLOYMENT, EDUCATION, TRAINING & YOUTH AFFAIRS

Science and Technology in the Portfolio Budget

Through Employment, Education, Training and Youth Affairs portfolio the Government will provide about $1.6 billion in 1998-99, to support research and research training in Australian universities.

Support through university operating grants

The major part of the Government's support for university research and research training, approximately $1,150 million in 1998-99, is provided through operating grants. This amount includes the following nominal components: (a) the Research Quantum (RQ), approximately $219 million; (b) the Research Training Component (RTC), estimated at $468.4 million; and (c) approximately $150 million of The Australian National University's operating grant.

Targeted research programs

Approximately $450.8 million will be provided in 1998-99 directly to universities, researchers and other bodies through a range of targeted research programs: Research Grants ($131.4 million); Postgraduate Awards ($78.8 million); Research Fellowships ($28.4 million); Research Centres ($18.8 million); Research Infrastructure ($113.8 million); the Strategic Partnerships with Industry Scheme ($46.7 million); Overseas Postgraduate Research Scholarships ($15.8 million); High Performance Computing and Communications Centres of Expertise Program ($7.3 million); Learned Academies ($1.5 million); Anglo-Australian Telescope Board ($3.6 million); Research Evaluation Program ($0.7 million); Advanced Engineering Centres ($1.6 million); and other research funds (approximately $2.5 million).

Where appropriate, these funds are allocated on a competitive basis to ensure their allocation to the universities and researchers able to make the best use of them. Research Grants, Research Centres and Research Fellowships are awarded on the advice of the Australian Research council.

Research Funding Activities

University Operating Grants

The Commonwealth is the major source of research income for universities and, given that universities perform the bulk of Australia's basic research, the major source of funding for basic research in general. Most of this is

channelled through universities' operating grants which support both high quality undergraduate teaching and their research and research training capacity.

By supporting higher education research, the Government aims to achieve:

- internationally competitive basic and applied research;
- high quality research training;
- research collaboration between universities and industry;
- commercialisation of research outcomes;
- international research linkages; and
- the development and maintenance of Australia's capacity in key technological areas.

The estimate of the research and research training component of the operating grant is based on the ABS survey of research expenditure of universities by source of funds (the ABS methodology is outlined in *1994 Research and Experimental Development — Higher Education Organisations* (8111.0)). One of the sources identified by the ABS is General University Funds (GUF). The operating grant component is the major part of GUF, and can be estimated by using the operating revenue figures from DEETYA *Selected Higher Education Finance Statistics.* Using this method, the estimated research and research training component of university operating grants for 1998-99 is $1,048 million (see Table 6, Section 3, Science and Innovation in the Budget and accompanying footnotes).

Within this amount three components can be identified:

- *The Research Quantum (RQ):* RQ is an amount within the operating grant which is reallocated to institutions on the basis of research performance, as measured by the Composite Index. In 1998-99, the RQ will be approximately $219 million.
- *an estimate of the component of the operating grant used for research training:* this estimate is derived by using the actual higher degree research student load, weighted in accordance with the relative teaching costs matrix developed in 1990 in the context of the RFM, and using funds allocated to operating grants excluding capital roll in. In 1990, theResearch Training Component (RTC) was estimated to be 7.6% of the operating grant. Due to strong growth in postgraduate research student load since 1990, the estimate of research training has increased and is currently estimated to be 11% of the operating grant, or $468.4 million.
- *Funding for the schools and centres of Institute of Advanced Studies* of the Australian National University. For 1998-99, funding for the John Curtin School of Medical Research will be provided through the EETYA portfolio. The IAS block grant is estimated to be $150 million. This amount includes some $104 million which is allocated by the University to the annual budget of the Research Schools (including the John Curtin School of Medical Research) and Centres of the Institute of Advanced Studies (IAS). In addition, the University estimates that a further $40-45 million can be regarded as being

attributable to the IAS in respect of University overheads, major equipment and such campus-wide costs as the library, information technology and central administrative activities.

Targeted research funding

Australian Research Council (ARC)

The Australian Research Council's mission is to provide advice on research funding and research policy, and to promote the conduct of research and research training of the highest quality for the benefit of the Australian community. The Council has special responsibility for research in the higher education sector, basic research and research training.

The majority of targeted research funding is allocated on the advice of the ARC, which conducts competitive peer reviews through its committees discipline panels. The primary criterion is the performance record of researchers and the quality of their proposals. Some weight may be given to other criteria such as national priority areas and links to industry. In 1998-99, the budget for targeted research programs referred to the ARC is approximately $345.7 million.

ARC Referred Programs

Research Grants

The 1998-99 allocation for Research Grants is $131.4 million. The Research Grants program has two components:

- *Large Grants Scheme:* supports basic and applied research projects in all disciplines except clinical medicine and dentistry. Grants range from a minimum size of $20,000 for the social sciences, humanities, mathematics and theoretical physics, up to more than $250,000 for Special Investigator Awards.
- *Small Grants Scheme:* provides block grants to universities to enable them to offer research grants at less than the minimum value of Large Grants. Eligible universities receive a base grant of $50,000. The remaining funds are distributed according to a formula that takes into account institutional success in obtaining Large Grants and the distribution of Small Grants in the previous year.

A sub-element of the Large Grants Scheme is the Aboriginal and Torres Strait Islander Researchers Development Program which aims to encourage Aboriginal and Torres Strait Islander researchers to improve their research skills to a level where they will be competitive for mainstream research funding. Emphases of the Program include the provision of support for research projects, training in research methodology and the preparation of larger research proposals. Up to $213,000 is available for this Program in 1998-99.

Strategic Partnerships with Industry — Research and Training Scheme

The Strategic Partnerships with Industry — Research and Training (SPIRT) Scheme supports research collaboration between universities and industry. It covers projects in basic, strategic, applied and developmental research and training in all fields, funded on a dollar for dollar arrangement with industry collaborators.

Funds are made available under three categories for a combination of research and training opportunities: Collaborative Research Projects; Australian Postdoctoral Fellowship Industry Awards; and/or Australian Postgraduate Awards (Industry). Funding single grants from one or more of these components leaves researchers free to negotiate with industry for a customised package suited to their particular activity.

In the calendar year 1998, $17.9 million has been awarded to 340 new SPIRT Scheme projects. This includes $12.1 million in funding for 200 Collaborative Research projects; $1.0 million for 21 Australian Postdoctoral Fellowship Industry Awards and $4.8 million for 232 Australian Postgraduate Award Industry places. In 1998-99 funding will total $46.7 million.

In 1998, 263 Collaborative Research Grants and 448 Australian Postgraduate Awards (Industry) that commenced before 1998 are also being supported at a cost of $25.6 million.

Additional funding in 1999 has been approved for 50 additional Australian Postgraduate Award (Industry) places in the fields of information, technology and communication.

Research Fellowships

Fellowships provide support for individuals to undertake research at postdoctoral level and above. In 1998-99, $28.4 million will be available for Research Fellowships.

There are five types of Fellowship:

- *Australian Postdoctoral Research Fellowships (APRF):* These are normally for researchers with less than three years of postdoctoral experience. Fifty five new APRFs have been taken up in 1998.
- *Australian Research Fellowships (ARF):* These are normally for researchers with more than three years of postdoctoral experience. Fifteen new ARFs have been taken up in 1998.
- *Queen Elizabeth II Fellowships (QEIIF):* These are for outstanding researchers who would usually have no more than six years' postdoctoral experience. Fifteen new QE1 IPs have been awarded in 1998.
- *Senior Research Fellowships (SRF):* These are for researchers with established reputations who would normally have no more than fifteen years of postdoctoral experience. Fifteen new SRFs have been awarded in 1998.

- *International Research Fellowships (IRF):* These fellowships arise from the implementation of reciprocal research award agreements with the Alexander von Humbolt Foundation of Germany, the Korea Science and Engineering Foundation, the United Kingdom Office of Science and Technology and the United Kingdom Particle Physics and Astronomy Research Council. Thirteen Fellowships were awarded for 1998. From 1999, these Fellowships will form part of the new International Researcher Exchange Program.

International Researcher Exchange Program (IREX)

IREX provides funding to support the movement of researchers to and from Australia between researchers in research institutions and centres of research excellence. In 1999 the budget for IREX is $2.75 million. The program specifically targets:

- bi-national agreements for reciprocal exchange of researchers, previously funded under the International Research Fellowships Scheme (IRF), the Anglo-Australian Observatory (AAO) Fellowship, and the new agreement with the United Kingdom for reciprocal Fellowships; and
- promotion of links between research centres of excellence in Australia and overseas by funding the exchange of researchers for research collaboration either by:
  - exchanges involving targeted Asia-Pacific countries, in particular, Japan, China, Indonesia and South Korea, with which the ARC has Memoranda of Understanding; or
  - exchanges involving other countries or organisations with which the ARC has a Memoranda of Understanding or traditional research ties.

Research Centres

A total of $18.8 million is being provided to Research Centres in 1998-99. Two types of centres are supported:

- *Special Research Centres* are established on the basis of research excellence and their potential to contribute to the economic, social and cultural development of Australia. They receive between $0.5 million and $1 million per annum. In 1998 funding of $14.45 million is being provided to 19 Special Research Centres. A review of Centres and a selection round for further Centres will be conducted in 1999. Funding for the new Centres will commence in 2000.
- *Key Centres of Teaching and Research* give equal weight to teaching and research. They are based in existing university departments and aim to boost expertise in areas relevant to national development and to promote cooperation between the higher education sector and industry. Key Centres receive an average grant of $360,000 a year from the program, and most obtain additional funding from other sources. In 1998, funding of $2.9 million is being provided to 8 Key Centres of Teaching and Research. A selection round for up to a further eight new Key Centres will take place during 1998 with funding to commence in 1999.

Postgraduate Awards

Two types of award with stipend are available under this program, Australian Postgraduate Awards with stipend and Australian Postgraduate Awards (Industry). $78.8 million is available under the Scheme in 1998-99. In addition, 21,500 Equivalent Full-time Student Units (EFTSU) are provided with exemption from the Higher Education Contribution Scheme. The stipend elements of the Scheme are:

- *Australian Postgraduate Awards (APAs):* Around 4,500 APAs provide a stipend of up to $20,503, mainly for students undertaking postgraduate research degrees. They are tenable for up to two years for a Masters student, and three and a half years for a student undertaking a PhD. 1,595 new awards were available in 1998. APAs with stipend are allocated to institutions on a formula reflecting research student load, research degree completions and comparative research strength measured by the Composite Index.
- *Australian Postgraduate Awards (Industry) (APA(I)s):* 580 APA(I)s were provided in 1997 (205 new awards), giving a stipend of $20,180. In addition, 50 APAIs were provided specifically for information technology and communications research. APAIs support higher degree research training for postgraduate students on research projects developed to meet the needs of industry. Each project is sponsored by an industry partner who is required to contribute $5,000 in cash plus an additional $5000 in cash or kind for each year of the higher degree training course. APA(I)s are awarded on the recommendation of the ARC.

Overseas Postgraduate Research Scholarships

The Overseas Postgraduate Research Scholarships Scheme supports high quality overseas postgraduate students in areas of research strength in higher education institutions. The scholarships offer students the opportunity to acquire a postgraduate qualification and experience with leading Australian researchers. In 1998-99, $15.8 million will be available to the scheme. In 1998, three hundred new scholarships are available.

Research Infrastructure Equipment and Facilities Program

The Research Infrastructure Equipment and Facilities (RIEF) Program is an element of the Research Infrastructure Program (see below) referred to the ARC for advice on the allocation of funds. The Program funds relatively large scale initiatives which develop major research infrastructure on a cooperative basis across groups of institutions and with organisations outside the higher education sector. Grants can also be made to individual institutions in cases where cooperative arrangements are impractical or inappropriate. In 1998-99, this element of the Research Infrastructure Program will provide $25.8 million. In 1999, $2.0 million will be provided from RIEF to the Australian National University to be allocated within the Institute of Advanced Studies. As announced in last year's Statement, from 1998 the Institute of Advanced Studies is eligible to compete for funds from the RIEF Scheme.

DEETYA Non-ARC Referred Programs

Research Infrastructure Program

The Research Infrastructure Program provides the Commonwealth Government's contribution, $113.8 million in 1998-99, to research infrastructure in higher education institutions. It supports high quality research by ensuring that areas of recognised research potential have access to the support necessary for their development; by enhancing support for established areas of research strength; and by remedying deficiencies in research infrastructure.

The Research Infrastructure (Equipment and Facilities) Scheme element of the Program, referred to the ARC, is described above.

The non-referred element is the Research Infrastructure Blocks Grants (RIBG) Program. RIBGs are provided to universities to assist in the development and maintenance of research infrastructure. Consistent with the program priority of providing infrastructure support for Commonwealth competitive grant schemes, the RIBG is allocated to institutions on the basis of the National Competitive Grants Index (NCGI). This element of the Program will provide an estimated $85.2 million in 1998-99.

High Performance Computing and Communications (HPCC) Centres of Expertise Program

The High Performance Computing and Communications (HPCC) Centres of Expertise Program will provide funding to establish a National HPCC Centre of Expertise to begin during 1998. It is part of the Government's national strategy to facilitate the establishment of an integrated HPCC capability in Australia which promotes international competitiveness through enhanced cooperation between universities, existing HPCC centres and facilities, Government (Commonwealth, State or local) and industry, including infrastructure and applications level sharing and support. It complements the HPCC Technology Diffusion Centres Program administered by the Department of Industry, Science and Technology.

The establishment of an integrated national HPCC infrastructure and system through a National HPCC Centre of Expertise will support science, engineering, social sciences, humanities and industrial research programs across Australia at an internationally competitive level. It will also provide skilled training for Australian personnel, develop financial support for HPCC, and support Australia's long term HPCC development.

Advanced Engineering Centres

DEETYA provides the Government's contribution to the operation of three Advanced Engineering Centres (AECs):

- Advanced Engineering Centre for Information Technology and Telecommunications, involving Adelaide and Flinders Universities and the University of South Australia in conjunction with the SA Department of Technical and Further Education;

- Advanced Engineering Centre for Manufacturing, involving Melbourne University and the RMIT; and
- Australian Graduate School of Engineering Innovation, involving Sydney University and the University of Technology, Sydney.

The Centres were established as a part of a wider agenda to enhance the contribution of engineering skill, research and development in the evolution of internationally competitive industries for Australia. They are designed to promote collaboration between higher education and industry to:

- improve advanced engineering education;
- increase industry's capacity to apply and commercialise technology; and
- focus on teaching and short term research and consultancy projects.

Each Advanced Engineering Centre received establishment funding of $2.1 million in 1992 and 1993 and receives recurrent funding of $0.6 million annually. University and industry partners also contribute to operating costs. $1.6 million will be provided to AECs in 1998-99.

A review is currently being conducted to determine the effectiveness of the program. The outcome of the review is expected to be announced in the first half of 1998.

Targeted Institutional Links Program

The Targeted Institutional Links (TIL) Program, launched in 1990, provides seed grants to Australian higher education institutions to form collaborative research links with Asian advanced research and technology institutions. In 1997-98, $530,000 will be spent under this Program. The funding ceases at the end of 1997-98 and seems unlikely to be renewed.

1998-99 Science and Innovation Priorities

In the Higher Education Budget Statement 1996, the Government announced additional support totalling $132.5 million in 1997, 1998 and 1999 for targeted higher education research (in 1998 outturn prices). This increased support included an additional $92.8 million for research infrastructure, $30.1 million for collaborative research grants and $9.6 million for Australian Postgraduate Awards. The Government's statement *Investing for Growth* provided funding for a further 50 Australian Postgraduate Awards (Industry), as part of the Strategic Partnerships-Industry Research and Training Scheme (SPIRT) in each of 1999, 2000 and 2001 at a cost of $9.2 million to enhance university-industry linkages in information technology related areas.

The Department of Employment, Education, Training and Youth Affairs (DEETYA) and the Australian Research Council (ARC) have continued to implement a monitoring and evaluation strategy for the higher education targeted research program. In the past year the following reviews have been completed: a review of the ARC Small Grants Scheme, a study of ARC/DEETYA grant allocation processes, and Discipline Research Strategies in Management, Information Technology, the Humanities and the Social Sciences. A number of major reviews are nearing completion including a review of ARC/DEETYA industry-linked research schemes, a review of ARC supported biological science research and a review of the ARC Large Grants Scheme.

The ARC/DEETYA Research Evaluation program is about to commence major reviews of research infrastructure in the higher education system, research training, engineering research and methods to monitor and evaluate research outcomes.

Through its annual research grants programs, the ARC will continue to advise the Minister on the performance of researchers and institutions seeking funding for research grants, fellowships, postgraduate awards, research centres and infrastructure in 1998-99. The performance of the higher education research system will be monitored through performance indicators and a component of university's general funding allocated on this basis.

In April 1998, the West Review Committee released its final report on the Review of Higher Education Financing and Policy. The Review Committee's task was to develop a policy framework including financing options to ensure that Australia's higher education system is responsive to long term environmental challenges while meeting the Government's broad goals for higher education. The Government is in the process of considering its response to the West Review's report.

ENVIRONMENT

Science and Innovation in the Portfolio Budget

The Environment portfolio consists of the Australian Antarctic Division, the Bureau of Meteorology and Environment Australia. Environment Australia contains six work groups: Biodiversity, Environment Protection, Environmental Priorities and Coordination, Portfolio Marine, Supervising Scientist, and Australian and World Heritage. This structure includes several research organisations and programs, for example, the Environmental Research Institute of the Supervising Scientist and the National Greenhouse Research Program. Also within the Environment portfolio is the recently established Australian Greenhouse Office (AGO). The AGO is the lead Commonwealth agency on greenhouse matters, providing a major focus for greenhouse policies and programs, including research. The AGO reports directly to the Minister for the Environment and through him to a Ministerial Committee on Greenhouse.

Australian Antarctic Division

The Australian Antarctic Division directly undertakes and supports scientific research in the Australian Antarctic Territory, the Southern Ocean and Australia's subantarctic islands. Its priorities are: understanding global climate change; undertaking scientific work of practical importance; and protecting the Antarctic environment.

The Bureau of Meteorology

As the national meteorological service for Australia, the Bureau of Meteorology has primary responsibility for national research which supports its own operations and services and for liaison with the World Meteorological Organisation in relation to international concerns. The Bureau maintains a wide involvement in atmospheric and oceanographic research at both a national and international level, encompassing partnership in three Cooperative research Centres, collaboration in research and development projects with several Australian and overseas universities and government agencies, as well as through bilateral and multilateral agreements with overseas governments and national meteorological services.

To fulfil its research objectives, the Bureau:

- encourages high quality research in-house as a foundation for effective collaboration with the external research community and for the implementation of improved systems and techniques for the provision of services;

- fosters meteorology in the tertiary sector to ensure access to well-trained graduates and maintenance of the national research infrastructure for atmospheric science; and
- ensures effective coordination with the research programs of other relevant institutions both within Australia and overseas.

The main research activities are carried out by the Bureau of Meteorology Research Centre in collaboration with the various operational units of the Bureau. Major research areas are mesoscale meteorology, regional meteorology, medium-range prediction, climate, climate-change modelling and oceanography. The activities involved include theoretical studies, field experiments and mathematic modelling of atmospheric and oceanographic systems, with increasing effort being directed to the practical application of research results to improving the quality of Bureau services. Research is also undertaken into atmospheric constituents including greenhouse gases and atmospheric ozone.

Environment Australia

Biodiversity Group

Within the Biodiversity Group (BG) work will continue on the implementation of the Convention on Biological Diversity. This includes research activities which contribute to the conservation and sustainable use of biological diversity.

The BG is responsible for management of parks and reserves owned or leased by the Commonwealth. To assist in this management, research is conducted in a number of parks, including Kakadu and Uluru-Kata Tjuta National Parks. Research topics cover such fields as assessment of rabbit control at Uluru-Kata Tjuta National Park and assessment of aboriginal art sites and their management for Kakadu and Uluru-Kata Tjuta National Parks.

The Biodiversity Group also administers the Australian Biological Resources Study (ABRS). The ABRS promotes taxonomic and biogeographic studies of biodiversity through two programs:

- the Participatory Program, a unique research grant scheme which provides funds towards taxonomic and biogeographic research; and
- the Publications Program which produces major national series of flora and fauna books and databases.

The Australian National Botanic Gardens conducts research on the horticulture of Australian plants and, through the Centre for Plant Biodiversity Research (a collaborative venture with the CSIRO Division of Plant Industry), undertakes research on the taxonomy, systematics, identification, genetics and biology of the Australian flora.

Environment Protection Group

Within the Environment Protection Group, the National Greenhouse Research Program (NGRP) continues to provide national level focus and direction for greenhouse research, meet policy needs for information on the science and impact of climate change, meet commitments under the Framework Convention on Climate Change and the National Greenhouse Response Strategy to advance scientific knowledge of climate change, and maintain a level of core climate change scientific research that provides the foundation for present and further information needs. The Commonwealth provided $3.9 million for 1998-99 and a total of $13.7 million over 1996-2000. Scientific research findings from the NGRP provide the strategic and immediate foundation for Australia's climate change policy response, and continue to improve the information basis on which environmental decisions are made.

The Climate Change Program has funded a number of research projects which aim to enhance our knowledge of the likely impacts of climate change so that environmental, economic and other costs and benefits of climate change can be identified and informed decisions made on mitigative and adaptive responses. The funding level for these activities in 1997-98 was approximately $340,000.

The National Greenhouse Gas Inventory Committee Research Program is funded from the National Greenhouse Gas Inventory Program with a budget of approx $850,000. Funds are allocated to improve National Greenhouse Gas Inventory (NGGI) emissions estimates, fill deficiencies in knowledge and improve understanding of the scientific processes governing greenhouse gas emissions especially in those sectors with a relatively high degree of uncertainty associated with greenhouse gas emissions. The results provide the basis for mitigation strategies both at a technical and policy level.

Portfolio Marine Group

The Great Barrier Reef Marine Park Authority is directly responsible for management of the Great Barrier Reef Marine Park and is also involved in the management of the Great Barrier Reef World Heritage Area. The Authority works jointly with a range of Commonwealth and Queensland government agencies to more effectively achieve the Marine Park's management objectives. The Authority has identified a number of critical areas and is establishing a team based structure to address the issues of water quality/coastal development; tourism; fishing; and conservation/World Heritage.

During 1998-99, GBRMPA will give highest priority to addressing conservation issues, including the protection of threatened species; the development of a comprehensive system of strictly protected representative areas; assessment of the ecological integrity of GBR ecosystems; protection of GBR ecosystems from pollutants discharged from the land; and tourism use management.

Supervising Scientist Group

The Supervising Scientist Group is jointly managing the Riverworks Tasmania program with the Tasmanian Department of Environment and Land Management. Riverworks Tasmania (TRERP) has a budget of $8.75 million over 3 years from 1996-97 to improve water quality and amenity in key Tasmanian rivers.

The Australian Centre for Minesite Rehabilitation Research is supporting research projects which will increase knowledge and expertise at minesites and thus the ability to develop mineral resources in an environmentally sustainable manner.

In 1998-99, the Environmental Research Institute of the Supervising Scientist will continue to carry out research on the impact of mining on people and ecosystems in the Alligator Rivers region, and on the protection and management of wetlands. Priorities will be allocated to:

- Assessing the impact of the possible development of the Jabiluka mine;
- Radiological impact assessment for the rehabilitated Nabarlek mine;
- Application of remote sensing techniques to environmental monitoring of rehabilitated mine sites;
- Determination of optimum landform designs in mine site rehabilitation;
- Treatment of mine waters by constructed wetland filters;
- Management planning for wetlands on Aboriginal lands;
- Development of techniques and databases for monitoring wetlands;
- Risk assessment for wetlands; and
- Review of water quality guidelines for Australia and New Zealand.

Chief Science Adviser

The position of Chief Science Adviser for Environment Australia is jointly held with the appointment of Supervising Scientist. The Chief Science Adviser initiative has been developed:

- to provide a channel of communication between EA, other portfolios with scientific interests and scientific agencies;
- to translate EA's short and long-term science needs into prescriptions for development of the science base;
- to enhance linkages between portfolio science and technology functions and the policy elements of EA;
- to develop strategies of a scientific nature in relation to the portfolio's responsibilities;
- to represent EA on bodies responsible for wider coordination of science and technology activity such as the Coordination Committee for Science and Technology; and

- to represent EA in major national and international scientific fora.

The Chief Science Adviser has prepared a study of Australia's environmental science and technology effort which will make recommendations about national environmental science and technology priorities.

1998-99 Science and Innovation Priorities

Australian Antarctic Division

In 1998-99, the Antarctic program will continue to implement the 1995-2000 science strategic plans and associated logistic and operational activities, and maintain the existing four stations in support of the Government's goals for Antarctica.

Maintaining the Antarctic Treaty System and Australia's influence in the System

Further development, through the Commission for Conservation of Antarctic Marine Living Resources (CCAMLR), of sustainable management practices, including reviews of catch limits for fisheries and improved controls on illegal fishing.

Understanding Global Climate Change

Sea-ice, which plays an important role in the global climate system and is a sensitive indicator of climate change, will continue to be monitored using ship based observations, satellite imagery, moored oceanographic instruments and drifting data buoys.

A major marine science program will determine the role of high ice production areas in modifying ocean structure and influencing global ocean circulation, affecting high latitude weather and controlling total sea-ice production.

Observations of temperature and winds in the upper atmosphere will be conducted using the Division's new Light Ranging and Detection instrument (LIDAR) due to be deployed at Davis during 1998-99.

Fine detail climate change over the last century will be derived from shallow (to 270 m) firn drilling at various elevations on Law Dome, near Casey during the summer of 1997-98. This project also includes CSIRO and ANSTO.

Undertaking Scientific Work of Practical Importance

The Division will continue to maintain its support of the Bureau of Meteorology, Ionospheric Prediction Service and Australian Geological Survey Organisation in obtaining meteorological, ionospheric, magnetic, and seismological observations which are of practical importance to their functions in Australia.

A major marine geoscience program will be conducted in collaboration with the Italian Antarctic Program.

Protecting the Antarctic Environment

The Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol), in which Australia took a leading initiating role, was finally ratified by all Antarctic Treaty nations and came into effect on 14 January 1998. Residual legislative amendments and introduction of procedures will continue to be brought into force.

A continuing study into exotic toxins and pathogens in Antarctic penguins and seabirds will provide baseline data for strategies for their conservation. As a result of earlier Division initiatives in this area, a major international conference on diseases of Antarctic wildlife is scheduled to be held in Hobart in August 1998.

A human impacts program, seeking information to help protect the values of the Antarctic and its region from impacts caused by human activity, will be continued. This includes a new element of the human impacts program, initiated in the vicinity of Casey station during the summer of 1997-98, which commenced a diving program to map distribution of seafloor sediments and biota and to trace contaminant pathways and possible contaminant effects as a result of runoff from past waste sites in the area.

A major contribution to a circumpolar international survey into the distribution and abundance of seals on the Antarctic pack-ice will be undertaken. The seals are a major player in the Antarctic food chain.

Fieldwork during the summer of 1997-98 in the Prince Charles Mountains, designed to further an understanding of the path of evolution to the modern environment, yielded valuable collections that will continue to be studied fully over the next few years.

Tourism activity in the Australian sector will be appropriately managed, including the assessment of environmental impacts of proposed activities.

A management plan for the Larsemann Hills, including a plan for the future directions in science, will be developed following a successful meeting in Hobart during 1997-98 between China, Russia and Australia.

Bureau of Meteorology

The Monitoring and Prediction program provides, operates and maintains the basic observation, communications and data processing systems necessary to maintain a round-the-clock nationwide weather watch and to meet present and future national and international needs for raw and processed meteorological data. In support of the Monitoring and Prediction program in 1998-99, the Bureau of Meteorology will:

- continue the re-equipment and modernisation program with emphasis on replacement of obsolescent equipment and enhanced operational effectiveness;
- maintain the Bureau's basic observational networks to the standards made possible through the additional funds provided in response to the recommendations of the 1996 Review of the Operation of the Bureau of Meteorology;
- accelerate the implementation of systems for improving the efficiency and effectiveness of external access to the Bureau's data and products; and
- enhance the efficiency and effectiveness of forecasting operations through the operational implementation of the Australian Integrated Forecast System (AIFS).

The overall objective of the Scientific Development Program is to advance the science of meteorology, develop an integrated, comprehensive description and scientific understanding of Australia's weather and climate, develop the application of meteorology in the national interest and improve the operations and services of the Bureau. In support of the Scientific Development program in 1998-99, the Bureau of Meteorology will:

- improve further the scope, accuracy and reliability of the Bureau's numerical weather prediction systems;
- continue work towards improved climate prediction including the development of the seasonal prediction system;
- maintain a program of climate research directed towards improved understanding of the natural variability of Australia's climate and reducing uncertainties in simulated changes to climate resulting from increased concentrations of greenhouse gases;
- apply the results of the continuing strategic research on severe weather events to the development of operational systems and techniques to improve the Bureau's very short range forecasting and nowcasting capability;
- improve operational marine services through the development of advanced systems, such as a unified storm surge model and an ocean data assimilation system; and
- continue active participation in the meteorology- and hydrology-related Cooperative Research Centres to strengthen the overall foundations of Australian meteorology and especially basic meteorological research in the tertiary education sector.

The overall objective of the Weather Services Program is to meet the needs of the general public and specialised users for relevant, accurate and timely weather data, information, forecast and warning services. In support of the Weather Services program during 1998-99, the Bureau of Meteorology will:

- continue to monitor the extent and nature of community needs for Bureau weather services and the effectiveness of services provided;
- promote the application of weather services within the community and redesign and develop weather services in response to community needs as appropriate;
- continue to monitor and evaluate the Bureau's weather service operations to enable services to be provided efficiently and to a high and gradually improving standard; and
- develop a comprehensive, integrated and robust system for access to and delivery of weather services.

The overall objective of the Climate Services Program is to meet the present and future needs of the general public and specialised users for reliable, responsive climate data, information, monitoring, prediction and advisory services. In support of the Climate Services program in 1998-99, the Bureau of Meteorology will:

- continue the development of the national computer archive for meteorological data (ADAM - Australian Data Archive for Meteorology) through enhancement of the suite of parameters stored and improved user access;
- review and update the range of standard data summaries and the format and media through which climate information is provided for public use;
- prepare a suite of new reference maps of climate parameters as the basis of a major climate review;
- continue the initiatives identified under the Climate Monitoring and Prediction Upgrade and, in particular, improve the user focus of service products; and
- monitor the status of the national Reference Climate Station Network and participate in international programs analysing global trends in climate.

The overall objective of the Consultative Services Program is to meet the need for effective application of meteorological information and expertise in the national interest through the provision of consultative services to specialised users. In support of the Consultative Services program during 1998-99, the Bureau of Meteorology will:

- continue production, in collaboration with industry representatives, of a leaflet series on bio-climatic urban design for use by planners and builders;
- provide, via the World Wide Web, information about the benefits of the application of climate information to tourism, public health and building design; and

- enhance its cost-recoverable and commercial provision of professional advice on meteorological matters.

The overall objective of the Hydrological Services Program is to provide an effective national source of hydrological and hydrometeorological data and advice and to meet the needs of the general public, emergency services and other specialised users for effective reliable flood warning services. In support of the Hydrological Services program during 1998-99, the Bureau of Meteorology will:

- develop a Probable Maximum Precipitation (PMP) methodology for Western Tasmania that is consistent with the Generalised Southeast Australia Method and provide PMP estimates for evaluation of dam spillways in the region;
- implement relevant components of the AIFS in Regional Hydrology Sections, in accordance with the timetable of that project, to improve the robustness of the operational flood forecasting system; and
- complete the component of the Climate Monitoring and Prediction Upgrade related to upgrading the networks for drought and water resources purposes.

The overall objective of the International Activities Program is to meet Australia's international obligations, advance Australia's interests and support the operations and services of the Bureau through participation in international meteorology. In support of the International Activities program during 1998-99, the Bureau of Meteorology will:

- contribute to high level decision making and scientific and technical planning in international meteorology through the programs and activities of the World Meteorological Organization (WMO) and related international organisations;
- establish closer mutually beneficial cooperation with a selection of relevant National Meteorological Services and multinational bodies, through the WMO Voluntary Cooperation program, cost sharing or other means, to enhance bilateral, regional and global cooperation; and
- collaborate with AusAID and other international aid agencies as well as other relevant organisations in assisting with the strengthening and capacity building of meteorological networks and services in the developing countries of the SW Pacific and SE Asia.

Environment Australia

In the context of science and innovation, the Biodiversity Group's priorities will be to ensure effective administration and management of the various R&D programs the Group is involved in (viz the native vegetation research program through Bushcare, the National River Health Program and the National Wetlands R&D program), as well as continuing with its activities under the ABRS program, the Centre for Plant Biodiversity Research, and Parks research.

The BG will continue to provide funding for research into the role native vegetation plays within the landscape and will establish best practice principles for sustainable ecological management. The Commonwealth will also develop and test a range of indicators to monitor the role and effectiveness of vegetation in, for example, ameliorating land degradation.

In the Environment Protection Group the recently established Australian Greenhouse Office will be responsible for the development of a National Carbon Accounting System (NCAS) to support the NGGI and sustain Australia's ability to account for our emissions and sinks in the land use change and forestry sector with greater confidence, particularly in the period covered by the Kyoto Protocol. Developing and maintaining an accurate carbon base is important to a number of different areas across government. The Office will provide the focus for the cross linkages which will be essential to the development of a credible and transparent system. Funding of $12.5 million to develop a NCAS was made available over five years in the PM's Statement of November 1997, Safeguarding the Future: Australia's Response to Climate Change.

The Atmospheric Protection Branch primarily commissions greenhouse science research under the auspices of the National Greenhouse Research Program. Research is also conducted under the National Greenhouse Gas Inventory Committee Research Program focusing on improving NGGI estimates. Other assessments of climate change, such as those focused on the identification of possible climate change impacts and adaptation strategies to address those impacts are conducted through the Climate Change Program.

The Environmental Research Institute of the Supervising Scientist, part of the Supervising Scientist Group, carries out independent research on behalf of the Australian community to establish the best methods available for the protection of people and ecosystems in the Alligator Rivers Region both during and following mining of uranium in the region. The Institute also carries out research on the protection and management of wetlands to ensure that the owners and managers of wetlands have reliable scientific information available to them to enable the development of management plans based upon the principles of ecologically sustainable development.

Great Barrier Reef Marine Park Authority

The Great Barrier Reef Marine Park Authority is directly responsible for management of the Great Barrier Reef Marine Park and is also involved in the management of the Great Barrier Reef World Heritage Area. The Authority works jointly with a range of Commonwealth and Queensland government agencies, such as the Queensland Department of the Environment, the Queensland Fish Management Authority and the Queensland Department of Primary Industries to more effectively achieve the Marine Park's management objectives. The Authority will continue to focus on issues which are critical for appropriate protection and use of the Great Barrier Reef Marine Park and World Heritage Area.

These critical issues as identified in the Authority's Corporate Plan are:

- World Heritage values;
- conservation: threatened species, representative areas, crown-of-thorns starfish and other large-scale ecological perturbations;
- tourism and recreation;
- shipping and marine pollution;
- coastal development
- effects of fishing
- water quality; and
- Aboriginal and Torres Strait Islander issues.

To improve focus on these issues the Authority is reorganising its structure by establishing formal teams dealing with water quality/coastal development; tourism; fishing; and conservation/World Heritage.

During 1998-99, GBRMPA will give highest priority to addressing conservation issues, including the protection of threatened species, the development of a comprehensive system of strictly protected representative areas, assessment of the ecological integrity of GBR ecosystems, protection of GBR ecosystems from pollutants discharged from the land, and tourism use management.

HEALTH AND FAMILY SERVICES

Science and Innovation in the Portfolio Budget

Research activities are undertaken within the Health and Family Services Portfolio and external research is funded through major portfolio research funding programs. Research is undertaken by the Australian Radiation Laboratory, the Nuclear Safety Bureau, the National Acoustic Laboratories and the Australian Institute of Health and Welfare. Research funding is provided through the National Health and Medical Research Council (NHMRC), the Commonwealth AIDS Research Grant Scheme and a number of smaller grant schemes which fund applied medical and health research relevant to the activities of the Department of Health and Family Services.

Funding for health and medical research through the NHMRC in 1998-99 will be approximately $176.0 million which includes funding for health services research ($156.4 million in 1997-98). Research into HIV/AIDS will be the subject of a $12.0 million program ($12.0 million in 1997-98).

The Australian Institute of Health and Welfare will receive $7.7 million ($7.7 million in 1997-98).

The Budget for the National Acoustics Laboratories is allocated from the appropriation for community services obligations under the Hearing Services Program. Funding in 1998-99 is expected to be of the same order of magnitude as previous years.

Legislation has been introduced to establish the Australian Radiation Protection and Nuclear Safety Agency (ARPNSA). This is to be formed by combining the resources of the Australian Radiation Laboratory (ARL) and the Nuclear Safety Bureau(NSB). Funding for 1998-99 is expected to be around $8.2 million which will at least maintain funding for Australia's radiation protection and nuclear safety ativities at the level of past years.

In the 1998-99 Budget, the Government has provided funding to maintain base funding for health and medical research through the NHMRC at current levels. The funding will enable the NHMRC to maintain its 1998 calendar year level of grant funding in future years. In this way, it will provide longer term certainty for the health and medical research industry, enable longer teerm research projects to be undertaken and encourage those with research skills to participate in or continue in such research.

1998-99 Science and Innovation Priorities

Priorities for 1998-99 are:

- a high level of national research capacity directed towards improving the health and well-being of the population;
- the advisory, information and research management capacity to support Commonwealth leadership in evidence-based medicine;
- a high standard of ethics in national health and medical research; and
- health policy, health practice and government funding decisions based on sound scientific evidence.

The NHMRC is currently working on a number of proposals to facilitate meeting the above priorities through new research policy directions including:

- Strengthening health research and industry links.
- Conceptualising NHMRC-supported research around broad themes - "Health Research Streams".
- Introduction of Health Research Partnership grants - a new multidisciplinary mechanism, involving networks of researchers, focussed on specific outcomes and funded in partnership with State and Commonwealth governments, the private sector and research institutions. A call for expressions of interest in "Network Grants/Partnerships" is scheduled for 1998.
- Working with other government and charitable granting bodies, and with the private sector, to increase overall efficiency in Australian health funding by reducing the overall assessment load.
- A review of Research Fellowships scheme mechanisms and strengthening the status of NHMRC fellowships through new and wider opportunities.
- A review of all current funding arrangements aimed at introducing a simple one-line budget grant system for researchers to manage.
- Strategic research initiatives in the areas of injury, Aboriginal and Torres Strait Islander health, health services and information capabilities in the Australian health research system.

INDUSTRY, SCIENCE AND TOURISM

Science and Innovation in the Portfolio Budget

Portfolio activities in science and innovation are focused on developing Australia's science and technology capabilities and infrastructure; ensuring public sector scientific research delivers effective benefits; and on stimulating innovation in the Australian business sector.

The portfolio contains three scientific research organisations and three scientific service providers. The former three are the Australian Institute of Marine Science (AIMS), the Australian Nuclear Science and Technology Organisation (ANSTO) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), with the latter three being the Australian Government Analytical Laboratories (AGAL), the Australian Surveying and Land Information Group (AUSLIG), and the Ionospheric Prediction Service (IPS).

The portfolio also includes agencies and programs which support technological development in industry through the provision of grants, concessions and services. For example, the Industry Research and Development (IR&D) Board, which includes both industry and government representatives, promotes research and development activities so as to improve the efficiency and international competitiveness of Australian industry.

Science and technology policy advisory arrangements

Cross-portfolio advice and coordination of science, technology, engineering and innovation are provided by the combination of the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), the Chief Scientist and the Coordination Committee on Science and Technology (CCST).

- *PMSEIC provides information and advice* to the highest levels of government. The Council, which was established in December 1997, replacing the former Prime Minister's Science and Engineering Council, is chaired by the Prime Minister and has a membership consisting of senior ministers and leading figures in business, science and technology. The non-ministerial members of the Council constitute the Standing Committee, which is chaired by the Chief Scientist, who is also the Council's Executive Officer. The Standing Committee examines issues in science, engineering and innovation and prepares reports and recommendations for consideration by the full Council. It is in the process of taking over the responsibilities of the Australian Science, Technology and Engineering Council

(ASTEC). The Government has introduced legislation to repeal the ASTEC Act and intends that ASTEC be wound up once its present work program is completed.

- *The Chief Scientist* also provides advice directly to the Prime Minister and the Minister and maintains close and effective working relationships between the Government and organisations with responsibilities for science, technology and engineering.
- The CCST enables departments and agencies with responsibilities in science and technology to share information about their programs, policies, problems and future work plans. The Committee takes a close interest in issues being considered by PMSEIC.
- *Policy advice and analysis* across a broad front relating to science, innovation, research and technology is provided by the Science and Technology Policy Branch of the Department's Science and Technology Division.

Business growth through AusIndustry

AusIndustry offers a suite of programs to help eligible businesses to grow, including support for R&D activities. AusIndustry programs include:

- the *Research and Development Tax Concession,* which allows companies registered with the Industry Research and Development Board to deduct eligible R&D expenditure at a rate of 125% when lodging their tax returns;
- the *R&D Start (Strategic Assistance for Research and Development) Program,* which is a competitive scheme that provides companies with a mix of support measures, including grants and loans; and
- the *Innovation Investment Fund (IIF)* program, which helps small technology-based firms to access venture capital through funds which are restricted to investing in companies engaged in commercialising technology, with an annual revenue of $4 million or less, averaged over the past two years, and a maximum of $5 million in any one year.

Industry development through innovation

- The *Australian Technology Group Limited (ATG)* is a technology commercialisation company specialising in investment and management in early stage commercialisation of research outcomes.
- The *Pharmaceutical Industry Development Program,* of which the Factor (f) Scheme is a major element, contributes to the development of an internationally competitive pharmaceutical industry in Australia. Under Factor (f), companies can gain increased prices for some of their products listed in the Pharmaceutical Benefits Scheme in return for increased activity in Australia, including new investment, production, research and development. The Factor (f) Scheme will be succeeded by the Pharmaceutical Industry Investment Program (as reported in last years Statement, page 2.8).

- *IP Australia* provides industrial property rights services for inventions, trade marks and designs. Legal protection given with the rights encourages industry to develop and exploit new technologies as well as facilitating the transfer of overseas technology to Australia. The organisation operates on full cost recovery.
- The *Telecommunications Industry Development Plan* arrangements assist the development of the Australian telecommunications industry by encouraging carriers to undertake strategic investment, R&D and export activities which contribute to the growth of the industry and wider economy, while recognising that the carriers' actions must remain fundamentally strategic and commercial in nature.
- The *Partnerships for Development and Fixed Term Arrangement Programs* encourage international companies in the information technology and telecommunication industries to undertake strategic investment, R&D and export activities in Australia which are integrated into the global marketplace.
- The *Renewable Energy Industry Program (REIP)* is a granting program to support the commercialisation of renewable energy technologies. The objectives of the program are: to encourage the development of an internationally competitive renewable energy industry by overcoming impediments to its growth; and to contribute to the Government's goal of reducing greenhouse gas emissions. The program will move to the Australian Greenhouse Office in the new financial year.

Science, technology and industry linkages

- The *Cooperative Research Centres (CRC) Program* provides support for long-term collaborative ventures linking researchers and research users from universities, Commonwealth- and State-funded research organisations and business enterprises. It promotes high quality cooperative research and education programs through centres of research concentration, strengthening the links between research and its commercial and other applications.
- The *Major National Research Facilities (MNRF) Program* is directed at keeping Australia at the leading edge of scientific and technological developments. Under the Program, funding is provided for facilities in a range of key scientific fields where the establishment costs are beyond the capacity of any individual Australian institution. These facilities will create centres of capability for pursuing research with state-of-the-art equipment.
- The *Space Industry Development Centres (SIDC) Program* was established to accelerate industry investment in the development of commercial space products and services. Under the scheme, private companies and universities collaborate to develop innovative space technologies with commercial potential. Of the three SIDCs established in the early 1990s, two have completed their Grant Agreements with the Commonwealth. The Space Centre for Satellite navigation at the Queensland University of Technology expects to complete its final work program late in 1998.

- *The Science and Technology Awareness Program* aims to increase awareness and understanding of the central role which science and technology play in Australia's economic and social well-being.

Program or agency	Estimated expenditure 1997-98 $m	Budget estimate 1998-99 $m
Factor (f) Pharmaceuticals	174.1	159.3
AIMS	16.4	18.5
ANSTO	76.7	80.0
CSIRO	466.8	475.4
AUSLIG/AGAL	40.7	35.3
Ionospheric Prediction Service	4.2	4.2
Industry Innovation Program grants	91.2	132.3*
Innovation Investment Fund	-	14.0
CRC Program	146.9	137.9
Enterprise Development Program	29.9	14.5*
Enterprise Networking Program	7.5	3.5
National Space Program	0.7	0.04
Science & Technology Awareness	2.3	3.4
Technology Diffusion Program	24.8	18.0
National Research Facilities	21.4	9.6
TOTAL	1103.6	1105.9
PORTFOLIO TOTAL (Outlays)	3365.1	3534.6

compiled on an accrual basis

* includes payments to Australian Greenhouse Office Reserve Money Fund

Budget support for these programs is shown in the table. IP Australia is not included in the above figures as it operates on full cost recovery.

1998-99 Science and Innovation Priorities

AusIndustry

The key priorities for the AusIndustry sub-program in 1998-99 are discussed below.

125% R&D Tax Concession Program

Increased monitoring activity for both R&D syndicates and company applications under the general concession will be undertaken over the next two years.

An upgraded information and education program will be introduced to help reduce uncertainty and to facilitate compliance with the provisions of the concession, principally through updating, revising and expanding the range of Industry Research and Development Board guidelines for particular industries/sectors.

Measures will be implemented to streamline and enhance the integrity and efficacy of the concession, and to inform companies of the changes through seminars, printed material and other publicity.

Strategic Assistance for Research and Development (R&D Start) Program

Within the context of improving the competitiveness of Australian industry by increasing innovation, the R&D Start Program aims to achieve increases in the number of research and development projects with high commercial potential undertaken by companies.

A key indicator of effectiveness will be if the portfolio of projects established by the R&D Start Program:

- demonstrates, or is likely to demonstrate, commercial focus with potentially high rates of return;
- generates productive linkages between leading research, commercialisation and financial capability; and
- generates net national benefits.

Performance will be measured by:

- the number and quality of applications received from companies for each program element;
- the timeliness of the implementation of the extended R&D Start Program; and
- the average time taken between submission of applications and the Board's decision.

It is anticipated that grant offers of between $170-200 million will be made in 1998-99.

Innovation Investment Fund (IIF)

The Innovation Investment Fund program seeks to provide access to venture capital to:

- encourage early stage technology based companies to improve the commercialisation outcomes of Australia's strong research and development capabilities; and
- create a self-sustaining early stage venture capital industry.

The program will licence five fund managers under round one funding and an additional three to five fund managers under the recently announced round two. It is anticipated that each licensed fund will invest in between 15 to 20 companies each over the 10 year life of the Fund.

Renewable Energy Innovation Investment Fund (REIIF)

This program aims to develop and broaden the Australian renewable energy industry through the provision of venture capital. It is anticipated that the fund manager will be licensed in the 1998-99 financial year and will ultimately invest in between 15 to 20 companies.

National Business Information Service

Funding was provided in 1997-98 for the development of the National Business Information Service (BIS). The BIS will provide the framework that will link the provision of business licensing and other transactions and business information across the three levels of government. Access to information will be made easier, quicker and cheaper for business. The initiative will result in reduced compliance costs in dealing with government.

The National Business Information Service web site will be operational in July 1998 and increased functionality will be added to the service as it is developed and agreed between governments over the next two years.

By July 1998 phase 1 of the website will be operational and will:

- include initial registrations for the Australian Tax Office and the Australian Securities Commission;
- host the enhanced BizLink OnLine product;
- link to major State and Territory business information sites; and
- commence trialing data and information management standards for potential whole of government application.

By June 1999 the site will have enhanced interactive links; provide Commonwealth licence information to the State and Territory on-line services; involve an expanded range of Commonwealth transactions; and provide enhanced and expanded information modules in key areas for business.

Science and Technology

Advisory arrangements

The Department will seek to obtain the maximum benefit from the new advisory arrangements by:

- supporting members of the Prime Minister's Science, Engineering and Innovation Council in a substantial work program;
- exploring and reporting on issues of major national importance; and
- recommending actions designed to make effective use of Australia's investment in science and technology.

Gene technology

The Department is leading negotiations with the States and Territories on the development of a uniform national system of regulation for gene technology. The intention is to reach agreement on the detailed structure of such a system by the end of 1998, with a view to the passage of legislation early in 1999. The Department will continue its support of existing voluntary regulation.

International Science and Technology

The Department will implement and monitor the operation of the new Technology Diffusion Program (TDP). This will include:

- supporting Australian scientists to access major international research facilities;
- supporting strategically focused international science and technology collaborations and related projects, missions, workshops, fellowships and exchanges using the expertise of Australia's major science academies;
- administering competitive grants to encourage science/industry alliances by supporting international research collaboration for projects which have the promise of real commercial outcomes;
- forging better links between industry and the international science and technology community;
- gaining benefits from strategically targeted international science and technology collaboration (by identifying opportunities for technology diffusion and industry innovation flowing from Australia's involvement in global science and technology); and
- developing and implementing country specific collaborative activities in accordance with industry development priorities.

Science Policy

The Department will provide policy advice and analysis in relation to science, innovation, research and technology. Key priorities during 1998-99 will be:

- the *Science and Technology Budget Statement 1999-2000*, which will provide an account of Commonwealth science and innovation expenditure, priorities and recent outcomes;
- a marine science and technology plan, as an integral part of the Government's oceans policy;
- advice on performance indicators for the portfolio science authorities for the 2000-2001 to 2002-2003 triennium;
- domestic and international forums on science, innovation, research and technology policies to secure more effective commercialisation of Australian research;
- advice on the performance of the Australian science, technology and innovation system to meet Government, community and international needs (including through targeted publications);
- policy advice to Government on nuclear science and technology, including the operation of the existing research reactor and construction of its replacement, the management of spent reactor fuel and completion of work associated with the Probabalistic Safety Assessment of the existing reactor; and
- policy advice on management of gene technology intellectual property in Australia and on implementation of decisions in this regard.

Cooperative Research Centres (CRC) Program

During 1998-99 the CRC Program will be refocused to improve the linkages between the science and industry sectors and to achieve greater levels of commercialisation (with greater emphasis on novel technologies which can assist industry to become more innovative, competitive and productive).

The Program will ensure that:

- the research is world class;
- there is a continued focus on the development of international linkages;
- there is a greater emphasis on novel technologies which can assist Australian industry to become more innovative, competitive and productive;
- there is further development of a strong research management culture; and
- Centres develop a clear business focus, and a business plan that includes commercialisation strategies as well as diffusion strategies.

Program guidelines will be revised and a selection round conducted in 1998, with applications to be submitted by 30 September 1998 and announcement of successful Centres by 31 March 1999.

Fifth Year Reviews of sixteen Third Round Centres, Third Year Reviews of three Fourth Round Centres, and a Second Year Review for the Australian CRC for Renewable Energy will be completed.

Science Awareness

Key priorities in 1998-99 will be to:

- award the 1999 Australia Prize in the field of energy science and technology;
- arrange for the 1999 Michael Daley Awards to be awarded with the Eureka Prizes;
- provide infrastructure and publicity support for National Science Week 1999; and
- advertise for applications for National Science Week 1999 project grants.

The Australian Institute of Marine Science (AIMS)

AIMS is seeking to generate knowledge to support the sustainable use and protection of the marine environment through innovative, world-class scientific and technological research. In pursuit of this objective AIMS is working closely with some industries (e.g. offshore oil and gas, tourism, pharmaceuticals), works indirectly with others (e.g. fisheries) and has close links with management agencies (e.g. Great Barrier Reef Marine Park Authority).

1998-1999 is the second year of the triennium. During this period AIMS will continue research identified in the Australian Institute of Marine Science Research Plan: 1997-2000. This document is available on the Internet: http:/ /www.aims.gov.au/pages/research/trp/pages/trp2-00.htm 1.

Australian Nuclear Science and Technology Organisation (ANSTO)

Consistent with ANSTO's Strategic Plan (1997-2000) ANSTO has continued to focus its science activities on five core areas where nuclear science and technology and related capabilities offer strategic and technical benefit to Australia.

In order to maximise benefits, resources will be directed to priority activities, that is, those likely to deliver the greatest benefits ANSTO's investment strategy will be a balance between developing project plans and seeking new capabilities and strengthening existing research capabilities and researcher skills.

In 1998-99 ANSTO's strategic research will continue on seven knowledge generation topics that have the potential to contribute to the socio-economic development of Australia:

- ecological sustainability and competitiveness of the mining and mineral (particularly uranium) industries;
- international cooperative research to enhance safety of nuclear facilities and safeguards for nuclear materials;
- environmental dynamics - application of nuclear techniques;
- global climate change - application of nuclear techniques;
- radioactive waste management;
- designer materials; and
- radionuclides and radiopharmaceuticals for the 21st century.

ANSTO's efforts over the forthcoming year will be directed at:

- ensuring completion of the Environment Impact Statement (EIS) for the replacement research reactor; and
- completing, in consultation with the scientific community, the detailed specifications needed for the replacement reactor tender documentation.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

1998-99 is the second year of the funding triennium for CSIRO. CSIRO's budget for the triennium was agreed at the time of the 1996-97 budget. There are no significant budget measures for 1998-99.

CSIRO seeks to secure maximum benefits from R&D for Australia by assembling strong interdisciplinary teams that are internationally competitive and focusing effort on those areas where there are firm signals of strong commercial or community support for CSIRO's research. CSIRO's planned investment of appropriation funds, and of total funds including external earnings, is illustrated in the accompanying table.

Priority areas and planned outcomes for each of 22 Sectors identified by CSIRO for planning purposes are specified in the CSIRO Strategic Research Plan 1997-1998 to 1999-2000. Annual operational plans set out how the Sector plans are put into effect through the work of CSIRO's 23 research Divisions. The operational plans also describe the major activities and outcomes for CSIRO's corporate support areas. CSIRO's Operational Plan for 1998-99 will be published in July 1998.

CSIRO's Planned Investment Profile 1998-99

CSIRO Alliance and Sector	Appropriation Funds	Total Funds[1]
Agribusiness		
Field Crops	6.2%	6.6%
Food Processing	3.9%	4.3%
Forestry, Wood & Paper Industries	3.8%	3.7%
Horticulture	2.3%	2.2%
Meat, Dairy & Aquaculture	9.3%	9.0%
Wool & Textiles	6.5%	7.0%
Environment & Natural Resources		
Biodiversity	4.6%	4.6%
Climate & Atmosphere	4.5%	4.2%
Land & Water	5.0%	4.9%
Marine	5.3%	4.5%
Information Technology, Infrastructure & Services		
IT&T	4.6%	4.3%
Infrastructure	5.5%	5.3%
Measurement Standards	2.1%	1.7%
Radioastronomy	2.8%	2.4%
Services	1.9%	1.8%
Manufacturing		
Chemicals & Plastics	3.8%	4.2%
Integrated Manufactured Products	7.3%	6.9%
Pharmaceuticals & Human Health	4.7%	4.2%
Minerals & Energy		
Coal & Energy	4.3%	4.6%
Mineral Exploration & Mining	4.1%	4.9%
Mineral Processing & Metal Production	6.0%	6.5%
Petroleum	1.9%	2.1%

Source: Calculated from CSIRO Strategic Research Plan, Table 1.

1. Including projected external earnings, total funds available in 1998-99 are estimated to be $720 million.

Australian Government Analytical Laboratories (AGAL)

Key AGAL outcomes forecast for 1998-99 are:

- develop the National Analytical Reference Laboratory as a primary centre of reference for the accuracy and validity of chemical measurements;
- develop new analytical methods for use in the Australian Sports Drug Testing Laboratory for the Sydney 2000 Olympic Games;
- further develop analytical methods for determination of trace impurities in drug seizures, for use by the Australian Federal Police in the National Heroin Signature Profiling Program;
- identify technical barriers to Australian processed food exports, and develop strategies to minimise them; and
- achieve a profitable trading result in commercial services.

The following table provides a financial performance forecast for the Australian Government Analytical Laboratories.

Item	**1997-98 Forecast $('000)**	**1997-98 Estimated Actual $('000)***	**1998-99 Forecast $('000)**
Total operating revenue	29,675	26,761	30,228
Operating profit/(loss)	266	(1,931)	1,032
Revenue per employee #	90	87	105
Costs per employee #	89	93	102
Operating profit/(loss) per employee #	1	(6)	4
Operating profit as % of revenue	1	(7)	3
Return on total assets (%)	1	(7)	3
Return on net assets (%)	1	(27)	21
Debtor turnover days	48	45	42

* Provisional outcome. Remains subject to finalisation and audit examination.
# Calculations = full time equivalent of permanent and contractor staff

Australian Surveying and Land Information Group (AUSLIG)

Key AUSLIG outcomes forecast for 1998-99 are:

- convene a forum of Commonwealth, State and Territory Ministers with responsibility for land information matters to further develop the Australian Spatial Data Infrastructure;
- continue a cyclical program of revision and maintenance of national topographical maps and map data;
- assist with delineation of maritime zones in accordance with the United Nations Convention on the Law of the Sea;

- commission a new satellite laser ranging observatory at Mt Stromlo, ACT;
- acquire and process Global Positioning System and satellite laser ranging data, and ensure availability of data via the Internet;
- maintain a program of acquisition and processing of remote sensing data obtained from earth observation satellites; and
- facilitate private sector value adding to the products derived from these programs.

The following table provides a financial performance forecast for the Australian Surveying and Land Information Group.

Item	1997-98 Forecast $('000)	1997-98 Estimated Actual $('000)	1998-99 Forecast $('000)
Total operating revenue	30.585	30.550	30.000
Operating profit/(loss)	N/A*	1.734	N/A*
Net operatingprofit/loss	N/A*	(0.526)	N/A*
Revenue per employee #	268	301	273
Costs per employee #	268	301	273
Operating profit/(loss) per employee #	N/A*	17	N/A*
Operating profit as % of revenue	N/A*	5.75	N/A*
Return on total assets (%)	N/A*	N/A*	N/A*
Return on net assets (%)	N/A*	N/A*	N/A*
Debtor turnover days	49	53	45

* AUSLIG's commercial activities were sold in July 1997. Total operating revenue now consists of appropriation and sale of public interest products.

Ionospheric Prediction Service - Radio and Space Services (IPS)

Key IPS outcomes forecast for 1998-99 are:

- increase in customer base and customer satisfaction;
- complete the automation of solar data collection and data transfer, with forecast analysis centred at the Sydney Forecast Centre, and automation of ionospheric data collection; and
- achieve acceptance as a World Data Centre in the Australasian region for Sun-Earth data used for space weather services.

PRIMARY INDUSTRIES AND ENERGY

Science and Innovation in the Portfolio Budget

The objective of the research and assessment programs operating within the Primary Industries and Energy Portfolio is to contribute accurate information and high quality scientific and economic research, analysis and advice to assist informed and objective decision-making processes for resources management, ecologically sustainable development and industry competitiveness.

Strong linkages with industry and relevant parts of Government, at both corporate and program levels, are essential to ensure the structural and administrative arrangements for research and development facilitate these outcomes. Portfolio R&D structure and arrangements are designed to take into account Government and industry needs and objectives in the development of research programs, and to facilitate the rapid integration of outcomes from new technologies into industry so it benefits directly from the R&D.

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

- three independent research bureaux; and
- twelve Research and Development Corporations and one Research and Development Council.

These institutional arrangements allow the key stakeholders in the Portfolio's research effort, including producers, scientists, and Commonwealth and State Government policy and program managers, to have an input into research priority setting.

Research Bureaux

The structure of the Department of Primary Industries and Energy includes three independent research bureaux:

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

The research bureaux play a vital role in the conduct of public sector research and provide scientific and economic analysis to assist the process of government. The intention is to ensure that research, scientific, technical support and resource related policy advice to Government is provided in the most efficient way and takes into account the interests of Australia's primary and energy industries and the broader community.

Research undertaken by these bureaux is funded predominantly from consolidated revenue and will total around $73 million in 1997-98. It is generally directed to areas where the external benefits are high, to the more basic lines of research, to research that may have a wide social impact, and where user-pays funding is not generally cost-effective. In addition, the bureaux undertake research on a contract basis for other agencies and industry.

R&D Corporations and Councils

The R&D Corporation model is an alliance between industry and the Government that seeks to increase the economic, environmental and social benefits to industry and the general community with innovation through R&D.

R&D Corporations and Councils were established to:

- attract a higher level of industry expenditure on R&D by providing funding incentives for statutory levies;
- maximise the benefits to both industry and the general community by integrating public and private good R&D;
- achieve effective transfer of technology and a high rate of adoption and commercialisation of research by placing emphasis on the total innovation process;
- cause the research undertaken to be demand driven by involving industry in the setting of R&D priorities; and
- allow R&D Corporations to operate in a commercial environment relatively free from Government control of their R&D investment while making research managers fully accountable to both industry and Government.

There are currently twelve rural industry R&D Corporations, and one rural industry R&D Council:

- Australian Wool Research and Promotion Organisation;
- Cotton R&D Corporation;
- Dairy R&D Corporation;
- Fisheries R&D Corporation;
- Forest and Wood Products R&D Corporation;
- Grains R&D Corporation;
- Grape and Wine R&D Corporation;
- Horticultural R&D Corporation;

- Meat Research Corporation;
- Pig R&D Corporation;
- Sugar R&D Corporation;
- Tobacco R&D Corporation;
- Dried Fruits R&D Council.

The R&D Corporations and the R&D Council are jointly funded by industry and the Commonwealth, with Commonwealth contributions generally matching on a dollar-for-dollar basis levies (or export charges) up to a maximum of 0.5 percent of the industry's gross value of production (GVP). Beyond the GVP limit, no Government funds are provided to match levies (or export charges). Exceptions to these arrangements are the Fisheries R&D Corporation which, in addition to appropriation funding of 0.5 percent GVP, has dollar-for-dollar matching up to 0.25 percent of GVP, and the Forest and Wood Products R&D Corporation which receives one Commonwealth dollar for every two industry dollars matching up to 0.25 percent of GVP.

Three other R&D Corporations in the Portfolio receive the majority of their funding through appropriation:

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

The Energy Research and Development Corporation (ERDC) will continue to meet its commitments that were contracted prior to the 1997-98 Budget. However, the Government has indicated that ERDC will not be appropriated funding for undertaking new projects.

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

In addition to its appropriation, the Rural Industries R&D Corporation also receives funding from industry levies from smaller industries which are matched by the Commonwealth in a similar manner to the industry specific R&D Corporations.

The Corporations and the Council report and are accountable to both their respective industry and either the Minister for Primary Industries and Energy or the Minister for Resources and Energy. As a result they are aware of, and responsive to, the needs of both industry and Government.

1998-99 Science and Innovation Priorities

Australian Bureau of Agricultural and Resouce Economics (ABARE)

In 1998-99, ABARE will:

- further develop the next generation of its global trade general equilibrium model (GTEM) to inform policy development in the leadup to the Fourth Conference of the Parties to the UN Framework Convention on Climate Change at Buenos Aires in November 1998;
- study the economic framework required to establish an international emissions trading system within the terms of the Kyoto Protocol prior to the Fourth Conference of the Parties to the UN Framework Convention on Climate Change at Buenos Aires in November 1998;
- further its current water modeling program to design a set of optimisation network modeling tools which incorporate economic decision making with hydrological and biological processes. The models when integrated with a representation of the water trading market in the southern Murray-Darling Basin will allow a comprehensive economic analysis of different aspects of the economic implications of the COAG water reform agenda; and
- provide economic analyses on the impacts of the changes in forest use in the final year of the Comprehensive Regional Assessment (CRA) process — a key initiative of the National Forest Policy Statement. As part of this process ABARE will continue to enhance FORUM, ABARE's spatial economic model of forest industries.

Australian Geological Survey Organisation (AGSO)

In 1998-99, the Australian Geological Survey Organisation (AGSO) will deliver four categories of client-focused geoscience-based outputs:

- *mineral and petroleum (frontiers exploration) promotion:* these outputs are being delivered to enhance the development of a more productive, competitive and diversified Australian mineral and petroleum exploration industry;
- *land, groundwater and ocean resource management:* these outputs are being delivered to enhance the management of Australia's land, groundwater and ocean resources consistent with the principles of sustainable development;
- *petroleum (conceptual frontiers) promotion:* these outputs are being delivered to enhance the development of a more productive Australian petroleum exploration industry; and
- *geohazards and geomagnetism:* these outputs are being delivered to enhance the development of effective strategies to mitigate the effects of natural geological hazards and to enhance the development of a more competitive Australian mineral and petroleum exploration industry.

Additional funds provided in the 1998-99 budget are being used by AGSO to deliver client-focussed geoscience-based outputs related to onshore minerals promotion and offshore petroleum frontier promotion.

Bureau of Resource Sciences (BRS)

Outlook for 1998-99:

- BRS's National Residue Survey will underpin market access for Australia's agricultural commodities by designing, conducting and reporting on residue monitoring programs to meet importing countries requirements and to enhance national management of residue issues.
- BRS will provide high quality independent scientific advice to assist in policy development on Genetically Modified Organisms (GMOs).
- BRS will provide production and mineral resource assessments to underpin Comprehensive Regional Agreements of Forests for Eden, north east Victoria, Western Australia and south east Queensland and produce the inaugural State of the Forests Report.
- BRS will provide technical analyses and advice for the management of Australian Fisheries and Aquaculture, further developing methods for assessing the impact of fishing and publishing 1998 Fisheries Status Reports.
- BRS will continue to provide high quality independent scientific advice on pest, disease and food safety emergency management, as well as quarantine issues such as risk assessment of proposed imports.
- BRS will continue to monitor and assess the petroleum industry and promote exploration in Australia by producing reference maps, digital data and status reports; managing physical and seismic data lodged under the *Petroleum Search Subsidy Act 1957* and the *Petroleum (Submerged Lands) Act 1967*.
- BRS will provide scientific analysis and advice on petroleum and minerals exploration and development, possible environmental impacts and multiple and sequential land and marine use.
- BRS will continue to provide expert scientific analysis to support Australia's position in international greenhouse negotiations leading up to Conferences of Parties 4 in Buenos Aires. BRS will continue to develop a national carbon accounting system for land-based greenhouse gas emissions and sequestration.
- BRS will continue to provide expert scientific analysis and advice on Drought Exceptional Circumstances in rural Australia using sophisticated computing and spatial analysis techniques.
- BRS will develop capacity to provide social science assessments for portfolio policy and programs.

TRANSPORT AND REGIONAL DEVELOPMENT

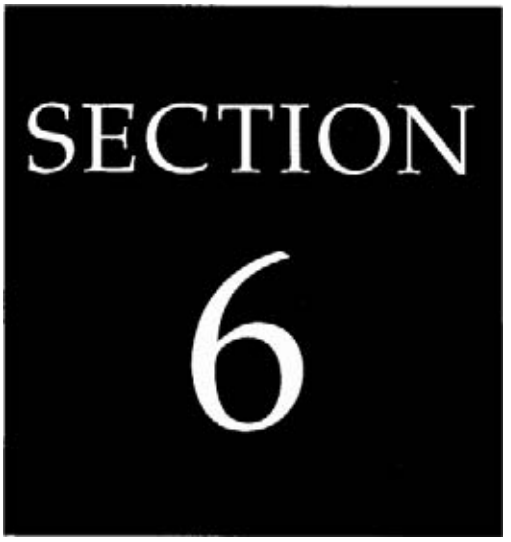
Science and Innovation in the Portfolio Budget

Areas in the portfolio dealing with science and technology relate to road safety and motor vehicle emissions research conducted by the Federal Office of Road Safety, and transport sector research conducted by the Bureau of Transport and Communications Economics, and by ARRB Transport Research Ltd. Expected expenditure outcomes are $6 million for 1997-98 and $4.6 million for 1998-99.

1998-99 Science and Innovation Priorities

Priorities in 1998-99 include:

- implementation of new Australian Design Rules including side impact protection standards for four wheel drive and light commercial vehicles, heavy vehicle braking standards, and emissions standards for petrol and diesel vehicles. Research emissions for LPG, petrol and diesel vehicles and improve vehicle design for pedestrian safety;
- undertaking research and analysis integrated with national strategies: including research on vehicle safety standards; speed management; heavy vehicle driver fatigue; and alcohol and drugs;
- development of common vehicle design rules between Australia and New Zealand, emphasising the role or vehicle standards harmonisation for improved export prospects. Promotion of Australian road safety expertise in APEC and ASEAN region;
- progressing road transport reform, including the national road transport reform program strategy, the second Heavy Vehicle Reform Package and alternate compliance schemes for industry. Implementing the outcomes of the Review of National Road Transport Legislation, as agreed by COAG. Facilitating the development of Intelligent Transport Systems (ITS), including through involvement in developing a National Strategy; and
- finalisation of the review of the Motor Vehicle Standards Act and implementation of a new vehicle certification system with electronic lodgement and processing. Improved client services with the development of a Client Service Charter.



Research Achievements

Introduction

This Section complements the discussion in other sections with an account of recent achievements for the major research agencies and programs. While necessarily selective, these are intended to be illustrative of the discoveries, advances in understanding, improvements in techniques, or steps in commercialisation which are the outcomes of the financial support received.

Where contact details have been provided by contributors, these are included after each achievement.

COMMUNICATIONS, THE INFORMATION ECONOMY AND THE ARTS

National Film and Sound Archive

Role *To increase use and enjoyment of Australia's screen and recorded sound heritage by acquiring, preserving and providing access to a national collection of film, television, video, radio and recorded sound materials.*

The Engineering Research Group of the National Film and Sound Archive is responsible for a variety of support, research and engineering programs for the Archive. The group focuses on future directions in technologies, as well as conservation of audiovisual materials and assessment of current handling and storage practices.

Recent Achievements

Monitoring for audiovisual preservation

A study was finalised at the end of 1997 on the effects of fluctuating storage conditions on the micro-environments inside film cans and tape boxes. The study found that thermal transfer takes place fairly rapidly, often within hours. The time to reach moisture equilibrium is much longer, however, which can lead to significant variations in the actual moisture content of audiovisual materials. The main benefits of the study are the maximising of cost-effectiveness of storage systems, particularly in terms of energy expenses, as well as labour and packaging. A paper was presented at the Association of Moving Images Archivists conference in Washington which brought positive recognition of this work from international audiovisual archives.

{Contact: David Boden, Preservation Branch, National Film and Sound Archive; tel: +61 (0) 2 6209 3055; fax: +61 (0) 2 6209 3165; e-mail: David_Boden@nfsa.gov.au; Internet: http://www.aa.gov.au/nfsa/nfsa.htm/}

DEFENCE

Defence Science and Technology Organisation (DSTO)

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

Recent Achievements

Transportable mobile phone network
A major military exercise involving armed forces from Australia and the United States successfully demonstrated the world's first deployable personal communication system network. The mobile wireless local area network is the first defence and smallest Global System for Mobile Communications (GSM)-based network in the world. It is capable of completely stand-alone operation. Industry (OPTUS and Ericsson) is developing it into a complete information network, capable of instantaneously meeting the entire telephony and data communications services requirements of a deployed headquarters.
{Contact: Dr Tony Bedford, Defence Science and Technology Organisation;
tel: +61 (0) 8 8259 5654; fax: +61 (0) 8 8259 7110;
e-mail: tony.bedford@dsto.defence.gov.au}

Ballistic missile detection
The United States Ballistic Missile Defense Organisation (BMDO) and DSTO launched a series of four sounding rockets from a temporary launch site on the coast of North West Australia (Anna Plains) in September 1997 as part of a collaborative program. These trials demonstrated the capability of a range of systems, including high frequency radars and electro-optical sensors, in detecting ballistic missiles during the initial boost phase.
{Contact: Dr Bruce Ward, Defence Science and Technology Organisation;
tel: +61 (0) 8 8259 5479; fax: +61 (0) 8 8259 6673;
e-mail: bruce.ward@dsto.defence.gov.au)

Dummy leg helps landmine research
DSTO has developed an instrumented model of a human leg that can both reproduce the real life incapacitation and record the characteristics of the shock wave produced by a landmine explosion. DSTO is using the instrumented leg to improve the survival of soldiers as part of research into methods of absorbing the shock from an explosion. This can be done through the use of shock decoupling of vehicle floors and the development of shock absorbing boots. DSTO is taking patent action on the leg design and

materials. The United States, the United Kingdom and Canada are currently discussing transfer of technology under The Technical Cooperation Program.

{Contact: Mr Mick Chick, Defence Science and Technology Organisation;
tel: +61 (0) 8 8259 5258; fax: +61 (0) 8 8259 6247;
e-mail: mick.chick@dsto.defence.gov.au}

Heat sensing images

DSTO has developed an Airborne Thermal Imaging Sensor system which can acquire high-quality, temperature-calibrated infrared images of various objects such as aircraft, vehicles and structures. The system uses low-cost infrared imager technology developed by DSTO combined with a state-of-the-art infrared video camera, mounted in a pod that can be carried by an aircraft. The Airborne Thermal Imaging Sensor can be adapted to civil applications such as monitoring faults in transmission lines or observing bush fires.

{Contact: Mr Bill Dickson, Defence Science and Technology Organisation;
tel: +61 (0) 8 8259 6405; fax: +61 (0) 8 8259 5616;
e-mail: bill.dickson@dsto.defence.gov.au}

Improved combat gear for soldiers

DSTO has developed two improved items of individual protection for soldiers. They are a lightweight ballistic protection vest and a chemical and biological combat suit (CBCS). Both provide the same protection as existing protective items but possess increased comfort and wearability properties, and, in the case of the CBCS, significantly reduce the risk to wearers of heat illness. DSTO has entered into a licence agreement with a United Kingdom firm to produce the CBCS, using fabrics made and supplied by an Australian company.

{Contact: MrDenys Amos, Defence Science and Technology Organisation;
tel: +61 (0) 3 9626 8474; fax: +61 (0) 3 9626 8410;
e-mail: denys.amos@dsto.defence.gov.au}

Corrosion in aircraft

DSTO in collaboration with the Defence Evaluation and Research Agency, Farnborough, the United Kingdom, has developed a new capability to monitor corrosion in Royal Australian Air Force (RAAF) aircraft. The technique is based on transient eddy current and allows measurement of material loss due to corrosion in multi-layer metallic aircraft structures, whereas present techniques have been limited largely to single layers. Several other techniques for the detection and monitoring of corrosion in Defence platforms have also been developed, including a RAAF corrosivity monitor for airframes.

{Contact: Dr John Ritter, Defence Science and Technology Organisation;
tel: +61 (0) 3 9626 8211; fax: +61 (0) 3 9626 8210;
e-mail: john.ritter@dsto.defence.gov.au}

New colours for the Navy

DSTO has developed advanced coatings and coating systems for applications aboard naval vessels. Specific developments include high performance two-pack polyurethane topcoats in a low gloss finish, flexible

non-chalking non-skid deck coatings, low solar absorbing paints to reduce solar heating, abrasion-resistant tank coatings and alternative paint colours on the external topside surfaces to reduce detectability in Australian waters. DSTO has trialed these systems successfully on naval patrol boats resulting in significant improvements in durability, corrosion protection and stealthiness.

{Contact: Dr Lindsay Wake, Defence Science and Technology Organisation;
tel: +61 (0) 3 9626 8433;fax: +61 (0) 9626 8210;
e-mail: lindsay.wake@dsto.defence.gov.au}

Hearing with fibre optics

DSTO has developed fibre optic hydrophones suitable for use in acoustic arrays. Fibre optic hydrophones have a number of advantages over ceramic and polymer hydrophones in that they require no electrical power and are much lighter in weight. These hydrophones have a very high dynamic range which allows a weak target to be detected against high background noise. Another feature of the hydrophones is their ability to determine the direction of the sound source.

{Contact: Dr Eric Magi, Defence Science and Technology Organisation;
tel: +61 (0) 8 8259 5880; fax: +61 (0) 8 8259 5139;
e-mail: eric.magi@dsto.defence.gov.au]

Improvements in sonar operations

In April 1997, DSTO conducted a major international trial in Australian waters to demonstrate a new processor designed for multi-static sonar operations. The trial used small underwater sound sources with a number of passive sensors, in this case Barra sonobuoys. The processor, which has attracted international attention because of its high performance and suitability for helicopter and maritime patrol aircraft operations, is being developed by DSTO together with Australian industry.

{Contact: Dr Lesley Kelly, Defence Science and Technology Organisation;
tel: +61 (0) 8 8259 6491; fax: +61 (0) 8 8259 7115;
e-mail: lesley.kelly@dsto.defence.gov.au}

EMPLOYMENT, EDUCATION, TRAINING & YOUTH AFFAIRS

Research activity in universities is supported by all of the programs listed in Section 5 as well as funds from other sources including Commonwealth Government agencies, State Governments, business, private non-profit organisations and international sources. Any given group of researchers is likely to receive support from several sources, including more than one ARC/DEETYA program. The recent research achievements listed below have all benefited from ARC/DEETYA research support programs and are arranged by broad field of research from the Australian Standard Research Classification. Given the increasingly multidisciplinary nature of research and technology, some activities involve major inputs from more than one major field of research. In most cases, researchers themselves have indicated the appropriate field of research classification for each research achievement.

Recent Achievements

Medical and Health Sciences

Diagnostic test for *Cryptosporidium* — human or animal?
Thousands of Australians visiting developing countries each year need to take stringent precautions to prevent gastrointestinal illnesses. Researchers in Murdoch University's Institute for Molecular Genetics and Animal Disease have developed a novel DNA test to detect the waterborne parasite *Cryptosporidium parvum*, small enough to pass through the water filters of most water authorities and resistant to chlorination procedures for disinfecting water. The test is a significant advance on time-consuming and insensitive conventional techniques and is an international first in that it can differentiate directly between human and animal sources of *Cryptosporidium.* The University has filed a patent on the invention.
{Contacts: Professor Andrew Thompson, Murdoch University; lei: +61 (0) 8 9360 2466; Dr Una Morgan; tel: +61 (0) 8 9360 2457}

New strategy for preventing childhood middle ear infections
Acute middle ear infection (otitis media) can affect all ages, but is a particular problem in young children and results in significant pain and hearing loss. Acute otitis media is currently treated with antibiotics; however, this does not prevent reinfection and frequently does not resolve the accumulation of fluid in the middle ear following infection. Research centred at the University of Canberra has identified protective antigens, and in combination with some innovative molecular biology, has produced a novel formulation for an oral vaccine to prevent bacterial middle ear infections.

This vaccine technology will soon be in phase I clinical trials in Australia.
{Contact: Professor Allan Cripps, University of Canberra; tel: +61 (0) 2 6201 5047}

Exercise rehabilitation
After injury or surgery on a limb, immobilisation can bring muscle atrophy and strength reduction. Interestingly, strength training on one limb has a cross-educational effect on the untrained other limb. A project at Southern Cross University aimed at reducing the recovery period in these cases has shown, with healthy subjects, that four weeks of isometric stimulation training on one limb increased the contractile strength of the other limb's untrained muscles.
{Contact: Dr A Davie & Dr Shi Zhou, Southern Cross University; tel: +61(0) 2 6620 3236}

Chronic Fatigue Syndrome and exercise
Chronic Fatigue Syndrome (CFS) is a debilitating disorder with no known cause and little effective treatment available. Researchers at Southern Cross University have conducted studies which have investigated the role of exercise in the condition. The studies involved the use of treadmill walking and used both evening primrose oil and caffeine to modify responses to the exercise. The finding that exercise alone had significant effects adds to anecdotal evidence and suggests that moderate, graded exercise which improves capillary blood flow has a role in the management of CFS.
{Contact: Dr R P Weatherby, Southern Cross University; tel: +61 (0) 2 6620 3671}

Falls in the elderly
Falling is the single greatest cause of accidental death in people over 65 years of age. In a 12 month intervention study conducted at Southern Cross University, researchers have determined that a specially designed resistance training program aimed at increasing power output, as well as the size and strength of muscles, is effective for improving walking speed and resistance to falling. Consideration of the findings of this study in the design of exercise programs for older people may reduce the incidence of falling and thus the financial, social, and personal cost of falls in the elderly.
(Contact: R Newton, Southern Cross University; tel: +61 (0) 2 6620 3234}

Test for genetic predisposition to obesity
Obesity is a common nutritional disorder that affects approximately 30% of adults in the Western world. Researchers at Griffith University have identified a gene which indicates a predisposition to obesity. ADNA marker for the low density lipoprotein receptor gene has been shown to have a significant association with obesity and it is potentially suitable for matched therapeutic development. The detection method has been patented in the United States.
{Contact: Dr Lyn Griffiths, Griffith University; tel: +61 (0) 7 5594 8664}

Genetic link to migraine
Research at Griffith University has identified a predisposing gene which will enable health professionals to detect individuals who are predisposed to migraine, a condition which has significant adverse impacts on individuals

worldwide. The detection of this predisposition should eventually enable more accurate diagnosis and the formulation and implementation of preventative and mitigative treatment regimes by health professionals. The detection method is the subject of a patent application.
{Contact: Dr Lyn Griffiths, Griffith University; tel: +61 (0) 7 5594 8664}

Blood cell hormone could aid in cancer treatment
Cancer patients undergoing chemotherapy often face life-threatening side effects — the treatment designed to kill cancer cells can also damage healthy cells. Researchers at the Centre for Developmental Cancer Therapeutics, have performed the world's first clinical study of the new blood cell hormone, called Megakaryocyte Growth and Development Factor, or MGDF. The addition of MGDF to a cancer patient's treatment may allow doctors to increase the number of rounds and intensity of chemotherapy — improving the chances of killing the cancer.
{Contact: Dr Glenn Begley, Department of Medical Biology, Walter and Eliza Hall Institute of Medical Research, University of Melbourne; tel: +61 (0) 3 9344 4000}

Glaucoma breakthrough
University of Melbourne researchers have made a vital contribution to the identification of a gene responsible for glaucoma — an eye disease affecting up to three percent of Australians over 40. The identification of the TIGR gene is a major medical and scientific breakthrough which gives insight into the cause of glaucoma and should lead to the development of accurate and inexpensive tests to assist in early intervention.
{Contact: Dr David Mackey, Department of Ophthalmology, University of Melbourne; tel: +61(0) 3 9655 9564}

Motor Neurone Disease
Researchers at the Prince of Wales Medical Research Institute, University of New South Wales, have been examining changes in excitability of nerve fibres in patients with Motor Neurone Disease. Abnormalities were found that contribute to one of the early characteristics of the disease, namely spontaneous twitching and cramps in muscles. An excess leakage of sodium into nerve fibre helps trigger spontaneous activity. The task now is to determine how to control this leak of sodium into the nerve fibre and, presumably into its nerve cell. This could help alleviate some of the distressing symptoms of the disease.
{Contact: Associate Professor David Burke, Prince of Wales Medical Research Institute, University of New South Wales; tel: +61 (0) 2 9382 2671}

Older persons at risk of falls
In a study aimed at identifying older persons at risk of falls undertaken by researchers at the Prince of Wales Medical Research Institute, University of New South Wales, non-invasive tests were carried out on populations of older people living in the community or in institutions. The groups were followed up for 12 months to ascertain which subjects suffered falls. The findings indicate that there are five key variables that increase the risk of falling: reduced visual contrast sensitivity; poor sensation in the legs; weak quadriceps strength; slow reaction time; and increased body sway. In

addition, the tests predicted the people who fell with an accuracy of over 75%.

{Contact: Dr Stephen Lord; Prince of Wales Medical Research Institute, University of New South Wales; tel: +61 (0) 2 9382 2721}

Grasping for insight into the brain

Researchers at La Trobe University's School of Physiotherapy, are studying the body components involved in the deceptively ordinary movement of grasping. Analysing the detailed manner in which the arm moves also gives us insights into the brain mechanisms responsible for executing these movements. Data have been collected over more than nine years using a special infrared camera to record hundreds of subjects of all ages reaching to grasp an object. The database provides information of how the brain coordinates the arm and is being used to test patients with Parkinson's Disease, a debilitating illness that leads to gradual degeneration of cells at the base of the brain. The camera test can also be used to determine how blind people move and why older people move carefully towards objects.

(Contact: Dr Kerry Bennett, School of Physiotherapy, La Trobe University; tel: +61 (0) 3 9479 5785}

Testing for risk of blood vessel disease

The formation of fatty deposits in blood vessels (arteriosclerotic plaques) causes vessel narrowing and blockage, resulting in major health problems. The risk of plaque formation is thought to be partly determined by the efficiency with which fatty material absorbed from a meal, is removed from the bloodstream by specialised molecular uptake mechanisms. Researchers at the University of Western Australia have developed a number of methods for assessing this clearance efficiency in animal models and human subjects. The research is planned to lead to the development of a method of assessing patients for their risk of developing arteriosclerosis.

{Contact: Professor Trevor Redgrave, Department of Physiology, University of Western Australia; tel: +61 (0) 8 9380 3313}

Magnetic particles in brain cells

A new cell extraction process developed by researchers at the University of Western Australia and the Swiss Federal Institute of Technology has led to the discovery of specialised cells in the human brain. These very rare cells contain large amounts of tiny magnetic crystals and may play an important role in the interaction of the brain with environmental electromagnetic fields, such as those produced by some electrical devices. Other experimental evidence uncovered by the group indicates that the region of the brain in which these cells are found may be activated in some epileptic patients by the application of relatively weak magnetic fields. These results may have important implications for public health and the diagnosis and treatment of some neurological disorders.

{Contact: Dr Jon Dobson, Department of Physics, University of Western Australia; tel: +61 (0) 8 9244 2738}

Men and women smokers respond differently to death threats

Many health promotion appeals focus on the consequence of premature death arising from risk behaviours like smoking (lung cancer), eating too much fat (heart disease), driving too fast ("speed kills") or over exposure to the sun (melanoma). However, there has been little research to support this emphasis on premature death as an effective threat. A recent study by researchers at the University of Western Australia and Edith Cowan University showed that men responded more to death threats, whereas women responded more to disablement threats. There was one exception. Women responded more to death threats relating to the consequence of the death of their loved ones. The research also showed that overall, disablement threats are more effective than premature death threats.

{Contact: Associate Professor Rob Donovan, Graduate School of Management, University of Western Australia; tel: +61 (0) 8 9380 1437}

A novel approach to spinal cord injury

A research group in the University of Tasmania has developed a new model of spinal injury which uses the only experimental colony in Australia of the marsupial species *Monodelphis domestica*. The group has shown that injury in the first complete spinal cord transection in the first two weeks of life is followed by a substantial degree of normal development and recovery, whereas at older ages this does not occur. This was the first demonstration of such a substantial degree of recovery from a major spinal cord injury in a mammal. This work enables the investigation of the properties of the immature nervous system which allow it to recover from injury, and application of that knowledge in the injured, mature nervous system.

{Contact: Professor Norman Saunders, Division of Anatomy & Physiology, University of Tasmania; tel: +61 (0) 3 6226 2678}

Glaucoma

The Glaucoma Inheritance Study in Tasmania (GIST) is aiming to find the genes that cause the eye disorder, glaucoma. The GIST is examining the premise that the principal factor used to detect glaucoma should be family history. During 1997, together with collaborators from the University of Iowa, GIST discovered one gene responsible for glaucoma, the GLC1A gene. The team have now embarked on an ambitious project to screen every patient in Tasmania with glaucoma for the presence, or absence of mutations in the GLC1A gene. This study, unique in the world, will potentially identify the number of gene carriers in the population with glaucoma and then the number of these patients who actually have familial forms of the disease. The GIST is conducting more research to identify other genes responsible for other forms of glaucoma.

{Contact: Professor T Dwyer, Menzies Centre, University of Tasmania; tel: +61 (0) 3 6226 7703}

Early embryo growth

A Brisbane research team has made a major advance in the fundamental understanding of how the embryo grows in the crucial first few days of life. A combined University of Queensland and Queensland University of Technology team has found evidence suggesting a role for growth hormone

(GH) in development of the embryo as from the time of fertilisation, challenging the widely-held view that embryonic and foetal growth occur independently of GH. The findings have attracted intense international interest and have important medical and veterinary applications, for example, improving the viability of the developing egg and the success rate for in-vitro fertilisation in humans and animals.

{Contact: Professor Mike Waters, Department of Physiology & Pharmacology, University of Queensland; lei: +61 (0) 7 3365 2607}

Management of stomach ulcers

The bacterium *Helicobacter pylori*, an Australian discovery (Barry Marshall, 1983), is now known to be responsible for most cases of stomach ulcer and is implicated in many stomach cancers. Analysing a sample of the patients' breath is acknowledged as the best method to diagnose infection. However, it is expensive and involves complex instrumentation. Researchers at the University of Wollongong have developed an instrument that costs only a fraction of the current technology while offering the same diagnostic precision. Australian and international patents on the method are being secured and the University has entered into an R&D and commercialisation contract, with release onto the global market expected during 1999.

{Contacts: Dr Michael Esler & Associate Professor David Griffith, Department of Chemistry, University of Wollongong; lei: +61 (0) 2 4221 3555}

State of the art knee replacements

Using a tough ceramic developed by the CSIRO, researchers at the University of Technology, Sydney, have developed high-tech knee replacements which are more compatible with the body and last much longer than existing replacements. A unique aspect of the Australian design is that while several of the components of the knee joint prosthesis can be mass produced, it allows a custom fit for each patient's particular therapeutic requirement. Another important advantage of this procedure is that whereas in traditional total knee replacement surgery the cruciate ligaments are discarded, the ceramic knee replacement allows the retention of all ligaments, so the knee joint will be more stable.

{Contact: Dr Besim Ben-Nissan, University of Technology, Sydney; tel: +61 (0) 2 9514 1784}

Anti-parasite drug

Researchers at the University of Technology, Sydney (UTS) have identified an important enzyme in the replication of the parasites *Toxoplasma* and *Leishmania.* The diseases Toxoplasmosis and Leishmaniasis are major causes of death in immunocompromised patients. Based on the discoveries made at UTS, specific enzyme inhibitory drugs could be developed to treat these parasitic infections.

{Contact: Professor Alan Johnson, University of Technology, Sydney; tel: +61 (0) 2 9514 4063}

Biological Sciences

Test for lupin disease

As part of the fight to combat the fungal disease, lupin anthracnose, which appeared two years ago in Australian lupin crops, workers at the Western Australian State Agricultural Biotechnology Centre have developed a highly sensitive test for presence of this fungal pathogen in seed samples. The test can detect one infected seed in a 10,000 seed sample. It is now being offered commercially to farmers, and forms an important part of the overall package to control this potentially devastating disease.

{Contact: Associate Professor Mike Jones, Western Australian State Agricultural Biotechnology Centre; tel: +61 (0) 8 9360 2424}

Genetically engineered yellow lupin

The world's first transgenic yellow lupins have been developed at the Western Australian State Agricultural Biotechnology Centre and are now undergoing glasshouse and screenhouse tests to identify virus resistant lines for this potentially valuable new crop. There are about 300,000 hectares of acid soil in the eastern wheatbelt of Western Australia which are not suited for growth of narrow-leafed lupins, the main grain legume grown in Australia. However, the acidic soil is suitable for growth of yellow lupins, and this new crop is being developed by collaboration between Murdoch University, Agriculture WA and CLIMA. One trait needed for the success of the new crop is resistance to bean yellow mosaic virus.

{Contact: Associate Professor Mike Jones, Western Australian State Agricultural Biotechnology Centre; tel: +61 (0) 8 9360 2424}

Simple remedy for pig disease

Researchers at Murdoch University have identified a simple, effective — and unexpected — drug free method of disease prevention that could save the Australian pig production industry millions of dollars annually. They have found that a diet low in soluble fibre (for example, cooked rice and animal proteins) protects pigs from swine dysentery. The research has international implications, with swine dysentery widespread throughout the world. In Western Australia alone, a survey conducted in the 1980s revealed that swine dysentery was present in up to one-third of pig herds. While control of swine dysentery was possible through management procedures supplemented by drugs and vaccines, efforts were hampered by increasing resistance of pathogens and the limitations of vaccines.

{Contact: Associate Professor David Hampson, Murdoch University; tel: +61(0) 8 9360 2287}

Simple test kit for cyanide in cassava

Cassava is a staple food for 500 million people in the tropics. Researchers at the Australian National University have developed a simple test kit to determine the amount of cyanide compounds (cyanogens) in cassava roots and cassava flour. The cyanogens produced by the plant are a health hazard particularly in tropical Africa, South America and parts of Asia. The picrate field test requires only a small amount of water for its operation and field testing with collaborators in Mozambique showed cyanogen levels up to 20

times the World Health Organisation safe level. The Australian Centre for International Agricultural Research supports the research and has agreed to provide the kit free to developing countries where there is a need.
{Contact: Dr J Howard Bradbury, Division of Botany and Zoology, Australian National University; tel: +61 (0) 2 6249 0075}

Bid to save Orange-bellied parrot
The Orange-bellied parrot is one of Australia's endangered species; less than 200 wild birds remain. Environmental scientists at the University of Melbourne have been working to improve the conservation and rehabilitation of the species. The group has pieced together information about the parrot's requirements for survival and this information is used with appropriate land management decisions to secure the long term future of this endangered species.
{Contact: Dr Mark Burgman,Department of Environmental Science, University of Melbourne; tel: +61 (0) 3 9344 7151}

Restoration of habitats for rare coastal species
Many of Australia's coastal invertebrate species are unique to our continent, but are rare. Some are found in sparse, patchy habitats such as intertidal boulder-fields. But boulders are overturned by people seeking bait and food. So near urban centres, habitat is often disturbed, threatening the diverse rare invertebrates that live there. Dr Gee Chapman's research has identified patchiness in the distribution of many coastal species of molluscs (snails and limpets). Her recent experiments have manipulated hundreds of boulders to create new habitat. Results are preliminary, but exciting. Numerous rare species have colonised artificial habitat and created the prospect for long-term conservation of some of Australia's least-known and rarest inhabitants.
{Contact: Professor A J Underwood, Centre for Research on Ecological Impacts of Coastal Cities, University of Sydney; tel: +61 (0) 2 9351 2222}

Why bandicoots are successful omnivores
Special features of the digestive tract of several small mammalian herbivores, such as rabbits, include a Colonic Separation Mechanism (CSM) which separates large from small particles of food residues. Researchers have found that a CSM is a feature of even a group of omnivorous marsupials, the bandicoots. Bandicoots have a rather simple digestive system anatomically. In summer they are primarily insectivorous, but in winter when insects are scarce they eat mainly plant and fungal material. This dramatic shift in diet between the seasons is only possible because a CSM allows the bandicoots to process much larger quantities of plant matter than would be expected for a small mammal with a simple digestive tract. In their most recent experiments, the group showed that a CSM was only switched on when the fibre content of the diet exceeded a certain minimum. The research explains why bandicoots are so successful in nutritionally unpredictable environments such as sandy heaths, which are regularly completely burnt out by wild fires.
{Contact: Professor I DHume, School of Biological Sciences, University of Sydney; tel: +61 (0) 2 9351 2222}

Preventative management of aquatic ecosystems

The toxins of cyanobacteria, or blue-green algae, kill native and domestic animals and cause sickness and cancer in humans. Cyanobacteria regularly proliferate into so-called "algal blooms" in Australian rivers, lakes, and water supply reservoirs. These toxins pose a threat to both recreational and drinking water supplies.

Researchers in the School of Microbiology and Immunology at the University of New South Wales have isolated and characterised a gene in cyanobacteria which is responsible for the production of these toxins. This finding is leading to the indentification of the environmental conditions which lead to toxic algal blooms. More importantly, as a result of this research funded by the ARC and CRC programs, it is now possible to detect potentially toxic cyanobacteria by screening water samples for this gene, before a full-scale bloom has developed and the toxins released. This enables early warning and preventative management of aquatic ecosystems.

{Contact: Dr Brett Neilan, University of New South Wales; tel: +61 (0) 2 9385 3235}

Dispersal of reef fish larvae

By utilising a unique marking and tracking method for larval fish, researchers at James Cook University have refuted the assumption that larval reef fish disperse away from their natal reefs. Fluorescent compounds were used to mark otoliths (earbones) of developing embryos which were subsequently allowed to hatch and disperse. A significant number of marked juveniles returned to their natal reef. Current reef management strategies assume that protected reef areas will supply exploited reefs with a regular supply of larval recruits, thus sustaining fisheries production. The results of this research show that the opposite is often the case, and thus management strategies need to be reworked to prevent further depletion of sensitive areas of the reef.

{Contact: Dr Geoff Jones, Marine Biology, James Cook University;
tel: +61 (0) 7 4781 4111}

Healthier crayfish

Researchers at James Cook University have developed and rigorously tested a protocol that allows the production of virus-free Redclaw crayfish. Prior to implementation of the protocol, north Queensland crayfish farms could experience mortality rates of up to 80% due to various viruses. The University has also established a virus-free stock for use by farmers in the aquaculture industry. Research has allowed the discovery of four new viruses from freshwater crayfish, one of which was successfully controlled, putting Australia at the forefront of crayfish virus investigations.

{Contact: Dr Leigh Owens, Microbiology and Immunology, James Cook University;
tel: +61 (0) 7 4781 4111}

New method for advance warning of extinction

James Cook University researchers have pioneered the application of a new technique for measuring the health of populations of frogs and other animals. Developmental stability analysis (DSA) involves simple measurements that can be taken from living animals during field studies to

measure how much stress they have experienced during their growth and development. Researchers used DSAto determine that two populations of rainforest frogs that underwent severe declines in numbers in the early 1990s, were exposed to increased environmental stress at least two years before populations crashed. This new information will aid in the search for the causes of these declines. The results of this research have changed the way that amphibian populations are monitored worldwide.

{Contact: Associate Professor Ross Alford, Zoology and Tropical Ecology, James Cook University; tel: +61 (0) 7 4781 4111}

Using water wisely

Ground water represents a renewable resource for industrial, horticultural and domestic use. Demand on ground water throughout Australia — the driest inhabited continent in the world — is increasing dramatically. Demand is also increasing globally. The question that has to be addressed is: to what extent can ground water be used without damaging ecosystems that are reliant upon ground water for their functioning? Many ecosystems use ground water to a greater or lesser extent, including riparian systems, savannas, monsoon vine forests and paperbark swamps. This project at the Northern Territory University is applying a multi-disciplinary approach to this problem in north Australia. Measurements of canopy water use, tree water use, ground water depth and ground water chemistry are revealing the importance of ground water to ecosystems in the Northern Territory. This new knowledge is being incorporated into models used for land and water management systems and planning for urban development. The techniques and methodologies are applicable to the rest of Australia and overseas.

{Contact: Associate Professor Derek Eamus, School for Biological and Environmental Sciences, Northern Territory University; tel: +61 (0) 8 8946 6716}

Survival of threatened marsupials

Many Australian animals face long periods of starvation. Survival of these animals becomes dependent on the production of blood sugar from their own body's protein reserves, which are gradually depleted. One model study being undertaken by scientists at the University of Western Australia is determining the levels of protein and nitrogen turnover in honey possums. Rapidly-disappearing *Banksia* woodlands may be causing stress on these tiny marsupials which feed exclusively on pollen and nectar from *Banksia* blossoms. The data will help determine this animal's needs and the extent of its reliance on *Banksia* woodlands. The study also draws on a new method of nitrogen determination which is highly sensitive and involves tissue micro-samples being analysed on ANSTO's Tandem Linear Accelerator.

{Contact: Professor S D Bradshaw, Zoology Department, University of Western Australia; tel: +61 (0) 8 9380 3838}

Ballast water heat treatment

The transport of unwanted marine organisms via ship's ballast water is receiving increasing recognition as a global environmental problem. Species which have been introduced into Australia by this means include seaweeds, toxic dinoflagellates, crabs, starfish, molluscs, fanworms and fish. This concern is reflected, for example, by the intention of the International

Maritime Organisation to introduce mandatory ballast water guidelines as an annex to MARPOL in the year 2000.

During 1997, scientists from the University of Tasmania in collaboration with BHP shipping engineers successfully pioneered the use of ballast water heat treatment on board the bulk carrier *Iron Whyalla* (56,325 tonnes ballast water capacity). Heated salt water from the main engine cooling circuit, normally discharged back into the ocean, was rerouted into the test ballast water tank and allowed to overflow on to the deck via breather pipes. The temperatures achieved (37-38°C after 24-30 hours) effectively killed all zooplankton and most phytoplankton (including toxic dinoflagellate cysts). Other treatment options evaluated previously by these same workers include mid-ocean reballasting (the complete emptying and refilling of tanks) or mid-ocean ballast exchange (flushing of three tank volumes to exchange 95% of original water).

{Contact: Associate Professor Gustaaf Hallegraeff, School of Plant Science, University of Tasmania; tel: +61 (0) 3 6226 2623)

Transmission of caliciviruses

The Department of Crop Protection at the University of Adelaide, in collaboration with CSIRO, has shown that caliciviruses can be transmitted by insects. Sensitive diagnostic tests were developed to identify single virus particles in insects fly spots, which were recognised as the major potential source of the virus for oral or conjunctival transmission of the calicivirus to rabbits.

{Contact: Dr J Brooker, Department of Animal Science, University of Adelaide; tel: +61 (0) 8 8303 7357}

Gene research deal with US researchers

The University of Queensland's technology transfer company, UniQuest Limited, has signed a licensing agreement with one of the world's leading independent technology management organisations, covering intellectual property for a gene controlling formation of bone and cartilage. The gene was discovered in 1995 by a team led by a principal research fellow with the University's Centre for Molecular and Cellular Biology. Further research could result in the gene's practical application in medicine, for example in cartilage reconstruction. The agreement, signed with Research Corporation Technologies (RCT) of the United States, covers Sox-9, a pivotal gene in skeletal development in vertebrates.

{Contact: Dr Peter Koopman, Centre for Molecular and Cellular Biology, University of Queensland; tel: +61 (0) 7 3365 4491}

Cell evolution

University of Queensland researchers have discovered a new distinctive form of cell organisation within bacteria with possible implications for cell evolution. This form of cell organisation was previously believed not to exist within bacteria but is analogous to the type found within the cells of animals, plants, fungi and protozoans. The discovery has implications for cell evolution because it shows bacteria can package DNA in a separate compartment within the cell — like cells of more complex forms of life. The findings were published by *Microbiology*, an internationally prestigious

journal of the United Kingdom's Society for General Microbiology. The discovery provides a better understanding of the diversity of bacteria in terms of structure. It may well be an evolutionary model for the ancestral origins of animal, plant, protozoan and fungal cells.
{Contact: Dr John Fuerst, Department of Microbiology, University of Queensland; tel: +61 (0) 7 3365 4643}

Predicting birds prone to extinction
A University of Queensland researcher has developed a computer model to identify and predict the world's most endangered birds. The collaborative work, involving researchers from the University's Department of Zoology and the Institute of Zoology in London, began by compiling one of the world's largest and most detailed biological databases on birds.

Funded by the United Kingdom's National Environmental Research Council, the researchers have so far compiled information on 3,362 of the world's 9,500 known species. An index quantifying each species' importance in terms of representing biological diversity has also been developed. Each species is given a number in a scale culminating in certain species being classified as being "highly vulnerable and highly unusual". For the purposes of the study, a bird's unusualness is defined as its importance to overall bird biodiversity. Researchers intend that the computer model will be used by conservation groups to guide selection of species for protection.
{Contact: Dr Ian Owens, Department of Zoology, University of Queensland; tel: +61 (0) 7 3365 4823}

Applied Sciences and Technology

Natural flavouring
Often a large number, even hundreds, of different compounds are involved in the overall taste of a natural product. Amethod developed by a University of Queensland researcher for extracting flavour from natural beverages is set to revolutionalise current food and drink flavouring practices based on synthetic manufacture (for example, coffee, orange juice). The extraction process selectively adsorbs flavour compounds from natural beverages onto a porous solid. It also allows producers to select the fractions of natural flavours adsorbed from beverages. Companies therefore have control of the end strength of flavour concentrates. Industrial applications would involve companies using the process to produce either liquid flavour concentrates for sale to food and beverage manufacturers or using the flavours to produce end products themselves (for example, flavoured ice-cream).
{Contact: Dr Suresh Bhatia, Department of Chemical Engineering, University of Queensland; tel: +61 (0) 7 3365 4263}

Understanding salt flats
The benefits of vast areas of salt flats on Australia's northern coast have in the past been a mystery but novel techniques developed in Physics at James Cook University have shown that salt flats are crucial in maintaining high

nutrient levels in mangrove creeks. Electromagnetic conductivity sensing technology was utilised to measure groundwater flows in the salt flats, comprehensive measurements of evaporation over salt flats and detailed surface water fluxes have shown that the flats provide a continuous source of nutrients to mangrove creeks rather than a sporadic one, as rivers do. Results will aid the management of mangrove areas which are an important nursery ground for many species of fish and crustaceans.

{Contact: Dr Peter Ridd, Department of Physics, James Cook University; tel: +61 (0) 7 4781 4111}

Quiet light

Researchers at the University of Canberra have devised and patented a novel quantum electronic device with potential applications in optical computing, communications and instrumentation systems. The patent is generic and foreshadows a new generation of optoelectronic devices which utilise "quiet light" — laser light from which the quantum noise has been stripped. Development rights to the invention have been taken up by industry leader Hamamatsu Photonics KK. The concept arose out of fundamental studies in quantum electronics at the University of Canberra. The research has been supported under DEETYA's Targeted Institutional Links Program and the Australian Research Council's Large Grant Program.

{Contact: Professor Paul Edwards, University of Canberra; tel: +61 (0) 2 6201 5111}

New battery materials

A University of Wollongong team of reseachers has developed a new high energy battery alloy which improves the storage capacity and life of rechargeable batteries. The new alloy is based on a class of compounds called metal hydrides which store energy in the form of hydrogen atoms packed between the metal atoms of certain metals or alloys. During the battery charging and discharging processes, hydrogen is forced into the electrode material and then removed. The successful research at Wollongong has shown that magnesium alloys can be made into electrodes which will not only be useful at ordinary temperatures, but will have a useful cycle life and extremely high capacity. Patent protection has been sought in order to enable the University to negotiate with parties interested in exploiting the technology for the manufacture of rechargeable batteries in the future.

{Contact: Professor S X Dou, Director, Institute for Superconducting & Electronic Materials, University of Wollongong; tel: +61 (0) 2 4221 5730}

Direct reduction of manganese alloys from Australian ore

Researchers in the School of Materials Science and Engineering at the University of New South Wales, have for the first time, reduced manganese oxide and manganese ore to the metallic state (carbide) by using the reducing CH_4-H_2~Ar gas mixture . This opens new opportunities for energy-efficient and environmentally-friendly technology. On the basis of the findings of this research, a provisional patent has been prepared.

{Contact: Associate Professor Oleg Ostrovski, University of New South Wales; tel: +61 (0) 2 9385 5956}

Satellite technology helps remote resource managers

Staff and postgraduate students at Northern Territory University are integrating satellite remote sensing and geographical information system (GIS) technologies for use by natural and cultural resource managers in Aboriginal organisations. The research team successfully established a GIS comprising a number of themes for use by the Jawoyn Association in the Katherine region. Managers in the Association have been able to incorporate results from the GIS with their own strategies to guide decision making, including identifying areas with potential for mineral exploration. The research team also investigated the use of remote sensing and GIS technologies for mapping crocodile nesting sites and hypothetical clan boundaries within the area serviced by the Bawinanga Aboriginal Corporation at Maningrida. Results demonstrated how the natural resource questions and cultural issues could be incorporated together in a single management information system.

{Contact: Professor Greg Hill, School for Biological and Environmental Sciences, Northern Territory University; tel: +61 (0) 8 8946 6894}

Computers making ships more efficient

Australia is the world leader in the design and construction of high-speed ferries and catamarans, building some 40% of the total production in the world. This industry represents Australia's largest manufactured export, which has now reached a value of $500 million annually. Researchers at the Naval Architecture Department at the University of New South Wales have been developing extensive computer software for performing the complex calculations associated with the design of these vessels. This unique computer program, called HYDROS, has been under continuous development for some ten years now. HYDROS is able to compute the amount of power required to drive a typical ferry, such as a catamaran, as well as to estimate how the ferry will respond to waves in a seaway. Other important calculations include the prediction of the size of the waves generated when a vessel travels in a river. This is an important element in determining whether these waves will damage the river banks.

{Contact: Associate Professor Lawrence Doctors, University of New South Wales; tel: +61 (0) 2 9385 4098}

Improved solar cells

Researchers from the University of New South Wales have had two additional world records for silicon solar cell performance confirmed on the same day! One is 19.8% energy conversion efficiency on low-grade, multicrystalline silicon substrates, while the second is 24.4% for cells of the best quality material. Previous efficiency improvements by this group have found their way into commercial production, with BP Solar recently announcing plans to convert all their silicon cell manufacture to the group's "buried contact" cell technology. BP Solar plans to be producing 10 Megawatts per year of cells under license to the University by the end of 1998 with this new technology, or about 8% of the total world production.

{Contact: Professor Martin Green, University of New South Wales; tel: +61 (0) 2 9385 4018}

Advancements in seed sowing

Many Australian farms have some degree of soil surface undulation. Sowing crops with conventional wide, fixed-tine seeding implements can lead to poor seed depth control and hence reduce potential yields. However, all this has changed with the design of a unique contour following seeding mechanism, developed by researchers at the University of South Australia's Agricultural Machinery Research and Design Centre in collaboration with the NSW machinery manufacturer, Agrowplow. A depth wheel positioned close to the soil opener follows the soil contour and thus maintains a constant soil opener operating depth and therefore accurate seed depth control.

{Contacts: Professor Terry Riley or Mr Michael Slattery, Agricultural Machinery Research and Design Centre, University of South Australia; tel: +61 (0) 8 8302 3007}

Intelligent robot server

Researchers from the University of South Australia's Centre for Advanced Manufacturing Research have developed an intelligent robot server that overcomes the shutting down of entire manufacturing systems whenever a new product is added, a new machine is used or a machine breaks down. The robot server performs the required function that requires attention while the system continues to operate. The result of this will be significant cost savings associated with machine downtime, set-ups, changes to configurations etc.

{Contacts: Professor Grier Lin or Dr Tien Fu Lu, Advanced Manufacturing Research Centre, University of South Australia: tel: +61 (0) 8 8302 3006}

No more foul-tasting water!

Research undertaken by scientists from the University of South Australia in collaboration with Professor John Ramsay from the University of Montpellier II has led to a better understanding of how taste and odour can be removed from water using activated carbons. The taste- or odour-causing molecules replace water molecules on porous activated carbons leaving the water smell- and taste-free. The team has discovered that the amount of energy needed to make this replacement is correlated to the oxygen content of the carbon. This discovery has important implications for the cost effective treatment of drinking water. Understanding how activated carbons clean water means that carbon manufacturers can improve and customise their products so that they work more effectively.

{Contact: Dr Philip Pendleton, Porous Materials Research Group, University of South Australia; tel: +61 (0) 8 8302 3561}

Olympic standard roof for stadium

A team from the Department of Applied Physics at the University of Technology, Sydney, researched and designed the two sided roof for the main stadium at the Sydney 2000 Olympics to eliminate shadowing of the roof across the grounds which inhibits television coverage and spectators' vision generally. The research was aimed at controlling glare spots while not obstructing light. Professor Geoff Smith and his team had to measure and sort out the best materials for glare and distribution of light and then use sophisticated computer modules to see exactly what lighting will be around

the seats and pitch at different times of the day on cloudy and sunny days.
{Contact: Professor Geoff Smith, University of Technology, Sydney; tel: +61 (0) 2 9514 2224}

Information, Computer and Communication Technologies

Computer controlled anaesthesia

A world-leading computer-assisted intravenous syringe system is set to change the way drugs are administered in anaesthesia, chemotherapy, cardiac and general care. Called CAIVAS (Computer-assisted, Intravenous Anaesthesia System), it uses a computer-controlled syringe pump to deliver drug requirement automatically. World patents on the systems have been granted and commercialisation is underway.
(Contact: Associate Professor David Crankshaw, University of Melbourne; tel: +61 (0) 3 9342 7678}

Fair value share market derivatives

A University of Queensland researcher has developed a method for computing fair prices for a new derivative security being traded on world share markets. The method was developed using Chicago Board Options Exchange data for the past year. In constructing the valuation formula, the researchers from the University's Commerce Department and Duke University in North Carolina found American investors had consistently been paying inflated prices for the exotic derivative known as a bear market warrant. Their formula will ensure investors pay a fair price for the warrants if and when the instrument is introduced to the Australian share market.
{Contact: Associate Professor Stephen Gray, Department of Commerce, University of Queensland; tel: +61 (0) 7 3365 6586}

Taking the bugs out of Chinese quarantine inspection

Chinese quarantine officers will be able to identify and manage insect pests and plant pathogens more efficiently thanks to a software program developed at the University of Queensland. The Lucid program, developed in 1997 by the Entomology Department and the Cooperative Research Centre for Tropical Pest Management (CRCTPM), provides a faster, simpler system for identifying insect pests. The system uses insect images rather than complicated taxonomic terms, allowing quarantine officers with limited insect knowledge to identify a particular species of insect or plant disease quickly and plan a course of action on-the-spot, rather than sending specimens away for identification, potentially holding up cargo for weeks.
{Contact: Professor Gordon Gordh, Department of Entomology, University of Queensland; tel: +61 (0) 7 3365 1747}

Thin film based ozone detectors

Ozone is an ultraviolet absorbing greenhouse gas of particular importance in the atmosphere. Researchers at the Royal Melbourne Institute of Technology (RMIT) have developed novel ozone sensors based on Indium thin films on

sapphire substrates with integrated cone structures prepared by the sol-gel process. Compared to earlier thin film detectors, these new devices have the advantages of a significantly higher ozone sensitivity, lower working temperature and low production cost.
{Contact: Professor Wojciech Wlodarski, Department of Communication and Electronic Engineering, RMIT; tel: +61 (0) 3 9925 3169}

Chemical Sciences

Searching for the key to cell life

Monash biochemists are utilising a new way of viewing molecular details of the life and death of cells, which could pave the way for developing improved means of treating cancer and other serious diseases. The new technique involves inducing cells to make proteins with a fluorescent tag. The group has built a fluorescent tag into an enzyme critical to the release of energy to cells. This enzyme, known as ATP synthase, is located in mitochondria — the membranous structures in cells where food is burned to provide energy in the form of ATP. Mitochondria are now known to be involved in the processes that trigger cell death.

The researchers have been able to exactly locate the mitochondrial membranes with ATP synthase attached by tracking the fluorescent version of the enzyme within cells. Having demonstrated how the technique works, the group intends to use it to study the location and function of ATP synthase within cells under different physical and chemical environments.
{Contact: Professor P Nagley, Department of Biochemistry and Molecular Biology, Monash University; tel: +61 (0) 3 9905 3735}

Coral pharmacists

James Cook University researchers are investigating a novel way of producing pharmaceuticals by chemically manipulating soft corals and sponges. Startling results have indicated that main metabolites found in these corals and sponges are not actually produced by the animals themselves, but are mediated by the presence of the symbiotic algae associated with the animals. Further research demonstrated that chemical production in soft corals and sponges is switched off when the wrong strain of symbiont is present; thus the key to inducing chemical production in these animals was to introduce the "right" strain of symbiont into a "non-normal" host. These results will help to establish a methodology to produce chemicals from invertebrates for medical purposes.
{Contact: Associate Professor Bruce Bowden, Chemistry and Chemical Engineering, James Cook University; tel: +61 (0) 7 4781 4111}

World health guidelines for copper

University of Queensland researchers have guided the United Nations World Health Organisation (WHO) development of international standards on the health effects of copper. The guidelines developed by Centre staff established for the first time a safe minimum level of copper in humans (20 micrograms per kilogram per day) and documented poisoning cases at levels

of greater than 25 milligrams per day. The University's National Research Centre for Environmental Toxicology developed the guidelines following an international workshop on the subject convened by WHO officials in Brisbane in June 1996. Published in 1997 as part of WHO's International Program in Chemical Safety, the guidelines will be accessed by governments throughout the world.

{Contact: Professor Michael Moore, Director, National Research Centre for Environmental Toxicology, University of Queensland; tel: +61 (0) 7 3274 9001}

Engineering

Applying heat to aerospace industry

Monash Mechanical Engineering researchers in collaboration with the Cooperative Research Centre for Advanced Composite Structures have played a key role in developing technology to reduce the cost of making aircraft parts from composite materials such as carbon fibre/epoxy composites. During the fabrication process a resin is cured or hardened by applying heat and pressure. Traditionally, curing has been achieved by placing the whole part in a pressurised oven or an autoclave (steam pressure cooker). But the Monash-CRC research group have developed new methods for applying heat only where it is needed. This saves time and energy, as well as money, without loss of quality. The new technique has so far only been applied to the process of making one part of an aircraft wing—longitudinal stiffeners known as stringers. The technology developed should boost the ability of the Australian aerospace industry to win contracts to supply parts to the world's major aircraft manufacturers.

(Contact: Professor R. Jones, Department of Mechanical Engineering, Monash University; tel: +61 (0) 3 9905 3809}

Technology from insects

A project funded by an ARC Collaborative Grant to the University of Adelaide and Britax Rainsfords Pty Ltd has developed a number of motion detection techniques having applications in many areas, using principles believed to underly the vision systems of insects. VLSI integrated circuit technology was employed to produce electronic sensors able to detect the motion of objects within sensor's visual field. The techniques are suitable to many areas where small inexpensive sensors are required including automotive and robotics applications.

(Contact: Dr D Abbott, Department of Electrical and Electronic Engineering, University of Adelaide; tel: +61 (0) 8 8303 548)

Portable lightning protection

A University of Queensland researcher has developed a portable lightning protection device aimed at saving lives and equipment, especially people at risk of being caught in the open during thunderstorms. The device consists of three aluminium pipes joined together to create a triangular frame large enough to allow a person to stand under it. As part of its development, the device has been tested by being subjected to a simulated lightning strike of

one million volts. The device has been granted a provisional patent through the University's technology-transfer company UniQuest. The next stage is identifying commercial partners to manufacture and distribute the product.
{Contact: Professor Mat Darveniza, Electrical and Computer Engineering Department, University of Queensland; tel: +61 (0) 7 3365 3775}

Earth Sciences

Towards high-performance computer chips

Research by a Monash physicist could lead to production of computer chips of much higher performance than are now available. A technique has been developed for analysing the interaction of X-rays with solid surfaces to provide detail of the structure of crystals down to the atomic level. Software has also been developed to analyse data on the intensity of scattered X-rays, thus revealing new information on crystal structure. The analysis can provide a measurement of the composition and the strain forces inside crystals to less than 1.5 millionths of a millimetre, about the distance between four atoms. Until now, the most accurate method of analysis has been through the use of electron microscopes, which involves slicing and destroying the silicon wafer. Already two makers of scientific instruments — Rigaku of Japan and Australian Diffraction Technology in Canberra — are preparing to distribute the software with their X-ray crystallography devices.
{Contact: Dr A Nikulin, Department of Physics,Monash University; tel: +61 (0) 3 9905 1353}

Life back into mining residues

Mining residues make a difficult, if not hostile, environment for plant regrowth. Few studies have attempted to revegetate mining sites without first capping or covering them with substrates. Direct revegetation offers huge potential savings on earthmoving alone. The research team at Murdoch University has developed a method for the direct revegetation of gold ore refining residue in the Darling Scarp, in the eastern jarrah forest of South-Western Australia. To maximise plant growth the land was prepared by ripping, ploughing, and rotary tilling of the residue; followed by the application of gypsum, poultry manure and topsoil. A mix of pioneer species was introduced to stabilise and ameliorate the residue so that within three to five years a greater species diversity could be introduced. The pioneer species mix comprised a fast-growing annual — triticale *(Triticosecale sp.);* a perennial salt-tolerant grass — tall wheatgrass *(Agropyron elongatum);* and a salt-tolerant shrub — salt bush *(Atriplex amnicola).* Trees were later planted into the mounds, including locally occurring salt-tolerant species such as golden wattle *(Acacia saligna),* salt river gum *(Eucalyptus camaldulensus),* river gum (E. *rudis)* and the swamp sheoak *(Casuarina obesa),* with considerable success. The work has demonstrated that the residue can be amended to be suitable for plant growth.
{Contact: Professor Richard Bell, Murdoch University; tel: +61 (0) 8 9360 2370}

Accurate mapping

Traditional paper maps often contain indications of accuracy and estimates of positional error. These aids serve to convey the cartographer's measure of a map's limitations. Unfortunately, they are absent from many geographic information system (GIS) databases. Geomatics researchers at the University of Melbourne have developed rigorous models of spatial data error so that those using map data can be educated as to the limits of such tools. This information is important to land administrators, emergency service managers, environmental scientists, business analysts, bankers and retailers making decisions based on geographic information.

{Contact: Dr Gary Hunter, Geomatics, University of Melbourne; tel: +61 (0) 3 9344 4626}

Climate change poses threat to Australia's snow pack

The effect of global warming may mean that by the year 2050 temperatures across the globe will increase by one to two degrees Celsius. A doctoral student in the University of Melbourne's Department of Geography and Environmental Studies has used computer modelling to determine how expected climate changes will affect snow pack in Australia's High Country. Modelling showed that snow pack may be reduced by 40 to 50% if there is a rise of one degree Celsius within the next 50 years. A reduction of up to 50% in the snow cover could have a devastating effect on snow tourism. It is unlikely that artificial snowmaking facilities could make up the loss.

{Contact: Mr Simon Hewitt, Centre for Environmental Applied Hydrology & Associate Professor Brian Finlayson, Department of Geography & Environmental Studies, University of Melbourne; tel: +61 (0) 3 9344 6333}

Geologists on a virtual journey into the past

This ambitious project which will help geologists view ancient landscapes and locate potential sites of mineral deposits, is being undertaken at La Trobe University. The La Trobe geologists are building up a picture of these large-scale movements by collecting rocks at the earth's surface which have come from much deeper in the earth's crust. Fission track dating shows how the rocks have cooled on their passage to the surface thereby allowing the rates of surface erosion to be understood.

This information can be fed into a computer model which calculates the amount of material lost through erosion, then adds it back to reconstruct the ancient landscapes at different times in the past. The model is linked to a powerful graphics program to produce animated 3-D images which show what the topography looked like through time. Researchers are using the fission track technique to generate a completely new "thermotectonic" imaging approach to the evolution of the entire continent. These dynamic images will provide important new tools in the search for mineral deposits both here and overseas.

{Contact: Professor Andrew Gleadow, Department of Earth Sciences, La Trobe University; tel: +61 (0) 3 9479 2649}

Antarctic not as cold in the recent past

Outcomes of an international Antarctic study, involving researchers from the University of Queensland, are providing better understanding of the Earth's climate over time which will help improve future understanding of climate changes. According to geological surveys, the Antarctic may have been warmer in the last one to two million years than previously thought. The presence of more than 40 different species of mollusc suggests a temperate sea and that the Antarctic was warmer, rather than Ice Age, during this period. Scientists say this is the first record of a warmer climate at this time, suggesting the Earth's previous climatic record is more complex than acknowledged. It also suggests that Ice Ages were not continuous and may have been interspersed by warm spells.

{Contact: Associate Professor Chris Fielding, Department of Earth Sciences, University of Queensland; tel: +61 (0) 7 3365 2373}

Social Sciences and Humanities

Soundworks

Dr Ros Bandt has researched and documented a new musical artform, sound sculpture, an art form which interfaces sound and sculpture in diverse ways. Her study presents works ranging from sounding objects to kinetic sculptures, original musical instruments, environmentally sensitive sound sculptures, sound installations, interactive works, the body as sound sculpture and spatial music. Dr Bandt's book on the history of sound sculpture is contracted to Craftsman House, Australia's main Fine Arts Press, and is due for release in June 1998. This is a first for the company to include sound in one of their publications.

{Contact: DrRos Bandt, Department of Music, Monash University; tel: +61 (0) 3 9905 3238}

A history of music in Australia

Dr Therese Radic of Monash University has produced a comprehensive history of Australian music from a particular viewpoint that sees music as a tool of special interests. Dr Radic's book on the history of music in Australia traces the formation, creation and use of music in Australian cultural development, emphasising its use as Empire, nationalist, religious, class and sexual propaganda. The book covers aboriginal music (traditional and urban), Anglo-Celtic folk and migrant musics, popular (jazz, country and western, rock), church and high-art musics, and will provide an overview placing music usage in Australia in its national and international context. Dr Radic's book is expected to be released in 1998 with musical illustration, and be a significant research tool in the young discipline of Australian music studies.

{Contact: Dr Therese Radic, Department of Music, Monash University; tel: +61 (0) 3 9905 3238; fax: +61 (0) 3 9905 3241}

Fear of crime

The Centre for Cultural Risk Research has conducted a major study for the Criminology Research Council, the National Campaign Against Violence and Crime and the National Anti Crime Strategy. A major part of the study focussed on young people. Although they are often constructed as the source of crime, young people are in fact the major victims of crime. The report indicates significant fear of crime among young people, however the object of fear varied according to gender. Teenage girls fear the unknown male stranger, and devise a range of strategies to cope with their fear. Teenage boys have a much more specific focus for their fear, indicating particular sub cultures of youths who may harm them, and where they are likely to be most threatening. The study resulted in a major report to the Criminology Research Council which will be used to influence policy in relation to fear of crime.

{Contact: Centre for Cultural Risk Research, Charles Sturt University, tel: +61 (0) 2 6933 2000}

The impact of court decisions on government administration

Over the period 1983-1993, just over 3,300 applications for judicial review were made to the Federal Court. Analysis of those applications has shown that 60% of the applications were ultimately successful in obtaining the visa, grant, licence, or concession which was sought from the government.

This Judicial Review Project is the first major study of this kind in the common law world and has been conducted by three Australian National University researchers at the Faculty of Law. The project, entitled *The Impact of Court Decisions on Government Administration,* is looking also at whether and to what extent, Federal Court decisions which are adverse to the agency's practices result in changes to those practices or whether the agency seeks to entrench its practice by giving it legislative force.

{Contact: Robin Creyke, John McMillan & Dennis Pearce, Faculty of Law, Australian National University; fax: +61 (0) 2 6249 0150; e-mail: robin.creyke@anu.edu.au, john.mcmillan@anu.edu.au, dennis.pearce@anu.edu.au}

Legislating for best practice occupational health and safety management

Researchers at the Australian National University and the University of Melbourne conducted a research project reviewing the current system of regulatory and enforcement measures for occupational health and safety (OHS) in Australia and in selected jurisdictions internationally. The project recommended innovative solutions and strategies to improve the enforcement of OHS legislation. In particular the project focused on ensuring that criminal prosecution of contraventions of the OHS legislation and regulations is more effective and developing alternatives to criminal prosecution.

{Contact: Professor Neil Cunningham, Australian Centre for Environmental Law, Faculty of Law, Australian National University; tel: +61 (0) 2 6249 3397}

Shady places

Researchers from the University of Queensland's Department of Architecture have developed the State's first shade guidelines for young children, public pools and sporting fields. Funded by a Queensland Health grant, the three guideline books, *Shade for Sports Fields, Shade for Public Pools* and *Shade for Young Children,* were published and launched between 1995 and 1997. The aim of the books is to promote good shade design and planning principles to improve the quality and effectiveness of shade offered in public settings. Effective shade creation at pools, child care centres and sporting grounds is an important step in helping reduce rates of skin cancer. The researchers are also developing a training program to inform groups such as architects, builders, local government officers and community groups about effective shade creation.

{Contact: Mr Michael Keniger, Head, Department of Architecture, University of Queensland; tel: +61 (0) 7 3365 3843}

New measures of health and education output

The treatment of economic statistics in the community services sectors of health and education has been inadequate, despite increasing importance to the community. Research at James Cook University has concentrated on developing theoretically consistent methods of incorporating health and education sectors into measures of output, investment, living standards and economic growth. As a result, a new theory of demand for health care has been formulated.

{Contact: Professor John Quiggin, Department of Economics, James Cook University; tel: +61 (0) 7 4781 4111}

Facial attractiveness and the evolution of beauty

Biologists have established that many species find symmetry attractive, and that a preference for symmetric mates enhances reproductive success because symmetry signals good health. Research at the University of Western Australia shows that people also find symmetry attractive: Perfectly symmetric faces (created by blending the normal and mirror images of a face) are preferred to the original faces, which typically have slight asymmetries. Naturally symmetric faces are also more attractive than naturally asymmetric faces. These findings suggest that humans, like other animals, may have evolved to find symmetry attractive. Symmetry, therefore, appears to be a standard of beauty set by nature rather than culture.

{Contact: Professor Gillian Rhodes, Department of Psychology, University of Western Australia; tel: +61 (0) 8 9380 3251}

Economic growth models for Australia and Asia

Economic growth and long term development are essential economic targets for all governments. These targets affect policy issues relating to taxation, international trade, welfare, and education, among others, and have strong implications for improving the economic and social conditions of all citizens. This project examines how different economies grow at different speeds, whether such growth can be sustained, and the policy implications of differing growth rates between Australia and its major Asian trading

partners. The significance of the research lies in determining which factors influence the levels of and the changes in the growth rates across countries and over time. Determination of long run economic development and the crucial roles of human capital (such as education and training), the degree of migration, and employment and participation rates by various sectors in the economy (such as industrial output per worker), are highlighted. Formal procedures for testing alternative theories of economic growth are developed.

{Contact: Professor Michael McAleer, Department of Economics, University of Western Australia; tel: +61 (0) 8 9380 3400}

The burden of unemployment on the family unit

This project examines a number of dimensions of the severe unemployment problem currently faced by a large segment of the Australian labour force. Two major findings have emerged. First, examination of the determinants of employment outcomes within the family unit has shown that family and regional circumstances are more important in determining unemployment outcomes than personal characteristics. This suggests, for example, that regional employment initiatives might be a more appropriate focus for policy than policies such as job training aimed simply at improving the employability of individuals. Second, examination of labour market outcomes in Australia and the United States provides considerable support for microeconomic reform that will increase the flexibility of the Australian labour market.

{Contact: Professor Paul Miller, Department of Economics, University of 'Western Australia; tel: +61 (0) 8 9380 2898}

Positive parenting

The Positive Parenting Program (Triple P), based at the University of Queensland's Parenting and Family Support Centre in the School of Psychology, aims to prevent serious behavioural or adjustment problems in children by teaching parents alternatives to harsh, inconsistent and coercive methods of discipline. The program provides early intervention for children with severe disruptive behaviour disorders, who may be at risk of becoming involved in anti-social behaviour, criminal activity and violence in later life. The program aims to take a preventive approach while at the same time removing the stigma of parent training so people are not seen as failures for taking parenting courses. Triple P has won the national 1997 Australian Violence Prevention Award.

{Contact: Associate Professor Matt Sanders, Director, Triple P, University of Queensland; tel: +61(0) 7 3365 7309}

20 year Down's syndrome research project

The University of Queensland's Schonell Special Education Research Centre celebrated the 20th anniversary of its Down's Syndrome Research Program in late 1997. The program is recognised as the world's longest continuous study of Down's syndrome, involving over 200 familes, to provide unique and important insights into the health and development of the children as well as information about family functioning.

The longitudinal study has collected data about the children's cognitive development, motor development, temperament and family functioning, including the impact on parents and siblings of having a child with Down's syndrome in the family. As the children have grown up, studies have included looking at their ability to learn to manage their own behaviour, and the choices they and their families have made with regard to a range of issues.
{Contact: Professor Adrian Ashman, Fred and Eleanor Schonell Special Education Centre, University of Queensland; tel: +61 (0) 7 3365 6472}

Agricultural Sciences

Boost to canola crops in China

A recently completed research program by a Murdoch University scientist has solved an enduring problem limiting crop production in South-East China. Boron is a soil trace element which is essential for the successful development of all plants. Without sufficient boron, plants will grow well until flowering, but will then either shed their flowers, or fail to fruit or set seed as well as they should. China is the world's largest producer of canola — also called oilseed rape *(Brassica napus).* The researchers found that the huge amount of harvested material was rapidly removing boron from the fields, necessitating regular replacement. In many cases, individual farmer's yields have increased by between 50 and 75% with regular boron applications. There have also been a lot of other benefits to arise from the study, particularly in the area of training, sharing research expertise and the publication of findings.
{Contact: Professor Richard Bell, Murdoch University; tel: +61 (0) 8 9360 2370}

Single sex hybrid cauliflower breeds value for money

University of Melbourne scientists have developed a single sex hybrid cauliflower that offers growers in Australia's $40 million cauliflower industry a clear 20 to 30% higher yield. The genetically engineered hybrid cauliflower and its University-patented technology have worldwide export potential with major opportunities in Asian markets. Industry gains from the breakthrough include lower production costs and more competitive pricing for the hybrid seeds. Similar potential exists for related high value crops.
{Contact: Dr Prem Bhalla, Agriculture and Resource Management, University of Melbourne; tel: +61 (0) 3 9344 9651}

Vaccine for deadly tick toxin

University of Technology, Sydney (UTS) scientists have secured an international provisional patent for the method of developing a vaccine for tick toxin. A clinical trial is planned for December 1998 before the vaccine is released commercially. This is the world's first tick toxin vaccine and has the potential to save the lives of tens of thousands of domestic dogs and farm animals in eastern Australia, where the most deadly species of tick is concentrated. Isolating the tick poison was a major scientific breakthrough

for the UTS research team with attempts to achieve this spanning more than 70 years.

{Contact: Associate Professor Kevin Broady, University of Technology, Sydney; tel: +61 (0) 2 9514 2000}

Keeping caterpillars off the grog

Millions of tiny wasps have been released over the past two years by La Trobe University geneticists in a bid to help the wine industry become pesticide-free. La Trobe University researchers have bred a strain of wasps with the traits that will make it an efficient parasite and biological control agent. The wasps are on a mission to wipe out the wine industry's most voracious pest — a caterpillar with a taste for chardonnay grapes. In a cool season, the pests can eat up to 20% of a crop, with damage estimated to cost $2,500 a hectare. This squad of natural moth killers could replace the use of chemical pesticides and save the industry millions of dollars worth of lost grapes.

(Contact: Professor Ary Hoffmann, School of Biochemistry and Genetics, La Trobe University; tel: +61 (0) 3 9479 2769}

Fungus increases wheat yields

Australian soils are generally low in phosphate which is readily available for plant growth while phosphate from fertiliser is rapidly converted to less soluble chemical forms unavailable to plants. Researchers at Charles Sturt University have isolated a new species of the *Penicillium* fungus which makes the phosphate already in the soil more available to plant roots. Field trials using wheat inoculated with this fungus showed an average yield increase of 13% across a range of added phosphorus concentrations. Biological control of root pathogens was shown not to be a factor in the plant response to inoculation.

{Contact: Professor Geoffrey Scollary, Head, School of Wine and Food Sciences, Charles Sturt University; tel: +61 (0) 2 6933 4030}

Supersniffer dogs snare drugs

Australia's Customs Service is producing some of the world's best 'supersniffer' drug detector dogs using a breeding program based on research undertaken at the University of Melbourne. The success of the program excited worldwide interest, including a 4 page feature article in *New Scientist.* The aim of the program was to breed reliable and healthy puppies suitable to train as drug detector dogs. The first step was to understand how detector dogs are trained, then define what behavioural traits make a dog suitable for training. In only three generations, a success rate of over 50% has been achieved.

(Contact: Dr Kath Champness, Royal Guide Dogs Association of Australia; tel: +61 (0) 3 9854 4453 & Dr Rolf Beilharz, Agriculture and Resource Management, University of Melbourne; tel: +61 (0) 3 9344 5013}

Pristine waterways

The days of building roads along foreshores and filling swamps with refuse are over. The vital role played by fringing (riparian) vegetation in filtering and purifying water flowing into streams has been highlighted by this study. A research package offered to end-users enables the metabolic activity of the

stream community to be measured and the level of its "health" immediately assessed. This technique has been used nationally in preliminary river health programs and developed to a stage of commercialisation.
{Contact: Dr Pete Davies, Zoology Department, University of Western Australia; tel: +61 (0) 8 9380 3838}

New pasture variety improves farmers options

Studies at the Cooperative Research Centre for Legumes in Mediterranean Agriculture has led to the release of a new pasture species, "Cadiz". This variety of pink serradella grows well on poor sandy soils which are highly acidic and suffer from aluminium toxicity. It also holds its seeds up high and therefore can be harvested using conventional grain harvesting machinery. Seed produced this way is both cheaper and less destructive to the environment than is the case with conventional clover and medic varieties, which are harvested with the farming equivalent of a large vacuum cleaner. Released in 1996, it is expected that nearly 100,000 hectares will be sown with Cadiz in 1998. The variety will increase profitability of farmers and at the same time improve the sustainability of their farms.
{Contact: Professor John Hamblin, CLIMA, University of Western Australia; tel: +61 (0) 8 9380 2505}

New malt barley

A new high malt quality barley has been released by the University of Western Australia to deal with the evolution of herbicide-resistant weeds. Registered as "Unicorn", it has a lower yield than other cultivars. However, because it flowers early, it can be planted late so that growers can control weeds by mechanical means. If planted early, it can be cut when the weeds are flowering, so reducing their seed set. Either way, Unicorn is a new weapon for growers to use against herbicide-resistant weeds.
{Contact: Dr Rodger Boyd,University of Western Australia; tel: +61 (0) 8 9387 3646; fax: +61 (0) 8 9383 9907}

Boronias — early ones, late ones, pink ones, purple ones!

The boronia cutflower industry is based largely on a single variety of one species. Floriculture is a major export industry for Western Australia and development of new crops is its lifeblood. A method for breeding boronias and germinating the seeds has been developed at the Faculty of Agriculture, University of Western Australia. Superior selections were identified and tested in collaboration with the horticulture industry. This will increase the flower colours available and the period for which they can be supplied to the market.
{Contact: Dr Julie Plummer, University of Western Australia; tel: +61 (0) 8 9380 1786; fax: +61 (0) 8 9380 1108}

How some plants grow in waterlogged soils

Two small clovers, woolly and cluster clovers, have colonised the wheatbelt of Western Australia. Although both are widespread they often inhabit different parts of the landscape. Cluster clover is always found on well-drained soils, while woolly clover is often found where the soil becomes waterlogged in winter. When the clovers were examined closely it was found

that woolly clover had porous roots that conducted oxygen readily to the root tips. Furthermore, some of the oxygen leaked into the surrounding soil, which encourages the growth of beneficial soil organisms. Since much of the Western Australian wheatbelt suffers from intermittent flooding, it is important that clovers with porous root systems be used.

{Contact: Professor Phil Cocks, University of Western Australia; tel: +61 (0) 8 9380 2555; fax: +61 (0) 8 9380 1108}

Macadamia nuts fight tropical crop disease

Macadamia nuts may hold the key to developing disease resistant banana, sugarcane and sunflower varieties, according to University of Queensland researchers. A research team from the Cooperative Research Centre for Tropical Plant Pathology screened 250 Australian native plant seeds and found that proteins from the macadamia *(Macadamia integrifolia)* possess excellent antifungal and antibacterial properties against a number of commercially important pathogens affecting tropical crops. Further testing will establish the proteins' viability for use in new varieties of tropical crops such as banana, sunflower and sugarcane.

{Contact: Dr John Manners, Deputy Director, Cooperative Research Centre for Tropical Plant Pathology, University of Queensland; tel: +61 (0) 7 3870 3773}

Physical Sciences

Quantum optics

Optical technology is used to transmit more information and can measure with ever increasing sensitivity. Following this trend, optical instruments will be limited by quantum effects very soon. In fundamental physics there are alternatives based on the use of non classical light. Australia and New Zealand had a lead in this area a decade ago, but practical problems remained: How to avoid losing the precious non classical light? How to incorporate the complications of quantum mechanics into engineering design?

The quantum optics group at the Department of Physics and Theoretical Physics, Faculty of Science, Australian National University has made big advances in both these questions. It has demonstrated a way to communicate and amplify weak signals without loss in quality. It has also shown a new approach, quantum transfer functions, which is easy to comprehend but incorporate all details of the fundamental theory. Quantum optics now has a more practical future.

{Contact: Professor Hans Bachor, Department of Physics and Theoretical Physics, Faculty of Science, Australian National University; tel: +61 (0) 2 6249 5111}

Laser-based method for studying fuel-air mixing at supersonic speeds

Scientists in the Department of Physics and Theoretical Physics at the Australian National University have successfully developed a laser-based method to study fuel-air mixing in a supersonic flow environment. The technique has been developed in support of collaborative research efforts

with the Australian Defence Force Academy to design more efficient fuel injectors for a supersonic combustion ramjet (scramjet) engine. The method uses a technique known as planar laser-induced fluorescence (PLIF) to visualize fuel as it mixes with air at supersonic speeds. Special "PLIF-active" molecules are added to either the air or the fuel. These molecules fluoresce when illuminated by a sheet of laser light that passes through a flow, providing an image of the two-dimensional slice of the flowfield. From the images, one can determine how well the fuel and air mix under different flow conditions and for different injector designs.

{Contact: Dr Frank Houwing, Department of Physics, Faculty of Science, Australian National University; tel: +61 (0) 2 6249 2807}

Dark matter explained?

There is compelling evidence that at least 90% of the matter in the Universe does not emit radiation which we can easily detect. The nature of this so called "dark matter" is one of the major unsolved problems of modern astronomy.

Two researchers in the Special Research Centre for Theoretical Astrophysics at the University of Sydney, have proposed that the dark matter is in the form of clouds of cool, molecular gas formed shortly after the Big Bang. The two scientists were trying to explain a phenomenon known as Extreme Scattering Events in which the intensity of radio waves from point-like sources varies wildly but only for periods of weeks to months. Their interpretation is that as one of these clouds moves into and out of the line of sight to the radio source, a "skin" of ionised material on the surface of the cloud scatters the radio waves. The clouds have very little emission of their own and are almost entirely transparent, which is why they have not been detected previously. Each cloud is expected to have about as much mass as the planet Jupiter, but with a size of roughly the Earth-Sun distance. From a knowledge of the rate at which Extreme Scattering Events have been observed, they estimated the number of these clouds in the Galaxy and found that they could account for the missing mass in our Galaxy! They have shown that their model is broadly consistent with a wide variety of astronomical data, and they are now concentrating their efforts on specific tests of the theory.

{Contact: DrMark Walker, SRCfTA, University of Sydney; tel: +61 (0) 2 9351 2546}

The Hubble Telescope discovers new bullets in Orion

A new infrared camera on the Hubble Space Telescope has been used by a researcher at the University of New South Wales, and US collaborators, to study star formation in the heart of the Orion Nebula. Five years ago, using the Anglo-Australian Telescope, a discovery was made of a barrage of planetary mass "bullets", debris from some explosive process, hurled out from the core of Orion within the past 1,000 years. With the greater resolution of the Hubble Telescope, another set of bullets has been found in the very heart of Orion, vivid evidence for the energetic activity associated with the formation of massive stars, and witness to how recent its last outburst must have been.

{Contact: Dr Michael Burton, University of New South Wales; tel: +61 (0) 2 9385 5618}

The binding of positrons to atoms

One of the longest standing conundrums of atomic physics has been the question of whether it is possible to bind a positron (the positively charged anti-particle to the electron) to an atom. In spite of numerous attempts to solve this problem since the initial speculations 50 years age, no decisive answer to the question has been given until recently. Rigorous calculations have shown that the ground states of positronic lithium (Lie+) and beryllium (Bee+) are stable with binding energies of about 0.066 and 0.0076 eV respectively. It has been shown that positronic sodium (Nae+) and magnesium (Mge+) are also stable with binding energies of 0.35 and 0.0013 eV respectively. These results have an impact on experiments performed using the technique of Positron Annihilation Spectroscopy This technique is used by about 100 groups world wide to investigate the behaviour of electrons in the gaseous, liquid or solid phase. The knowledge that positrons can bind to neutral species will help in the interpretation of these experiments.

{Contact: Jim Mitroy, School for Maths and Physical Sciences, Northern Territory University; tel: +61 (0) 8 8946 6816}

Lead isotope ratios track environmental dispersion of lead

Analytical methods and sampling techniques have been developed to allow the determination of lead isotope ratios and concentrations at very low levels in seawater, sediments, biota and atmospheric particulates. Lead produces distinctive isotope ratios depending on its origin that allow the source of the lead to be determined. The technique has been applied in baseline studies and environmental monitoring programs in northern Australia, particularly with both established and developing mining operations. The lead isotope ratio method provides a sensitive and cost effective monitoring tool allowing an unambiguous assessment of the source of the lead.

{Contact: Associate Professor David Parry, School for Maths and Physical Sciences, Northern Territory University; tel: +61 (0) 8 8946 6701}

Mathematical Sciences

Controlling chaotic systems

Members of the Centre for Applied Dynamics and Optimization at the University of Western Australia and collaborators at the Institute for Nonlinear Science, University of California at San Diego have developed new ways to understand and control chaotic systems such as certain electronic circuits and mechanical devices. The methods are widely applicable and show promise for biomedical and industrial applications.

{Contact: Professor A I Mees, University of Western Australia; tel: +61 (0)8 9380 3387}

Institute of Advanced Studies, Australian National University

Role *To be one of the world's great basic research institutions, distinguished also by outstanding teaching, guiding students to the frontiers of knowledge and the best standards of scholarship.*

The Institute of Advanced Studies aims to maintain and enhance the University's world class standing and excellence by:

- engaging in research and scholarship at the highest international standards;
- strengthening Australia's capacity to undertake fundamental research both generally and in relation to subjects of national importance;
- providing outstanding post-doctoral and graduate training in all areas of the Institute's research activity;
- encouraging collaborations which allow other Australian universities to benefit from the concentration of research resources available at the Institute;
- fostering international exchanges and collaborations which enable Australia to contribute to and benefit from the latest advances in front-line research;
- encouraging links which make the scholarship and research resources of the Institute accessible to the Australian community, industry and government;
- being well-placed to respond rapidly to a changing environment and new opportunities; and
- optimising use of its resources by promoting internal links, including those with the Faculties, based on shared or complementary technologies and interests.

The Institute of Advanced Studies (IAS) of the Australian National University consists of eight research schools and two research centres. In addition, staff of the Institute participate in several cross-campus research groupings and centres. The Institute's fields of academic inquiry include biological sciences, chemistry, bio-medical sciences, physical sciences including mathematics, astronomy and the earth sciences, information technology and cognate areas of engineering and broad interests in the social sciences and environmental sciences.

The Institute has a distinctive place in the Australian higher education system. Uniquely, it is block funded to undertake full-time research at the highest international standards and to provide post-graduate and post-doctoral research training. Approximately $150 million of the Australian National University operating grant can be regarded as block

funding for the research schools and centres of the IAS. Thus the Institute has a major role in carrying out basic research, as a resource for Australian research as a whole, and as a world leader in the research fields in which it is engaged.

Recent Achievements

Rapid appraisal of biodiversity in Papua New Guinea
The Biodiversity Rapid Appraisal Project or BioRAP aims to identify priority areas for biodiversity, both within the context of establishing a national protected-area network and to identify options and constraints for land management in the forestry and agricultural sectors. BioRAP employs a "toolbox" of three new software packages. The ANUDEM program produces a national digital elevation model, the ANUSPLIN package produces climate surfaces, and the ANUCLIM package produces environmental and biological models for the study region. Apilot study has been undertaken in Papua New Guinea.

Further information about the Centre for Resource and Environmental Studies software packages ANUDEM, ANUSPLIN and ANUCLIM can be found on the Internet at http://cres.anu.edu.au/software/index.html

Cellulose gene patent coup
A team of researchers at the Research School of Biological Sciences has identified and cloned a gene that codes for the catalytic subunit of the enzyme cellulose synthase, RSW1. Cellulose is a major component of all plants, a key part of dietary fibre and the critical component of cotton and wood fibres. The group have been working on the model plant *Arabidopsis.* They analysed a mutant gene, whose expression leads to failed cellulose production at high temperatures.

The discovery of the gene opens the way to modifying the rate at which plants produce cellulose and the physical properties that the cellulose shows. Apatent has been filed covering its wide potential applications in the fibre and food industries.

Health of Aboriginal and Torres Strait Islander people
A commissioned study by the National Centre for Epidemiology and Population Health in conjunction with the Australian Institute of Health and Welfare, has concluded that, per person, total spending for and by Aboriginal and Torres Strait Islander people was, in 1995-96, only about 8% higher than that for or by other Australians. However, because private spending by indigenous people is low, the overall ratio of government expenditure per person was over 1.5:1. On average, indigenous people die at three times the rate of other Australians and life expectancy for Aboriginal and Torres Strait Islander men is about 17 years less than for other Australian males. Although infant mortality has improved, there are few signs that the gap in life expectancies between indigenous and other Australians is diminishing. Public expenditures on the health of Aboriginal and Torres Strait Islander people appear to have been very similar to those for other Australians in the

same income category. However, their health status was almost certainly much worse. All of the indigenous to non-indigenous expenditure ratios were less than had been previously assumed.

Unflued gas appliances and respiratory health
Epidemiologists at the National Centre for Epidemiology and Population Health have shown that hourly-peak levels of nitrogen dioxide produced indoors by unflued gas appliances are associated with dose-related increases in sore throat, cough with phlegm, colds and school absenteeism in children aged between 6 and 11 years. These findings have contributed to Australian data for use in the development of air pollution standards for nitrogen dioxide as proposed by the National Environmental Protection Council. As well, this study provides a novel epidemiological method for the examination of short-term peak levels of nitrogen dioxide exposure.

Fatty acid compounds limit immune response
Researchers at the Research School of Chemistry and the Adelaide Medical Centre for Women and Children, in collaboration with Peptech Ltd, have discovered correlations between the chemical structures of novel fatty acid derivatives and their activity in immunological assays. Through this process, they have developed compounds suitable for the treatment of inflammatory disorders, and to limit immune response, which is a major problem associated with organ transplants. Related compounds have been designed for the treatment of malaria.

Walk-in Virtual Reality theatre
The Research School of Physical Sciences and Engineering has developed a walk-in Virtual Reality theatre, the WEDGE, for visualising complex sets of experimental and theoretical data. Two large back projected screens arranged as a right angle define the space where stereoimages can "float" and be manipulated. Uses for this Australian developed system range from many areas of science (physics, astronomy, molecular biology, mathematics) to architecture and engineering, business (visualisation of complex archival data), defence, remote learning and entertainment.

New business opportunities with high performance computing
Very large data sets which have been collected over many years by insurance companies, banks and retailers contain a wealth of information on customer behaviour otherwise only obtainable through expensive customer surveys. Companies can exploit this information in marketing research and profitability analysis. However, traditional data analysis cannot handle data of this complexity and size.

New methods have been developed at the Research School of Information Systems and Engineering which have the demonstrated capability to analyse very large data sets. Other techniques developed elsewhere require hours of processing time while the Australian National University's methods require only minutes for the same problem. The key to this is the application of parallel computers located at CSIRO and ANU and new algorithms based on principles similar to ones used in computational engineering for the construction of aircraft.

Vision system for tracking human activity

Recently, the Robotics Research Laboratory, Research School of Information Sciences and Engineering, achieved real time vision systems for tracking facial and hand expressions for applications such as driver or pilot sleep detection, and more user friendly human-computer interaction. The work has attracted funding from industry to develop for global markets.

The Fiji constitution

Pacific historian Brij Lai from the Division of Pacific and Asian History, Research School of Pacific and Asian Studies, was invited by the Fijian government to serve on a three-member Constitution Review Commission chaired by former New Zealand Governor-General Sir Paul Reeves. The Commission's 800 page report with 797 recommendations was tabled in Parliament in September 1996 and formed the basis the following year of the new unanimously approved constitution, paving the way for Fiji's re-entry into the Commonwealth. Lai, an internationally respected Fiji specialist, follows in the footsteps of former ANU Pacific historian J W Davidson who advised the Samoan Government on its constitution at the time of independence in 1962. The Commission's report and the manner of its work has been widely praised as a model of its kind and an example of constitutional review for other developing countries.

Papua New Guinea drought management

A report on the 1971-72 frosts and drought in Papua New Guinea (PNG) commented on the "almost complete lack of knowledge of the agriculture practised in the worst affected area". In 1997, frosts and drought again assailed PNG. When the PNG Government, with support from AusAID, requested assistance to assess the effects, researchers from the Research School of Pacific Asian Studies at the Australian National University were able to respond immediately. Over a period of three months in late 1997, they orchestrated two PNG-wide surveys of food and water supplies, and produced a database and maps showing where the worst affected areas were located and how many people were starving. This information was used by the Australian and PNG Governments to plan and implement relief programs. The rapid response was aided by the fact that for the last five years this research group has been carrying out basic research into PNG village agricultural systems.

Great Barrier Reef “climatic optimum” 6,000 years ago

Research by geochemists at the Research School of Earth Sciences has led to the finding that the surface water of the Great Barrier Reef about 6,000 years ago was 1°C warmer than today. The team made high-precision measurements of Sr/Ca and $^{18}O/^{16}O$ ratios in fossil coral to reveal seasonal patterns in temperature and rainfall. The $^{18}O/^{16}O$ ratios in the coral suggest that monsoonal rainfall was weaker, but more dependable, and possibly linked to a weakening of the El Niño - Southern Oscillation. Preliminary results for fossil corals from eastern Indonesia suggest that this pattern of warming and more dependable rainfall may have prevailed throughout the region.

High-Z Supernova Search
The High-Z Supernova Search combines the talents of almost twenty astronomers on 4 continents to find distant exploding stars. This project, undertaken at the Mount Stromlo and Siding Spring Observatories, Australian National University, aims to measure the ultimate fate of the Universe: Will the Universe expand forever, or will gravity eventually halt its expansion, and send it crashing into the "gnaB giB" — the "Big Bang" in reverse.

Type Ia supernovae (SN Ia) form a fairly homogeneous class of objects. These explosions of white dwarf stars have similar spectra and light curves. Small differences do exist, and by observing many objects, researchers have demonstrated that the rate at which a SN la brightens and fades depends on its intrinsic luminosity. Measuring distances in the Universe is extremely difficult, but by comparing the relative brightnesses of SN Ia, it is possible to measure a distance to a single object with a precision of about 7%.

In 1997, the researchers discovered the most distant star yet. The light from this extremely faint object, designated SN 1997ck, was emitted some 8 billion years ago and was discovered by comparing an image taken with the Canada-France-Hawaii Telescope, located on Mauna Kea, in early April with one taken 3 weeks later. This SN and 3 others were followed with the Hubble Space Telescope, so their light curves could be compared to supernovae discovered in the nearby Universe.

The Anglo-Australian Telescope Board

Role *The Anglo-Australian Telescope Board (AATB) provides world class facilities for the Australian and British astronomical communities through its operational arm, the Anglo-Australian Observatory, to enable astronomers to undertake research for the advancement of scientific knowledge.*

The Anglo-Australian Telescope Board operates under an agreement between the Governments of the United Kingdom and Australia and is equally funded by them. The Australian Government will contribute approximately $3.6 million in 1998-99. The facilities include the Anglo-Australian Telescope (AAT) and the UK Schmidt Telescope (UKST) at Siding Spring Observatory outside Coonabarabran, and a laboratory in Sydney.

The Anglo-Australian Telescope (AAT) was state-of-the-art when officially opened in 1974. Two decades later, the AAT remains at the leading edge in astronomical research against considerable international competition. Throughout those years many significant astronomical discoveries have been made using the Observatory's telescopes, and as a consequence Australian and British astronomers have a very high standing in the

worldwide scientific community. One of the reasons for this continued excellence is the vision and expertise of the Observatory's scientific and engineering staff, who have constantly upgraded the telescopes by incorporating the latest technological developments into instrument design. In fact, staff at the Observatory are considered world leaders in many areas of astronomical instrumentation.

Recent Achievements

2dF used in earnest

It is now common for more than a thousand galaxies and quasars to be observed in one night, thanks to an instrument called 2dF. The 2dF is an instrument for the AAT which has been under development for the past seven years. It uses optical fibres to enable 400 galaxies to be analysed simultaneously, without resetting the telescope. This is the first time so many objects have been observed and analysed in such a short amount of time, anywhere in the world. Previously it would have taken years for the same amount of data to be collected and analysed, by painstakingly observing the faint targets one at a time. Mapping the universe in three dimensions is now possible and astronomers are now confident of completing an ambitious "redshift survey" of a quarter of a million galaxies and 30,000 quasars in only two years.

Brown dwarf detected

Spectroscopic observations taken at the AAT have confirmed the first detection of an isolated brown dwarf in our Galaxy. Brown dwarfs are star-like objects which are not massive enough to burn nuclear fuel and so are extremely faint and difficult to detect. The newly discovered brown dwarf is in the constellation of Corvus.

Origins of X-ray background become clearer

The AAT has played a major role in identifying the origin of the cosmic X-ray background, which has been poorly understood until recently. AAT data taken for sources detected with the ASCAX-ray satellite have shown that the X-ray background comes from active galactic nuclei, 40% from quasars and the bulk of the remainder from Seyfert galaxies. A Seyfert galaxy is one with an "active" nucleus, identifiable because of the strong emission lines in its spectrum.

ENVIRONMENT

Australian Antarctic Division

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

Recent Achievements

Antarctic sea ice
Reanalysis of data from whaling vessel records during the years 1931 to 1987 has indicated that the edge of the Antarctic sea-ice zone in summer had moved southwards by almost 3 degrees of latitude during that interval. This, in effect, means that the area covered by sea-ice around Antarctica has contracted by some 25%, a significant amount which has raised widespread national and international interest.

Conservation of Antarctic marine resources
Krill biomass estimates from a 1995-96 research cruise of *RSV Aurora Australis* were used to set a Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) precautionary catch limit on the krill fishery off most of the Australian Antarctic Territory. At the seventeenth meeting of CCAMLR held in Hobart in late 1997, Australia reported the arrest of two vessels fishing illegally in the Australian Territory of Heard Island and the McDonald Islands. Another arrest has since taken place.

Generation of Antarctic Bottom Water
During recent marine science voyages concerned with the role of oceanographic events in the Antarctic south of Australia, one program funded by the National Greenhouse Research Program demonstrated that the area off the eastern sector of the Australian Antarctic Territory generates about 25% of the total Antarctic Bottom Water. This is an exciting and unexpected result which has significant implications for climate and ocean circulation models. Future voyages will be examining this further.

Bureau of Meteorology

Role *To observe and understand Australian weather and climate and provide meteorological, hydrological and oceanographic services in support of Australia's national needs and international obligations.*

To fulfil its research objectives, the Bureau:

- encourages high quality research in-house as a foundation for effective collaboration with the external research community and for the implementation of improved systems and techniques for the provision of services;
- fosters meteorology in the tertiary sector to ensure access to well-trained graduates and maintenance of the national research infrastructure for atmospheric science; and
- ensures effective coordination with the research programs of other relevant institutions both within Australia and overseas.

The main research activities are carried out by the Bureau of Meteorology Research Centre in collaboration with the various operational units of the Bureau. Major research areas are mesoscale meteorology, regional meteorology, medium-range prediction, climate, climate-change modelling and oceanography. The activities involved include theoretical studies, field experiments and mathematical modelling of atmospheric and oceanographic systems, with increasing effort being directed to the practical application of research results to improving the quality of Bureau services. Research is also undertaken into atmospheric constituents including greenhouse gases and atmospheric ozone.

Recent Achievements

Climate change affects wheat yields

A relationship has been identified between Australian wheat yield and changes in climate. Australian wheat yields have increased substantially since the 1950s, with much of this increase clearly the result of improved cultivars and crop management. However, scientists at the Bureau of Meterology Research Centre (BMRC) have shown that interannual variations in wheat yield are also closely related to interannual variations in temperature, with an increase in minimum temperatures leading to increased yield. In the period since 1950, temperatures, especially minimum temperatures, have increased substantially and the study shows that a significant portion of the increased wheat yield since that time appears to be attributable to the rise in minimum temperature.

Study of climate extremes
A joint study by the Bureau, CSIRO Division of Atmospheric Research and the National Institute for Water and Atmospheric Research (of New Zealand) into twentieth century changes in climate extremes concluded that some aspects of climate extremes in the Australia-New Zealand regions had changed. Changes in extreme temperatures, rainfall intensity, and extratropical and tropical cyclones over the region were studied. For Australia, increases in rainfall from high intensity events, an increased frequency of extreme warm days and nights, and a decrease in cool days and nights were particularly significant in recent decades.

Successful field trial of the Aerosonde at NW Cape
Bureau of Meteorology Research Centre (BMRC) scientists initiated development of a small robotic aircraft for environmental monitoring several years ago. This project has now proceeded as a collaboration between the Melbourne-based SES Pty Ltd and the US-based Insitu Group. Ten aircraft have recently completed an intensive operational field trial off the West Australian coast near Port Hedland. During flights totalling 150 hours, with individual flights of up to 31 hours, the Aerosondes were regularly commanded remotely from Perth. They flew a number of missions including through the periphery of a tropical cyclone and several severe thunderstorms, and monitored offshore conditions to aid aviation forecasting. Successful completion of the trial signifies that Aerosondes are now moving towards operational implementation.

Vertical wind profiler
The Bureau of Meteorology is collaborating with a company associated with the University of Adelaide in the development and evaluation of an automated tropospheric wind profiler capable of providing round the clock, remotely-sensed vertical profiles of wind from the surface to eighteen kilometres and detailed information on the vertical structure of the atmosphere, especially important in cold frontal passages and severe weather situations. A twelve month operational trial is being conducted at the Bureau's Mt Gambier Observing Office. Implementation at other Bureau upper wind stations is being assessed.

Tropical cyclone track prediction
Scientists at the Bureau of Meterology Research Centre (BMRC) and the University of New South Wales have demonstrated substantial improvements in the accuracy of tropical cyclone track forecasts over the data-sparse oceans. The methodology they have developed uses high resolution satellite data and a new four dimensional data assimilation technique, and features a very high (15km) resolution model. Through automatically tracking cloud elements on consecutive satellite images, high spatial and temporal resolution satellite cloud drift winds are calculated to augment the often quite poor observational data on which operational forecasts are currently based.

Biodiversity Group of Environment Australia

Role *To assist the Minister and Environment Australia in the conservation and appreciation of Australia's biological diversity and associated cultural heritage, through leadership and cooperation.*

Recent Achievements

Botanical research

Taxonomic and systematic research on Australian native plants emphasised the identification, biogeography and evolutionary relationships of the Orchids, the *Proteaceae* genus, *Grevillea* and the mosses. Computer-based identification tools for major plant groups were developed: an interactive key to the families of flowering plants; an interactive key to the eucalypts of SE Australia called Euclid; and an interactive key to the rainforest trees and shrubs of N Queensland.

Mollusca: the southern synthesis

In the first half of 1998, the Australian Biological Resources Study released a major publication entitled *Mollusca: the southern synthesis* in the Fauna of Australia series. This two part volume presents a series of overviews at one or more levels for the phylum and six classes, as introductions to the treatments of the 423 molluscan families presently recognised in the region. These families contain an estimated 19,000 species.

Potential impact of cane toads on native frogs in Kakadu

The University of Queensland has been contracted to conduct a baseline study of the native frogs in Kakadu National Park (KNP) over two years. The University has already conducted research on native frogs in the face of the expanding distribution of cane toads in the Gulf area of the Northern Territory. They have set up night recording sites, to identify native frog species and concentrations of all the frogs before and after the toad arrival. In KNP, they are identifying species and concentrations of the native frog population before the arrival of the toads.

Environment Protection Group of Environment Australia (EPG)

Role *:The EPG works with all levels of government, business and the community to help find nationwide solutions to Australia's environmental problems. The EPG manages Commonwealth environmental protection responsibioities, administers Commonwealth environment protection legislation and fulfils our international environment protection obligations.*

Recent Achievements

Impact of global wanning on El Niño
Modelling of the effects of climate change on the El Niño-Southern Oscillation (conducted with the Bureau of Meterology Research Centre) confirmed expectation that El Niño will continue under climate change, and suggested that the El Niño-Southern Oscillation cycle (both wet and dry phases) will occur more frequently.

Urban flooding may increase under climate change
Climate change scenarios indicate that changes in rainfall quantity and intensity across Australia could have major hydrological effects. Aproject by the Centre for Resource and Environmental Studies at the Australian National University showed that by 2070, climate change could increase the risks of urban flooding in the Hawkesbury-Nepean and Queanbeyan regions. The direct average annual damage costs in these regions, under the "most wet" climate change scenario, have been estimated to be $23 million and $15 million (in 1996 dollars) respectively - equivalent to an increase in annual insurance premiums of 12 and 6 fold from 1996 values.

Effects of defoliating insects in rural tree decline
A study by CSIRO Division of Entomology of the New England region showed that climate change and associated extremes in soil moisture are likely to increase rural tree decline, by increasing insect related defoliation and loss of mature trees from farmed land. The associated costs were estimated to be between $76m and $248m in current dollar terms for 2030, depending on the climate change scenario used.

Distribution of Australian plant and animal species
A project by the Environment Resources Information Network of Environment Australia showed that the species most likely to be affected by climate change were those with limited distribution, or with specific soil or habitat requirements. Of the fourteen rare and common species studied, the Kowari (a threatened desert-living mammal) and Curley Mitchell grass (a common plant important in rangeland agriculture), were the two species

most threatened by climate change. Areas of suitable climate for the species were projected to contract significantly under climate change and move to regions where the vegetation and soils did not suit their survival. Some species, however, were found to be largely unaffected by climate change, such as the Kookaburra which had more general habitat requirements.

Supervising Scientist Group of Environment Australia

Role *To ensure ihrough research, assessment and the provision of technical advice, thai the environment of the Alligator Rivers Region is protected from the effects of uranium mining to the very high standard required by the Commonwealth Government and the Australian people. The Supervising Scientist also provides technical and policy advice to the Minister for the Environment on a wide range of mining-related issues of national importance and on radiological matters, and conducts more broadly based*

Recent Achievements

Acid mine drainage in Australia
Funded by the Supervising Scientist Group and undertaken by the Australian Nuclear Science and Technology Organisation, a study has been completed of the extent and potential future liability of acid mine drainage from mine sites across Australia. Based on information collected during the study, the additional operational cost on properly managing sulphidic mine wastes has been estimated at about $60 million per year to the whole mining community. This cost is a very small fraction of the total annual costs of the mining industry, but a significant proportion of the amount spent on environmental issues. This study identified a need to improve the level of knowledge and awareness of acid drainage issues at mine sites and to assess the long-term effectiveness of management strategies being used.

Removal of radionuclides
In a collaborative project with the University of Queensland and CSIRO Division of Molecular Sciences, the Environmental Research Institute of the Supervising Scientist (ERISS) has assessed the effectiveness with which radionuclides can be removed from wastewaters using manganese-oxidising bacteria. The technique is based on the tendency of certain metal ions to adhere to the surface of manganese oxides. Since the bacteria continually produce a fresh oxide surface, the capacity of such a system to remove radionuclides from feed waters should remain high over a long period. The results show that use of a bioreactor containing such bacteria to remove radionuclides from mine wastewaters is feasible. A provisional patent has been registered on the site.

Modelling long-term erosion of rehabilitated mine sites
In collaboration with the University of Newcastle, the Environmental Research Institute of the Supervising Scientist (ERISS) has developed and calibrated a landform evolution model to enable the assessment of the stability of engineered landforms at rehabilitated mine sites. Recent research has concentrated on validation of the predictions of the model by comparing model outputs with observations of actual landform development over short, medium and long (greater than one thousand years) periods of time. Results have shown that the predictions of the model are reliable.

Herbicide effects on tropical Australian wetlands
Mimosa pigra is a woody aquatic weed which is causing great environmental concern. It forms large, dense stands in floodplain environments, and is severely degrading productive pastures throughout northern Australia. The herbicide, Graslan, is commonly used in northern Australia to help control mimosa. The Environmental Research Institute of the Supervising Scientist (ERISS) undertook an ecological risk assessment on the impacts of tebuthiuron on native, non-target aquatic organisms. The results show that the use of tebuthiuron to control mimosa appears to present very little, if any, risk to the aquatic organisms assessed in the study. Extension of the study to include plant and algal species has commenced.

Great Barrier Reef Marine Park Authority (GBRMPA)

Role *The GBRMPA is the principal advisor to the Commonwealth Government on the care and development of the Great Barrier Reef. The Authority's research and monitoring program conducts and supports research to assist in fair and transparent decision making in the Marine Park. Its focus is on obtaining, interpreting, disseminating and applying scientific information on the Great Barrier Reef, in order to manage human use and minimise impact to the Great Barrier Reef World Heritage Area.*

Recent Achievements

Water quality in the inner Barrier Reef
Major river flood plumes in the Great Barrier Reef lagoon are being studied to assess the extent of influence and effects of terrestrial runoff on the reef. The study is being undertaken by the Authority, the Australian National University, Sydney University and the Australian Institute of Marine Science. The information includes the extent of plumes and sediment composition and distribution. The results of the analysis indicate that terrestrial runoff will usually affect only the inshore parts of the Great Barrier

Reef; however, under calm conditions, flood plumes may extend to the outer reef.

Coral bleaching

A large-scale sea temperature monitoring program established in the Great Barrier Reef World Heritage Area in 1995 is paying dividends in helping our understanding of a major natural disturbance to the reef. In early 1998, elevated sea temperatures, combined with lowered salinity in some areas, caused extensive bleaching of corals, clams, anemones and sponges from reefs off Bundaberg through to the tip of Cape York Peninsula. The eventual fate of these organisms, in terms of possible recovery or death, is yet to be determined and little can be done for the reefs at this time. However, the temperature data will help in defining the envelope of tolerable conditions for reef organisms.

HEALTH AND FAMILY SERVICES

National Health and Medical Research Council (NHMRC)

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 interst of improving these standards.*

Recent Achievements

Alcohol genes
A major study, making use of twins enrolled on the NHMRC Twin Registry, and supported by grants from NHMRC and the US National Institutes of Health, has found that risk of alcoholism is genetic in both women and men.

In the largest study of its kind, over 6,000 adult twins throughout Australia were interviewed about their drinking habits and any associated drinking problems. In common with other western countries, 25% of males and 8% of females in the sample were thought to be dependent on alcohol. Almost two-thirds (65%) of the variation in alcohol dependency was due to genetic factors and this was true in both women and men. Earlier smaller studies had claimed that genetic factors were not important in alcoholism in women. The researchers are now looking for the particular genes responsible predisposing to alcoholism. Finding them may suggest new strategies for both prevention and cure.

Response triggers systemic illness
An NHMRC-funded group at the Australian National University pioneered the idea that most of the harmful effects of infectious disease are not caused directly by the invading organism. The cause was found to be molecules, including tumour necrosis factor (TNF), released from the patient's body in response to the presence of the infectious agent. The group also argued that these same mediators are sometimes released after antibiotics kill infectious agents, causing an acute illness. This second aspect of the work has now come to fruition, since an antibody that neutralises TNF has been shown to prevent the acute systemic illness that occurs after antibiotic treatment of a serious epidemic disease in tropical Africa. The demonstration of this principle shows that it should apply to a wide range of other infectious

diseases, and thus be of considerable economic value in the management of these conditions.

Hydatid vaccine

At the University of Melbourne, a vaccine has been developed for the prevention of hydatid disease. This disease is caused by the larval form of a tapeworm parasite. The infection causes the growth of large parasitic cysts which often grow in the liver and lungs, but may occur in any organ including the heart and brain. It is a zoonotic disease, being spread to humans by dogs harboring the parasite *Echinicoccus granulosus.* The disease is widespread in the world population, particularly in countries bordering the Mediterranean, in Africa, China and Central and South America. It is one of the few parasitic diseases which causes deaths in Australians each year. The vaccine was developed using recombinant DNA methods. It has achieved 96+% protection in several different vaccine trials against the disease in its natural animal hosts. Successful field trials with the vaccine have been completed in China and Argentina. To date, no other vaccination has been successful in controlling any human parasitic disease. The very high level of effectiveness of the hydatid vaccine suggests that a human vaccine against hydatid disease could be the first highly effective anti-parasite vaccine.

Identifying serious medical complications in chronic alcoholics

Researchers at the University of Sydney and the Prince of Wales Medical Research Institute have conducted a clinicopathological survey of over 4,000 people. The survey has identified sets of symptoms which can distinguish with high degree of certainty serious medical complications in patients with a history of alcohol abuse. Unfortunately, in a proportion of cases the seriousness of their medical condition is often masked because of intoxication, and in these instances permanent brain damage or death can occur. The sets of symptoms identified predict the course of the medical illness and, in many instances, simple treatments can be implemented to prevent any serious outcome.

Alcohol — permanent brain damage?

There has been some doubt over whether there is any permanent brain changes from the habitual consumption of medium to high levels of alcohol. Using operational criteria to identify chronic alcoholics, researchers at the University of Sydney and the Prince of Wales Medical Research Institute carefully analysed the cellular content of different brain regions. There was no permanent damage in brain regions crucial for adequate memory function, a function often transiently compromised by alcohol ingestion. However, all alcoholics, even those with medium levels of alcohol consumption, had a small reduction in the number of neurons in the frontal region of the brain. This suggests that selective neurons in brain regions responsible for decision making processes are permanently damaged by chronic alcohol consumption.

Sex differences in the brain

Volume analysis of the brain from an autopsy sample of average men and women found that women have proportionally larger regions of the brain that deal with language. The work was performed by researchers at the University of Sydney and the Prince of Wales Medical Research Institute. The men were on average larger in size and therefore had larger brains. This was an expected outcome. However, the language regions of the brain were equivalent in size in both men and women, despite women having smaller brains on average. This is the first evidence of substantial anatomical differences underlying brain function in men and women.

Sticky "knobs" cause malaria deaths

Malaria is one of the major scourges of tropical countries, debilitating 300 to 500 million people a year and killing up to 2.7 million. The principal cause of death is brain damage, caused by the clogging of capillaries by malaria-infected red blood cells. In 1997, in a world-first, Dr Alan Cowman and his colleagues at the Walter and Eliza Hall Institute of Medical Research (WEHI) made a major technological breakthrough which permits them to incapacitate individual genes within the malaria parasite. They used this technique to identify the malaria gene responsible for generating thousands of sticky "knobs" on the surface of infected red blood cells. Together with Professor Graham Brown (also of WEHI) and Professor Ross Coppel (at Monash University) and their colleagues, the researchers went on to demonstrate that blood cells infected with malaria parasites lacking this gene retain a smooth surface and can no longer adhere to endothelial cells under flow conditions mimicking those in blood vessels. These experiments are of major significance in understanding the pathology of malaria. The new technology will reveal the function of many more malaria genes, thereby enabling development of new strategies to cripple the parasite.

INDUSTRY, SCIENCE AND TOURISM

MAJOR POLICY ACTIVITIES

Overview of Policy Advisory Arrangements

Policy advice to ministers, awareness of key issues and the high-level coordination of activities across portfolios is maintained by a combination of the Chief Scientist, the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) and the Coordination Committee on Science and Technology (CCST).

As described in Section 2, the Government has decided to form a standing committee of PMSEIC to take over the responsibilities of the Australian Science, Technology and Engineering Council (ASTEC). The new standing committee will oversee and contribute to studies and research aimed at an improved understanding of science, technology, engineering and innovation issues.

CCST brings together Heads of science and technology agencies and Deputy Secretaries of departments with an interest in science and technology, to share information about their programs and policies, problems and opportunities. It is chaired by the Deputy Secretary of the Department of Industry, Science and Tourism with science and technology responsibilities.

The Chief Scientist is currently chair of ASTEC, Executive Officer of PMSEIC, and a member of CCST.

Secretariat support for PMSEIC, ASTEC, the Chief Scientist and CCST is provided by the Science and Technology Advisory Branch of the Department of Industry, Science and Tourism.

Prime Minister's Science, Engineering and Innovation Council (PMSEIC)

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

PMSEIC is a high-level discussion forum on national science and technology related issues. Ministers with key portfolio responsibilities for science and technology are members, and there is high level representation from business, science and technology. The Prime Minister chairs PMSEIC and the Minister for Industry, Science and Tourism is the Deputy Chair. PMSEIC gives ministers the opportunity to hear expert presentations and interact directly with leading representatives of science, technology and industry, such as the Presidents of the two science-based Academies.

PMSEIC has the following terms of reference:

- to advise on important issues in science, technology, engineering and relevant aspects of education and training, including as they relate to economic growth, employment creation, the development of new industries and the sustainable development of new resources;
- to examine the contribution of science, technology and engineering to the innovative capacity and economic and socialdevelopment of Australia;
- to enhance awareness in the community of the importance of science, technology and engineering for Australia's economic and social development;
- to examine Australia's science and engineering resources and the effectiveness of their organisation and utilisation; and
- to examine Australia's science and engineering infrastructure and the effectiveness with which it achieves the application of science and technology in the economic and social development of Australia.

Recent Achievements

See Section 2.

The Chief Scientist

Role *The Chief Scientist provides policy advice, briefing and support to the Prime Minister and the Minister for Industry, Science and Tourism on strategic and operational issues affecting the science and technology system and its contribution to national goals.*

The Chief Scientist, Professor John Stacker, provides advice to the Prime Minister and the Minister for Industry, Science and Tourism on such matters affecting science, technology and engineering as the Prime Minister or Minister request, and on other issues to which science and technology are relevant. Professor Stocker is Executive Officer of the Prime Minister's Science, Engineering and Innovation Council.

Australian Science and Technology Council (ASTEC)

Role *To advise the Commonwealth Government on the development of a clear, long-term strategic approach to maximise the contribution of science, technology and engineering to national well-being.*

The Prime Minister announced in December 1997 changes to the science and technology advisory structures in the Commonwealth Government. This will involve the incorporation of the functions of ASTEC and the Prime Minister's Science and Engineering Council into a new high level policy advisory body, the Prime Minister's Science, Engineering and Innovation Council. The new body will continue ASTEC's work. The Minister for Industry, Science and Tourism has requested that current ASTEC studies be carried to completion by the present Council and its working groups.

ASTEC provides the Government with detailed analysis of issues based on extensive research. It deals principally with issues where a full examination of all relevant facts is needed. ASTEC's advice to Government represents the outcome of deliberation by experts, both on the Council and co-opted to ASTEC working parties.

The functions of the Council are to investigate and to furnish information and advice to the Commonwealth Government in respect of issues relating to science, technology and engineering including:

- the advancement of scientific knowledge;
- the development and application of science and technology in relation to national well-being;
- the adequacy, effectiveness and balance of scientific and technological activities in Australia;

- the identification and support of new ideas in science and technology likely to be of national importance;
- the practical development and application of scientific discoveries;
- the fostering of innovation in industry; and
- the means of improving efficiency in the use of resources by the application of science and technology.

Recent Achievements

See Section 2.

Coordination Committee on Science and Technology (CCST)

Role *To allow departments and agencies with an interest in science and technology to share information about their programs, policies, problems and work plans. This helps ensure coherence and consistency in the implementation of Government policy for science and technology, and allows an overview by the Committee of that policy.*

The CCST's terms of reference are:

- to provide coordinated advice to the Government through the Minister for Industry, Science and Tourism on national science and technology issues;
- to improve coordination of administration of government science and technology programs among departments and agencies, including cooperation among departments and agencies on specific science and technology issues and opportunities; and
- to exchange information among departments and agencies on domestic and international science and technology programs, policies, work plans, issues and opportunities.

Recent Achievements

See Section 2.

Genetic Manipulation Advisory Committee (GMAC)

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

The Genetic Manipulation Advisory Committee (GMAC) is a non-statutory body established to oversee the development and use of novel genetic manipulation techniques in Australia. GMAC's role is to identify and manage risks to the safety of workers or potential hazards to the community or environment associated with genetically manipulated organisms. GMAC is supported by a secretariat within the Department.

In December 1997, the Commonwealth commenced discussions with the States and Territories on proposals for regulation of gene technology. These proposals, announced in October, provide in principle for:

- amendment of current legislation and introduction of new legislation to ensure that gene technology is covered by uniform laws and that compliance is compulsory;
- establishment of a Gene Technology Office to administer a national regulation system which will ensure that comprehensive scientific analysis and risk assessment are undertaken before genetically modified organisms (GMOs) are released (the Office would coordinate the release of GMOs by existing bodies, make decisions on release of GMOs not covered by existing bodies, and regulate gene technology research);
- retention of the provision of expert scientific and technical advice by an advisory committee with functions based on the existing Genetic Manipulation Advisory Committee.

Recent Achievements

New release proposals

Between 1 July 1997 and 30 March 1998, GMAC assessed fourteen new proposals, and thirteen extensions to previous proposals, for the planned release of genetically modified organisms into the environment in field trials. All but one of the proposals were for field trials of genetically modified plants. The plants involved were cotton, canola, Indian mustard, carnation, barley and poppy. The genetic modifications included resistance to pests and diseases, resistance to herbicides, improved quality traits, and marker genes. The remaining proposal was for a field trial of a genetically marked insect virus; this trial was a precursor to possible future work involving strains of the virus modified to provide better control of insect pests in Australian crops.

GMAC also assessed two proposals for general (unrestricted) release of genetically modified organisms into the environment. These were for the release of herbicide-resistant cotton and herbicide-resistant hybrid canola. GMAC's view is that general release of herbicide-resistant crops should only take place in the context of a national strategy for deployment of such crops. Since a national strategy is not yet in place, the proposals were permitted to proceed only under the conditions applied to field trials of these crops.

MAJOR RESEARCH ACTIVITIES

Australian Government Analytical Laboratories (AGAL)

Role *To develop analytical methods of suitable precision, accuracy and efficiency to meet demands for emergency testing services related to the protection of public health and safety, threats to Australia's export markets for agricultural produce, and protection of the environment. Investigatory andf advisory capability resides with the Scientific Services Laboratory in the areas of fire safety, construction and related activities.*

The Australian Government Analytical Laboratories (AGAL) play an important strategic role in protecting Australian public health and safety and international trade, through its quality services in analytical chemistry, microbiology, fire safety and physical testing. AGAL's operations are aimed at providing support for government and industry and in particular they provide a crisis response capability.

Recent Achievements

Fingerprinting illicit drugs
AGAL scientists have participated in a collaborative program with the United Nations Drug Control Committee to further develop high resolution analytical methodologies for profiling impurities in drug seizures. Such profiling of illicit drugs, for example heroin and amphetamines, is being used by the Australian Federal Police as part of the National Heroin Signature Profiling program, which was announced by the Prime Minister.

Rapid detection of marine chemical pollution
Organotin compounds are active agents in antifouling paints used in the shipping industry to prevent the build-up of barnacles on ships' hulls. A major initiative in AGAL's environmental chemistry program was the development of methods to determine levels of organotin compounds in sea

water, sediments and shellfish. The new methodology has been made available for commercial use in Australian laboratories, so that environmental consultants now have a rapid method with which to monitor levels of tin accumulated in the environment from these antifouling agents.

The Australian Institute of Marine Science (AIMS)

Role *To generate the knowledge to support the sustainable use and protection of the marine environment through innovative, world-class scientific and technological research.*

Recent Achievements

Status report for the Great Barrier Reef

The Long Term Monitoring project at AIMS has continued to monitor the status of reefs on the Great Barrier Reef (GBR) using both broad scale and intensive surveys, providing timely input to managers. The second status report has now been completed. Following the widespread effects of the crown-of-thorns starfish during the 1980s, surveys show the average coral cover over all the survey reefs increased by 3-5% during 1992 to 1996. In 1997, Cyclone "Justin" caused coral damage in the central regions of the GBR and the effects of increasing numbers of crown-of-thorns starfish in the north became evident. During this summer coral bleaching has been noted on many near-shore and mid-shelf reefs. This bleaching coincides with large amounts of freshwater from flooding rivers and high water temperatures. The longer-term consequences of this will be followed.

{Contact: Dr H Sweatman, Australian Institute of Marine Science;
tel: +61 (0) 7 4753 4470; fax: +61 (0) 7 4772 5852; e-mail: h.sweatman@aims.gov.au;
Internet: http://www.aims.gov.au/}

Improved knowledge for coastal management

Recent publication of the book *Coastal Ecosystem Processes* by Dr Daniel Alongi provides the latest information on coastal ecosystems to enable informed management decisions concerning the ecology of our oceans. As a nation, Australians associate strongly with the sea and our coastal waters support important industries such as fisheries, oil and gas, shipping and a growing tourism industry. Effective management of these resources for future generations is essential and relies upon high quality science and particularly on an understanding of the processes operating within coastal ecosystems.

{Contact: Dr D Alongi, Australian Institute of Marine Science;
tel: +61 (0) 7 4753 4313; fax: +61 (0) 7 4772 5852; e-mail: d.alongi@aims.gov.au;
Internet: http://www.aims.gov.au/}

Innovative partnership with industry

An innovative joint project between AIMS and BHP Petroleum (BHPP) has provided new knowledge on the habitats of marine flora and fauna in the Central Timor Sea. AIMS assisted BHPP in the design of surveys and in the interpretation of habitat data sets. The principal aim of the project was to underpin the development of strategies to minimise the environmental impact of hydrocarbon exploration and production activities. Baseline environmental information, for the seabed biota on submerged carbonate reefs in the area, supports the concept of a national bioregion of oceanic shoals fringing the continental shelf along Australia's north west boundary.

Results of the study have been published in an atlas, *The Big Bank Shoals of the Timor Sea — An Environmental Resource Atlas.* The publication, which includes a foreward in Indonesian, was the recipient of the 1997 Golden Gecko Environmental Excellence Award from the Western Australian Government.

{Contact: Dr A Heyward, Australian Institute of Marine Science;
tel: +61 (0) 8 9183 1122; fax: +61 (0) 8 9183 1085; e-mail: a.heyward@aims.gov.au;
Internet: http://www.aims.gov.au/}

Australian Nuclear Science and Technology Organisation (ANSTO)

Role *To undertake research and development in nuclear science and associated technologies to contribute to Australia's industrial innovation and development, and environmental and health management. Maintain a core of essential nuclear expertise and nuclear facilities, and further Australia's non-proliferation, nuclear safeguards and wider nuclear technology policies.*

Recent Achievements

Cooperative waste disposal demonstration

A Cooperative Research and Development Agreement (CRADA) has been negotiated with the Argonne National Laboratory (ANL) in the United States to demonstrate the use of a hot isostatic press to produce high-level radioactive wasteforms in a hot-cell environment. Under this Agreement, ANSTO will demonstrate its proprietary can (container) technology for use with ANL wastes and, in return, ANL will demonstrate the production of Synroc in a remotely operated hot-cell facility.

Safety

As part of ANSTO's core business area of International Strategic Relevance of Nuclear Science and Technology, a major strategic research and development project, Safety Culture, is underway. This is contributing

towards the enhancement of safety arrangements for nuclear facilities in the region. ANSTO has taken the initiative in Nuclear Safety Culture with regional activities in this area, conducting two very successful workshops in early 1997 and 1998. These were attended by nine regional countries, including China and Indonesia. The recent workshop in Sydney focused on the application of Safety Culture to research reactor operation and management.

Developments in neutron scattering facilities
There have been several significant milestones reached in instrument development of the neutron scattering facilities at the HIFAR research reactor. The single crystal diffractometer, together with its low temperature attachment, is now fully operational, and being used by an increasing number of external users for scientific problems of increasing complexity.

The commissioning of a small angle neutron scattering instrument at the HIFAR research reactor will open up previously unexplored areas for Australian research and industry. The new instrument is a very powerful addition to the inventory of nuclear facilities capable of supplying information on the structure of materials. As part of a national and international collaborative network, answers are being sought to a number of important industrial/technological questions posed in consultation with the Australian environmental, polymer, petrochemical and power generation industries.

Australian Surveying and Land Information Group (AUSLIG)

Role *AUSLIG is the Government's primary source of advice on land information matters and is responsible for:*

- *policy, standards and coordination associated with delivery of national and international land information programs;*
- *management of national mapping, maritime boundary, remote sensing and geodesy programs; and*
- *implementation of the Australian Spatial Data Infrastructure.*

Recent Achievements

Satellite laser ranging
A state-of-the-art satellite laser ranging observatory has been constructed at Mount Stromlo in the ACT. The new facility will replace AUSLIG's existing geodetic observatory, which has operated in the ACT's Orroral Valley since 1975. Special features of the new observatory include automated operations,

eye safe laser emissions and aircraft detection facilities. The observatory, which will be one of only three such observatories in the Southern Hemisphere, will make a significant contribution to the understanding of global change processes, such as continental drift and the rise or fall of the Earth's land mass.

CSIRO

Role *CSIRO'S primary functions are to carry out scientific research to:*

- *assist Australian industry;*
- *further the interests of the Australian community;*
- *contribute to the chievement of Australian national objectives or the performance of the national and international responsibilities of the Commonwealth;*
- *encourage or facilitate the application or utilisation of the results of this or any other scientific research; and*
- *carry out services, and make available facilities, in relation to science.*

Recent Achievements

Agribusiness

CSIRO cotton on sale in the United States

Australian cotton varieties are to go on sale to farmers in the cotton-growing heartland of the southern United States. The outcome of 30 years of research by CSIRO Plant Industry, the five varieties consistently gave top performance in tests against the best US cotton types, proving equal in yield and superior in quality in areas such as fibre length, strength and fineness. ACSI, a joint venture between Australian-owned company Cotton Seed International (CSI) and the European crop protection and biotechnology giant AgrEvo, will begin seed production in the United States in 1998. The market is worth $A200 million a year.

Lifting logs to save forest soil

CSIRO Forestry and Forest Products has demonstrated that a new way of moving sawn logs significantly reduces damage to forest soils and water. The system uses a modified excavator to lift and carry logs from stump to roadside landing; current practice involves a skidder dragging logs over the ground. A skidder needs up to seven trips to move two dozen logs to the landing, but an excavator can do the same job in one trip. Soil disturbance, erosion and compaction is therefore much lower.

New rust-resistant winter wheat

CSIRO has developed a new variety of winter wheat that is resistant to current strains of stem, leaf and stripe rust in Australia. "Gordon" will be sold by the Australian Wheat Board (AWB) for initial planting in the northern and central tablelands of NSW and some areas of South Australia. It will eventually replace the previous CSIRO variety, Paterson, in the NSW regions, and become available to all growers in the long growing season areas as well as those in the irrigation areas. Gordon is the third winter wheat variety developed by CSIRO Plant Industry and funded by the AWB, the Grains Research and Development Corporation and royalties collected from growers.

Sexless seeds for greater grain production

A world-first discovery by scientists at CSIRO Plant Industry brings closer to reality plants that produce seed without pollination. Since pollen formation and transfer is very sensitive to weather — about $400 million a year is lost in world rice production through drought-related pollination failure, for example — the discovery could dramatically lift world grain output. The scientists have found a gene that allows a test plant to bypass normal pollination processes and begin seed formation. The hunt is now on to find equivalent genes in commercial plants like rice. The Australian Centre for International Agricultural Research (ACIAR) estimates benefits of up to $8.6 billion worldwide.

Knowing and growing the prawn industry

On two fronts, CSIRO scientists are helping develop and sustain Australia's prawn fishing industry. One group of researchers at CSIRO Tropical Agriculture has produced the world's first prawn gene map, the first step in enabling farmers to grow prawns bigger and faster in the future. The map will also help identify genes for other important traits such as flesh quality and disease resistance. Off Australia's far north-west coast, CSIRO Marine Research is getting to know the red-legged banana prawn, now being caught in record numbers and sold around the world. The information gleaned from tagging the prawns will tell of the pressures on the fishery and provide managers with what they need to know to manage it sustainably in the long term.

Environment

The salvation of the handfish

The first Australian marine fish to be listed as endangered may escape extinction as a result of biological research and successful breeding trials by CSIRO Marine Research. The tiny spotted handfish, ironically one of the first Australian marine fish collected and first described in 1804, is found only in Tasmania's lower Derwent estuary and adjoining waters. Supported by the Tasmanian university and government agencies, CSIRO has bred 35 baby fish from two adult pairs. They will proceed with a large-scale breeding program and then develop a plan to support the recovery of the species.

Breakthrough to aid grain storage
Scientists at CSIRO Entomology have developed a device to measure tiny amounts of the furrtigant phosphine, in order to protect the environment and lessen risk to human health. Worldwide each year, millions of tonnes of grain are treated with phosphine to rid it of insects. Using the device around grain storages in four States, the researchers confirmed that fumigation need not be an environmental concern, which will enable bulk handling companies to use phosphine with confidence. Since the discovery of just one live insect on a grain belt will stop loading, and zero tolerance of live insects is a major trading advantage for Australia, it is essential that fumigation is successful — and safe.

Minesite rehabilitation
Scientists at CSIRO Wildlife and Ecology have developed a way of judging how successful a minesite restoration really is. Their insights are helping the nation's miners develop a world lead in restoring damaged areas, and contributing to better ways of managing national parks, nature reserves and rangelands. The team's system is built on indicators that tell how resistant the land is to erosion, how well it retains and recycles nutrients, and how it absorbs and stores water. An understanding of the mix and impact of plant and animal species in the landscape is also important. Interest in the work is coming from places as disparate as Iceland, South Africa and the United States.

New ways to clean up oil spills
By proving that a spray of finely ground Australian clay causes floating films of oil to form into clumps, CSIRO Land and Water scientists have enlisted a potentially powerful warrior in the fight against large oil spills at sea. The clay — which could be sprayed from an aeroplane — repels water but attracts oil, soaking it up and making it form into small floating clumps. Mopping up then becomes much easier. Australia has large, unexploited reserves of the clay, which is turning out to have many unexpected uses in environmental clean-up work.

Information Technology & Services

Editing system for film, video and multimedia
Revolutionary editing software for the film, video and multimedia industry has been launched on the world market by MediaWare Solutions, a high-tech spin-off company from CSIRO Mathematical and Information Sciences. "Webflix" is designed to analyse, navigate and edit compressed video (MPEG) files, and is positioned to capture a significant market share for audio/video tools both in the home and in industry.

High-tech solutions for power and water problems

Collaboration by CSIRO and ACT Electricity and Water (ACTEW) has put the latest information technologies to work on power and water problems in suburban backyards. Mobile Maps, a system that combines the global positioning satellite system, existing databases and mobile data communications, enables field crews to log in to home base for the latest information on where they are working. They can then update network maps back at base while still in the field. Swift, reliable and safe customer service is the result. Mobile Maps has been supported by the Commonwealth Department of Industry, Science and Tourism through its Online Technologies Program.

Manufacturing

Starch to cut bowel disease

CSIRO scientists at the Division of Human Nutrition have discovered that the kind of "resistant starch" now being used to make environmentally friendly packaging can also boost health-giving bacteria in the human bowel. Modern Australians eat only half the starch they need. Many scientists now believe that it is not fibre but resistant starch — that is, starch that resists being digested before it gets to the colon — that may give protection against bowel cancer. It could save many of the 4,300 Australians who die from cancer and bowel diseases each year.

Gene shears drug on trial in humans

CSIRO's revolutionary "gene shears" technology has entered clinical trials in adults — the first step in developing a potential treatment for the human immunodeficiency virus (HIV) that causes AIDS. The Sydney trial involves six pairs of identical twins, where one of each pair is HIV-positive. Over the next three years, gene shears will be tested on a range of other diseases, and research is well advanced into its use in agricultural and food industries. The gene shears technology was developed from basic research carried out at CSIRO Plant Industry.

"Green" coatings for cars

Australian scientists have gained a world lead in environmentally benign coatings for cars and trucks which is driving a revolution in the $US5b-a-year global automotive paints industry. Working in strategic partnership with US chemical giant Du Pont, researchers from CSIRO Molecular Science have pioneered a new range of coatings that are cleaner, "greener" and more durable than today's car paints. The new generation of tailored resins uses a catalytic process which gives precision control over the molecular weight and structure of the coating, and significantly reduces the need for solvents, making paint production healthier and much more environmentally benign.

Minerals & Energy

Oil flow meter licensed

A revolutionary oil flow meter developed by CSIRO Minerals has been licensed to Kvaerner FSSL Ltd, a major international engineering and services company. The meter could save the Australian oil industry millions of dollars in capital, operating and maintenance costs. It eliminates the current need for bulky test separators on oil platforms, and the subsea version could save oil companies from having to lay kilometres of pipes needed to reach the separators. Much of the meter's development was undertaken as a CSIRO-industry joint venture under the auspices of the Australian Petroleum Industries Research Association.

Energy from the wind

CSIRO Land and Water scientists are successfully prospecting for wind. Using an array of sciences and working with energy supplier Pacific Power, the scientists pinpointed a spot at Crookwell in the NSW Southern Tablelands that will be the site of Australia's largest and first grid-connected wind farm. The Crookwell farm can meet the average electricity demands of at least 3,500 homes and reduce carbon dioxide emissions by 8,000 tonnes a year through replacement of fossil fuel power. The new method of finding wind resources could mean that wind may supply much of the two percent of national energy which need to be sourced from renewables under the Federal Government's greenhouse strategy.

New gold discovery technique

A revolutionary geological exploration technique is helping uncover a vast new gold province in central South Australia, triggering a gold rush in a region previously difficult, costly and unproductive to explore. A team of scientists from CSIRO Exploration and Mining and the CRC for Landscape Evolution and Mineral Exploration has developed the calcrete geochemistry method of finding gold deposits. Mineral companies are moving in fast — and successfully. Using the technique, one explorer struck gold at 36 out of 38 sites drilled.

Advance in hunt for oil and gas

Scientists from CSIRO's Divisions of Petroleum, and Land and Water have achieved an international advance in the hunt for oil and gas that will lower the costs and risks of exploration and production. By studying the dynamics of underground flows, the scientists can help oil companies know whether reservoirs are sealing or leaking through fault lines. The companies can then be more confident of the location, size and characteristics of fields potentially worth exploiting. CSIRO is collaborating with the Australian Geological Survey Organisation (AGSO) and is backed by the Western Australian Government and 12 of the nation's major petroleum resources companies.

The Cooperative Research Centres (CRC) Program

The objectives of the Program are:.

- *to contribute to national objectives, including economic and social development, and the establishment of internationally competitive industry sectors through supporting long-term, high quality scientific and technological research;*
- *to stimulate a broader education and training experience, particularly in graduate programs, through initiatives such as the active involvement of researchers from outside the higher education system, and to enhance the employment prospects of students through initiatives such as involvement in major cooperative, user oriented research programs;*
- *to capture the benefits of research, and to strengthen the links between research and its commercial and other applications, by the active involvement of the users of research in the work and management of the Centres; and*
- *to promote cooperation in research, and through it a more efficient use of resources in the national research effort by building centres of research concentration and strengthening research networks.*

The Cooperative Research Centres Committee, which is appointed by the Minister, provides advice on the CRC Program. Under the CRC Program, Government funding of $138 million will be provided in 1998-99 to support the existing 67 CRCs.

CRCs are established under formal contracts with the Commonwealth, normally for seven years, to undertake long-term strategic research focusing primarily on the natural sciences, engineering and their application. By their very nature, CRCs do not achieve significant results in their early years. Often, the benefits of research will not be apparent for many years. Nevertheless, a considerable number of promising achievements are now evident.

Recent Achievements

A cleaner future with gas
The CRC for Materials Welding and Joining has made a substantial contribution to reductions in Australia's greenhouse gas emissions through its industry-sponsored research program, which has reduced the cost of pipeline construction through faster welding speeds and improved weld quality. Savings of over $110 million in pipeline construction costs will help win an increasing share for Australia's plentiful supplies of natural gas against less environmentally attractive energy options.

New vaccine to control bovine respiratory disease
Bovine respiratory disease, also called shipping fever, or pneumonic pasteurellosis, causes reduced growth and feed efficiency, sickness and death of Australian cattle. The CRC for the Cattle and Beef Industry (Meat Quality) has developed a revolutionary new vaccine to control bovine respiratory disease. The disease, which costs the Australian feedlot sector $20 million per year, does not currently have a vaccine. CRC scientists have developed a novel mutant form of the bacterium *Pasteurella hemolytica*, which is the basis of the new killed vaccine. Use of the vaccine will reduce antibiotics treatment of cattle, a practice which compromises meat quality and puts beef markets at risk.

Automated large scale testing of genetic disorders
CRC for Diagnostic Technologies research continues into the design of automated technologies for large scale genetic testing of common genetic disorders to identify large "at risk" groups in Australia and other western societies. The Centre is examining the suitability of its patented First Nucleotide Change technology for screening large numbers of samples. For example, valuable information on the Australian incidence of factor V Leiden, a recently identified alteration which predisposes to increased risk of blood clots; and the mutation thought to cause haemochromatosis which results in excessive iron storage in the liver, can be discovered. AMRAD Biotech is providing assistance with the commercialisation of these studies, which also have generated significant interest from national and international clinical investigators.

Novel test kit to determine rain damage to wheat and barley
The CRC for Quality Wheat Products and Processes has developed a test kit which enables farmers, merchants, handlers, buyers and users of wheat and barley to quickly assess the amount of rain damage that has been done to a crop. Rain just before harvest can degrade a cereal crop, making it unsuitable for premium-paying uses such as bread-making. The existing test (called the "falling number" test) is slow, tedious, imprecise and difficult to carry out other than in a fully-equipped laboratory with skilled staff. The test under development is quick, requires no skill, and costs $5-$15 per test.

Maritime research helps win $27.5 million yacht export orders

The Sydney 40 yacht, designed by Murray, Burns & Dovell (MBD), had been selected as the standard design to race for the Champagne Mumm Admiral's Cup in 1999. The design of the yacht is the result of cooperative research on hull forms and resistance conducted between MBD and the Australian Maritime Engineering CRC. It is expected that 55 yachts (worth approximately $A500,000 each) will be built to this winning design.

New bacteria to revolutionise wastewater treatment

Research at the CRC for Waste Management and Pollution Control has revealed that managers depend on the wrong bacteria to clean up wastewater from sewage effluent, stormwater, abattoirs and aquaculture farms. Nitrogen is a major wastewater pollutant. It is however the *Nitrospira* bacteria, not the *Nitrobacter*, which converts the harmful form of nitrogen to a less harmful form. This finding will contribute to a more effective and cheaper treatment of wastewater. A provisional patent has been taken out on *Nitrospira* bacteria, and a simple DNA-based test to identify and count the bacteria has been developed.

Dragline automation system

The Australian coal mining dragline fleet will gain a significant increase in productivity from the development of a dragline automation system estimated to be worth some $20 million a year as a result of the research activities of the CRC for Mining Technology and Equipment. The huge draglines, which can cost up to $100 million each, strip overburden from coal seams in coal mines and are considered one of the world's biggest robots. The Centre has developed a computer control system to automate the swing cycle which will improve efficiency of the dragline operation.

Novel biosensor

This year the CRC for Molecular Engineering and Technology announced what has been hailed as the world's first "nanomachine". The "nanomachine" is so sensitive that it would register something with the concentration of a sugar cube in a volume of liquid the size of Sydney Harbour. The biosensor, developed by Ambri and the CRC, has applications in a wide range of industries, ranging from the $20 million medical diagnostics market, to the $75 billion pharmaceutical research industry, as well as the emerging markets of genetic testing, proteonics, food safety and environmental testing. The exclusive, worldwide license to commercialise the technology has been granted to a large Australian transnational group.

DNA probe commercialised

The CRC for Soil and Land Management has developed a DNA probe for the rapid and cheap diagnosis of the soil borne cereal disease "Take-all". The test increases the opportunity for remedial strategies and replaces the costly and time consuming bioassay test. An agreement with one of the joint venture partners, the South Australian Research and Development Institute, who launched an innovative Root Disease Testing Service, has seen the test commercialised. A partnership between the major fertiliser companies and service agents will market the diagnostic test in conjunction with other soil

tests and industry services. The direct result of Take-all disease prevention strategies in a year of high disease incidence is estimated at $100 million extra farm gate value of the Australian grain crop.

Nucleus 24 cochlear implant system

The CRC for Cochlear Implant, Speech and Hearing Research, in collaboration with Cochlear Ltd, has developed and trialled the new CI-24M cochlear implant. This implant incorporates sophisticated diagnostic neural telemetry functions, simplifying its use by young children. The CI-24M is also especially shaped so infants can receive the implant during their critical period of speech and language learning. Based on the CI-24M implant, the Nucleus 24 Cochlear Implant System incorporates two new speech processors, the ESPrit™ ear-level speech processor and the SPRINT™ body-worn speech processor. The ESPrit™ is the world's first multiple channel ear-level cochlear implant speech processor, in a package similar in size and weight to current commercial behind-the-ear hearing aids. The SPRINT™ body-worn speech processor is a significant advance, allowing a choice of speech strategies to best meet the needs of each individual user. Cochlear Ltd manufactures all its devices in Sydney for world-wide export, and last year reported earnings of $72 million.

Continuous casting of magnesium ingot

The CRC for Alloy and Solidification Technology has developed a new technology for continuous casting of high quality magnesium ingot. Not only does the new process produce ingot with a much improved quality, but it reduces safety hazards, contributes to a substantial decrease in greenhouse gas emissions, and provides financial benefits for both the producers and customers. The project, fully funded by the Australian Magnesium Corporation, willbe used in the proposed 90,000 tonnes per year Queensland smelter (valued at $350 million per annum).

Antarctic ice sheet mass balance

The 10,000 years or more of relatively stable Earth climate since the last ice age has been enough for the Antarctic ice sheet to settle down to a situation where, on average, the input of snow over the continent each year is almost exactly balanced by the loss of ice as the Antarctic glaciers flow into the sea and melt. This steady-state situation implies that the total mass of ice on the continent (equivalent to about 3% of all the water in the world) remains more-or-less constant. Numerical modelling of the overall Antarctic ice sheet at the CRC for Antarctica and the Southern Ocean indicates that it was probably very close to equilibrium early last century. Since that time the net accumulation from snowfall has increased. The modelling suggests that the overall ice sheet is no longer in equilibrium and in fact is growing at a rate corresponding (roughly) to a fall in sea level of about 6 millimetres per decade.

Industry Research and Development Board

Role *To increase the level and commercial success of industry research and development undertaken in Australia.*

The Industry Research and Development (IR&D) Board was established on 1 July 1986 under the *Industry Research and Development Act 1986.* Under this Act the Board has responsibility for administering several innovation programs including the *Tax Concession for Research and Development,* the *R&D Start* (Strategic Assistance for Research and Development) program, and the *Innovation Investment Fund.* The Office of AusIndustry, a Division of the Department of Industry, Science and Tourism, assists the Board to administer the innovation programs.

Innovation Programs

R&D Tax Concession

The *Tax Concession for Research and Development* (R&D) aims to encourage increased investment in R&D by Australian companies in order to make them more innovative and increase the international competitiveness of Australian industry. The program is effectively market driven, being structured in a manner which is neither industry nor product specific, allowing companies to determine both the area of innovation and the direction of their R&D activities.

Since the changes to the tax concession announced in a joint statement by the Minister for Industry, Science and Tourism, the Hon John Moore, and the Treasurer, the Hon Peter Costello, on 23 July 1996 and in the 20 August 1996 Budget, there has been a small decrease in the numbers applying for the concession. The overall impact of these changes has been to provide a more cost-effective approach to meeting the Government's commitment to R&D by concentrating on current or new R&D and not on that performed in past years.

The tables below show, as at 4 May 1998, the number of companies registered and the expenditure on R&D by State and by the year expenditure was incurred, from 1985-86 to 1996-97. It should be noted that the 1996-97 details are incomplete as there are still close to 650 applications that either need to be processed to ascertain the applicability of registration or the Office of Auslndustry is waiting for those applications where an extension of time to lodge has been granted. Not all of these companies may be registered as some may not meet the eligibility criteria.

Figure 15 BUSINESS EXPENDITURE ON R&D

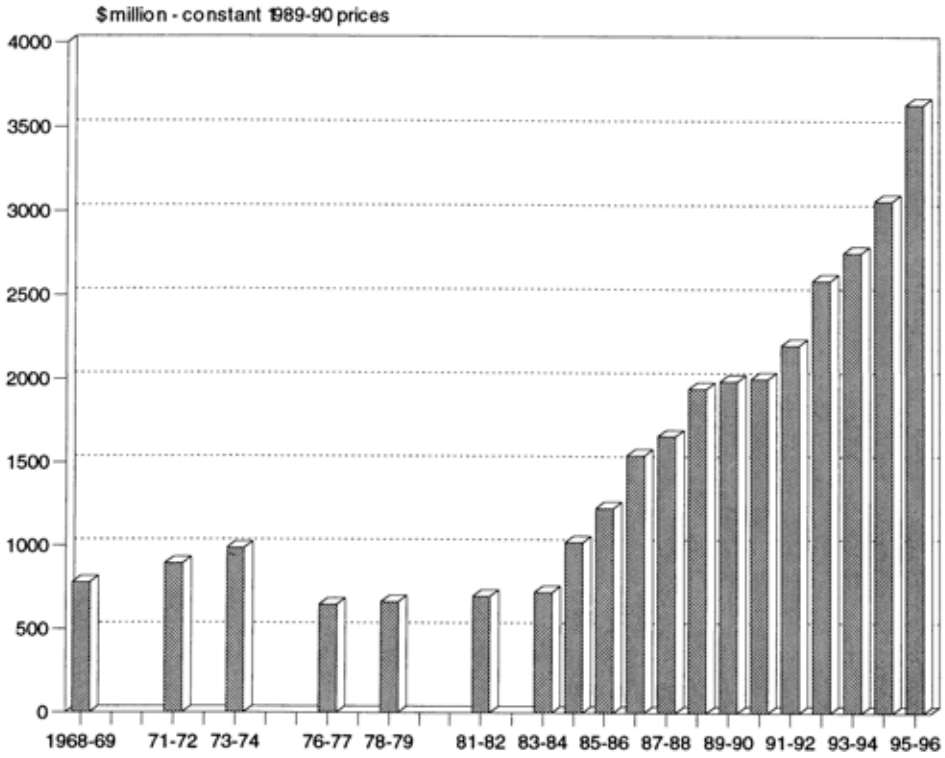


Table 11: Number of registrations by year when expenditure was incurred and State as at 4 May 1998

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	**TOTAL**
1985-86	15	780	1	202	145	31	548	141	**1863**
1986-87	14	640	3	173	89	24	390	110	**1443**
1987-88	15	862	5	234	124	27	572	145	**1984**
1988-89	17	873	6	263	135	35	600	151	**2080**
1989-90	18	965	7	307	147	35	626	180	**2285**
1990-91	20	1041	7	317	159	32	705	191	**2472**
1991-92	29	1150	7	372	177	35	812	213	**2795**
1992-93	27	1177	10	388	169	44	838	228	**2881**
1993-94	33	1354	9	479	204	40	980	269	**3368**
1994-95	38	1373	5	526	219	42	1052	294	**3549**
1995-96	36	1388	7	541	229	45	1107	313	**3666**
1996-97	28	1093	9	422	171	33	919	242	**2917**
TOTAL	**290**	**12696**	**76**	**4224**	**1968**	**423**	**9149**	**2477**	**31303**

Table 12: R&D expenditure by year when expenditure was incurred and State as at 4 May 1998 ($ million)

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	**TOTAL**
1985-86	0.1	61.9	0.0	19.3	0.8	0.3	22.3	2.9	**107.6**
1986-87	1.4	273.4	0.0	64.0	17.4	4.7	288.0	41.6	**690.5**
1987-88	3.0	425.2	0.3	125.3	35.8	7.8	404.6	52.2	**1054.2**
1988-89	5.3	477.0	0.9	131.2	43.6	11.6	555.2	71.9	**1296.7**
1989-90	4.3	529.2	1.8	184.1	54.9	13.2	705.2	105.5	**1598.2**
1990-91	5.1	651.6	1.8	287.7	69.1	11.9	1023.1	122.4	**2172.7**
1991-92	8.9	716.0	1.8	314.7	82.0	33.3	1257.5	142.7	**2556.9**
1992-93	10.7	785.2	2.2	448.9	81.7	17.9	1238.0	178.2	**2762.8**
1993-94	11.4	911.8	36.9	479.3	120.2	28.2	1527.7	239.6	**3355.1**
1994-95	13.6	1124.9	0.8	478.3	143.8	28.7	1757.2	357.2	**3904.5**
1995-96	21.7	1195.6	1.1	649.2	131.5	33.8	1867.1	363.0	**4263.0**
1996-97	21.2	1040.2	3.0	350.9	113.7	34.0	1476.5	351.1	**3568.6**
TOTAL	**106.7**	**8192.0**	**50.6**	**3532.9**	**894.5**	**225.4**	**12300.4**	**2028.3**	**27330.8**

Monitoring

AusIndustry has increased the resources devoted to the monitoring of R&D syndicates.

The majority of active syndicates are expected to receive detailed review at some stage over the next three years. The stated policy of the Industry Research and Development Board is to ensure that syndicates deliver, where possible, the commercial outcomes identified at registration.

The general R&D tax concession continued to be monitored through selective case review by AusIndustry technical assessors, with case selection based on a risk management approach operated on a consultative basis with the ATO. Resources devoted to case review are being supplemented through a trial of contract assessors.

Effective detection and correction of non-compliant claims has resulted from continued coordination of data base and information matching activities with the ATO.

Innovation Investment Fund

In March 1997, the Prime Minister announced the establishment of the *Innovation Investment Fund (IIF)* program, formerly called the *Small Business Innovation Fund,* in his Small Business Statement — *More Time for Business.* The program aims to provide access to venture capital (management assistance and equity) to encourage small, new technology-based companies to improve the commercialisation outcomes of Australia's strong research and development capabilities and to create a self-sustaining early-stage, technology-based venture capital market.

The Commonwealth has announced funding of $173 million for the program, which will be matched by $87 million of private sector investment — creating a capital pool of around $260 million.

The Government, through the Industry Research and Development Board, expects to finalise the first round of funds by May 1998. Five funds, each approximately $40 million in size, will be licensed. It is expected that applications for the second round of IIFs will be called shortly after, with successful funds becoming operational in July 1999.

An additional $20 million was allocated to the establishment of a specialised *Renewable Energy Innovation Investment Fund (REIIF)* in the Government's statement *Safeguarding the Future: Australia's Response to Climate Change.* It is expected that applications will be called early in the 1998-99 financial year.

R&D Start program

The *R&D Start* program has been designed to encourage and support industry research and development (R&D) by providing a range of financial assistance schemes to encourage businesses to invest in R&D and innovative activity.

The *R&D Start* program has been in existence since November 1996. Following a period of extensive industry consultation, an expanded and enhanced *R&D Start* program was announced by the Government in its Industry Statement in December 1997. The expanded program has been designed to further encourage stronger research and development through an increased budget of $556 million over four years, bringing the total expenditure to nearly $739 million over the period to June 2002.

Grants under the expanded program are available for research conducted in Australia by companies which are non-tax-exempt and are incorporated in Australia. Projects that are targeted under *R&D Start* are those in which the expected outcome is a clearly defined product, service, process or technology - including R&D activities. The previous regime of the R&D *Start* program, in which companies had to have a turnover of less than $50 million in each of the previous three years to be eligible, has been revised. All Australian companies can now apply for grants irrespective of the size of their annual turnover.

The expanded *R&D Start* has been developed with an aim to provide national benefits by increases in:

- the number of projects involving research and development activities with high commercial potential undertaken by Australian businesses;
- the commercialisation of the outcomes of such projects; and
- collaborative R&D activities in industry and between industry and research institutions.

The *R&D Start* program is competitive and not an entitlement. The Government sees the advantages of competition as ensuring strong support for the best projects, encouraging private sector participation and concentrating on high-value projects. As in the wider marketplace, firms compete against each other for support.

Under the expanded and enhanced *R&D Start* program, proposals for funding will be assessed against published selection criteria, with the most meritorious being offered support.

Detailed technical, managerial, commercial and financial assessments are conducted on each proposal for funding. Applicant firms need to demonstrate they have the technical expertise to succeed with the project and that they have the management skills and the industrial capacity to commercialise the product, service or technology. Equally important is a strong market potential for the product along with an effective commercialisation strategy. The financial viability of applicant companies is given serious scrutiny. Funding decisions are made by the Industry Research and Development Board (whose membership is drawn principally from the private sector; their qualifications and experience cover a wide range of commercial and technical areas in various industries). Applicant companies are required to contribute significant funds to the projects or arrange private sector financing.

The Industry Research and Development Board has the flexibility to vary the level of support to companies depending on levels of spillovers, closeness to market, nature of technology and capacity to attract private finance.

The expanded and enhanced *R&D Start* program has the following three elements:-

- *R&D Start*, which provides grants of up to 50 per cent of project costs for projects in companies with less than $50 million group annual turnover in each or the three financial years preceding the year in which the application is made;
- a new *R&D Start Plus* element, which will provide grants for up to 20 per cent of project costs, for companies with $50 million or more group annual turnover in at least one of the three financial years preceding the year in which the application is made;
- a new *R&D Start Premium* element, which will fund up to 56.25% of the project costs for projects of high merit — amounts in excess of the benefits applicable to the first two program elements are repayable.

Applications for grants can be received at any time and will be considered every six to eight weeks.

Eligibility for *R&D Start* funding and eligibility for the R&D Tax Concession are not mutually exclusive under the expanded program. If funding is received under *R&D Start* and the tax concession is also claimed, then the "clawback" provisions of the concession will apply.

In 1996-97, the IR&D Board approved $170 million in grants to 57 small and medium sized companies. Projects covered a broad range of technologies. In 1997-98, the Board has (as at 30 March 1998) approved grants of around $80 million. Application forms and client information kits will be available after the program is officially launched. Applications under the expanded program will be received anytime following the launch and gazettal of the Ministerial Directions establishing the program.

Recent Achievements

Sleep apnea treatment
Episodes of sleep apnea lead to fluctuations in heart rate, blood pressure and oxygen saturation, leaving people both tired and at risk of cardiovascular complications. Four percent of women and nine percent of men suffer from sleep apnea. In 1994, Resmed Pty Ltd obtained a government grant to trial the home monitoring and diagnostic tool of its continuous positive airways pressure (CPAP) feedback system, developed with the help of an earlier grant from the Industry Research and Development Board. The CPAP device was developed for the treatment of sleep disorders by assisting breathing when breathing is obstructed due to the closing of the upper airway during sleep. Resmed's Sydney manufacturing operation now produces some 5,000 units of the device each month for sales in 40 countries. The company is listed on the United States NASDAQ stock exchange, and has annual sales of around $80 million.

Landmine detection
Minelab Electronics Pty Ltd is emerging as a leader in the detection of unexploded mines. The company was awarded a Federal government grant in 1989 to develop a metal detector which incorporated microprocessor controlled discrimination circuitry, automatically minimising interference from ground mineralisation. Minelab has recently won a $1.5 million contract to supply the UN-sponsored Cambodian Mine Action Centre (CMAC) with these metal detectors. Further orders are expected from other heavily mined countries. Almost half of Minelab's current sales revenue of $15 million is earned in the United States, Europe and other export markets.

Advanced telecommunications power conversion
Rectifier Technologies Pacific Pty Ltd, with $8 million in annual turnover, has a world-class reputation in telecommunications facilities that incorporate a new generation of high power telecommunication system management technology. The company undertakes the development, design and licensing of advanced telecommunications power conversion equipment for the international market. In 1993, Rectifier Technologies received an R&D grant of $170,000 to develop an advanced Rack Power System. This system incorporates a new generation of high power telecommunications rectifiers, and provides compact, high quality DC power for telecommunications facilities.

Production techniques upgrade
Kador Engineering (Australia) Pty Ltd won an R&D grant in 1995 under the Government's Graduate-Based R&D Related Projects scheme, administered by the Industry Research and Development Board. Under the scheme, a graduate was engaged to work with the Queensland University of Technology on upgrading the company's engineering operations. Over the next two years, improved repetitive production techniques were introduced, and a new shop floor management system was developed. These measures

have improved production and quality, and increased profitability. After the two year project was completed, the company employed the graduate.

IPS Radio and Space Services (IPS)

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

Recent Achievements

Support for JORN HF radars

The computerised ionogram scaling system (Autoscale), which was developed by IPS and is used to analyse the data from the IPS ionospheric network, has been incorporated into the data analysis software for supporting the JORN over-the-horizon HF radar system of the Department of Defence.

{Contact: Dr J Caruana, IPS Radio and Space Services; tel: +61 (0) 2 9213 8050; fax: +61 (0) 2 9213 8061; e-mail: john@ips.gov.au; Internet: http://www.ips.gov.au/]

Support for geophysical explorers

To assist geological exploration companies to plan aeromagnetic surveys and to analyse their high resolution data, IPS has developed a new service for monitoring high frequency variations of the Earth's magnetic field. These variations are usually referred to as geomagnetic pulsations. The pulsations have magnetic survey "signatures" similar to those of some sedimentary basin anomalies, in which valuable amounts of minerals can be found. This service is possible because of the availability of real-time data from two high resolution fluxgate magnetometers, one of which is a collaborative installation in conjunction with the Solar Terrestrial Environment Laboratory (STEL) of Nagoya University in Japan.

{Contact: Dr R Marshall, IPS Radio and Space Services; tel: +61 (0) 2 9213 8048; fax: +61 (0) 2 9213 8061; e-mail: ram@ips.gov.au; Internet: http://www.ips.gov.au/}

Next generation ionosonde

IPS has designed, constructed and commissioned the next generation of ionosonde. An ionosonde is an instrument for recording real-time data on the weather in the ionised region of the upper atmosphere, called the ionosphere. The flexibility of the "IPS-5D" ionosonde and the quality of its data output allow full software control and improved measurement of ionospheric characteristics.

{Contact: Mr B Paterson, IPS Radio and Space Services; tel: +61 (0) 2 9213 8045; fax: +61 (0) 2 9213 8061; e-mail: bruce@ips.gov.au; Internet: http://www.ips.gov.au/}

PRIMARY INDUSTRIES AND ENERGY

Australian Bureau of Agricultural and Resource Economics (ABARE)

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

Recent Achievements

Water resource modelling
The Managing Water Resources research program is designed to investigate economic issues in water resource use and management. The current focus is on the economic implications of the COAG water reform agenda and the implementation of the cap on irrigation diversions in the Murray-Darling Basin.

In 1997-98, a benchmark survey of irrigation industries was undertaken, focusing on water use and farm performance. Information on these items is available on ABARE's website: http://www.abare.gov.au/. Also in 1997-98, decision models at farm level have been developed for the Murrumbidgee Irrigation Area and Karrang districts. These models incorporate the climatic and moisture balance relationships, and allow for the interseasonal differences in irrigation water supply and demand.

GIGABARE - global trade equilibrium model
ABARE further developed the next generation of its global trade general equilibrium model. In addition to the features of the existing model (MEGABARE), GIGABARE incorporates substantially greater detail in the representation of key sectors and economies and an enhanced representation of the dynamics of technological change. The new features provide the capability to supply projections and scenario analyses for fields such as energy supply, demand and trade. Planned developments will represent forest sinks, urban development implications of economic growth and environmental analysis, including integrated assessment of climate change. GIGABARE provided analysis that was drawn upon by the Australian government in the negotiations for differentiated targets at the Third Conference of the Parties to the UN Framework Convention on Climate Change at Kyoto in December 1997. Further developments are being made to GIGABARE to inform policy development in the lead up to the Fourth

Conference of the Parties to the UN Framework Convention on Climate Change at Buenos Aires in November 1998.

Forest Resource Use Model (FORUM)
ABARE developed and used FORUM for analysing the direct economic effects on regional forest-based industries of changes in wood flow. The model simulates the complex interactions between regional forest resources, wood-based forest industries and the final product markets. In 1997-98, FORUM was used in setting the Tasmanian and Central Highlands Regional Forest Agreements (RFAs), and in the development of interim reports in the Eden and Southern and Central Western Australian RFAs.

Australian Geological Survey Organisation (AGSO)

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

AGSO's research outputs underpin informed Government, industry and public decision making by satisfying client needs for high quality geoscience information and innovative research so as to enhance:

- the development of a more productive, competitive and diversified Australian mineral and petroleum exploration industry;
- the management of Australia's land, groundwater and ocean resources consistent with the principles of sustainable development; and
- the development of effective strategies to mitigate the effects of natural geological hazards.

Recent Achievements

New information for mineral and petroleum explorers
AGSO has released a number of information sources to aid exploration for minerals and petroleum. A geographic information system (GIS) for the Broken Hill region was produced as part of the Broken Hill Exploration Initiative (a joint project undertaken by AGSO with its New South Wales and South Australian counterparts). An extensive series of geological maps to assist minerals exploration in the WA Goldfields was released, as was a comprehensive publication on the geology of the nine provinces that make up the North Queensland region. To encourage and support petroleum exploration investment, AGSO provided information to support DPIE's

Petroleum Acreage Release Program, and released a major geological and geochemical study on certain areas of the North West Shelf.

Hydrogeology map of the Great Artesian Basin
AGSO produced a 1:2 500 000 scale hydrogeology map of the Great Artesian Basin, the first to be produced of the entire region. The Basin is Australia's largest groundwater basin and contains some of the nation's most important groundwater resources, underlying one-fifth of Australia. The map will be a major information source for Commonwealth and State authorities involved in the planning, development and management of the Basin's artesian groundwater resources.

Gravity Anomaly Map
AGSO released its Gravity Anomaly Map, which combines onshore gravity measurements with the recently released worldwide satellite gravity coverage over marine areas. Gravity measurements are useful for mineral and oil exploration, in determining the shape and structure of the Earth, enabling accurate satellite global positioning system (GPS) navigation equipment, calibrating accurate weight and pressure measuring equipment, and computing the exact orbits of satellites. The map incorporates significant open file data made available by State Governments and exploration companies.

Murray-Darling Basin soil information strategy
AGSO has recently completed the compilation of a regional digital geology map of the entire Murray Darling Basin. This map, the first of its kind nationally, provides essential information for soil mapping and related land use planning as part of a joint CSIRO/AGSO/BRS project funded by these agencies and the Murray-Darling Basin Commission.

Urban and coastal impact studies
AGSO has undertaken major projects aimed at understanding nutrient and toxicant elements in coastal zones and the continental shelf. Outcomes have focused on delivering high quality data to State agencies and regional authorities to assist with the development of environmental management plans as part of their operations. Studies have been undertaken in the Swan and Canning River estuaries (WA), Wilson Inlet (WA), Port Phillip Bay (Vic) and Moreton Bay (Qld). A separate study contracted by industry has been completed on formation water discharge, from an oil production platform into the sea, on the North West Shelf.

Bureau of Resource Sciences (BRS)

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

Recent Achievements

Regional Forest Agreements
BRS completed mineral and forestry resource assessments for the East Gippsland and Tasmanian regions. This led to the signing of the two Regional Forest Agreements.

Animal and plant health
Drought amplified the need to import grain for stock feed in Australia. BRS prepared a report to the Australian Quarantine and Inspection Service (AQIS) on the quarantine risks associated with the importation of bulk grain. BRS also prepared a report to AQIS on the importation of salmon into Australia. As an important national communication centre for animal health issues, BRS published the annual Australian Animal Health Report and the Animal Health Surveillance Quarterly and provided advice on current animal health issues such as lyssavirus and anthrax. It also developed an Internet site on Animal Health in Australia: http://www.brs.gov.au/aphb/aha/.

Greenhouse
BRS developed greenhouse gas emission projections for the agricultural and forestry sectors to the year 2020 as key inputs to Australia's negotiations at Kyoto on greenhouse gas emission reductions.

Forests
BRS played a key role in compiling and analysing data for the First Approximation Report, the Montreal process, the national State of the Forests Report and the National Plantation Inventory of Australia. These reports enable Australia to report internationally on the state of its forests and its capacity to sustainably manage them.

National Residue Survey
The National Residue Survey within BRS has implemented and managed five targeted testing programs to give domestic and international consumers confidence in the quality and safety of meat: National Organochloride Residue Management, National Antibacterial Residue Management, Hormonal Growth Promotants Audit, Chlorfluazuron and Endosulfan.

Cotton Research and Development Corporation (CRDC)

Role *CRDC's mission is to increase the contribution that R&D makes to the well-being of the cotton industry and the community in general. Its major goals are to: develop efficient, sustainable production systems, to improve fibre quality to better meet market needs, and to develop efficient handling, transport and marketing systems and infrastructures.*

In pursuit of these goals, the Corporation has identified the following major objectives:

- reduce chemical protection of crops against pests, diseases and weeds;
- develop, and have adopted, environmentally sound, sustainable farming practices;
- develop new, improved cultivars;
- reduce post-harvest costs and better meet market requirements;
- maintain the effectiveness of the R&D effort;
- improve the transfer of technology; and
- improve and support human involvement in the R&D effort.

Recent Achievements

Best Management Practice

The Corporation recently produced a Best Management Practice manual. This is virtually a "road map" to help in achieving ecological and economic sustainability in the industry. BMP training sessions are underway in all cotton growing areas and are being enthusiastically supported. The Australian Cotton Industry Council has endorsed the BMP concept and all sectors of the industry are committed to its effective adoption.

Transgenic cotton — further reducing pesticides

The National Registration Authority permitted an increase from 30,000 hectares to 60,000 hectares in INGARD cotton this season, i.e. to around 15% of the total cotton area. INGARD cotton contains genes to express the naturally insecticidal *Bacillus thuringiensis.*

The experience of the last two seasons suggests a 60% reduction in the use of traditional pesticides. However the effectiveness of the new costly technology was variable. Further adoption of the technology will depend as much on cost benefit considerations, as it will on NRA approval.

{Contact: Ralph Schulzé, Executive Director, Cotton Research and Development Corporation; tel: +61 (O) 2 6792 4088; fax: +61 (0) 2 6792 4400}

Dairy Research and Development Corporation (DRDC)

Role *The Dairy Research and Development Corporation's mission is "to maximise the economic, environmental and social benefits for our stakeholders through targeted, innovative anti energetic R&D. "*

To realise this mission, the DRDC objectives are to:

- increase industry competitiveness and profitability;
- improve social and environmental sustainability of dairying; and
- improve the human resource capability of the dairy industry.

Recent Achievements

New dairy blend

A major project to enable manufacturers to rapidly respond to consumer demands has proven its worth, with the formulation of a new dairy blend table spread in just six weeks. It was developed by researchers at the Australian Food Research Institute, at Werribee in Victoria, and Bonlac Foods, one of Australia's largest dairy co-operatives. Consumers like dairy blends because they combine the taste of butter with the spreadability of margarine. It is the only segment of the market showing any growth; sales are up 5%, compared with a 10% decline in butter and a 4% drop in margarine sales. The new dairy blend, Country Gold Soft 'n' Light, is now available on supermarket shelves.

Australian Starter Culture Research Centre

Since its inception in 1992, the Australian Starter Culture Research Centre (ASCRC) has saved the cheese industry more than $60 million in manufacturing costs. Benefits include reduced down time, development of new and improved products, the availability of frozen bulk-set cultures and reduced cost of in-house starter maintenance. Based at Werribee in Victoria, the Centre is a joint venture with dairy companies and operates commercially by providing a large collection of more than 1,000 bacterial strains and over 400 bacteriophage isolates to the Australian dairy industry. The collection is used for various research and strain improvement programs. It also plays an important part in understanding the sources and geographical distribution of bacteriophages (bacteria viruses) throughout Australia.

Milk quality

More than 100 sets of quality management manuals have been released to the Australian dairy industry to help improve on-farm milk quality. The manuals, comprising the *Guidelines for a dairy farm HACCP (Hazard Analysis*

and Critical Control Point) system, can be adapted by dairy farmers and dairy companies to meet their specific quality management needs. Prototype manuals were developed and extensively trialed on 78 farms in Victoria and South Australia during the "On-Farm Quality Management for the Dairy Industry" project (also known as "Dairy First"®) funded by AusIndustry. The Australian Dairy Industry Council is managing the implementation of the guidelines on an industry-wide basis, initially focusing on the food safety elements.

Dried Fruits Research and Development Council (DFRDC)

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

The Council aims to achieve this by developing and funding research strategies, managing research programs and facilitating industry adoption of research outcomes.

Recent Achievements

New varieties
The South Australian Research and Development Institute have released two new apricot varieties, RKOH and #311 from the dried tree fruit breeding program for commercial evaluation. The new releases have high levels of sugar compared to existing Australian varieties. This characteristic provides low fresh to dry ratios and therefore improved yields of dried apricots from a given weight of fresh fruit. The colour and taste of the dried product are very attractive and fruit firmness, which facilitates mechanised harvesting, is good.

Chemical residue test
New chemical residue tests have been developed by the CSIRO Division of Plant Industry. The new tests were validated in a testing program run parallel to the industry's established residue monitoring system during the 1997 harvest season. The new tests have been used exclusively in 1998 to complete the primary screening of fruit samples from growers. The ELISA tests enable the industry to screen for a wider range of chemicals whilst significantly reducing the overall cost of testing grower fruit samples. The tests are conducted locally, hastening the clearance of fruit for processing and shipment.

Prune drying emulsions
The research into prune dehydration undertaken by the University of Wollongong showed that the drying process can be accelerated by using drying emulsions, similar to those used in the dried grape industry, to reduce significantly the cost of prune dehydration.

Plant nutrition analysis test
The Victorian Department of Agriculture has developed an inexpensive test for assessing the nutritional status of sultana grapevines in relation to nitrogen. The test enables growers to obtain an independent assessment on which to base decisions to apply fertiliser. The benefits of the tests are improved vine performance and a reduction in the overuse of costly fertilisers that can be leached into the river system.

Fisheries Research and Development Corporation (FRDC)

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

The national network of Fisheries Research Advisory Bodies and individual FRDC Subprograms identify priorities for R&D funding, and using a combination of public calls and communication with industry organisations, invites applications for R&D funding. This process ensures the relevance of fisheries R&D, minimises duplication and ensures maximum returns on investment.

In 1996-97 the FRDC spent $14.4 million on R&D and managed 411 R&D projects worth over $36 million.

Recent Achievements

Bycatch reduction
The FRDC trawling research subprogram is now in its fifth year. Over that time it has assisted fishermen around the country to significantly reduce the take of unwanted fish, crustaceans, turtles and other organisms. Researchers in NSW have reduced bycatch in prawn trawl fisheries by up to 70% in some instances. The FRDC has funded the extension of this technology into the South Australian fishing industry with the outcome being 100% adoption by trawl fishery operators in the Gulf St Vincent. The reduction in crushing and sorting has increased the value of Gulf St Vincent prawns by 10% while the accidental capture of juvenile fish has decreased by as much as 95%.

Fishmeal replacement
Fishmeal is the most expensive component of aquaculture feeds and approximately $17.5 million worth of fishmeal was imported in 1996-97. The FRDC fishmeal replacement sub-program has recently been completed and has resulted in the development of cheaper yet effective diets for many important aquaculture species. These new diets remove the fishmeal component by 80% - 90% and replace it with Australian produced, quality protein sources such as Lupin and meat meal. Replacing imported fish meal with locally produced protein sources has reduced aquaculture diet ingredient costs by up to 35 %.

Grains Research and Development Corporation (GRDC)

Role *The GRDC's mission is to invest in research and development for the greatest benefit to its stakeholders - graingrowers and the Commonwealth. The Corporation links innovative research with industry needs. The GRDC's vision is for a profitable, internationally competitive and ecologically sustainable grains industry.*

The GRDC's research portfolio covers 25 leviable cropping industries spanning temperate and tropical cereals, oilseed and pulses, worth over $7 billion a year in farm production alone. The Corporation is a statutory research investment body which operates as a partnership between growers and Government. Its operations, which are planned to involve a total budget of $93.5 million in 1998-99, are funded jointly by a levy on grain production and matching Commonwealth contributions.

To improve the profitability of grain producers, the GRDC has set out, in its Five Year Plan "Partners for Profit", four investment objectives for the period 1997 to 2002:

- Meeting Quality Requirements;
- Increasing Productivity;
- Protecting and Enhancing the Environment; and
- Delivering Outcomes.

Recent Achievements

Barley
Australia's billion dollar barley industry is poised for further growth. Backed by a nationally coordinated research investment program involving growers through the GRDC, maltsters and barley exporters, researchers have

released new world class varieties. Other exciting research advances include the development and use of molecular marker and double haploid breeding technology to fast track further varietal improvements. As well, Australian scientists have found ways to reliably transform barley by inserting genes with desirable attributes — technology which has previously proved elusive to world endeavours.

Noodles
Many years of development of market-targeted noodle wheats assures continued growth of Australia's $4.5 billion wheat industry. Long-life noodles produced from Australian wheats are highly regarded by Asian connoisseurs. These noodles, which have a shelf-life of six months at room temperature, are growing in demand in countries like Japan and Korea, as they are pre-cooled and attractive to the eye. Test marketing has been conducted by the Academy of Grain Technology at Werribee, which the GRDC supports through the CRC for Quality Wheat. As well as long-life noodles, precise targeting of our wheats for instant, yellow alkaline and Japanese udon noodles is also under the microscope—the udon market alone amounting to 1 .2 million tonnes of wheat a year.

Grape and Wine Research and Development Corporation (GWRDC)

Role *To improve the competitiveness, sustainability and profitability of the Australian wine industry by managing and funding an R&D program to meet the objectives of the industry's "Strategy 2025" 30 year development plan.*

Recent Achievements

Objective design of grapevine trellises
A three-year study has identified key design criteria for grapevine trellises enabling better and more cost-effective trellises to be adopted by the industry. Given the rapid expansion of this industry and the significant capital demand in industry development, this issue is of considerable importance, and results of this study have constituted the basis for the publication *Practical aspects of grapevine trellising.* This has been widely promoted since its launch in June 1997, and over 700 copies have been sold. A design handbook and software are being prepared for release in May 1998.

Oxidation of bottled wine
In work conducted by the Australian Wine Research Institute, variation in performance of cork closures has been identified as a significant contributor to the random oxidation of bottled wines. This sporadically observed fault is of concern to an industry noted for its high quality product and current effort is being directed to better segregating quality corks from poorer corks, and to evaluating the role of cork coatings in preventing or minimising oxygen transfer into the bottle.

Horticultural Research and Development Corporation (HRDC)

Role *To fund and coordinate research and development projects for Australian horticultural industries, including fresh and processed fruits, vegetables, turf, nuts, nursery products and cut flowers and foliage.*

Recent Achievements

New Australian strawberry varieties claw back early season market
Australian researchers have developed new strawberry varieties better suited to Australian conditions. Until recently, the strawberry industry in Australia has relied heavily on less suitable imported varieties, resulting in variable production per hectare, pest and disease susceptibility, lack of flavour and consumer dissatisfaction. In 1997, 30% of all plantings in the sub tropics and tropics were of new Australian bred varieties including: Redlands Joy, Kabarla and Redlands Hope. Early season varieties grown in the tropics and sub tropics have also enabled the Australian industry to recapture the early season market, previously supplied by the imported product.

Workshops on Waterwork
Runoff water is a major issue for many intensive horticultural industries in Australia. The nursery industry has recognised this environment concern and its potential legal ramifications for operators not adequately trained in water use.

The Waterwork workshop program is twofold. Initially it has involved the development and delivery of competency based workshops in major Australian production areas equipping nursery operators with improved skills and knowledge in irrigation, drainage and water re-cycling. The program was very well received and subsequent demand from the wider Australian industry has resulted. The Waterwork workshop program has now been extended to include "Train the trainer" workshops to enable its wider dissemination to industry and a Waterwork homestudy package for those unable to attend the workshops.

"Easy peels" citrus
Market access to Japan for "easy peels" citrus is expected to be granted following acceptance of successful breakthrough verification trial results and a public hearing process in Japan. The trial, funded by the Citrus Market Development Group and the Australian Horticultural Exporters Association, was successfully undertaken in the South Perth laboratory of Agriculture Western Australia in the latter part of 1997. A technical report was prepared and forwarded to MAFF Japan through the Australian Quarantine and Inspection Service (AQIS). Technical data provided by

Australian disinfestation researchers in support of a postharvest cold disinfestation treatment for "easy peel" citrus was accepted by Japanese quarantine. Subsequently, HRDC coordinated the planning for conduct of a verification trial to confirm the treatment in the presence of an officer from MAFF Japan.

Chemical free fruit
Consumers want fruit that is free of chemical residues as well as free from pests. To achieve this, growers are adopting Integrated Pest Management, or IPM which has been made available through significant HRDC investment in R&D. This involves a range of strategies, including monitoring pest outbreaks and releasing natural enemies. Any sprays are carefully selected and timed to avoid disrupting nature's own pest controllers. To assist growers to access this technology, a new book, *Citrus Pests and their Natural Enemies* was published in 1997. This uses photographs, maps and charts to present the knowledge gained from many years of pest research in Australia. A companion field guide was also produced by HRDC to assist in identifying pests and beneficials in the orchard.

Meat Research Corporation (MRC)

Role *To deliver and manage customer focused, research based initiatives and translate them into benefits for individuals and industry.*

Recent Achievements

VIAscan
VIAscan is objective description equipment for meat which is simply a camera connected to a computer. It is the most advanced of its type in the world and is now being used in commercial meat trading by companies as diverse as Qantas Flight Catering and Woolworths. Woolworths and others are now paying beef producers on the basis of the equipment's assessment of beef carcass quality and yield.

Consumer grading of beef
Until recently, Australian consumers have had to accept that buying a piece of tender steak is a lottery. Consumers of beef say the one thing they want is to be able to reliably buy tender steak. MRC has, after testing with 25,000 consumers in taste panels, perfected a production, processing, handling and retailing system for producing guaranteed tender beef in three grades. The scheme is being commercially piloted by Woolworths, Franklins and Coles in Brisbane and already represents over 20% of beef sold in some stores after only 2 months.

Drought feeding of sheep and cattle
Feeding sheep and cattle in a drought can be extremely perplexing for producers. Animals can be literally starving but if they are introduced to grain supplementation too quickly many die of acidosis. MRC funded research has found that virginiamycin, previously used mainly in pig diets, prevents this problem. Virginiamycin has now been registered for use as an additive to grain supplements for feeding to sheep and cattle without risk of acidosis. A simple solution to an age old problem, with both economic and animal welfare benefits.

Rural Industries Research and Development Corporation (RIRDC)

Role *To undertake and manage research and development investments on behalf of government and industry for the benefit of the people of Australia.*

RIRDC has three core businesses:

- fostering the development of new industries, both prospective and emerging (such as new animals and plants, agroforestry, Asian foods, deer, rare natural animal fibres);
- managing research and development investments for established industries (chicken meat, eggs, honeybee, horses, rice, fodder crops and pasture seeds); and
- addressing strategic cross-sectoral issues facing the rural sector (global competitiveness, resilient agricultural systems and human capital).

The Corporation also provides services for the semi-independent Dried Fruits Research and Development Council.

Recent achievements

New Rural Industries: A Handbook
In February 1998, the Corporation issued a comprehensive handbook on new and emerging industries in Australian agriculture. This handbook is a "first stop" reference point and includes not only a comprehensive menu of options but also lists key follow-up contact points and information sources. The handbook has been heavily subscribed, even though the full text is on the Corporations' Homepage.

Farmers and the Internet
The Australian Farmers' Guide to the Internet was published jointly with Farmwide Pty Ltd. It assists farmers to learn how to use e-mail, the World Wide Web, newsgroups and other Internet features. The guide includes over 250 Web sites of particular interest to farmers and a CD starter kit. Two

complementary publications assist farmers in understanding how to access communications infrastructure necessary for Internet use: *The Rural Guide to Telecommunications* and *A Framework for Developing Regional Communications Initiatives.*

Giving rural women a go
A national research project was carried out jointly with DPIE to define and quantify the role that women play in the agricultural sector. It identified barriers to women's greater participation in decision-making and recommended strategies for enhancing this participation.

A handbook of invertebrate pests of Australian rice fields
The knowledge gained from extensive research on rice pests was developed into an effective handbook which can now be used by rice growers and others in the rice industry to identify common rice invertebrates, determine their pest status and make informed choices about whether control is required. This important handbook will assist growers in the development of integrated pest management strategies that can result in reduced pesticide use in many situations.

Sweetening supplies of honey
A comprehensive research project looked in detail at the range of materials used in the bulk storage of honey. The aim of the project was to maintain honey's image as a quality natural product by ensuring that containers used to store honey met high standards on possible metal contamination. Results indicated that all containers used gave metal levels below the maximum permitted level, many being very low and often below the level of detection. Based on the results of the analysis, major packers have changed to using only those packaging materials which provide the lowest possible levels of any metal presence.

Land and Water Resources Research and Development Corporation (LWRRDC)

Role *To provide national leadership in utilising R&D to improve the long-term productive capacity, sustainable use, management and conservation of Australia's land, water and vegetation resources.*

LWRRDC will establish directed, integrated and focused research and development programs where there is clear justification for additional public funding to expand or enhance the contribution of R&D to sustainable management of natural resources.

Recent Achievements

World class river health

Australia became the first country in the world to undertake a continental-scale assessment of the ecological health of its rivers. This assessment has been made possible through the development of the Australian RIVer Assessment Scheme (AUSRIVAS), which has been managed by the LWRRDC.

Adapted from the highly successful British RIVPACS system, AUSRIVAS involves sampling aquatic macroinvertebrates (insects and crustaceans), that are known to be good indicators of river health. These river-living organisms are sensitive to changes in water quantity and quality and the physical condition of the stream. Certain species are absent or depleted from rivers that are affected by human activities. AUSRIVAS is a sophisticated sampling and modelling framework which allows a comparison to be made between an unhealthy site and a reference pristine or low-impacted site.

With the AUSRIVAS models in place, the First National Assessment of River Health (FNARH) was launched in 1997. About 1,500 river sites are being assessed in the first year and this will increase to 4,500 over three years. In addition, the FNARH will provide input to the second National State of the Environment report. AUSRIVAS is also being integrated into the new national water quality guidelines.

{Contact: Dr Peter Davies, National River Health Program Coordinator;
tel/fax: +61 (0) 3 6225 4660; e-mail: p.e.davies@utas.edu.au;
Internet: http://www.lwrrdc.gov.au/ or http://www.erin.gov.au/portfolio/epg/nrhp/}

Faster mosquito virus test

Research supported by LWRRDC, in cooperation with other agencies, has produced a "speedier" six-day test for virus infection rates in mosquitoes. The Queensland Institute of Medical Research, in collaboration with the Townsville-Thuringowa Water Supply Board and the Zoology Department of James Cook University, has developed new streamlined Ross River and Barmah Forest virus testing procedures, using "Eliza" (enzyme linked immunosorbent assay) methods, which were considerably faster than previous methods used. These procedures are now commonly used in detection programs in Queensland, Western Australia and New South Wales.

{Contact: Dr Brian Kay, Queensland Institute of Medical Research;
tel: +61 (0)7 3362 0350; fax: +61 (0) 7 3362 0111; e-mail: brianK@qimr.edu.au}

10 cent solution for expensive problem

For as little as 10 cents a hectare, land managers in Western Australia's wheat belt are using the latest technology to predict areas at risk of salinity. Funded by LWRRDC, the technique has been developed by the CSIRO Division of Mathematical and Information Sciences, Curtin University's School of Computing Science, Agriculture Western Australia and the WA Department of Land Administration. The technology consists of a combination of historical and current salinity maps, digital elevation data, satellite imagery

and a series of statistical calculations. The result is a new, low-cost approach which can be used over large catchments to predict areas at risk of salinity.
{Contact: Dr Norm Campbell, CSIRO;
tel: +61 (0) 8 9333 6305; fax: +61 (0) 8 9333 612;
Internet: http://www.cmis.csiro.au/rsm/}

Sugar Research and Development Corporation (SRDC)

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

Recent Achievements

Risks of exotic sugarcane diseases
The risk of invasion by exotic sugarcane diseases was assessed during 1997 by the Bureau of Sugar Experiment Stations. Twenty-two diseases present overseas were investigated, of which twelve were considered to pose a significant risk to Australia. The most serious is sugarcane smut, which causes major crop damage in Indonesia. A contingency plan was developed with assistance from staff of the Australian Quarantine and Inspection Service (AQIS). In the event of any suspected incursion, action plans are available for identification, eradication and/or containment of the disease. Sugarcane smut is a disease which will spread rapidly if it is not detected and eradicated urgently.

Improved raw sugar juice clarifier
Raw sugar juice extracted from sugarcane first has to be clarified to improve the efficiency of sugar extraction and the quality of final sugar. The operation has been mathematically modelled using advanced computational techniques and has resulted in design modifications to existing clarifiers which have increased the throughput by up to three times with no decrease in clarification quality. This represents a major breakthrough in clarifier performance and will provide significant advantage to the Australian Sugar Industry in reduced costs and higher throughputs at the same or better sugar quality.

Wool Research and Development Corporation (WRDC)

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

Research and development is primarily focusing on:

- rationalising the R&D portfolio to focus on high pay-off areas aligned with IWS strategic priorities; and
- partnerships and alliance with research providers, industry, and customers to bring customer focus, resources, management skills, market input, andindustry credibility to the portfolio.

Recent Achievements

Apparel Product Enhancement

Four key projects have been taken through to completion of their development stages and business plans are well developed for commercial implementation of these technologies. These are:

- weavable singles technology that will significantly reduce the cost of producing weaving yarns and also enable lighter weight fabrics to be produced from middle micron wool. Global implementation has commenced;
- modified wool technology, which has been taken through to commercial prototype stage and products test marketed in Japan. Commercial production of two types of modified wool will commence in Australia shortly;
- the know how for producing wool/micro fibre blend fabrics on the short staple system has been proven. Test marketing of lightweight easy-care products from this technology will shortly commence in Australia, the United Kingdom and the United States; and
- new non-woven technology, which has been evaluated as a low cost production pathway for wool apparel products. An initial product has been developed and commercial production is expected to commence early in 1999. Plans have been prepared developing two further products.

Organic dressing: spadeable sludge

A licence to market a new technology that can cheaply and effectively remove 95% of solid wastes from wool scouring effluents has been contracted. This technology results in a spadeable sludge of wool grease and dirt that can be easily composted both to denature residual pesticides and provide a high value organic dressing. The resulting water phase meets the requirements of most sewerage systems. A technology that is both environmentally and commercially attractive.

Comparing Merino bloodlines

Commercial growers are now able to get reliable comparisons of bloodline performance when choosing their ram source. This can have a very significant impact on the productivity and profitability of their enterprise.

IWS, in partnership with NSW Agriculture, have analysed the results of 76 wether trials run in NSW and Victoria over a period of 11 years and comparing 73 bloodlines. By removing the effect of different years and environments, researchers have been able to produce reliable genetic comparisons for major production traits, such as clean fleece weight, fibre diameter and body weight, and wool quality traits, such as style, length, colour and soundness.

Commercial growers can now use this information to benchmark their own flock bloodlines from the wether trial data and choose a more appropriate bloodline to meet their breeding objective.

Better plants for sheep

The IWS, in conjunction with GRDC, State Departments of Agriculture, the University of WA, CRC for Legumes in Mediterranean Agriculture and CSIRO Tropical Agriculture, implemented a national annual pasture legumes improvement program in 1997-98. The aim is to enhance woolgrower profitability via the development of highly productive, disease and pest resistant cultivars of sub clover, annual medics and a range of alternative pasture legumes. The newest commercial cultivar arising from the program is a late-maturing balansa clover suitable for high rainfall pastures which provides nutritious feed over summer when sub clover has set seed.

TRANSPORT AND REGIONAL DEVELOPMENT

Federal Office of Road Safety (FORS)

Role *To enhance the safety of Australian roads by providing leadership and coordination in the areas of road safety research and public education, and by developing and implementing vehicle safety design and construction standards.*

The Federal Office of Road Safety (FORS), in its role as the Government's adviser on national road safety policy, relies heavily on strategically applied research. This is to ensure that resources are directed towards achieving the most appropriate, cost-effective measures to minimise the national road toll.

Recent Achievements

Speed risks in urban areas

A case control study of car crashes in Adelaide has produced new evidence about the level of risk associated with different travel speeds in urban areas, and the potential safety benefits of improved speed management.

It was found that the risk of involvement in a serious casualty crash doubled with each 5 km/h increase in free travelling speed above 60 km/h. Even for travel speeds of 65 km/h, the increase in crash risk was statistically significant. The risk increase associated with speeds around 70 km/h were comparable to the effects of driving with an illegal blood alcohol concentration.

Large potential safety benefits from even small reductions in general travelling speeds, particularly on arterial roads, were the result if vehicle speeds were lower. If none of the crashed vehicles had been travelling above the speed limit, nearly half of the casualty crashes in this sample probably would have been avoided, or reduced to non-casualty crashes.

These results have important implications for many aspects of speed management, including potential safety benefits of increased enforcement, enforcement tolerances, setting of speed limits and public education about speed risks.

{Contact: Mr Chris Brooks, Federal Office of Road Safety; tel: +61 (0) 2 6274 7396; fax: +61 (0) 2 6274 7922; e-mail: CBrooks@email.dot.gov.au; Internet: http://www.dot.gov.au}

Advanced frontal crash test dummy
FORS carried out a research project as part of an international program to evaluate the next generation frontal crash test dummy. The new dummy has a large range of enhancements to the head, neck, shoulder, ribs, spine and abdominal areas to better evaluate the performance of restraints.

Side impact standard
Research into the benefits of introducing a dynamic side impact standard to replace the static door strength Design Rule introduced in 1977, saw the gazettal of Australian Design Rule (ADR) 72/00 in December 1996. ADR 72/00 is to be extended to cover four-wheel drive and light commercial vehicles from 2000. FORS is to chair an international working group to assist in the development of a harmonised regulation.
{Contact: Mr Keith Seyer, Federal Office of Road Safety, tel: (06) 274 7479, fax: (06) 274 7477, e-mail: kseyer@email.dot.gov.au, http://www.dot.gov.au}

Australian Road Research Board (ARRB) Transport Research Ltd

Role *ARRB TR undertakes contract research and consulting, develops and markets instrumentation, and provides information and training services to a wide range of public and private sector clients, both within Australia and internationally. ARRB TR maintains close links with both the road authorities and relevant industry bodies to ensure its research is coordinated with user needs.*

ARRD TR undertakes the majority of the contracts under the National Strategic Research Program (NSRP) in road transport, which is administered by AUSTROADS.

Recent Achievements

Development of road user cost models
Substantial progress has been made in the harmonisation of road user cost models in use by the different States and Territories. Models for the economic analysis of rural roads have reached a high level of compatibility in outputs, and work is now commencing on urban economic analysis models.

Pavement rehabilitiation techniques
Through the use of the ARRB TR Accelerated Loading Facility, a number of different pavement rehabilitation techniques have been proven, and guidelines issued for their use.

Index

This Statement was prepared by the Science and Technology Analysis Section, Department of Industry, Science and Tourism, based on contributions from many Commonwealth agencies.

The Section also produces a number of other publications designed to promote informed public discussion on science, technology and innovation issues. If you require more information on these publications, please contact the Section by telephone (02) 6213 6417 or email mavila@dist.gov.au.

Australia is one of the most inventive countries in the modern world. This is illustrated by the prolific list of publicly funded scientific and technological achievements presented each year in the *Science and Technology Budget Statement*. These achievements reflect the vision, talent and diversity of the Australian research community and profoundly affect the quality of all Australians' lives.

This year researchers from the University of NSW set more world records for silicon solar cell performance. Previous improvements by this group are to be used by BP Solar to produce solar cells amounting to about 8 per cent of total world production. Other Australian technological research has resulted in a generic patent on devices which utilise quiet light — laser light from which the quantum noise has been stripped. The patent, which foreshadows a new generation of optoelectronic devices, has already been adopted by industry leader Hamamatsu Photonics KK.

On the medical front, researchers at the University of Melbourne have developed a hydatids vaccine. In the light of outstanding results achieved in trial vaccinations of animal hosts (over 76 per cent protection), it could become the first vaccine able to control a human parasitic disease.

Specialised brain cells containing large quantities of tiny magnetic crystals have been discovered by researchers at the University of Western Australia and the Swiss Federal Institute of Technology. These cells may play an important role in the interaction of the brain with electromagnetic fields such as those produced by some electrical devices.

And there is more: a 'dummy leg' which reproduces and measures the effects of landmine explosions; motion sensing techniques based on insect vision; a technique for inducing coral to produce medicinal chemicals; a faster and more sensitive diagnostic test for that bane of the water authorities — the parasite *Cryptosporidium*; a method for extracting real flavour from natural beverages; and the discovery of the most distant star yet in the quest to measure the ultimate fate of the universe.

It is important to raise Australians' awareness of the important contribution by science and technology to economic and social well being. Descriptions of Australia's research accomplishments, and the Government funding arrangements which underpin them, will continue to attract the interest of journalists, policy makers, peak organisations, business interests and many others in the community.

Cover photograph:
Coral reefs of Northwestern Australia are just one of the rich, diverse ecosystems in Australia's Marine Jurisdictional Area which are receiving special attention in 1998, the International Year of the Ocean. High quality research is supporting the development of marine industries sustained by the natural resources of the region — offshore oil and gas, fisheries, tourism, shipping and transport.

Photograph courtesy of the Australian Institute of Marine Sciences (AIMS).