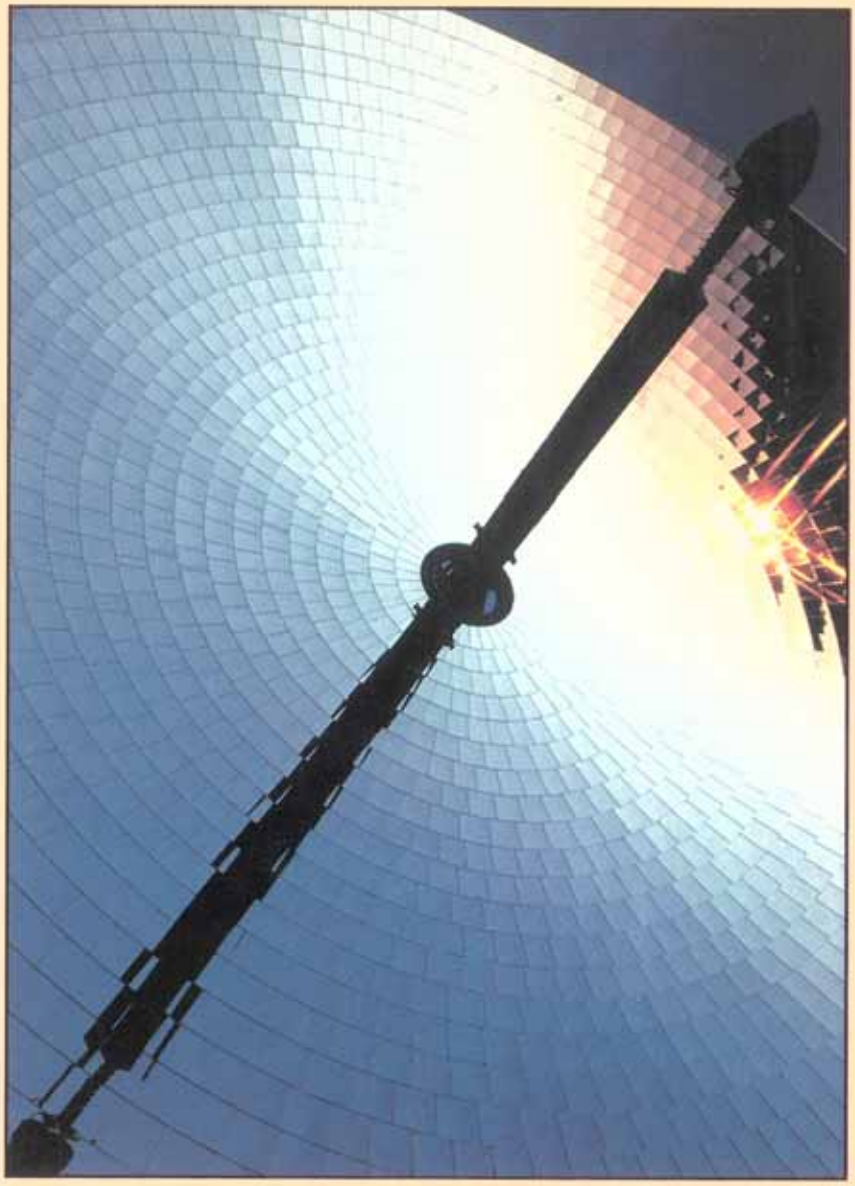
Science and Technology Budget Statement 1995-96



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

SCIENCE AND TECHNOLOGY BUDGET STATEMENT 1995-96

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

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Solar Collector at the ANU.

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HIGHLIGHTS

Commonwealth support for major programs of science and innovation in 1995-96 is estimated to be $3.6 billion, and is maintained in real terms with an increase of 0.7 per cent on the underlying trend.

This follows twelve years of very strong growth in Australia's science and innovation system, stimulated by real growth of 66 per cent in Government support. The strength of this commitment to science and innovation, and the effectiveness of policy within this, are demonstrated in Australia's growth in gross expenditure on research and development from 1.12 per cent of GDP in 1984-85 to 1.56 per cent in 1992-93. This takes Australia ahead of Austria, Canada and Italy to 13th place in OECD rankings.

Within this growth, the Government has enhanced the position of Australia's excellent public sector science, while fostering a very rapid expansion in business research and development. Higher education research, which stood at 0.33 per cent of GDP in 1984-85, had risen to 0.43 per cent of GDP by 1992-93. This is the consequence of real growth of 89 per cent in Commonwealth funding of university research over the Government's period in office. It takes Australia to fourth position in the OECD on public sector research as a proportion of GDP. Business investment in research and development sustained real growth over the period of 13 per cent a year, reaching 0.69 per cent of GDP in 1992-93 from a position of 0.34 per cent in 1984-85. Research by Government laboratories grew in real terms - in CSIRO's case by 23 per cent over the decade to 1994-95 - and entered a new era of external earnings targets, triennium funding arrangements and Management Resource Agreements.

The 1995-96 year will see the Government present an *Innovation Statement* and its response to the Industry Commission Inquiry into Research and Development. The *Innovation Statement* will seek to foster an innovative culture in Australia which firmly established Australia as the premier location for science and innovation in the Asia-Pacific region. It will address all elements of the innovation system, and have particular regard to enhancing the synergies between these elements. An important part of this will be the funding, management and utilisation of the nation's resources in science and technology, which issues will also lie at the heart of the Government's response to the Industry Commission report.

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

- The Australian Nuclear Science and Technology Organisation has been researching the treatment of arsenic wastes which are often generated during the processing of uranium, copper, lead and gold ores. Technology for the photo-oxidation, removal and immobilisation of arsenic has now been patented and is being demonstrated within companies in Australia and the United States.
- The Australian Maritime Engineering Cooperative Research Centre has developed an automatic motion stabiliser system that reduces pitching and rocking movement by over 50 percent. The system has been fitted to high speed ferries built in Australia. These ferries have been sold overseas and are operating in China,. Indonesia, Tahiti and Japan.

SUMMARY NOTES

SUPPORT FOR SCIENCE AND INNOVATION IN 1995-96

- In 1995-96, Commonwealth support for major science and innovation programs is expected to rise to $3592m from $3478m in 1994-95, maintaining Government support in real terms with an increase of 0.7% on the underlying trend. The underlying trend takes account of the flexibilities arising from triennial funding for the science agencies. In the context of these arrangements, a marginal real decrease of 0.4% in total support results from CSIRO advancing $20m of its projected 1995-96 appropriations into 1994-95.

- The Australian Research Council will receive $350m to support university research, a real increase of 9% ($310m in 1994-95). Total funds for university R&D are estimated to rise by about 1%.

- 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 $692m in 1995-96, a real increase of 4% and continuing the substantial support to this area over the past decade The major component of this increase is an estimated increase in the effect on business R&D of revenue forgone through the industrial R&D tax incentive, which increases to $532m from $507m.

- The Cooperative Research Centre Program is addressing the need for interaction between researchers in industry, government agencies and universities. Funding for CRCs rises this year by 8% in real terms, to $127m. Funding has now been provided for 61 CRCs.

- 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 $315m.

- A total of $903m will be provided to the major research agencies in 1995-96 ($942m in 1994-95), including $248m on defence R&D ($239m in 1994-95). Budget support for CSIRO will be $422m, and the Organisation's external earnings will bring its total income to $660m. In terms relative to GDP, appropriations for research in Government agencies in Australia are among the highest in the OECD.

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

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

SUMMARY TABLE

COMMONWEALTH SUPPORT FOR MAJOR PROGRAMS OF SCIENCE & INNOVATION

	1994-95 $m est	1995-96 $m est	Real change
AUSTRALIAN RESEARCH COUNCIL[1]	310.2	350.2	+ 9%
OTHER HIGHER EDUC. R&D	1167.1	1204.7	nil
CO-OPERATIVE RESEARCH CENTRES	112.7	126.6	+8%
INDUSTRY R&D & INCENTIVES[2]	639.0	692.4	+ 4%
RURAL R&D	134.0	130.0	- 6%
NH&MRC	125.5	139.2	+ 7%
OTHER HEALTH R&D	26.8	24.3	- 13%
OTHER R&D GRANTS[3]	21.3	21.9	nil
CSIRO[4]	467.8	422.4	- 13%
DSTO	239.3	247.9	nil
OTHER R&D AGENCIES	234.4	232.2	- 5%
TOTAL[5]	**3478**	**3592**	**-0.4%**

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

1 Represents total of Budget and HEF Act funding.

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

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

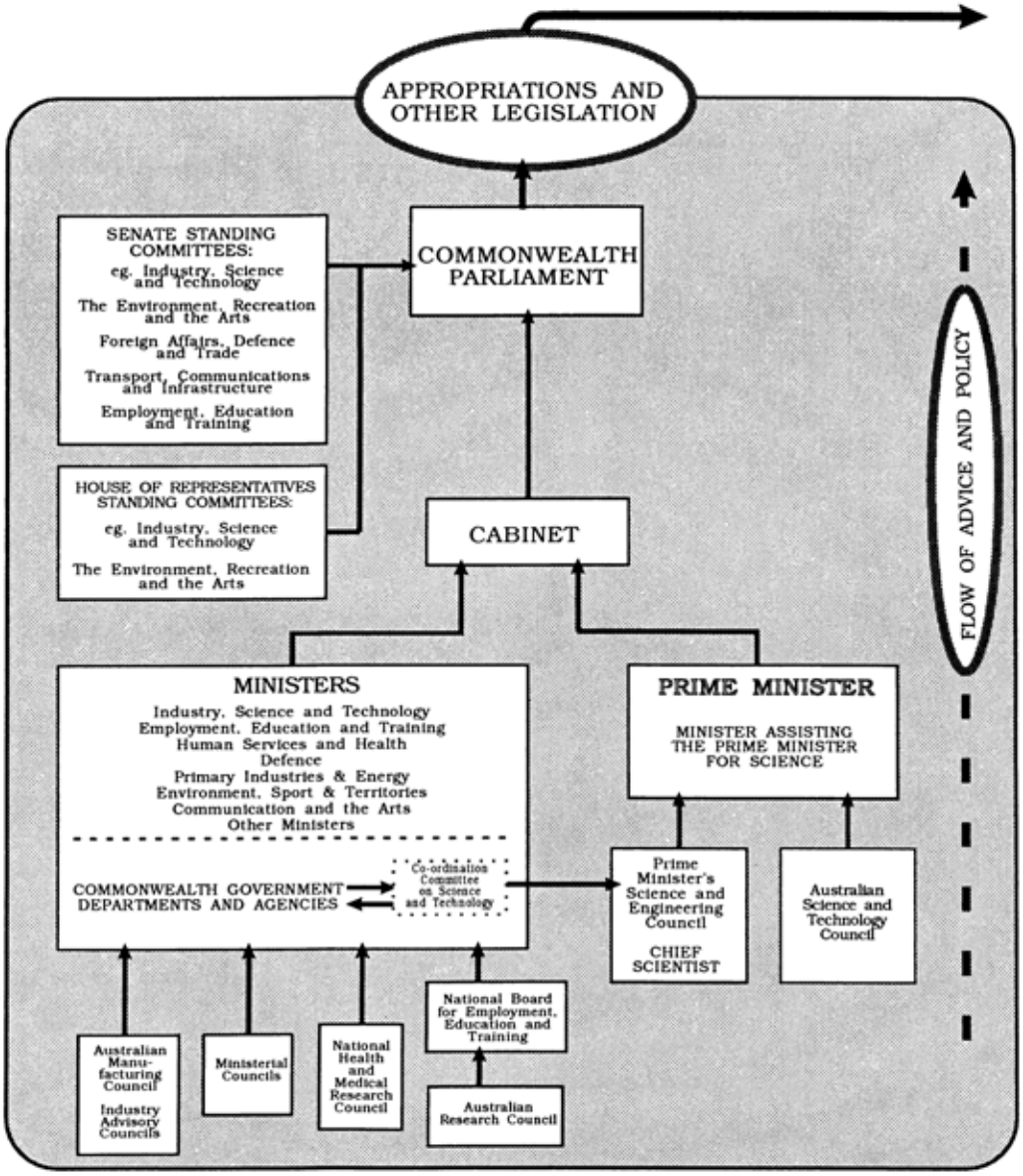
4 Includes funding through DPIE for Australian Animal Health Laboratories. Note that the apparent decline in 1995-96 is primarily due to $20 million borrowed in 1994-95 from 1995-96. In addition to the budget funding shown, CSIRO expects to earn over $240 million from external sources in 1995-96.

5 Taking account of the CSIRO borrowing (note 4), support is maintained in real terms with an increase of 0.7% on the underlying trend.

For more detailed information see Tables 2 to 6

Figure 1

MAIN CHANNELS OF ADVICE FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY

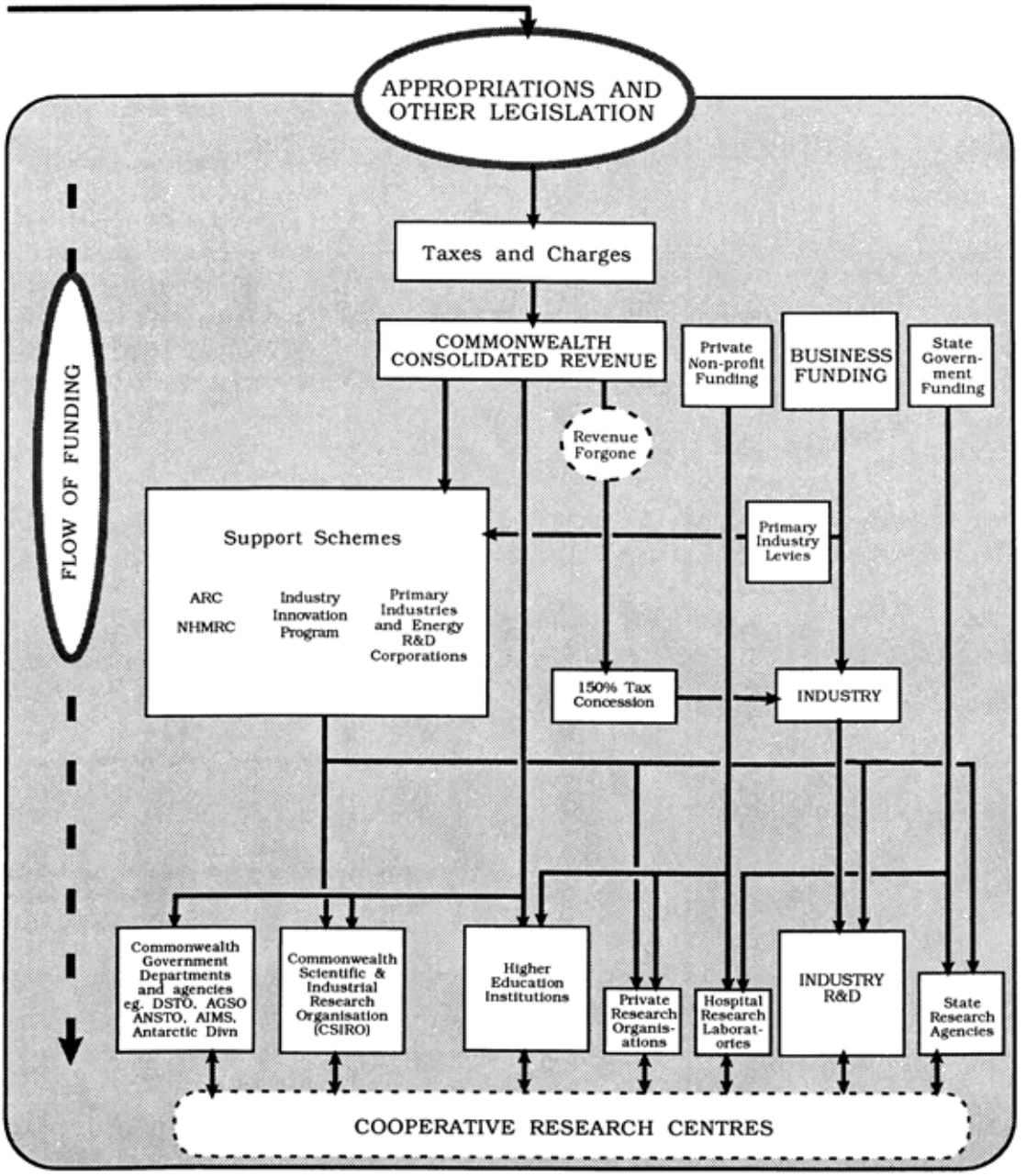


The figure is indicative of major bodies and principal channels for the flow of policy advice leading to Parliamentary and Cabinet decisions on science and technology issues. It does not purport to be other than illustrative.

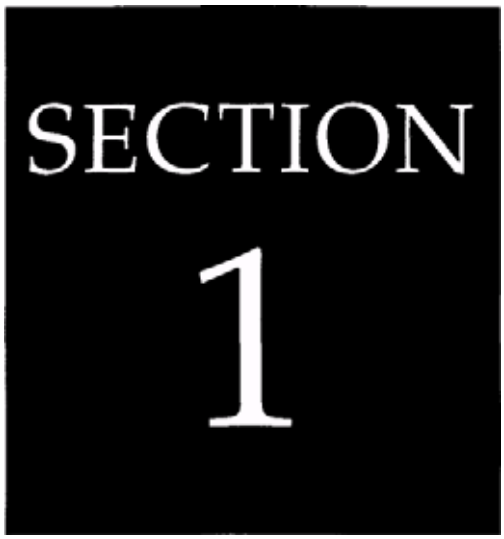
Of course, there are a host of influential forces, including professional organisations and other non-government groups, and there are many cross-links and productive interactions between them.

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.



Strategic vision

This section briefly reviews the very significant progress in Australia's science and technology performance over the past decade, and foreshadows future avenues for policy development.

State of play

1995-96 will see the release of the Government's *Innovation Statement* and the Government's response to the Industry Commission Report on Research and Development. It will be a landmark year for science and technology policy, and the most important such year since the Government's major statement on science and technology policy of 1989.

The *Innovation Statement* will range broadly over issues relating to the development, acquisition and application of technologies to national welfare. Its ambit will include the concerns of economic and social development, health and the environment. It will have particular regard to how the different elements of the national innovation system, including the business sector, financiers, educators, research institutions and the public sector, interact with each other to enhance the effectiveness of the system as a whole. The *Statement* will address the social values, education and training which underpin an innovative culture, Australia's development as the premier location for science and technology in the Asia-Pacific region, and the many issues associated with technology development and commercialisation.

Those elements of the *Statement* responding to the Industry Commission Report will address issues central to the funding and management of research and development, the interface between the public and private sectors within the science and technology system, and the promotion of private sector investment and the commercialisation of research.

This year of policy adjustment will follow on a decade of quite remarkable growth in Australia's investment in research and development. Throughout the decade, the Government has sought to enhance the already outstanding position of public sector research, while fostering very rapid growth in private sector research and improving the quality of interactions between the two sectors. The latest available data vindicate this policy approach and the effectiveness of programs implemented under it.

In 1992-93 Australia's gross expenditure on research and development stood at 1.56 per cent of gross domestic product. This took Australia ahead of Austria, Canada and Italy to 13th place on the OECD ladder. Australia climbed to 4th place on the index of public sector research, at 0.86 per cent of GDP, demonstrating the Government's unwavering commitment to placing Australian science at the forefront of both OECD and Asia-Pacific research performers. And with 0.69 per cent of GDP invested in business research and development, Australia also began to climb the OECD rankings on this indicator.

The improved rankings reflect the impact of Government expenditure and policies, which have seen Commonwealth support for science and innovation increase 67 per cent in real terms over its period of office. Real growth over the last two years of that decade alone was 16 per cent in real terms.

Business research and development

The biggest contributor to growth in national expenditure has been business, whose investment in research and development grew 28 per cent in real terms over the two years to 1992-93, sustaining a twelve year real growth rate of over 13 per cent a year - the highest in the OECD. This striking growth in research and development inputs to innovation was matched by an average 17 per cent annual growth in patent applications to foreign countries by Australians - also the highest OECD growth rate over the period from 1981.

The growth in business research and development over the two years to 1992-93 was associated with a 17 per cent real increase in claims under the 150% tax concession, reflecting the effectiveness of this lever on industry investment in research and development. These results demonstrate that considerable progress has been made towards the Government's objective of raising business research and development to internationally competitive levels.

The growth has also reflected the effectiveness of Government procurement policies in those technology intensive industries where Government purchasing power is significant. Investment in information technology research under the Partnerships for Development Scheme rose from $60 million in 1988 to over $300 million in 1993. The Factor (f) Program will have seen an investment of over $628 million in pharmaceuticals research over the seven years to 1999. Government funding for rural research grew from $35 million in 1983-84 to an estimated $134 million for 1995-96, and has benefited from tighter focus and more direct user management with the establishment of Rural Research and Development Corporations.

In a recent initiative, the Industry Research and Development Board announced its intention to produce a "research and development scoreboard". This will be produced annually as a listing of research and development expenditure by Australian companies, with a view to assisting the financial community in assessing the current and future innovative potential of companies.

Public sector research and development

As reflected in Australia's improved OECD ranking on public sector research, the Government's funding of this sector has grown significantly. Excluding the Cooperative Research Centres Program, funding for higher education research rose from $480 million in 1983-84 to an estimated $1.5 billion in 1995-96, representing real growth in Commonwealth funding of 89 per cent over the Government's period in office. The numbers of equivalent full time postgraduate research students rose 65 per cent from about 12,000 in 1988 to nearly 20,000 in 1992. The introduction of the Cooperative Research Centres Program has injected around $130 million a year into strategic research involving the universities, together with Government research agencies and industry, and the current Budget will provide a further $35 million for research infrastructure in universities, commencing in calendar 1996.

Funding for the National Health and Medical Research Council grew 92 per cent in real terms over the decade, and the current Budget will provide an additional $55 million over four years to the Council to maintain the Government's commitment to directing at least 2 per cent of health expenditure towards research.

The Major National Research Facilities Program announced in *Working Nation* a year ago, brings a further $60 million over eight years towards major basic research facilities - thirty five proposals seeking aggregate support of $370 million are currently being considered under the Program, covering fields as diverse as genetic engineering, high energy physics, astronomy, networked supercomputers, marine research and geological research. Funded projects will complement such existing major facilities as the Australia Telescope, the oceanographic *Research Vessel Franklin,* and the Australian Animal Health Laboratory. In funding large scale visionary science projects, the Program will further develop Australia's science and technology infrastructure, and underpin the capacity for real gains in indigenous industry research capabilities.

Research expenditure for CSIRO, funded by both appropriations and external sources, increased 23 per cent in real terms over the decade to 1994-95, with the external earnings target introduced in 1988 having delivered a significant part of this increase. CSIRO and the other Government research agencies have already achieved, or are progressing towards, their external earnings targets ahead of schedule. The research agencies are now benefiting from the triennium funding arrangements introduced in 1988-89, which provide for greater certainty in forward research planning. Management Resource Agreements are now being introduced to provide for performance measurement in the funding of agencies.

Commercialisation and diffusion

The very strong growth in both private and public sector research has been accompanied by a marked improvement in synergies between the two sectors. This can be observed in the influence of external earnings targets on Government research agencies, and in developing trends in university research, where some 9 per cent of research funding is now won from non-Commonwealth sources. This reflects not only the effectiveness of supply side incentives, but the growing deployment of public research capabilities by industry as its own demand for innovation accelerates. In addition to external earnings targets, industry-linked supplements to the basic research budget have provided another important incentive to interactions - the Cooperative Research Centres Program and the Australian Research Council's industry linkages program are cases in point.

Initiatives in the 1980s intended to support the commercialisation of technology were thwarted in large measure by the stock market crash of 1987. Experience has yielded a more effective approach to the commercialisation of technology and its diffusion within industry. The over-riding influence on both objectives will be industry's investment in its own research and development. At the margins, however, and particularly in the context of

commercialising public sector research, the establishment of the Australian Technology Group Limited in 1992 with a capital base of $30 million will be an important catalyst. The Group has committed some $6 million in its first five projects covering the fields of pharmaceuticals, information technology, agriculture and advanced manufacturing, and the Group is already exploring options for expanding its capital base.

In *Working Nation,* the Government allocated $63.5 million over four years to encourage the development and application of technology in industry. The first element, the Technology Access Program, will encourage the formation of a national technology access and diffusion network to improve industry's access to institutional sources of technology and technical advice, and to accelerate the uptake of appropriate technology. The second element, the Technology Development Program, will support the development and uptake by firms of strategic technologies essential for achieving international competitiveness. In both cases, a structured approach to information sharing will be key to the more rapid and effective diffusion of relevant new technologies.

International linkages

The process of economic restructuring and internationalisation has ushered in a fundamental shift in Australia's approach to its international linkages in science and technology. This has involved the emergence of APEC, which Australia strongly supports, as a focus of policy development and collaborative linkages - in parallel with Australia's traditional involvement with the policy work and performance benchmarking of the OECD.

It has also involved a reassessment of objectives in generating collaborative links with international research partners. The Government has always fostered Australia's active participation in the international community of science, funding exchange programs, fellowships and visits, as well as supporting technical collaboration through aid funding and international initiatives in health and education. The emergence of research-intensive industries over the decade, however, has given cause to seek access to the strategic research programs of the major industrial powers, particularly in North America, Japan and the European Union. These linkages will need increasingly to be tied in with investment relationships, most notably those between Australian subsidiaries and their parents abroad. At the same time, Australia's research capabilities will be an important lever in forging new investment relationships with regional partners in the Asia-Pacific region.

It is in the context of these new demands on our international linkages that Australia will play a leading role at the OECD meeting of science and technology Ministers in Paris in September 1995, and at the APEC meeting of science and technology Ministers in October 1995.

The benefits of continuity

In sum, the very strong growth in research and development, and the marked improvement in inter-sectoral and international linkages, attest to the Government's long-term commitment to science and technology. Most

notably, they demonstrate the effectiveness of policies in accelerating private sector investment in research, while building on the excellence of public sector science. They also reflect the time lags which follow between new policies and their impact on actual performance of research and development.

On the underlying trend, Commonwealth expenditure on science and innovation in 1995-96 will be maintained in real terms with an increase of 0.7 per cent compared to 1994-95. Expenditure will also reflect the policies and programs of the preceding year, including the initiatives announced in *Working Nation* in May 1994.

Policy for the decade ahead

The *Innovation Statement*

The Minister for Industry, Science and Technology, Senator Peter Cook, foreshadowed in his address to ANZAAS in September 1994 the development of an *Innovation Statement* for release in 1995, and set this against the backdrop of a decade of economic restructuring. He indicated the need for a statement on innovation policy at a time when Australia is rapidly changing its export base from commodity production to the generation of high value added goods and services, resulting in new demands upon the science and technology system.

Australia's capabilities in science and technology constitute an important asset able to contribute to a more innovative culture. To achieve this, all elements of the national innovation system, including the national resources in science and technology, must operate in a mutually supportive manner.

The *Statement* will thus address amongst other things, the fundamentals of the science and technology system with a view to optimising its capacity to adjust to new market forces. It will also aim to facilitate the increasing demands placed on public research by the needs of social and environmental policy, and address the role of science and technology in serving Australia's objectives in trade and investment, regional leadership and regional integration. These concerns, central to the structure of science and technology in Australia, will be accompanied by very close attention to the development of an innovative culture, with implications for the training of scientists, engineers and business managers. The commercialisation of research, and the diffusion of technologies, will also be important themes.

The *Statement's* over-arching goal will be to firmly establish Australia as the premier location for science, technology, engineering and innovation in the Asia-Pacific region. In his ANZAAS address, the Minister spelt out this goal more specifically as it relates to the science and technology aspects of the innovation agenda. He said Australia should:

- be, and be recognised as, a leading site of basic and strategic science and technology research;
- become the regional centre for training and education in science, technology and engineering;

- be a nation of high scientific and technological literacy with a community able to absorb and adapt leading technology and innovation;
- be the obvious choice as the regional location for research and development, and have a strong, active and fertile applied science sector able to successfully capture the commercial benefits of its achievements;
- be an important player in the international scientific community and contribute to the world scientific conversation;
- have a private sector with a strong science and innovation culture which carries its share of funding because it appreciates the significant competitive edge this generates; and
- have dynamic science and technology institutions with high global reputations and which lead the way in the region.

Since November 1994, there has been an intensive schedule of consultations with major stakeholders in the *Innovation Statement*, including the direct involvement of the Minister. This process will culminate in a Search Conference in June 1995 at which key ideas emerging from the process will be tested in dialogue with leaders of both the science and technology community and the various end users of technology. A key part of the process was a teleconference held in December 1994, to facilitate discussion with sixty leading scientists in six cities around Australia. Discussion ranged from the role of Government in innovation through to collaboration between industry and the science community, identification of Australia's strengths, regional linkages, communicating with Asia, and education.

More than 1,000 participants have been involved in the consultations on the *Innovation Statement*, which have spanned every capital city and the major regional centres of the country. The consultations have been arranged as both general meetings and discussions around specific sectors. They have included the science community, research agencies, industry and public sector innovators, and the oral consultations have been complemented by a : number of written submissions. Through the course of the consultations, discussion was structured around the themes of financing innovation, science and innovation, technological innovation, the management of innovation and linkages and partnerships which facilitate innovation. The issues which consistently came forth around these themes are summarised in the Box.

Industry Commission Report on Research and Development

An important input to the *Innovation Statement* will be the Government's response to the final report of the Industry Commission Inquiry into Research and Development. Available to the Government in mid-May 1995, the Commission's final report will conclude nearly twenty months of research, consultation and analysis, including the publication in December 1994 of a draft report. The Commission took a broad view of the science and technology system as a whole, including its application to medical, social

EMERGING ISSUES FOR THE INNOVATION STATEMENT

Financing innovation: perceived market deficiencies in the financial sector, regulatory impediments which act as a barrier to finance for innovation, the risk averse nature of the banks and the major institutions, the focus on Government assistance, and options for dealing with perceived constraints.

Management of innovation: the limited awareness of Australian successes, the need for a more innovative culture, the inadequate skills of existing managers and deficiencies in training, the role of mentors and personal networks, the adequacy and appropriateness of graduate training, the need for supporting resources and infrastructure (facilitators, one-stop shops and consulting engineers), the need for an improved ability to measure risk, and the impact of limited project management skills.

Technological innovation: the need for a positive national culture of innovation and nurture of the "invisible club" of experts with international linkages, the need for sustained further growth in private investment in research and development, recognition of the process of incremental change and the need for programs to support this, a perceived bias against small and medium sized firms in the operation of programs assisting innovation, the need for more effective catalysts on technology transfer given that 97 per cent of technology employed in Australia comes from abroad, recognition of the role of design in the commercialisation of technologies, ownership of intellectual property in joint public-private sector research ventures, ownership and development of intellectual property developed under public contract in the course of works or consultancies for Government, protection of intellectual property abroad, and access to protection for small and medium enterprises.

Science and innovation: the mobility of researchers, the need for a coherent international science and technology strategy, access to public sector capabilities especially for small and medium sized enterprises, national infrastructure for high performance computing and communications, the impact of external earnings targets on research agencies, and intellectual property and customer focus issues associated with CSIRO.

Linkages and partnerships which facilitate innovation: fostering linkages as conduits for information, knowledge and ideas, overcoming barriers to using linkage arrangements in business, loss of intellectual property control, mobility of researchers between sectors, utilising family links with the Asia/Pacific area to form foundations for business development, making Australia's science and technology infrastructure attractive to newly developing industrialised countries in the region.

and environmental welfare as well as industrial competitiveness. The Commission focused on the principles by which research and development investments are funded and managed, and the linkage mechanisms facilitating transfer of technology from laboratory to application, and its commercialisation by industry. It paid particular attention to the contestability of publicly funded research, and its management by end-users, as well as creating equivalent levels of assistance for equivalent activities. The Commission also focused on support available to firms unable to take advantage of the 150% tax concession.

The Commission's report will be publicly released in mid-July 1995. The Government's detailed response to it will be due by November 1995, and will be of major importance to the *Innovation Statement.*

Other studies

A number of other studies, evaluations and reviews affecting the science and technology system will report in the course of 1995-96. The Government will have regard, as appropriate, to relevant findings from these independent exercises in developing the *Innovation Statement.*

- The *Bureau of Industry Economics* is benchmarking the characteristics and performance of Australia's science and innovation. This study is now in train and an interim report will be handed to the Minister for Industry, Science and Technology by the end of May 1995. The Bureau is consulting with the Department of Industry, Science and Technology, the Australian Research Council and the Industry Research and Development Board in undertaking this study.
- A *mid-term evaluation of the Cooperative Research Centres Program* is presently under way. This Program has emerged as a vital mechanism linking the nation's research community and industry. The evaluation is being conducted by an eight person committee chaired by Sir Rupert Myers. The Committee is expected to report to the Minister for Industry, Science and Technology in July 1995. Key issues being addressed in the evaluation include the overall effectiveness of the Program, the impact of the Centres on universities, access to the Centres for small business, the development of Australia's research management skills, the most appropriate business structures for the Centres, and the ownership and protection of intellectual property.
- Late in 1994 the CSIRO Board initiated an *evaluation of CSIRO's management and structure.* The present structure was established in 1987-88. The Board published a Discussion Paper in April 1995 proposing a number of changes in the areas or customer focus and delivery, flexibility and adaptability, and corporate orientation. Following release of the Discussion Paper, the Board and Executive are undertaking an extensive process of consultations with staff and other stakeholders, with a view to providing the Discussion Paper and summary of responses to the incoming Chief Executive.
- International consultants completed a *Mission Review of the Australian Nuclear Science and Technology Organisation (ANSTO)* in late 1994. The Review concluded that ANSTO's primary mission should be to support the Government's nuclear policy objectives. It also recommended a set of key research areas for the organisation;

identified activities which should either cease, be controlled by other organisations, or be refocused; and recommended that a commitment to a replacement reactor should be generated at the earliest possible date. The recommendations are now being considered by the ANSTO Board and the Government.

Other reports with implications either for science and technology policy or the *Innovation Statement* include the *Enterprising Nation* report on leadership and management skills, the work of the House of Representatives Standing Committee on Industry, the Bureau of Industry Economics report on syndication under the 150% tax concession, the work of the House of Representatives Standing Committee on Industry Science and Technology on innovation issues, a design review, a standards review, and two reviews of finance structures and practice. The Government has commissioned a review of Rural Research and Development Corporations which will report in November 1995. Both the Coordinating Committee on Science and Technology and the Prime Minister's Science and Engineering Council (PMSEC) have considered innovation at recent meetings with a view to providing input to the *Innovation Statement.* PMSEC has also canvassed High Performance Computing and Communications, which is also of direct relevance to the *Innovation Statement.* The implementation of the recommendations of a substantial study on Australia's science and technology links with the Asia-Pacific region, discussed by PMSEC in 1992, will be reviewed.

Foresight

A major foresight study by ASTEC, launched in September 1994, is exploring Australia's needs for science and technology into the next century - focusing out to the year 2010. The study is intended to provide an information base which can assist Government and industry to make better informed decisions on the development and application of science and technology. In addition to the generic elements of the study, ASTEC is facilitating five separate collaborative foresighting studies called partnerships. These are being developed in collaboration with the key stakeholders - technology suppliers and end-users - in four industry sectors, and in the additional subject area of attitudes of youth to science and technology. ASTEC will publish its final report on the project at the end of calendar 1995, but will make its findings available for the development of the *Innovation Statement* as these come to hand.

Focusing the agenda

The complexity and range of policy analysis now feeding into the *Innovation Statement* require that it remain firmly anchored in the goals enumerated for science, technology and innovation policy by Senator Cook in his ANZAAS address of September 1994. Addressing these goals will require the resolution of certain core issues in seeking to adjust the institutions of science and technology to the needs of Australia entering the 21st century. It is clear that the most powerful force for change will be the growth in demand for

innovation resulting from continued economic restructuring and the increasing pressures resulting from the environmental responsibility and the agendas of social and medical change. Government's over-riding responsibility is to ensure that the institutions of education, training and research are optimally poised to satisfy these emerging patterns in demand and to fully exploit their considerable intellectual capital in so doing.

The first issue in this will be *the intellectual resource of the nation:* its children, students, researchers, and those who manage innovation in business. Cultivating this resource is the key not only to sustaining the genius of science in Australia, but also to maximising its application to the objectives of national development. The concerns here thus relate not only to the quality of science and engineering training, but to a culture of innovation which prizes the application of knowledge in commercially effective outcomes, and which prizes the responsible management of enterprises committed to innovation in the pursuit of international competitiveness. The issue is complex, therefore, in its reach, but is foundational to the future of innovation in Australia.

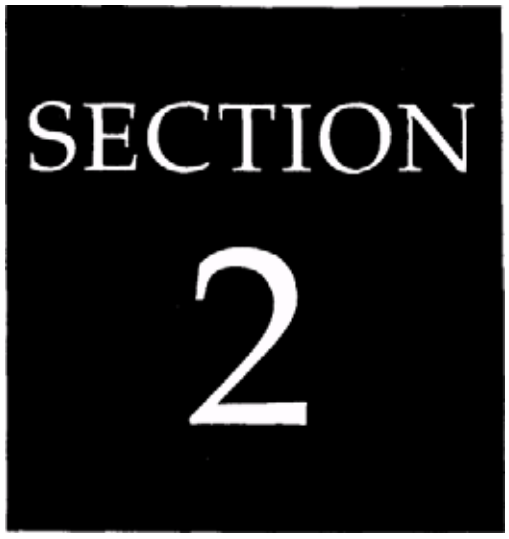
A second issue is *the funding and management of public sector research.* The exponential growth in science has for some time been pressing against the limits of necessarily scarce public funds. In Australia as elsewhere, this has generated pressure for the setting of priorities, so that critical mass is retained in select areas of national advantage. Alongside this, the effective management of public sector research calls for the direct involvement of end users, especially in strategic and applied research where market or public good outcomes are the object of research. The issues surrounding the funding and management of public sector research were central to the Industry Commission *Inquiry into Research and Development,* and will also be important to the policy framework of the *Innovation Statement.*

A third issue is *the demand for innovation in industry.* While market pressures will be the central force affecting this, culture, attitudes, managerial competence and incentives will still be important in determining whether the current growth rate in business research can be sustained. The issues surrounding technology transfer, commercialisation and diffusion are still more complex, and pose the most challenging questions to policy development in the lead-up to the *Innovation Statement.*

A fourth issue is the urgent need for *an enhanced international strategy* for Australia's science and technology. International linkages still tend to reflect conditions which predated the opening up of the economy. They are largely founded on collaborations in basic science under diplomatic protocols negotiated with a range of countries. Linkages today need to serve the trade and investment objectives of the nation, in addition to maintaining Australia's place in the international community of basic science. This calls for a more targeted approach to international linkages and one which works closely with industrial strategy.

While the Government has recognised the importance of the above issues in many of its present policies, they will take on greater importance for the coming decade and beyond. Against the backdrop of outstanding growth

over the decade now passing, and decisive trends towards a more balanced and synergistic science and technology system, the opportunity now presents itself to position Australia as the pre-eminent centre for science, innovation, research and technology in Asia and the Pacific well into the 21st century.



Recent Major Developments

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

Prime Minister's Science and Engineering Council (PMSEC)

The Prime Minister's Science and Engineering Council, which includes Ministers whose portfolios have a major science, engineering and technology interest, met in June and December 1994.

At the June 1994 meeting, there were two sessions relating to information networks and services, a presentation by the Broadband Services Expert Group on broadband services, and a presentation by the Australian Science and Technology Council working group on research data networks. These two reports culminated in a national strategy for information services announced by the Prime Minister in April 1995.

Topics discussed at the December 1994 meeting included:

- *Research for a Healthy Society* which dealt with challenges facing Australia's health and medical research effort, such as improved mechanisms for translating health and medical research into better clinical practice, the need for appropriate balance between basic and other categories of research, and funding and research infrastructure constraints;
- *High Performance Computing and Communications (HPCC) for International Competitiveness* which considered Australia's need for internationally competitive HPCC capability, and addressed ways of better linking such a capability with industry to enable industry to harness the power of HPCC more effectively; and
- *Innovation*, a discussion forum providing input into the Innovation Statement due for release by the Government in late 1995.

Outcomes are reported in Section 5.

The June 1995 meeting is expected to address sustainable agriculture as well as further ideas and directions for the Government's *Innovation Statement.*

Australian Science and Technology Council (ASTEC)

ASTEC's work during the year included the completion of a study of Australia's needs for research data networks, leading to a report to the Government, *The Networked Nation.* The report includes recommendations relating to the information superhighway industry, a national high-speed backbone service, universal affordable network access, promotion of Australian development of information network services, and improved network management. The Government's response to these recommendations together with those on broadband services have been incorporated into a national strategy for information services.

ASTEC is now engaged in a major study of the application of technology foresight to Australia's requirements in the future, *Matching Science and Technology to Future Needs: 2010* which aims to identify the key issues that will require the application of science and technology. As part of this study,

the Council is conducting a series of 'partnership studies' with research organisations and users in urban water life cycle, information and communications technology, health and shipping. As part of this study, ASTEC will examine the attitudes of youth to science and technology. This work will also involve young people in defining their preferred future for Australia. This work will provide the information base for better government and industry decisions in the development and application of science and technology.

The Minister for Industry, Science and Technology has asked ASTEC to assess the adequacy of Australia's science base to contribute to the development of information and communications services and technologies. The results of this work will allow the Government to determine whether there is an adequate science and technology base, including an adequate supply of skilled personnel, to support and sustain the Government's planned expansion in the use of networks.

Details of several of these studies are provided in Section 5.

Coordination Committee on Science and Technology (CCST)

The Coordination Committee met three times during 1994-95. During the year, the Committee's work included developing a statement of its own role and terms of reference, as well as an examination of its strategic directions; involvement in development of the Major National Research Facilities Program; and completion of advice to Government on responses to ASTEC reports on research and technology in tropical Australia, gene technology, and external earnings of science agencies.

The Committee discussed the development of the Government's *Innovation Statement* and the draft Industry Commission report on research and development. This led to advice to Government on key issues needing to be addressed. The Committee has continued its work on priorities for science and technology, publishing a paper on the links between national goals for science and technology, and agencies' priority-setting methods.

Industry Commission review of research and development (R&D)

In September 1993 the Government asked the Industry Commission to report on two broad issues:

- the effect of R&D on innovation, industry competitiveness and economic growth
- the performance of policies and programs which influence R&D and innovation in Australia.

The Commission's terms of reference have required it to evaluate numerous Government policies and programs which influence R&D, as well as to

examine incentives and impediments to the dissemination and commercialisation of research, international exchanges of information and the creation of linkages between public research institutions and business. From mid-1994, the Commission undertook a wide range of visits, engaged external consultants and organised a number of round table meetings on key topics, which were attended by people with a detailed knowledge of R&D policy or practice within Australia. An extensive range of written and oral submissions have also been made to the Inquiry. In addition, a conference was held on the subject *R&D and Economic Growth*, with international and Australian speakers.

The Commission released its draft report for public comment in December 1994. Following a further round of comments and submissions, the Commission is expected to provide its final report to Government in mid May. The report will become available to the public in July 1995.

Evaluation of the Cooperative Research Centres (CRC) Program

In an effort to ensure that the investment in the CRC Program is on target towards meeting its long-term objectives, the Government has initiated an evaluation of the Program. The evaluation is to report on the degree to which the Program is developing processes, such as effective research support, links to industry, cooperation and effective education projects, to make the long-term objectives achievable.

Broadband Services Expert Group (BSEG)

The Final Report of the Broadband Services Expert Group was received by the Government in December 1994, and released by the Prime Minister in March 1995. A package of nine consultancies, commissioned by BSEG, into likely future demand for broadband services was released concurrently.

The Final Report stresses the critical importance of the development of on-line, interactive broadband services for Australia's economic and cultural future. It advocates an evolutionary, demand-driven approach to developing the broadband industry, with strong emphasis on building export capacity, ensuring open access to networks for both content providers and users, and reinforcing and enhancing Australian cultural values.

The Government has provided a comprehensive response to the recommendations of the report. In particular, a National Information Services Council has been established to progress the National Strategy for New Communications Networks.

Multimedia

The Government's cultural policy statement, *Creative Nation*, emphasised the central role for new technologies in the development of a national identity

through new forms of presentation and distribution of cultural material. The statement announced a package of initiatives costing $84 million over four years, to assist the development of a multimedia industry in Australia, aiming in particular to encourage the application of multimedia technologies to content creation and cultural industries. These initiatives include:

- industry education and training support, which will be provided through six Cooperative Multimedia Centres to be established by the Department of Employment, Education and Training; and
- the Australian Multimedia Enterprise, which has funding of $45 million to provide financing for the development of multimedia products and services.

Sustainable management of Australia's tropical marine resources

The capacity of the Australian Institute of Marine Science (AIMS) to expand previous research has been enhanced by the receipt of a major international award from IBM. The award, one of only four granted worldwide, is funded under IBM's Environmental Research Program, providing $1.4 million of super-computing technology and cash funding for research by AIMS. The project that the funding will support seeks to develop a predictive model for the Great Barrier Reef of the physical and biological processes controlling dispersion and recruitment, thereby enhancing our ability to understand complex environmental issues and problems for the ecologically sustainable development of tropical marine resources in Australia and Southeast Asian countries.

Cultural and organisational change in Government research agencies

The CSIRO Board undertook an evaluation of the management and structure of the Organisation. Its charter was to build on the cultural change within CSIRO over the last decade and to examine areas where further improvements could be achieved. The findings of the evaluation, which are outlined in a discussion paper, relate to strengthening customer focus, improving flexibility and adaptability and enhancing corporate orientation.

In another initiative, the mission of the Australian Nuclear Science and Technology Organisation (ANSTO) was reviewed by a firm of international consultants. The main conclusion was that ANSTO's primary role should be to support the Government's nuclear policy objectives. Other issues dealt with included the Organisation's manufacturing of radioisotope products for medical and other purposes and replacement of its current nuclear research reactor.

Improving science and technology links with the Asia-Pacific region

With the rise of APEC as a major new regional political and economic forum, opportunities are emerging for collaboration in science and technology in the Pacific basin. Australia has been an active participant in moves to establish cooperation in science and technology as an important feature of APEC activities. Key meetings held during 1994-95 in Japan and New Zealand are expected to lead to Ministerial level discussions in Beijing later in 1995.

A National Video Conference, focusing on opportunities for scientific collaboration in the region, was held in December 1994. The conference linked discussions between sixty prominent Australian scientists based in seven centres around the country.

During the year, Australia and Indonesia signed a treaty on cooperation in science and technology (COSTAI) which provides a framework for cooperative activities. Activities such as remote sensing and marine science are of particular joint interest. In addition, a mission of over 20 Australian researchers and officials visited Jakarta to review current collaborations and identify proposed new joint projects. The officials agreed on new operating arrangements in line with the extended opportunities available under the Science and Technology Agreement.

At any given time some 100 science and technology projects are being advanced with Japan. Further collaborative commitments will be endorsed at the Australia-Japan Science and Technology Consultations to be held in May 1995.

In another initiative, a delegation of senior researchers from China visited Australia in late 1994, concluding their visit with a workshop at which the outcomes of joint research activities established in 1991 were reviewed. New collaborative activities were identified across a range of scientific interests.

Stemming from the 1993 report to the Prime Minister's Science and Engineering Council, *Australian S&T Opportunities and Strategies in the Asia-Pacific Region*, a study has been commissioned to identify ways of linking Australian science and technology into the fast growing economies in the Asian region. It is expected that the study will be completed in mid 1995.

The Environmental Cooperation with Asia Program has been established as part of the *Australia in Asia: Economies Growing Together* initiative. The program seeks to enhance awareness in Asia of Australian environmental management technology and expertise; strengthen environmentally based commercial relationships between Australia and the countries in the region; and contribute to stronger environmental management in neighbouring countries.

Australia also participated in the 13th Meeting of the Association for Science Cooperation in Asia (ASCA). As a founding member of ASCA in 1970,

Australia has participated in all meetings and is active in cooperating with other members in this major regional science forum.

Implementation of the Composite Index for allocating the research quantum of university operating grants

The broadening of the index which allocates operating grant funding to universities for research activities other than those directly linked to teaching and research training, has been the subject of extensive consultations. In late 1993, a Composite Index Working Party, chaired by the Australian Vice Chancellors' Committee, with representation from the Department of Employment, Education and Training, Higher Education Council and the Australian Research Council, was set up to develop a new index. In August 1994, the Government accepted the Working Party's advice concerning the Composite Index for assessing the allocation of this funding, which for 1995 is $213 million. This index consists of measures of institutional performance in nationally competitive and other research funding, categories of publications, and higher degree completions. The relative weightings for these measures will be further refined as their implementation is monitored and reviewed.

Enhanced support for research and research training in universities

The Government has announced that additional support for research and research training will be provided through the Employment, Education and Training portfolio in the form of enhancements to three key programs. The programs and additional support (in calendar years) are as follows:

- *Research infrastructure programs* - An additional $35 million each year will be provided for research infrastructure programs beginning in 1996;
- *Research grants program* - Additional research grants funding will be provided from 1996 onwards as follows: $9.1 million in 1996, $13.0 million in 1997, $15.3 million in 1998 and $7.6 million in 1998; and
- *Australian Postgraduate Awards Scheme* - Additional funding for Australian Postgraduate Awards will be provided from 1996 onwards as follows: $2.3 million in 1996, $3.5 million in 1997, $4.9 million in 1998 and $2.7 million in 1999.

Open Net

Open Net is the second element of the Open Learning Initiative, the first having been the establishment of the Open Learning Agency of Australia (OLA). Open Net will harness modern personal computers and telecommunications to provide support to open learners and other clients. At a minimum, it will provide e-mail services, bulletin board services, Internet access and access to library resources.

Open Net will strongly emphasise accessibility and affordability. It will be accessible from students' homes or workplaces (where they have the necessary equipment) and from access points located around the country in community-based facilities such as public libraries and telecentres. In late March 1995 Open Net extended services to all students studying through the OLA. The Open Net Company anticipates that some 5,000 students will use the service in 1995.

Establishment of the Australian International Education Foundation (AIEF)

The Government established the Foundation in 1994 in recognition of the need for a national strategy for international education and training. Its mission includes linking Australian international education and training to the scientific, technological and cultural activities of private and government institutions in Australia.

The Foundation is governed by an independent Council whose Members are chosen for their expertise in education, marketing and international affairs. The Council advises the Minister for Employment, Education and Training on policy and strategies and comes under the auspices of the National Board of Employment, Education and Training.

The AIEF's 38 overseas offices provide a permanent presence and a range of services linking Australia with key overseas markets. These services include government to government relations, diplomacy, market research and intelligence, sustained public relations activities, the display and distribution of information materials, in-country agent support programs, advice to members on market positioning, support for professional development, and assistance with official education and training missions overseas.

Review of technical infrastructure

A review of standards and conformance infrastructure has been undertaken by an independent Committee of Inquiry. The Committee's report, *Linking Industry Globally*, includes recommendations aimed at improving Australia's standards setting processes and maintaining the excellence of measurement and testing facilities. It also seeks to clarify the roles of peak bodies and of government. The recommendations and comments on the report are being considered by the Government.

Major National Research Facilities (MNRF)

The Government's May 1994 *Working Nation* White Paper included $60 million over the following eight years for the Major National Research Facilities Program. The Program will fund establishment costs of major research facilities required to keep Australia at the leading edge of key scientific and technological developments.

MNRF will focus on facilities involving establishment costs beyond the capacity of any individual Australian institution. The facilities must be capable of offering shared use by the widest pool of users from various scientific disciplines and areas of application including industry. Such facilities will be specifically identified as being for national use and will be made available to researchers according to the merit of their proposals.

The proposals will be assessed by the MNRF Committee chaired by the Government's Chief Scientist. The Committee has constituted three Expert Panels to ensure comprehensive evaluation of proposals in terms of the potential benefit, business planning and financial assessment criteria. Thirty five final proposals seeking aggregate support of over $370 million are currently being considered under the Program. New major national research facilities to be supported under the Program will be announced later this year in the *Innovation Statement*.

Review of rural research

A review has been undertaken in the primary industries and energy portfolio, of arrangements for rural research, including fisheries research. The report of the first phase, which was endorsed by Cabinet in April 1994, addressed the administrative efficiency of current arrangements and options for improved coordination with other Commonwealth programs. This report found that the Research and Development Corporation (RDC) model was performing well and meeting its broad objectives. The RDCs have been successful in making research and development more relevant to industry needs and in facilitating increased involvement and investment by industry in research.

The second phase of the review will consider the long term strategy for the support of rural research, including funding. The findings of this phase will be considered by the Government in conjunction with the Industry Commission report on research and development.

Audit of rural industry funding arrangements

The Australian National Audit Office (ANAO) has completed an efficiency audit which addressed whether government funding of rural research and development generated new technology useful to industry, whether the funding arrangements are managed effectively, and whether devolution of responsibilities for the management of these programs has been effective. The ANAO found that good commercial returns had been achieved from rural research and development, and that the Research and Development Corporations have been successful in achieving a high degree of industry focus and direction.

Other initiatives in support of science and technology

Other measures put in place during the year to enhance Australia's science and technology effort included:

- in industry, science and technology

- The Industry Research and Development Board is to produce a research and development Scoreboard. The Scoreboard will be an annual document consisting primarily of a listing of research and development expenditure by Australian companies. The listing will assist the financial community in assessing the current and future potential of companies.
- The Industry Research and Development (IR&D) Board undertook a major study on continuously improving the operation and delivery of its programs. This study formed the basis of two IR&D Board submissions in response to the Industry Commission's inquiry into research and development.
- In December 1994, the Government announced the selection of ten new Cooperative Research Centres (CRC) and the extension of two existing Centres. The new Centres will become operational in 1995-96, bringing the total number of CRCs to sixty one. The selection of the new Centres fulfils the Prime Minister's promise of 1993, to provide additional funding of $25 million per year to the CRC Program.
- The first round of funding for the National Technology Access and Diffusion Network, under the Technology Access Program occurred in April 1995. The Network will provide competitive grants to groups of institutions for feasibility studies or for seed funding directed at upgrading or expanding their facilities and services offered to firms in applied research, technology transfer, provision of technical advice or related training.
- A new Research and Development Corporation was established in July 1994 to promote an internationally competitive, sustainable and environmentally responsible forest and wood products industry in Australia. Together with funding from industry and research organisations, the Forest and Wood Products Research and Development Corporation will support projects which promote sustainability and environmental management of the forests.
- The Australian Research Council has commenced a longitudinal study of the 1990 Australian Postgraduate Awards (APAs) with Stipend holders. The review plans to examine completion times and rates of progress of APA holders, their major sources of funding, student views of their training experience, the nature and status of subsequent employment, and the career paths of the award holders compared with other students. A report is expected before mid-1996.
- The largest Australian Research Council research grant yet awarded, a total of $1.25 million over the next three years, has been awarded to a consortium of research groups and industry led by the Australian National University. The grant will coordinate a number of projects aimed at advancing the sensitivity and bandwidth of laser interferometer gravitational wave detectors. This research will assist in achieving the goal of producing practical earth-based systems for gravitational astronomy in the 21st Century. The involvement of

industry partners will enable the transfer of research developments to practical systems for incorporation into second generation detectors and/or into manufactured products.

- The Department of Employment, Education and Training (DEET) and the Australian Research Council (ARC) support and publish evaluations of project grant outcomes. Since June 1994, grant outcome reviews have been conducted in the areas of astrophysics and astronomy, inorganic chemistry, sedimentology, experimental physics and computer sciences.
- DEET and ARC also support and publish discipline review strategies which report on the future vision and direction of research disciplines. A review of Australian astronomy has recently been published by ARC. Further discipline reviews are currently under way in mathematics and psychology. It is expected that both will be published towards the end of 1995.
- The Government has provided increased funding in the 1995-96 Budget to the National Health and Medical Research Council to maintain its commitment to have 2 percent of health expenditure directed towards research. Funds provided will total $54.9 million over the next four years.
- The Research Reactor Review (RRR) found that the evidence strongly supports the view that the HIFAR research reactor at Lucas Heights, NSW, operates safely by an adequate margin. The review recommended that an independent safety assessment be undertaken to ascertain the reactor's remaining life and to indicate additional safety margins.

- in international science and technology collaboration

- The governments of Australia, Canada, Japan, Europe and the United States have jointly agreed on a framework for industry-led collaboration on manufacturing development. Known as the International Manufacturing Systems Program (IMS), the program will offer a structure for cooperation to study manufacturing opportunities and solve problems on a global scale.
- Under the National Space Program, $250,000 was allocated in 1994-95, and $500,000 agreed for 1995-96 to develop a collaborative program with Japan in hypersonics technology development. The program, which is based at the University of Queensland, aims to provide an avenue for Australian technology and ultimately industry, into ultra high speed aerospace transport systems in the next century.
- In 1994-95, $5.5 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 under ten collaboration treaties. Assistance was provided to around 450 Australian scientists, technologists and engineers for overseas travel for research collaboration and access to major research facilities. In the same period, ISTP helped sponsor 30 major international scientific, technology and engineering conferences in Australia.
- The French-Australian Industrial Research (FAIR) program organised a workshop in France which led to commitments on both sides to a

number of new commercially oriented for joint collaboration on agri-business research projects.

- Under the S&T Cooperation Agreement signed between Australia and the European Union in February 1994, many new opportunities opened up in 1994-95 for Australian participation in the EU 4th Framework Program. Several new projects are expected to gain approval by mid-1995.
- Since June 1994, the Australian Research Council has signed Memoranda of Understanding on research cooperation with research organisations in the Netherlands and France; the Netherlands Organisation for Scientific Research and the Centre National de la Recherche Scientifique.
- Under an agreement between the Australian Research Council and the National Natural Sciences Foundation of China two areas of scientific collaboration have been identified, lasers and computer integrated manufacture. A number of exchanges have since taken place, based on two Research Centres with those specialisations: the Centre for Lasers and Applications at Macquarie University and the Computer Integrated Manufacturing Key Centre of Teaching and Research at Swinburne University or Technology. Both centres have received additional funding of $50,000 per year to support scientific collaboration with China.
- An Australian Research Council commissioned study, *International Links in Higher Education Research*, by Professor Paul Bourke and Ms Linda Butler of the Performance Indicators Project, Research School of Social Sciences, Australian National University, was completed in March 1995. The study details the historical context of Australia's international research relationships, focusing on the relative lack of contact with researchers in our region, and the importance of international links to our science and technology system.

- in science and technology awareness

- The 1995 Australia Prize was awarded in the field of remote sensing to four scientists: three Australians - Dr Ken McCracken, Dr Andrew Green and Dr Jonathan Huntington - for their application and innovation of remote sensing in mineral exploration; and one American - Professor Richard Moore - for his work with microwave radar in developing and applying sensors to measuring variations in ocean surfaces contributing to more accurate weather forecasting.
- Financial support totalling $700,000 was provided from the Science and Technology Awareness Program for twelve ongoing and fourteen new awareness raising projects. These included school curriculum resources, a tertiary textbook on entrepreneurship, media related projects and projects which focus on women and science.
- A committee to advise the Minister for Industry, Science and Technology on how best to increase public awareness of the central role that science and technology can play in the economic, social and environmental well-being of Australians, was established in March 1995. The committee comprises representatives from industry, the media, science education (both formal and informal) and young Australians.

- A survey of attitudes to science and technology was undertaken late in 1994, building on a survey conducted in 1991. The key results showed an increase in the proportion of those who believed that science and technology were very important in the economic and social well-being of Australians. Other results were that fewer women thought of science and technology as job threatening and that the perceived barriers to careers in science and technology for women were decreasing.
- The 1994 Michael Daley Awards for Science, Technology and Engineering Journalism in ten categories were announced in December 1994. The overall award went to Dr Karl Kruszelnicki, a radio and print journalist, for his work in bringing science and technology to young Australians.

- in defence

- Australia and the United States signed an agreement to cover cooperative and collaborative defence research, development, and engineering.
- Australia and Indonesia embarked upon a program of studies to explore opportunities for cooperation in defence science and industry.
- Expenditure of $5.7 million for the refurbishment and upgrade of the Defence Science and Technology Organisation (DSTO) Transonic Wind Tunnel at Aeronautical and Maritime Research Laboratory, Victoria, and $14.7 million on a major new integrated research facility for DSTO, South Australia, were approved.

- in environment

- As part of the Government's additional package of greenhouse response measures announced in March 1995, a new Cooperative Research Centre on greenhouse gas abatement technologies is to be established. This Centre is to be operational by 1996-97.
- Amendments to the *Environment Protection (Alligator Rivers Region) Act* in 1994 abolished the former Coordinating Committee and established two new committees - the Advisory Committee and the Technical Committee. The Supervising Scientist was also given the additional function of supplying scientific and technical advice on environmental matters outside the Alligator Rivers Region.
- As part of Australia's commitment to the Montreal Protocol, the Scientific Services Laboratory (SSL) of the Department of Administrative Services has undertaken a range of investigations of gaseous fire suppression systems as alternatives to ozone depleting halons. SSL has also participated in the development of Australian standards for these environmentally-friendly agents.
- The National Meteorological Centre of the Bureau of Meteorology in Melbourne has been designated by the World Meteorological Organisation as a centre responsible for the provision of products for an environmental emergency response.

- in space

- The Australian Space Council, with representation drawn from industry, the research community and government, was established under the *Australian Space Council Act 1994* to develop and implement an Integrated National Space Program for Australian space-related activities over the next five years. The Council is the reference point for national and international space policy and interaction, and coordinates space activities within government and between the public and private sectors. The Council is required to produce and present to the government rolling, five year strategic plans. The second such plan is now under consideration by the government.
- The establishment of the Remote Sensing Board in 1994-95 will allow the Australian Space Council to provide a broader perspective on remote sensing policy matters. In its first year, the Remote Sensing Board finalised major studies covering an Australian Earth Observation Network, education and training requirements and the competitiveness of the earth observation value-added services sector.

- in transport

- In October 1994, Australian transport ministers endorsed Intelligent Transport Systems (ITS), which promotes computing and telecommunications technology in vehicle manufacture and road systems, as a priority issue in their work program. The Department of Transport is a member of ITS Australia, an industry/government/academic association formed to address strategic issues associated with ITS including the orderly introduction of the technology into Australia. This body, in association with Standards Australia, is working towards the implementation of compatible ITS standards throughout Australia.

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 include:

Parliament of Australia

- Senate Economics Reference Committee
  - *CSIRO, the Case for Revitalisation: Administration and Funding of Rural Research*, 1994

Prime Minister and Cabinet Portfolio

- Prime Minister's Science and Engineering Council Reports
  - *Food into Asia: The Next Steps*, June 1994
  - *Research for a Healthy Society*, December 1994
- Coordination Committee on Science and Technology
  - *National Goals and Priority Setting by Government Science and Technology Agencies*, December 1994
- Australian Science and Technology Council
  - *The Networked Nation*, September 1994

- *Matching Science and Technology to Future Needs: an Introduction*, July 1994
- *Matching Science and Technology to Future Needs: Background Report*, August 1994
- *Matching Science and Technology to Future Needs: An International Perspective* September 1994
- *Matching Science and Technology to Future Needs: Key Issues*, March 1995

Industry, Science and Technology Portfolio

- Minister for Industry, Science and Technology
  - *Science and Technology Budget Statement 1994-95*
- Department of Industry, Science and Technology
  - *Australian Science and Innovation Resources Brief 1994: Measures of Science and Innovation 4*
  - *The Pace of Change: Technology Uptake and Enterprise Improvement. Discussions of Science and Innovation 3*,1994
  - *Innovate Australia: The Pace of Change*, 1994
  - *Innovate Australia: Gain from Change*, 1994
- Australian Institute of Marine Science
  - *Annual Report 1993-1994*
- Australian Manufacturing Council
  - *The Wealth of Ideas: How linkages help sustain innovation and growth*, November 1994
- Bureau of Industry Economics
  - *Syndicated R&D: an Evaluation of the Syndication Program*, 1994
  - *Beyond the Innovator: Spillovers from Australian Industrial Research and Development*, 1994
  - *Empirical Estimates of External Returns to Business Expenditure on Research and Development: an Introduction to the Literature*, 1994
  - *The Economics of Patents*, 1994
- Australian Space Council
  - *National Space Program - Five Year Plan -1994*
  - *National Space Program - Five Year Plan* - Working Group Reports
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
  - *Strategic Review of the CSIRO Division of Human Nutrition*, August 1994
  - *Review Report on Research Directions*, CSIRO Division of Oceanography, September 1994
  - *Review of CSIRO's Human Resources Function - Review Team Report*, September 1994
  - *CSIRO Board Evaluation of Management and Structure*, April 1995
  - *CSIRO Data Book 1995*
  - *CSIRO Operational Plan 1994-95*
  - *Strategic Planning and Evaluation Strategy for CSIRO*, August 1994
  - *Australian Animal Health Laboratory, Stocktake Committee Report*, April 1995

Administrative Services Portfolio

- Genetic Manipulation Advisory Committee
  - *Guidelines for Large Scale Genetic Manipulation Work*, December 1994

- *Annual Report 1993-94*,1994

Communications and the Arts Portfolio

- Department of Communications and the Arts
  - *Creative Nation: Commonwealth Cultural Policy*, October 1994
- Broadband Services Expert Group
  - *Networking Australia's Future: The Final Report of the Broadband Services Expert Group*, December 1994

Employment, Education and Training Portfolio

- Department of Employment, Education and Training
  - *Postgraduates as Partners in University-Industry Liaisons*, Jan 1994
  - *Report on the Impact of the Discipline Review of Engineering*, 1994
  - *Establishing Effective PhD Supervision*, 1994
  - *The Casualisation of Research Postgraduate Employment*, July 1994
  - *The Conditions for Fostering Cooperative Education Between Higher Education and Industry*, July 1994
  - *Supplementary Higher Education Funding Report for the 1994-95 Triennium*, December 1994
  - Higher Education Series Paper No. 22 - *Diversity and Performance of Australian Universities*, April 1994
- National Board of Employment, Education and Training
  - *Using Basic Research: Assessing Connections between Basic Research and National Socio-economic Objectives, Part 1: Review of Current Theory and International Practices*, 1995 (NBEET Commissioned Report No. 36)
  - *International Links in Higher Education Research*, March 1995 (NBEET Commissioned Report)
  - *Higher Education Series Occasional Paper No. 8 - Honours Awards*, 1994

Environment, Sport and Territories Portfolio

- Bureau of Meteorology
  - *Annual Report 1993-94*, October 1994
  - *Research in the Bureau of Meteorology Research Centre 1994*, June 1994
  - *Climate Activities in Australia 1995*, March 1995
- Environment Protection Agency (EPA)
  - *A Report on Water Quality Monitoring in Australia Environment Protection Agency (EPA) and Land and Water Resources Research and Development Corporation (LWRRDC)* - Consultant's report to EPA
  - *Report of the First State and Territory Monitoring River Health Initiative Workshop under the National River Health Program*, June 1994

Primary Industries and Energy Portfolio

- *Evaluation of the Clean Food Export Program in Taiwan*, Frank Small and Associates, December 1994

Transport Portfolio

- Bureau of Transport and Communications Economics

- *Greenhouse Gas Emissions from Australian Transport: long-term projections (1995); Alternative fuels in Australian Transport (1994)*

Treasury Portfolio

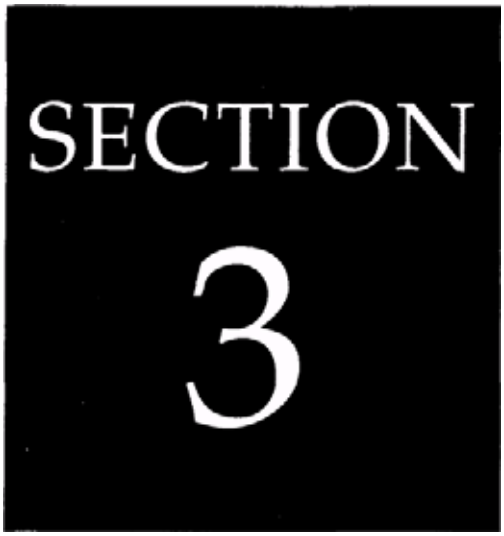
- Industry Commission
  - *Transcript of Conference on R&D and Economic Growth*, May 1994
- *Commissioned papers:*
  - *The role of R&D in growth: a survey of the new theory and evidence,June* 1994 (Steve Dowrick, Australian National University)
  - *Taxation concessions for R&D in selected Asian countries*, July 1994 (Shantha Liyanage and Stephen Hill, Centre for Research Policy, University of Wollongong)
  - *Economic justification for Government support of R&D: a review of modern microeconomic literature and its policy implications*, August 1994 (Clem Tisdell, University of Queensland)
  - *Advisory framework for Australian science and technology policies*, August 1994 (Colin Rubenstein, Monash University)
  - *Draft Report, Research and Development*, December 1994:

    Overview

    Volume 1: The Report

    Volume 2: Institutional appendices

    Volume 3: Quantitative appendices



Science and Innovation in the Budget

Australia's national R&D expenditure

Table 1 provides a broad outline of recent data on R&D expenditure in Australia, based on surveys by the Australian Bureau of Statistics (ABS). The most recent surveys showed that Australia's gross expenditure on R&D (GERD) stood at $6309 million in 1992-93, corresponding to 1.56% of gross domestic product (GDP). Broadly, about 44% of Australia's R&D expenditure, corresponding to 0.69% of GDP, was undertaken within business enterprises in that year.

TABLE 1 Australia's expenditure on R&D, by sector of performance, 1989-90 to 1992-93

Sector of performance	1989-90		1990-91			1991-92			1992-93		
	$m	%GDP	$m	%GDP	%real annual increase	$m	%GDP	% real annual increase	$m	%GDP	%real annual increase
Total business	1990	0.54	2082	0.55	0.0	2320	0.60	9.1	2788	0.69	17.1
- private business	1803	0.49	1879	0.50	-0.3	2103	0.54	9.6	2544	0.63	17.7
- public business	187	0.05	204	0.05	2.2	216	0.06	4.0	244	0.06	11.5
Total Government			1664	0.44	5.3				1744	0.43	-1.3
- Cwlth agencies			1026	0.27	3.4				1128	0.28	0.7
- State agencies			639	0.17	8.3				616	0.15	-4.4
Higher education			1333	0.35	6.1				1695	0.43	10.7
Private non profit			70	0.02	7.1				82	0.02	3.5
TOTAL			5150	1.36	3.8				6309	1.56	7.9

The other principal R&D sectors include higher education, where 27% of R&D expenditure (0.43% of GDP) was undertaken, and Commonwealth agencies, which accounted for 18% of R&D expenditure and 0.28% of GDP.

At 1.56% of GDP, GERD now stands at an all time high and has increased dramatically from 1.36% in 1990-91 and 1.26% in 1988-89. The substantial increases in GERD since 1988-89 partly reflect a decision announced in the May 1989 policy statement on science and technology, to maintain the 150% tax concession scheme for industrial R&D. The concession played a major role in stimulating the level of R&D in the business sector and hence in increasing GERD. Other initiatives of the May 1989 statement had the effect of increasing Commonwealth funding for public sector R&D, which had passed through a trough in 1988-89. These initiatives, some of which did not come fully into effect for two or three years, included increased support for postgraduate research awards and other research in the higher education sector, establishment of the Cooperative Research Centres Program, and additional funding for medical R&D.

Commonwealth support for R&D in a national perspective

As is seen in Table 1, Commonwealth agencies are significant performers of R&D, but undertake only 18% of total R&D expenditure. As a funding source, however, the Commonwealth Government provides about 44% of R&D funds directly, and another 8% through the indirect means of the R&D tax concession. Derived from ABS survey data, Figure 3 provides a schematic picture of the Commonwealth's activity in the national R&D context and its relative size and interactions compared with other elements of the system.

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

Commonwealth support for science and innovation through major programs

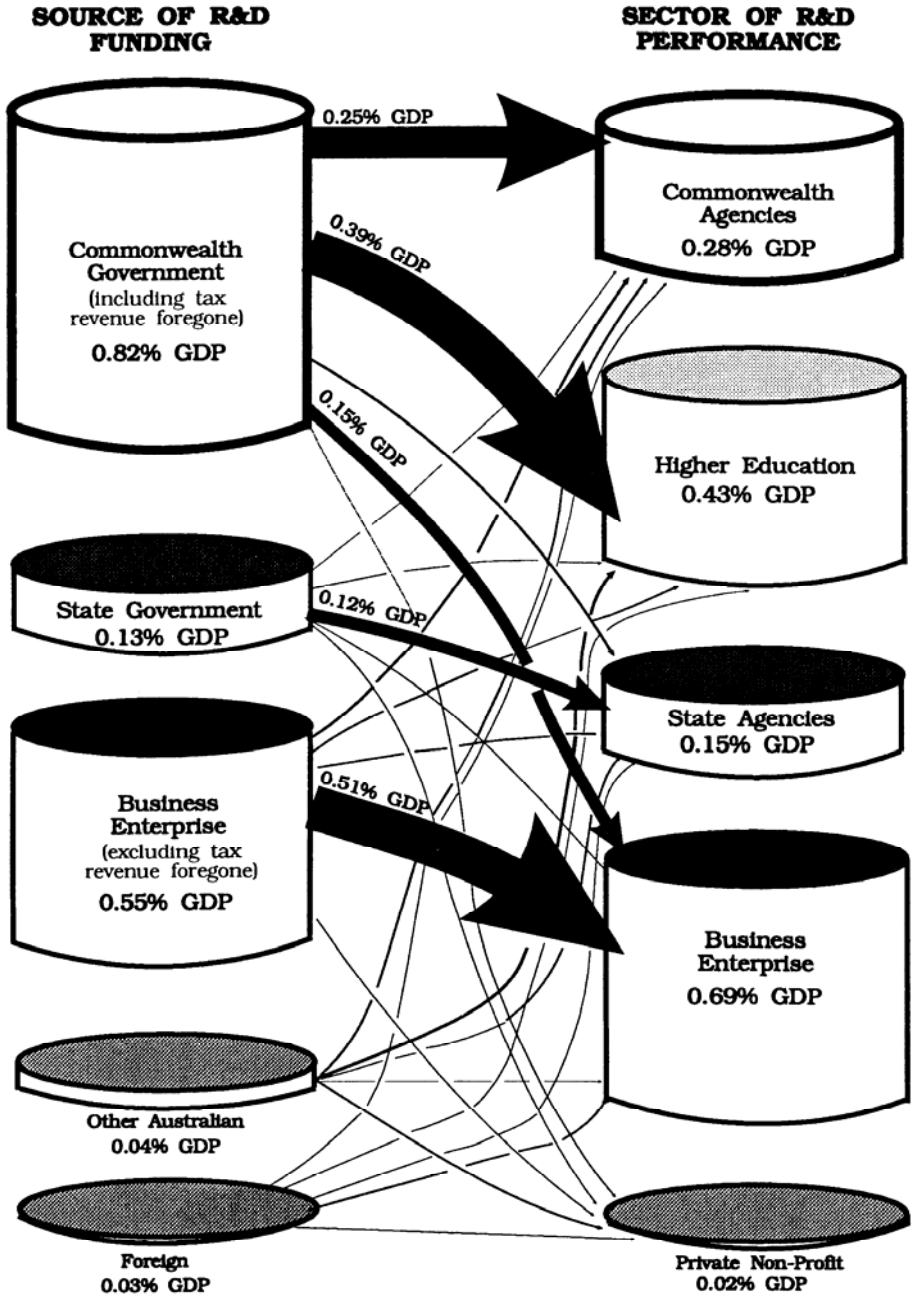
Commonwealth support for major science and innovation programs has risen from $3478 million in 1994-95 to an estimated $3592 million in 1995-96. This maintains Government support in real terms with an increase of 0.7 per cent on the underlying trend. The underlying trend takes account of the flexibilities arising from triennial funding for the science agencies. In the context of these arrangements, a marginal real decrease of 0.4 per cent results from CSIRO advancing $20 million of its projected 1995-96 appropriations into 1994-95. Broadly, there have been significant increases over the whole period since 1984-85, with the tax concession schemes providing particular stimulus from about 1985. Omitting those concessions, the rise in total Commonwealth support results from increased R&D overall in the higher education sector coupled with a steady rise in amounts disbursed through the various granting schemes.

Figure 4 and Table 2 present a summary of Commonwealth support for science and innovation at constant price values. They provide a four-way breakdown of the data as follows :

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

Figure 3

COMMONWEALTH R&D SUPPORT IN A NATIONAL PERSPECTIVE



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

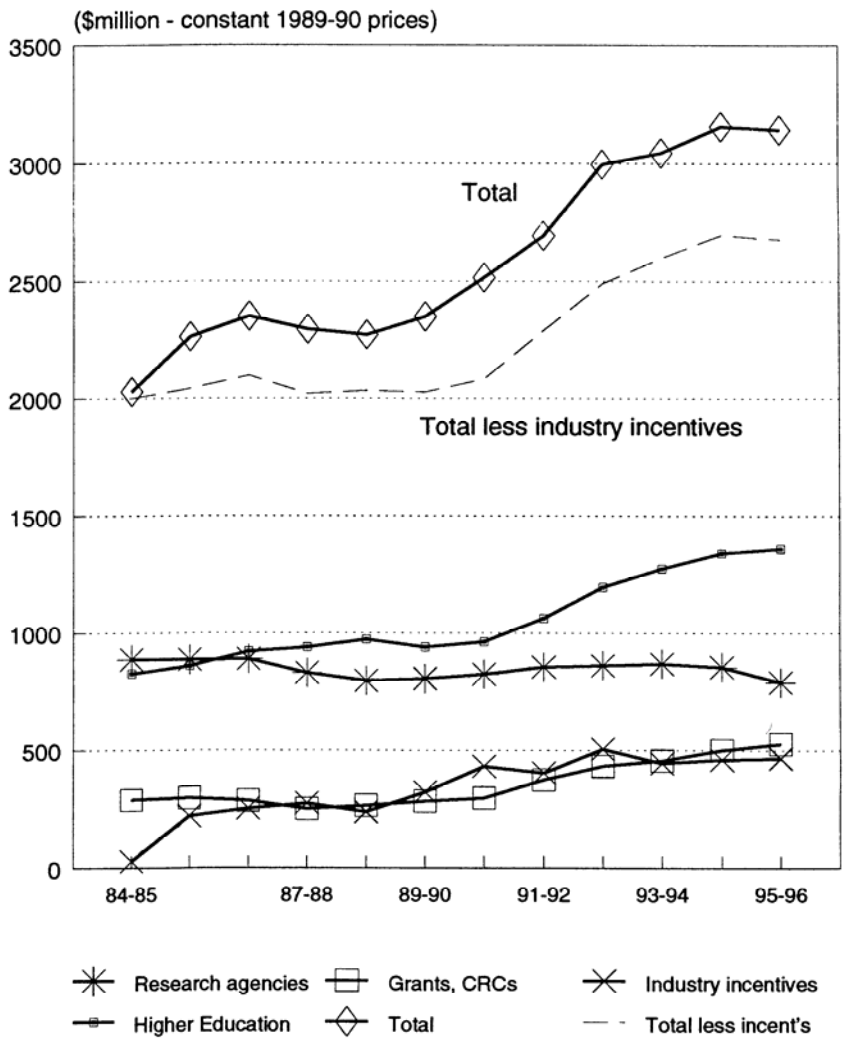
TABLE 2 Constant Price Summary *of* Major Commonwealth Support for Science and Innovation, through the Budget and Other Measures ($m at constant 1989-90 prices)

	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	(est) 1994-95	(est) 1995-96
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	224.4	218.9	225.0	215.2	223.0	225.2	218.1	218.7	215.7	220.4	217.1	216.9
• Civil	662.0	667.2	664.7	614.6	573.3	579.0	605.6	635.4	645.4	647.6	637.2	572.7
SUB-TOTAL	886.3	886.1	889.7	829.8	796.2	804.2	823.7	854.1	861.1	868.1	854.3	789.6
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	73.8	74.5	79.4	80.2	81.7	89.9	104.2	118.6	123.7	131.1	138.3	143.0
• Industry and space	129.3	137.7	109.1	90.3	91.3	92.8	95.0	124.9	143.4	114.0	119.7	140.3
• Cooperative Research Centres	-	-	-	-	-	-	-	17.2	42.3	84.3	102.3	110.7
• Rural	58.6	63.2	78.3	62.5	77.6	82.0	78.9	88.9	103.0	107.7	121.6	113.7
• Energy and environment	23.7	19.0	17.5	16.6	13.0	16.9	17.3	22.6	18.5	17.6	17.3	17.3
• Transport	3.5	3.4	2.5	2.3	2.1	2.0	2.1	2.1	2.1	2.0	2.0	1.9
SUB-TOTAL	289.0	297.9	286.8	251.8	265.7	283.6	297.6	374.2	433.0	455.8	501.2	527.0
COSTS OF IR&D & RELATED INCENTIVES	28.3	220.3	252.8	275.0	238.0	322.0	431.9	403.0	506.1	444.8	460.1	465.4
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	74.7	76.8	79.8	82.9	89.8	124.4	175.1	230.1	245.2	272.0	284.7	308.9
• Specific R&D support	158.6	155.7	154.6	154.2	170.0	165.0	163.1	172.5	188.0	198.2	208.3	207.2
• Est. general research support	592.1	626.6	687.1	702.0	712.0	650.0	623.8	659.1	762.3	804.8	847.5	844.3
SUB-TOTAL	825.4	859.2	921.5	939.0	971.9	939.4	962.1	1061.7	1195.6	1275.0	1340.5	1360.4
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 89-90 PRICES	**2029**	**2264**	**2351**	**2296**	**2272**	**2349**	**2515**	**2693**	**2996**	**3044**	**3156**	**3142**
EST. REAL % INCREASE/DECREASE		11.6	3.9	-2.3	-1.0	3.4	7.1	7.1	11.2	1.6	3.7	-0.4

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

Figure 4

MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION



Source: see Table 2

- *Higher Education Research*

Support for research in the higher education sector (excluding support from special purpose grant schemes) is estimated to increase to $1555 million in 1995-96 from $1477 million in 1994-95, representing a real increase of 1 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 $903 million in 1995-96, compared with $942 million in 1994-95 (a real decrease of 8 per cent). The apparent decline in appropriation funding for 1995-96 is due to CSIRO's $20 million borrowing in 1994-95 from 1995-96.

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 1995-96 are expected to amount to $417 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 $660 million.

- *Special Purpose Research Grant Schemes*

Support for R&D through the special purpose research grant schemes is estimated to increase to $602 million in 1995-96 from $552 million in 1994-95, representing a real increase of 5 per cent.

The Commonwealth has established a number of research grant schemes which are directed to special areas of interest - health and medical research (NH&MRC), rural research (RIRFs and other rural), industrial R&D (GIRD and its predecessors), energy R&D, and some smaller ones. The Cooperative Research Centres, established for the purpose of promoting linkages, are also included in this category.

– *Tax Incentive Scheme - Industrial R&D and Innovation*
Estimated support for R&D and innovation in the business sector through the industrial R&D tax concession will be $532 million in 1995-96 ($507 million in 1994-95), up 1% in real terms.

If the tax concession scheme is included with the industrial component of the special purpose grants, total support for industrial R&D and innovation is expected to be $692 million in 1995-96, up from $639 million in 1994-95, a real increase of 4 per cent.

Changes in the balance of funding

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

Looking at the broad changes apparent in Figures 4 and 5, Budget funding for the research agencies has remained approximately static in real terms over the period since 1984-85. The slight fall after 1986-87 is due to the conclusion of some substantial capital expenditures and recent policy changes to shift the balance towards non-Budget competitive funding. Over the same period, the special purpose schemes have increased significantly. This increase is even more substantial if the industry incentive schemes are included. When this is done, support for industrial R&D is seen to have received the largest increases. Support for health and medical research and for rural research has also risen significantly.

The increases in funding for industrial R&D followed policy changes which recognised its important role in innovation and competitiveness. Australian business R&D has been shown to be at comparatively low levels (see Section 4) and there has been little effective interaction between industry researchers and those in government agencies and universities.

The higher education sector has also seen a significant increase in funding since 1984-85. There has been a substantial shift so that the proportion of funds controlled by the ARC is now much higher. Total funds have increased overall and there has been a substantial change in the funding mechanisms.

The 1988-89 dip in total funding levels is traceable mainly to a real fall in the level of Budget funding for Commonwealth research agencies, since offset by increases in external funding. Such non-Commonwealth funding is not shown in Figures 4 and 5. The fall in 1993-94, visible in Figure 5, was due to the one-off payment in 1992-93 to initiate the Australian Technology Group Pty Ltd, and the decrease in the corporate tax rate (from 39 to 33 cents in the dollar) which reduced the tax revenue forgone from the 150% industrial R&D tax concession. The apparent decline in 1995-96 is due to CSIRO's $20 million borrowing from that year in 1994-95.

Detailed data

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

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

A further blurring results from the inclusion of the estimated costs of Commonwealth revenue forgone through the taxation concession scheme for industrial R&D. As already indicated, the amounts shown are estimates. (See footnote (4) to Table 6.) There are significant revisions to some historical data in this table.

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

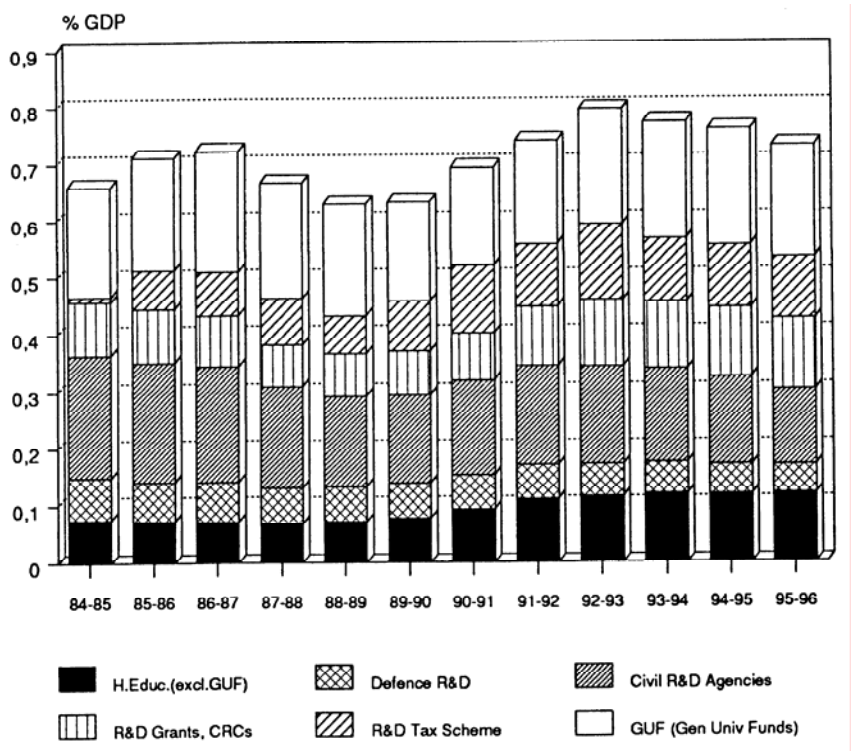
Over the past three decades there has been considerable international effort to reach agreed definitions of R&D. The resulting definitions have been applied with some rigour in periodic surveys conducted within most OECD countries. This so-called "Frascati" methodology has been applied in Australia since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

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

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

Figure 5

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

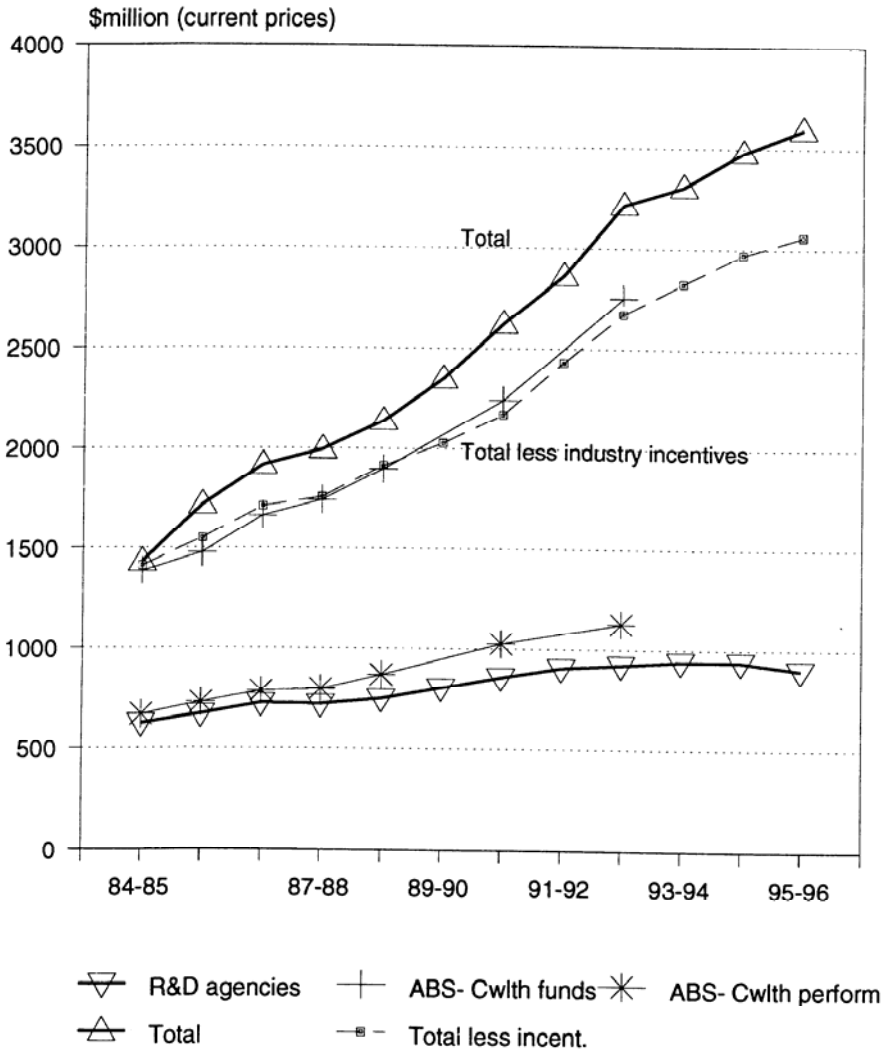


Source: *See Table 2 and ABS 5206.0*

Figure 6 shows the comparison between the "science and innovation" series presented in this Section and ABS (Frascati) R&D. The total 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 6

BUDGET-BASED DATA AND ABS R&D



Source: DIST and ABS

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

	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95 (est)	1995-96 (est)
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	158.4	165.9	183.4	187.0	209.8	225.2	227.2	232.3	231.4	239.4	239.3	247.9
• Civil	467.3	505.8	541.7	534.1	539.5	579.0	631.1	674.8	692.5	703.3	702.2	654.6
• SUB-TOTAL	625.7	671.7	725.1	721.1	749.3	804.2	858.3	907.1	923.9	942.7	941.5	902.5
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	52.1	56.5	64.7	69.7	76.9	89.9	108.6	125.9	132.7	142.4	152.4	163.5
• Industry and space	91.3	104.4	88.9	78.4	85.9	92.8	99.0	132.6	153.9	123.8	132.0	160.4
• Cooperative Research Centres								18.2	45.3	90.6	112.7	126.6
• Rural	41.4	47.9	63.8	54.3	73.0	82.0	82.2	94.5	110.5	117.0	134.0	130.0
• Energy and environment	16.7	14.4	14.2	14.4	12.3	16.9	18.1	24.0	19.9	19.1	19.1	19.7
• Transport	2.5	2.6	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
SUB-TOTAL	204.0	225.8	233.7	218.9	250.0	283.6	310.1	397.4	464.6	495.0	552.3	602.4
COSTS OF IR&D & RELATED INCENTIVES	20	167	206	239	224	322	450	428	543	483	507	532
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	52.8	58.3	65.0	72.0	84.5	124.4	182.5	244.3	263.1	295.4	313.7	353.1
• Specific R&D support	112.0	118.0	126.0	134.0	160.0	165.0	170.0	183.2	201.8	215.3	229.6	236.8
• Est. general research support	418.0	475.0	560.0	610.0	670.0	650.0	650.0	700.0	818.0	874.0	934.0	965.0
SUB-TOTAL	582.8	651.3	751.0	816.0	914.5	939.4	1002.5	1127.5	1282.9	1384.7	1477.3	1554.9
TOTAL COMMONWEALTH SUPPORT	**1432**	**1716**	**1916**	**1995**	**2138**	**2349**	**2621**	**2860**	**3214**	**3305**	**3478**	**3592**
% GDP	0.659	0.710	0.722	0.666	0.629	0.633	0.692	0.739	0.795	0.772	0.760	0.730
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 1989-90 PRICES	**2029**	**2264**	**2351**	**2296**	**2272**	**2349**	**2515**	**2693**	**2996**	**3044**	**3156**	**3142**
EST. REAL % INCREASE/DECREASE		11.6	3.9	-2.3	-1.0	3.4	7.1	7.1	11.2	1.6	3.7	-0.4

SOURCE See Tables 4, *5* and 6

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

	1984-85	1985-86	1986-87	1987-88	1988-89	Outlays 1989-90	1990-91	1991-92	1992-93	1993-94	(est.) 1994-95	(est.) 1995-96
THE ENVIRONMENT, SPORT & TERRITORIES												
Antarctic Division	37.4	42.2	47.4	49.2	46.3	57.7	62.8	67.3	65.4	61.0	62.7	61.7
Bureau of Meteorology Research Centre (BMRC)	1.8	1.8	2.3	2.5	2.2	2.4	2.8	3.3	3.3	3.6	3.7	3.7
Supervising Scientist - Alligator Rivers Research Inst	4.7	5.5	6.1	5.9	6.6	5.9	5.1	5.6	7.5	6.6	6.4	6.7
DEFENCE												
Defence Science and Technology Organisation[1]	158.4	165.9	183.4	187.0	209.8	225.2	227.2	232.3	231.4	239.4	239.3	247.9
EMPLOYMENT, EDUCATION & TRAINING												
Anglo-Aust Telescope	1.8	1.9	2.0	2.4	2.5	2.7	2.9	3.0	3.1	3.1	3.0	3.1
HEALTH & HUMAN SERVICES												
Australian List, of Health & Welfare (excl. grants)	4.6	5.1	5.2	3.4	4.2	4.4	4.2	5.0	6.8	7.2	8.1	7.0
CSL Ltd (Budget component)	8.8	12.8	15.8	17.3	16.6	9.4	3.0	5.9	8.2	17.0	4.3	2.9
Nuclear Safety Bureau	-	-	-	-	-	-	-	-	0.8	0.8	0.8	0.9
INDUSTRY, SCIENCE & TECHNOLOGY												
Aust Nuclear Science & Technology Organisation	41.9	45.4	45.2	50.8	54.3	57.5	62.6	65.1	68.2	64.2	66.2	65.6
Australian Institute of Marine Science	7.4	7.6	8.2	9.5	11.0	11.4	13.6	14.2	14.2	16.9	16.5	16.6
CSIRO	324.9	344.3	367.8	347.8	348.1	375.2	414.4	446.3	456.2	460.4	461.6	416.8
Kraft Pulp Mill study (CSIRO)	-	-	-	-	-	0.5	1.4	1.9	1.9	1.9	-	-
PRIMARY INDUSTRIES & ENERGY												
Contribution to CSIRO for Aust Animal Health Labs	3.9	4.1	4.4	4.7	4.7	4.9	5.3	5.5	6.0	5.9	6.2	5.6
AGSO	30.1	35.2	37.4	40.6	42.9	47.0	52.9	54.2	50.9	54.5	62.6	64.0
TOTAL	**625.7**	**671.7**	**725.1**	**721.1**	**749.3**	**804.2**	**858.3**	**907.1**	**923.9**	**942.7**	**941.5**	**902.5**

(1) For comparability with earlier years in the series, DSTO expenditure estimates for 1994-95 and 1995-96 include an attributable superannuation component from other Defence appropriations.

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

						Outlays					(est.)	(est.)
	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96
THE ENVIRONMENT, SPORT & TERRITORIES												
Aust Biological Resources Study	1.2	1.2	1.0	1.1	1.3	1.6	1.2	2.0	2.3	2.3	2.0	1.9
Greenhouse research (NGRP)	-	-	-	-	0.8	5.7	5.7	6.1	6.0	5.8	6.0	6.0
EMPLOYMENT, EDUCATION & TRAINING												
Research evaluation and Academies	-	-	-	-	-	-	1.6	2.0	2.0	2.0	2.1	2.1
ARGS & ARC grants/fellowships (including marine R&D grants)	30.8	34.6	39.8	42.7	50.7	35.6	1.2	-	-	-	-	-
Post-graduate Awards[1]	16.3	17.8	19.3	20.3	21.7	11.3	-	-	-	-	-	-
Targeted Institutional Links Program	-	-	-	-	-	0.2	1.0	2.0	1.1	1.4	1.4	0.8
HEALTH & HUMAN SERVICES												
AIDS Research	-	0.8	1.5	3.0	3.5	5.0	7.1	10.8	10.5	11.6	12.1	12.1
Health and Community Services Research Grants	1.6	1.8	2.3	1.1	1.4	1.9	1.8	1.8	1.9	1.9	1.7	2.2
NH&MRC Research Grants	44.2	51.2	59.4	65.6	72.0	83.0	94.7	103.3	110.3	118.9	125.5	139.2
Capital Works for Medical Institutes	6.3	2.6	1.6	-	-	-	5.0	10.0	10.0	10.0	13.0	10.0
Funds for John Curtin SMR	-	-	-	-	-	-	-	8.2	16.8	17.3	17.6	17.8
INDUSTRY, SCIENCE & TECHNOLOGY												
IR&D Incentives Act 1976												
. Commencement grants	16.3	14.3	16.9	3.1	0.1	-	-	-	-	-	-	-
. Project grants	38.1	37.7	17.9	6.4	2.8	0.3	-	-	-	-	-	-
. Public interest projects	9.8	6.3	3.5	1.0	0.3	-	-	-	-	-	-	-
IR&D Act 1986 (GIRD)	-	-	10.8	25.6	31.8	32.0	29.6	32.2	-	-	-	-
. Biotechnology grants	2.2	4.3	-	-	-	-	-	-	-	-	-	-
Advanced Manufacturing Tech Program	-	-	-	-	-	-	-	0.1	-	-	-	-
National Procurement Development Program (NPDP)	-	-	-	0.7	3.9	5.6	4.2	4.4	-	-	-	-
Technology Development Program	0.9	0.8	1.2	1.4	1.1	1.9	3.0	3.2	-	-	-	-
Industry Innovation Programs	-	-	-	-	-	-	-	-	43.5	40.3	47.3	63.1
National Research Facilities	-	-	-	-	-	-	-	-	-	-	-	15.4

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

	Outlays										(est.)	(est.)
	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96
National Space Program	-	3.0	5.0	3.2	5.4	2.4	5.5	5.7	5.4	5.4	7.6	6.1
Malaria Vaccine Joint Venture	-	0.3	0.4	0.8	1.2	0.8	2.3	9.4	-	-	-	-
Research associations[2]	1.9	1.9	2.0	2.0	-	-	-	-	-	-	-	-
Motor Vehicle R&D	20.6	22.9	11.6	8.4	8.3	4.7	2.3	-	-	-	-	-
Assistance under the Bounty[3] (Computers) Act 1984	1.5	13.2	19.4	25.7	31.1	45.0	51.3	74.5	75.0	78.0	77.0	75.8
Australia Technology Group Pty Ltd	-	-	-	-	-	-	-	-	30.0	-	-	-
Cooperative Research Centre Grants	-	-	-	-	-	-	-	18.2	45.3	90.6	112.7	126.6
PRIMARY INDUSTRIES & ENERGY[4]												
Wool Research	11.7	13.0	14.4	12.1	21.7	20.8	11.7	13.8	13.2	12.0	18.0	18.1
Meat Research	4.0	5.5	8.4	8.6	11.9	13.8	13.6	20.8	23.8	22.1	22.2	20.0
Fishing Industry Research	4.3	5.0	6.2	6.2	5.4	8.1	8.4	6.6	7.5	8.5	9.8	10.9
Grains	14.1	15.2	17.9	11.2	11.1	13.3	14.4	14.8	15.7	21.2	23.3	20.6
Horticulture Research	-	-	-	-	0.6	1.2	3.1	4.4	8.3	9.6	10.4	12.3
Energy research	15.5	13.2	13.3	10.2	9.6	11.2	15.9	11.8	11.6	11.0	11.1	11.8
Land & Water research	1.5	1.8	4.9	7.8	10.4	9.9	13.3	13.3	13.7	11.8	11.3	11.3
Rural Industries R&D Corporation	0.3	0.4	1.5	3.0	4.0	5.0	6.0	8.4	10.5	10.5	10.5	10.5
Other rural research	5.4	7.0	10.6	5.5	8.0	10.1	13.6	12.4	18.8	21.3	28.7	26.3
TRANSPORT & COMMUNICATIONS												
Payments to Australian Road Research Board	2.0	2.0	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
Railway R&D Organisation	0.5	0.6	-	-	-	-	-	-	-	-	-	-
TOTAL	**251.2**	**278.2**	**292.8**	**281.9**	**322.5**	**330.7**	**313.9**	**409.6**	**484.5**	**515.7**	**573.4**	**623.1**

FOOTNOTES TO TABLE 5

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

FOOTNOTES TO TABLE 5 - *continued*

(2) Since 1988-89 the Associations have been fully funded by industry.
(3) Assistance is provided for local manufacturers of computer hardware, systems software and electronic microcircuits. It covers design and development costs.
(4) For consistency, the expenditure figures for Wool, Meat, Other Rural Research, Fish, Horticulture and Grains exclude that component of Commonwealth outlays funded from industry levies. The component of outlays provided by way of industry levy or contribution is given in the following table .

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

	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95 est	1995-96 est.
Wool	12.32	11.88	15.25	18.31	14.21	19.63	17.11	14.05	12.32	12.45	17.97	18.12
Meat	4.61	5.55[a]	7.68[a]	8.65[a]	11.58[a]	13.30[a]	15.17[a]	25.60[a]	25.55	24.65	22.22	19.98
Grains												
- Grain[b]	1.30	2.16	2.07	2.35	2.53	3.99	4.27[b]	5.31[b]	9.36	12.61	8.17	11.19
-Wheat	5.40	5.48	6.40	5.16	8.35	9.84	8.45	12.92	18.35	19.95	16.00	16.75
Coal[c]	4.17	3.28	4.82	7.07	15.02	17.05	14.95	13.88	16.10	1.48	-	-
Special Rural	-	-	-	-	-	0.20	0.30	0.15	0.99	1.03	1.55	1.54
Fish	-	-	-	-	-	-	0.50	1.12	1.01	2.01	2.90	3.63
Horticulture	-	-	-	-	0.20	1.62	3.26	4.94	7.24	3.12	3.40	5.13
Other Rural												
- Chicken Meat	0.24	0.29	0.38	0.40	0.38	0.46	0.55	0.78	0.65	0.67	0.72	0.75
- Cotton	1.00	0.89	1.04	0.86	1.55	1.87	2.66	3.87	3.89	2.57	2.10	2.34
- Dairying	0.60	0.67	1.26	1.64	1.57	2.94	4.82	5.21	5.65	6.20	6.13	6.36
- Dried Fruit	0.12	0.16	0.32	0.26	0.29	0.39	0.45	0.78	0.92	0.46	0.55	0.74
- Grape & Wine	0.49	0.52	0.67	0.82	0.94	1.28	1.25	0.96	1.60	1.70	1.98	1.76
- Honey	0.05	0.08	0.09	0.11	0.10	0.12	0.14	0.07	0.12	0.15	0.12	0.16
- Pig Industry	0.60	0.78	1.00	1.43	1.37	1.95	2.58	2.68	2.88	3.61	3.54	3.50
- Egg Industry	0.16	0.22	0.31	0.28	0.37	0.30	0.45	0.57	0.68	0.67	0.59	0.68
- Sugar	-	-	-	1.28	1.40	1.37	1.48	1.28	3.40	4.48	4.89	4.85
- Tobacco	0.67	0.66	0.69	0.64	0.94	0.77	0.59	0.59	0.92	0.64	0.40	0.56
- Forestry	-	-	-	-	-	-	-	-	-	-	0.57	1.00
Total	30.61	32.61	41.98	49.25	60.82	77.09	79.00	94.86	111.62	96.97	93.79	99.03

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

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

	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95 (est)	1995-96 (est)
EMPLOYMENT, EDUCATION & TRAINING*												
Higher Education Funding Act: special research assistance [1]	5.6	5.9	6.0	9.0	12.1	77.3	178.7	240.3	260.0	292.0	310.2	350.2
Identifiable research support for universities[2,4]	112	118	126	134	160	165	170	175	185	198	212	219
Estimated research component of general university funding for both teaching and research[3,4]	418	475	560	610	670	650	650	700	818	874	934	965
Tax Concession[5] for industrial R&D	-	147	186	219	217	303	416	428	543	483	507	532
Tax Deduction for equity subscriptions in Management Investment Companies (MICs)[6]	20	20	20	20	7	19	34	-	-	-	-	-
TOTAL	**556**	**766**	**898**	**992**	**1066**	**1214**	**1449**	**1543**	**1806**	**1847**	**1963**	**2066**

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

(1) Includes funding for research grants, fellowships, centres, postgraduate awards and infrastructure provided on the advice of the Australian Research Council.

(2) Indicative estimates of identifiable research expenditure data from university operating grants. Later years are projections based on data collected by DEET from universities for the 1992 data year. Funding for John Curtin School of Medical Research of ANU was transferred to the Health portfolio and is therefore not included after January 1992. Data for the former advanced education sector are not included in the years prior to 1989 when the unified system was established by the amalgamation of this sector with the former university sector.

(3) Indicative estimates of research expenditure from university operating grants other than those identified in the previous row. The sum ot the estimates in the previous row and this row of figures is an estimate of the research component of university operating grants. It does not include funds spent on research by the former advanced education sector institutions prior to the 1989 amalgamations. Estimates for 1984-85, 1986-88, 1988-89, 1990-91 and 1992-93 are based on ABS R&D Surveys in the calendar year in which each of these financial years commences. Estimates for other years are interpolations and projections from the years for which survey data are available.

(4) The following table provides an alternative estimate of the research component of general university funding for teaching and research. This estimate is based on the Relative Funding Model which was developed and applied to the university operating grant in 1990. The methodology identifies that 6.2% of the operating grant is available for research purposes unrelated to teaching and research training purposes. The balance is allocated on the basis of student load in each cell of the matrix of levels of teaching and discipline cost clusters weighted by the relative teaching costs estimated for each cell of the matrix. The estimates assume that the relative teaching costs have not changed since they were estimated in 1990 based on 1988 teaching costs data. However, the estimates take into account changes in student load relativities in the different teaching levels up to the present time. The matrix of relative teaching costs and other details of the RFM are contained in the report, *Assessment of the Relative Funding Position of Australia's Higher Education Institutions* released in August 1990 by the Hon. Peter Baldwin, M.P., the then Minister for Higher Education and Employment Services.

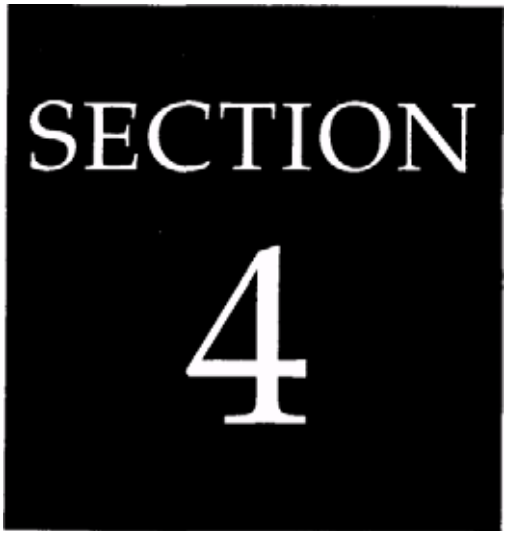
	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95 est	1995-96 est
ANU Institute of Advanced Studies (estimate) [a]	87	93	97	100	108	122	134	133	128	129	130	130
Estimated research and research training component of higher education operating grants [b]	271	293	315	334	366	397	414	455	528	579	624	683

(a) This is an estimate of funds provided for research and research training to the Institute of Advanced Studies through the operating grant of The Australian National University. Funding for the John Curtin School of Medical Research has been excluded from January 1992 when this was transferred to the Health portfolio.

(b) Sum of Research Quantum (RQ) and Research Training Component (RTC) of the operating grant. The Relative Funding Model estimated that the RTC was 7.6% of the operating grant in 1990. Based on shifts in student load relativities in the different teaching levels (undergraduate, higher degree research and other postgraduate), the RTC proportion of the operating grant is estimated to be 7.74%, 8.68%, 9.27%, 9.22%, 9.98% and 10.69% in the years 1991 to 1996, respectively.

(5) A 150% company tax deduction for eligible industrial R&D expenditure has applied from 1 July 1985. The data series comprise estimates based both on information provided in registrations for the concession and analysis by the Australian Taxation Office (ATO). They do not account for any recoupments arising from the dividend imputation system. The focus of the Table is on the effect of Government actions in the wider community. The figures in the Table 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 1985-86 to (estimated) 1995-96, as follows: nil, $105m, $150m, $190m, $215m, $300m, $405m, $415m, $520m, $480m and $505m. Figures published here are significantly revised over those published previously.

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



International Context

Broad international comparison of R&D levels

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

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

	GERD (1985 US$m)	GERD/GDP	Change since 1981	Average annual real increase in GERD	Average annual real increase in GDP
United States (1992)	131608	2.81	+0.38	3.7%	2.8%
Japan (1992)	57614	2.80	+0.67	7.0%	4.2%
Germany (1992)	28398	2.50	+0.07	4.2%	3.5%
France (1992)	20235	2.40	+0.43	4.1%	2.3%
China (1990)	19945	0.72	na	na	6.1%
United Kingdom (1992)	15747	2.12	- 0.25	1.8%	2.8%
Italy (1992)	10312	1.31	+0.44	6.6%	2.5%
Canada (1992)	6408	1.51	+0.28	4.1%	2.9%
India (1990)	5667	0.79	+0.20	9.4%	5.7%
South Korea (1990)	4790	1.86	+1.24	24.2%	9.9%
Netherlands (1992)	3866	1.86	+0.01	2.8%	2.5%
AUSTRALIA (1992)	**3800**	**1.56**	**+0.56**	**6.9%**	**3.2%**
Sweden (1993)	3598	3.11	+0.82	4.4%	1.9%
Spain (1992)	3363	0.85	+0.42	10.8%	3.4%
Switzerland (1992)	3195	2.68	+0.39	4.0%	2.2%
Belgium (1991)	2318	1.67	+0.05	2.9%	2.3%
Chinese Taipei (1990)	2241	1.69	+0.77.	15.8%	8.5%
Austria (1992)	1719	1.53	+0.36	4.8%	2.5%
Finland (1992)	1321	2.18	+0.98	7.6%	2.3%
Denmark (1991)	1227	1.70	+0.60	7.0%	2.1%
Norway (1993)	938	1.76	+0.47	5.3%	1.1%
Ireland (1992)	377	1.07	+0.38	7.8%	3.7%
New Zealand (1991)	331	0.88	- 0.13	0.1%	1.2%
Singapore (1990)	307	0.90	+0.62	22.3%	6.6%
Average		**1.76**	**+0.43**	**7.5%**	**3.3%**
Average (OECD only)		**1.91**	**+0.37**	**5.3%**	**2.3%**

Source: DIST based on ABS, OECD and US National Science Foundation data.

Table 7 shows the latest available GERD/GDP data for nineteen OECD and five Asian economies. Since it is also useful to know the relative scales of R&D effort, the list is ranked by the total R&D expenditure level (in US dollars at constant 1985 prices). The Table also shows the change in the GERD/GDP ratio since 1981, and the average annual real growth rates over the decade both for GERD and GDP.

The Table shows that the scale of Australia's total R&D expenditure is about one thirtyfifth that of the largest national effort (USA) and about ten times that of the smallest. In terms of the relative share of national wealth devoted to R&D (GERD/GDP), Australia lies in the middle range. Australia's relative R&D effort is about half that of Sweden (the highest in relative terms) and is just over double that of the lowest. In almost all economies, the real growth rate in GERD over the past decade was significantly higher than the corresponding growth in GDP. The three "dynamic Asian economies" shown (Singapore, South Korea and Chinese Taipei) have dramatically increased their total level of R&D effort and show exceptionally high growth rates in GERD and GDP.

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

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

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

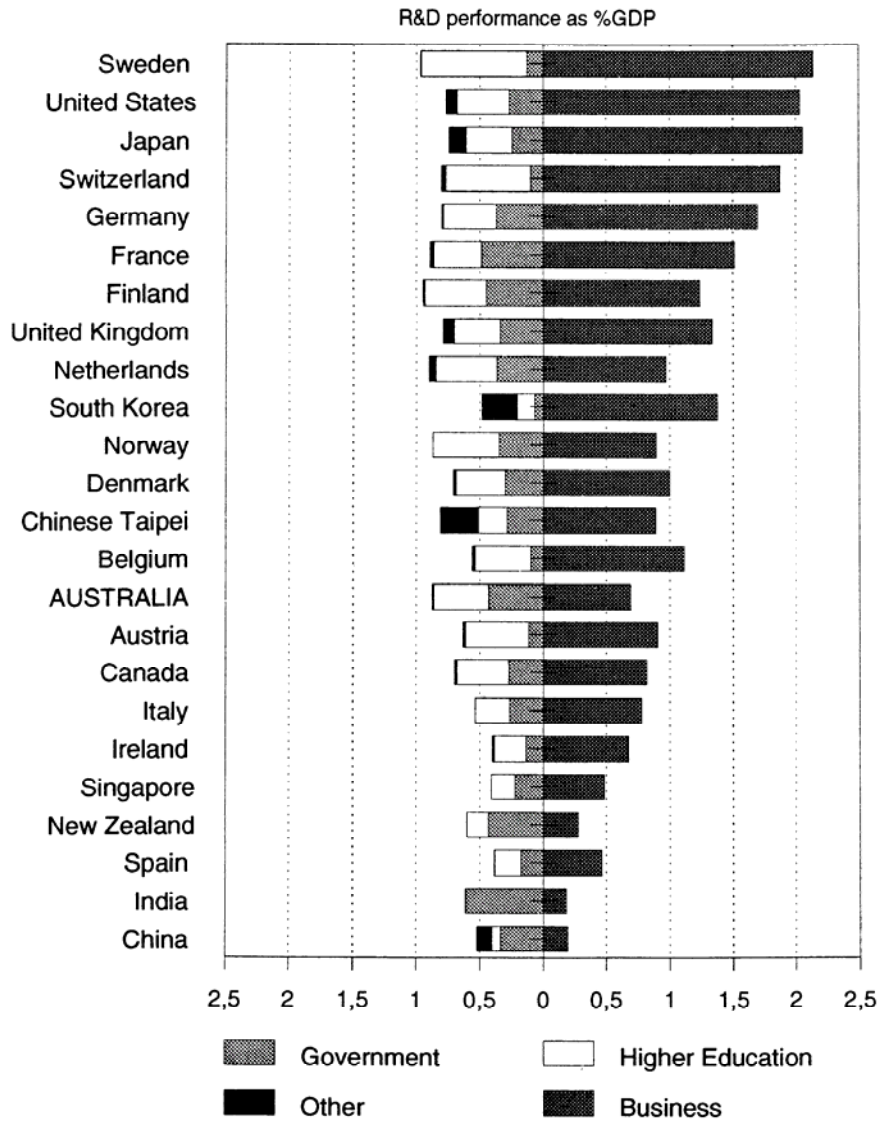
(ii)R&D in the business sector.

R&D expenditure in government agencies and universities

Table 8 shows comparative international data for combined R&D expenditure within government agencies and universities. In this list, the arrangement is in order of R&D expenditure as a percentage of GDP. The Table also shows shows changes in this ratio since 1981 and the average annual real growth rate since that time.

Figure 7

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



Source: DIST based on ABS, OECD and US National Science Foundation data.

In terms of the share of national wealth expended on R&D within government agencies and universities (R&D expenditure as a per cent of GDP), Australia has a high ranking of 0.86% compared with an average of 0.64% for all twentyfour economies listed. Australia's change since 1981 has been +0.11, equal to the average change. Among all countries, there was some convergence towards the mean over the period. The eleven economies which were highest ranking in 1981 increased by an average of +0.07, compared with an average increase of +0.18 for the lowest ranking eleven.

TABLE 8 Expenditure on R&D in government agencies and universities as a proportion of GDP, change and growth rates since 1981 - selected international comparisons

	R&D expend. in govt and universities as % GDP	Change since 1981	Average annual % real increase in R&D expend.
Sweden (1993)	0.96	+0.13	3.4%
Finland (1992)	0.93	+0.39	6.8%
Norway (1993)	0.87	+0.27	5.0%
AUSTRALIA (1992)	**0.86**	**+0.11**	**4.0%**
France (1992)	0.86	+0.07	3.0%
Netherlands (1992)	0.84	+0.03	2.4%
Germany (1992)	0.79	+0.07	4.8%
Switzerland (1992)	0.77	+0.18	5.2%
United Kingdom (1992)	0.70	- 0.11	0.9%
Denmark (1991)	0.69	+0.14	5.3%
United States (1992)	0.68	+0.03	3.6%
Canada (1992)	0.68	+0.06	2.6%
India (1990)	0.61	+0.18	10.1%
Japan (1992)	0.61	- 0.02	3.5%
New Zealand (1991)	0.60	- 0.17	- 1.2%
Austria (1989)	0.55	+0.06	3.7%
Belgium (1991)	0.54	+0.14	6.5%
Italy (1992)	0.53	+0.15	6.0%
Chinese Taipei (1990)	0.51	+0.25	12.7%
Singapore (1990)	0.41	+0.29	20.6%
China (1990)	0.41	na	na
Ireland (1992)	0.39	+0.00	3.3%
Spain (1992)	0.39	+0.15	8.7%
South Korea (1990)	0.21	+0.06	14.1%
Average	0.64	+0.11	5.9%
Average (OECD only)	0.70	+0.09	4.1%

Source: DIST based on ABS, OECD and US National Science Foundation data.

Business expenditure on R&D

Table 9 shows comparative international data for business expenditure on R&D (BERD). The list in this case is arranged in order of BERD as a percentage of GDP. The Table also shows changes in this ratio since 1981, the average annual real growth rate since that time, and the average annual increase in patent applications made by nationals of each country to all other countries ("external" patent applications).

TABLE 9 Business expenditure on R&D (BERD) as a proportion of GDP, change since 1981 and growth rates in BERD and patents applied for in foreign countries - selected international comparisons

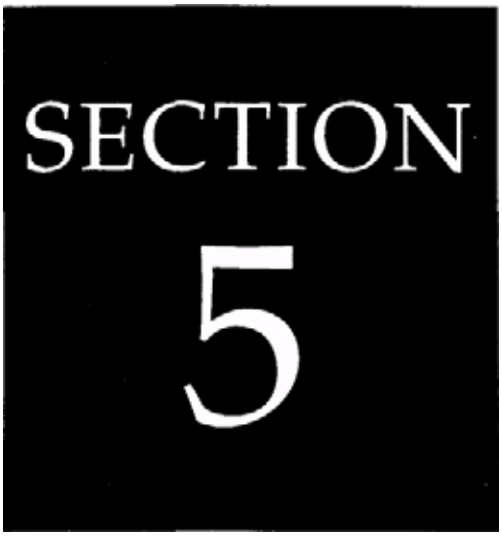
	%BERD/GDP	Change since 1981	Average annual real increase in BERD	Average annual increase in ext. patents
Sweden (1993)	2.14	+0.68	5.0%	9.3%
Japan (1992)	2.06	+0.65	8.2%	10.4%
United States (1992)	2.04	+0.33	3.8%	11.3%
Switzerland (1992)	1.88	+0.18	3.5%	5.1%
Germany (1992)	1.70	+0.00	4.0%	7.6%
France (1992)	1.51	+0.35	4.8%	8.1%
South Korea (1990)	1.38	+1.12	31.6%	na
United Kingdom (1992)	1.33	- 0.16	2.1%	11.6%
Finland (1992)	1.24	+0.59	8.2%	16.7%
Belgium (1991)	1.11	+0.06	2.8%	8.8%
Denmark (1991)	1.00	+0.45	8.3%	16.0%
Netherlands (1992)	0.97	- 0.02	3.2%	10.3%
Norway (1993)	0.89	+0.21	5.7%	16.6%
Chinese Taipei (1990)	0.89	+0.37	16.5%	na
Canada (1992)	0.82	+0.22	5.4%	8.8%
Austria (1989)	0.80	+0.15	4.9%	9.1%
Italy (1992)	0.77	+0.28	7.1%	9.7%
AUSTRALIA (1992)	**0.69**	**+0.47**	**13.0%**	**17.4%**
Ireland (1992)	0.67	+0.37	11.7%	14.1%
Singapore (1990)	0.49	+0.34	23.8%	na
Spain (1992)	0.47	+0.27	12.8%	14.1%
New Zealand (1991)	0.28	+0.06	4.6%	- 2.3%
China (1990)	0.19	na	na	na
India (1990)	0.18	+0.02	7.2%	na
Average	**1.06**	**+0.30**	**8.6%**	**na**
Average (OECD only)	**1.18**	**+0.27**	**6.3%**	**10.1%**

Source: DIST based on ABS, OECD and US National Science Foundation data.

There were substantial increases in levels of BERD in most countries over the 1980s and much higher growth rates than for the composite category of R&D expenditure in government agencies and universities. There was little sign of any convergence. As in most other economies beginning with low levels of BERD in 1981, Australia achieved increases in BERD/GDP and growth rates well above OECD averages. In fact, over the period 1981 to 1992, Australia's real growth rate in BERD was the second highest in the OECD. Nevertheless, growth rates in OECD nations were all much lower than for the three dynamic Asian economies in the Table. South Korea, with a real annual growth rate of about 32 per cent, Singapore on 24 per cent, and Chinese Taipei on 17 per cent, were all well ahead of the OECD leaders, Australia and Spain, each with corresponding growth rates of about 13 per cent.

While comparative R&D data for the business sector are often used as an indicator or proxy for innovation in the wider sense, national data on external patent applications provide an alternative indicator. Both indicators are partial and imperfect measures of different aspects of innovative levels or capacity. Data on external patent applications, at present available only for OECD countries, show Australia with substantially the highest growth rate. Since this information is statistically quite separate from the business R&D expenditure, it provides valuable confirmation that there was substantial growth achieved in Australia's business sector innovation over the 1980s - and that this growth was significantly higher than in most other OECD economies.

Table 9 thus confirms the picture of very significant increases in Australian business innovation over the 1980s, over a period in which an extensive range of Commonwealth programs was instigated with the aim of stimulating innovation. Nevertheless, in view of Australia's continued low ranking in BERD/GDP, which is also shown in Table 9 - and the remarkable BERD growth rates being achieved in the Asia-Pacific region - there is no room for complacency. If, over the next decade, Australia is able to continue the R&D growth rates achieved since 1981, a significant improvement in our international ranking is likely.



Budget allocations and Portfolio achievements

Introduction

This Section presents selected information on science and technology arranged by ministerial portfolio. For each portfolio, there is a brief summary of pertinent allocations for the 1995-96 Budget compared with the expected expenditure outcome for 1994-95. The financial summary for the portfolio is followed by an account of recent research outcomes arranged by program or agency.

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

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

COMMUNICATIONS AND THE ARTS

Science and Technology in the Portfolio Budget

The Government has recognised that science and technology's part of the cultural mainstream of Australian society. Through the creation of the Department of Communications and the Arts and in the cultural policy statement, *Creative Nation*, the Government has sought to develop fully the synergies between developments in communications and information technology and the creative industries sector.

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

The National Science and Technology Centre has been allocated $4.79 million for 1995-96 ($4.48 million in 1994-95) to promote confidence in, understanding of, and positive attitudes towards science and technology. The Centre achieves this through providing interactive exhibitions and education programs to audiences throughout Australia including regional and remote communities. Many of the Centre’s Outreach Programs are undertaken with the assistance of private sector sponsorship. The Centre is also working with a number of science centers in Asia to develop cooperative programs.

MAJOR RESEARCH ACTIVITIES

National Film and Sound Archive

Role *To increase knowledge, appreciation; 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.*

Recent Achievements

Electric film winders
In answer to a demand for more efficient work practices, the Archive has developed an electric winder to assist with the millions of metres of film handled each year. Although simple in concept and design, such machines are not commercially available, and following extensive prototype testing of mechanical and electrical components, these winders are now being produced in quantities to satisfy the large demand within the Archive.

Film preservation
The Archive, in association with eight other international film archives throughout Europe, the USA and Japan, has recently finalised testing of a Kodak developed substance designed to slow the deterioration of film materials. The substance is a molecular sieve designed to scavenge the acetic acid (vinegar) given off by deteriorating films, thus slowing the reaction. Successful field testing has provided film archives world wide with an additional weapon to save their archives.

MAVIS image and sound collection available on CD-ROM
The extensive data base relating to the image and sound collection of the Archive (MAVIS) has been compiled onto a CD-ROM. The compact disc format will allow clients remote from Canberra to interrogate the database and identify collection materials they wish to access. World-wide distribution of the CD-ROM will also offer overseas clients access to the collection.

DEFENCE

Science and Technology in the Portfolio Budget

The Budget allocation for the Defence science and technology function will be $221 million in 1995-96 ($225 million expected outcome in 1994-95)

MAJOR RESEARCH ACTIVITIES

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

Policy and Command
A major redevelopment of the signal processing and display capability of the No.l Radar Surveillance Unit (1RSU) at the Jindalee Facility, Alice Springs, has been completed. This has provided the 1RSU over-the-horizon radar with the capability to handle advanced signal processing algorithms.

The third phase of the Wide Area Surveillance Study has been completed. This phase of the study identified options and costs for enhancing the effectiveness of the ADF's capabilities in wide area surveillance, including the use of satellites.

Maritime Force Capabilities
The concept and operational requirement studies for the Progressive Upgrade Program for the FFG 7 Class guided missile frigates has been completed.

Assistance was provided to the operational test and evaluation program for the submarine HMAS *Collins*, and discussions have taken place with industry on a collaborative strategy for continuing improvement of the algorithms used in the sonar suite.

A number of experiments were completed on the decommissioned destroyer escort, *Derwent*, to help in the assessment of the vulnerability of surface ships in war and to develop damage control methods.

Trials to evaluate the performance of various countermeasures to protect ship platforms against potential missile threat systems have been completed.

New colorimetric tube technology has been developed for assessing the quality of diesel fuel. This has been adopted for routine use by the Royal Australian Navy (RAN) to monitor the quality of fuels at the source of supply.

Land Force Capabilities

The Land Surveillance Study, which delineates the land surveillance and reconnaissance problems facing the Land Force, particularly in Northern Australia, has been completed.

An algorithm to extend the service life of fatigue prone components of Squirrel helicopters without compromising safety has been developed. Analysis has also provided more accurate calculations of the replacement life of critical components of Blackhawk helicopters, contributing to the safe operation of the fleet.

Air Force Capabilities

Static-strength and fatigue tests of major structural components of the Macchi trainer have been completed. Analysis of the results will allow the aircraft fleet to be managed on a safety-by-inspection basis to achieve the current required RAAF life-of-type.

A computer graphics package has been developed to reconstruct and display combat aircraft flight trajectories based on data obtained from on-board and external sources. The package is particularly useful in the analysis of flight incidents.

Trials were carried out to evaluate an interim electronic warefare (EW) suite for transport aircraft. A study has been carried out to define the capabilities required for an EW suite to protect F-111C aircraft. An evaluation has been carried out of the capabilities of the current EW suite for the F/A-18 aircraft.

Industry interaction

A research and development syndicate has been formed by several Australian companies to develop and exploit the DSTO Laser Airborne Depth Sounder (LADS) technology to meet a range of local and overseas applications.

A modification to reduce smoke emissions from Allison T-56 turboprop engines fitted to Hercules and Orion aircraft has been sold to several overseas operators through a licensee company. Certification tests, scheduled for April 1995, should enhance the prospects of selling the modification.

A licence agreement for commercialisation of DSTO designed high frequency data modems has been established with an Australian company.

International cooperation

The most important multi-lateral defence science forum continues to be The Technical Cooperation Program (TTCP) between the United States, United Kingdom, Canada, Australia and New Zealand.

DSTO continues to build its defence-science links with South-East Asia. Most notable achievements include the establishment of study teams with Indonesia to explore opportunities for cooperation in defence science and industry, and a study on aircraft structural integrity which will be completed this year.

EMPLOYMENT, EDUCATION AND TRAINING

Science and Technology in the Portfolio Budget

The Government, through the Employment, Education and Training portfolio, will provide about $1163 million in 1995-96 to support research and research training in Australian universities through the operating grant and targeted research support programs.

Support through university operating grants
The major part of the Government's support for university research and research training is provided through the operating grant. This support is given in three nominal components; (a) the Research Quantum (RQ) ($213 million reallocated in 1995 plus a non-reallocated $5.0 million component of funding increases since 1990), (b) the Research Training Component (RTC) (about $420 million) and (c) approximately $130 million of the Australian National University's operating grant which could be regarded as funding for the research schools and centres of the Institute of Advanced Studies.

Targeted research programs
Substantial support for research is provided directly to universities and researchers through a range of targeted research programs. In line with Government policy, funds are allocated on a competitive basis to ensure that they go to the universities and researchers able to make the best use of them. Targeted research support promotes the following Government objectives: excellence in basic and applied research, support for research training, selectivity and concentration of research resources, improved collaboration between universities and industry, international cooperation in research and the development of infrastructure to support high quality research.

The Government has announced additional support for higher education research totalling $46.4 million in 1996, $53.0 million in 1997 and $55.2 million in 1998. This increases the targeted support for 1995 to $350.2 million.

Research grants, centres and fellowships awarded on the advice of the ARC

Research grants, centres and fellowships are awarded competitively on the advice of the-Australian Research Council, which conducts a peer review process through its panels and committees, in all fields except medicine and dentistry. The primary criterion for the awards is excellence, though some weight may be given to other criteria such as national priority areas

and relevance to industry where appropriate. For 1995-96, the existing allocations for research grants, centres and fellowships will total $190.5 million, divided as follows: Large Research Grants ($85.6 million), Small Research Grants ($23.8 million), Collaborative Research Grants ($13.02 million), Research Fellowships ($24.8 million), International Fellowships ($1.4 million), the Research Centres Programs ($18.2 million), Australian Postgraduate Awards (Industry) ($7.3 million), and the Research Infrastructure Equipment and Facilities Program ($16.4 million).

Other research support program

The existing 1995-96 allocation for targeted research support which is not awarded on the advice of the ARC totals $129.9 million and consists of the Research Infrastructure Block Grants Program ($42.3m), Australian Postgraduate Awards Scheme ($65.6m), Overseas Postgraduate Research Scholarships ($14.8m), grants to the Learned Academies ($1.5m), a grant to the Anglo-Australian Telescope Board ($3.1m), the Targeted Institutional Links Program ($0.8m), the Research and Development Internships in Asia Program ($0.4m) and the Advanced Engineering Centres Program ($1.6m).

MAJOR RESEARCH ACTIVITIES

Research Funding Activities

University Operating Grants

In addition to supporting high quality undergraduate teaching, university operating grants support the research and research training capacity of universities aimed at achieving internationally competitive basic and applied research, promoting research collaboration between universities and industry, high quality research training, the promotion of international links and the development and maintenance of Australia's capacity in key technological areas.

The following three components of the operating grant are identified as providing support for research and research training:

- Research Quantum (RQ) which is identified as the component of the operating grant supporting research activities unrelated to teaching and training.
- Research Training Component (RTC) which is estimated on the basis of higher degree research student load weighted in accordance with the relative teaching costs matrix developed in 1990 in the context of the Relative Funding Model.

- Funding of the Institute of Advanced Studies of the Australian National University for all of its research schools and centres with the exception of the John Curtin School of Medical Research.

Two distinct methodologies are used to estimate the research and research training components of the operating grant. The first is a methodology based on surveys of research expenditure of universities by source of funds. The calculation also includes an estimate of the research component of university overhead expenditures based on the proportion of staff time spent on research activities compared with total staff time as obtained from ABS and DEET surveys. An alternative methodology is based on the 1990 analysis of the operating grant undertaken in developing the Relative Funding Model. The first approach estimates the total research and research training support through the operating grant at $1184 million in 1995-96. The second approach provides a significantly lower estimate of $813 million for 1995-96.

The Minister for Employment, Education and Training, in the 1993 *Higher Education Budget Statement* stated that the research component of funding increases provided to universities since 1990 to sustain growth in student places will be retained by those institutions. Consequently, while the amount of the RQ that is reallocated is $213 million, for the purposes of estimating the total available for research unrelated to teaching and research training, a more appropriate estimate would be 6.2% of the current operating grant excluding capital funds. On this basis the total RQ is $263 million including the non-reallocated $50 million component of funding increases since 1990.

The research training component was estimated by the Relative Funding Model to be 7.6% of the operating grant in 1990. Due to strong growth since that time in postgraduate research student load at a significantly faster rate than the growth in total student load, the RTC has steadily increased and will be $420 million which is 10.7% of the operating grant in 1995-96.

In addition, approximately $130 million of the Australian National University's operating grant could be regarded as funding for the research schools and centres of the Institute of Advanced Studies. This excludes the John Curtin School of Medical Research which, since 1992, is funded by the Department of Human Services and Health.

Research Grants

The Government has announced an enhancement to the Research Grants Program with additional funding being available from 1996 onwards as follows: $3.7 million in 1995-96, $10.7 million in 1996-97, $15.4 million in 1997-98 and $15.2 million in 1998-99 or by calendar year, $7.2 million in 1996, $13.7 million in 1997, $16.3 million in 1998 and $13.3 million in 1999.

Large Grants

The Large Grants Scheme provides research grants on a competitive basis for high quality research by individuals and research teams based in Australian universities. Applications are invited each year for grants for the following year in support of pure and applied research in the physical, chemical, biological, earth, engineering, applied and social sciences, the humanities and designated priority areas. Priority areas for 1995 are as follows:

- Australia's Asian context
- Biology of Sustainability
- Citizenship
- Cognitive Science
- Materials science and minerals processing

Priority areas for 1996 are:

- Biology of Sustainability
- Citizenship
- Food science and technology
- Minerals processing science and technology
- Optics
- Exploration geophysics
- Technological change

Applications are assessed by the ARC's Research Grants Committee and its expert discipline panels with the aid of external assessors. The existing allocation for the Large Grants program in 1995-96 is $85.6 million.

Small Grants

Under the Small Grants program, the Commonwealth provides a block grant to universities to enable them to offer research grants at less than the minimum value of Large Grants. This is $20,000 for the Humanities, Social Sciences, Mathematics and Theoretical Physics and $30,000 for other disciplines.

The existing allocation for the Small Grants Program in 1995-96 is $23.8 million. Universities will receive a base grant of $50,000 with the remaining funds 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. Funding for Small Grants will account for 23 per cent of funding for Large and Small Research Grants in 1995.

Collaborative Grants

The Collaborative Research Grants Program aims to encourage research collaboration between universities and industry by supporting high quality research which has the potential to economically and socially benefit Australia. The scope of the Program is broad, covering projects in basic, strategic, applied and developmental research in all fields. Grants applications are assessed by the ARC University-Industry Research Collaboration Committee. It is a requirement of grants that dollar for dollar matching funds from industry are available to the grantee. 223 Collaborative Research Grants are provided each year. In 1995-96, $13.0 million will be available to the Program.

Research Fellowships

Fellowships provide support for individuals to undertake research at postdoctoral level and above. In 1995-96 $24.78 million will be available for Research Fellowships.

There are four types of Fellowship:

- Australian Postdoctoral Research Fellowships (APRF). These are normally for researchers with less than three years postdoctoral experience. There will be fifty new APRFs available in 1995.
- Australian Research Fellowships (ARF). These are normally for researchers with more than three years postdoctoral experience. There will be fifteen new ARFs available in 1995.
- Queen Elizabeth II Fellowships (QEIIF). These are for outstanding researchers who would usually have no more than six years postdoctoral experience. There will be fifteen new QEIIFs available in 1995.
- Senior Research Fellowships (SRF). These are for researchers with established reputations who would normally have no more than fifteen years postdoctoral experience. There will be five SRFs available in 1995.

It should be noted that restricted eligibility criteria will apply for SRF appointments for two years commencing in 1996.

Research Centres

This program supports research concentrations on the basis of excellence and their potential to contribute to the economic, social and cultural development of Australia. The Research Centres Program supports two types of Centres: Special Research Centres, and Key Centres of Teaching and Research. A total of $18.2 million will be available in 1995-96.

Special Research Centres

Depending on specific requirements, Special Research Centres receive between $0.4 million and $0.9 million a year. The primary objective of the centres is to concentrate research effort in areas of national importance.

Key Centres of Teaching and Research

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. Existing Key Centres receive funding in a range from $165,000 a year to $300,000 a year, with most Centres obtaining additional funding from other sources.

A new cohort of about eight Key Centres is to be established in mid 1995 and will receive funding of between $200,000 and $500,000 a year. A short list of twelve proposals are currently under consideration by the ARC's Institutional Grants Committee.

Australian Postgraduate Awards and Australian Postgraduate Awards (Industry)

Australian Postgraduate Awards

Under the Australian Postgraduate Awards (APAs) scheme, students are exempted from HECS. In 1995, 18,300 Equivalent Full-Time Student Units (EFTSU) are covered for HECS exemption under this scheme; in 1996 19,900 EFTSU will be covered. In addition, 1,475 new students each year are given awards which provide stipends. These awards with stipend are tenable for up to two years in the case of a Masters student, or three and a half years in the case of a student undertaking a PhD. Most APAs are allocated to students undertaking research.

The Government has announced an enhancement to the Australian Postgraduate Awards Scheme with additional funding being available from 1996 onwards as follows: $0.9 million in 1995-96, $2.7 million in 1996-97, $4.3 million in 1997-98 and $5.5 million in 1998-99 or by calendar year $2.3 million in 1996, $3.5 million in 1997, $4.9 million in 1998 and $2.8 million in 1999. The existing 1995-96 allocation for the APA scheme is $65.6 million.

Australian Postgraduate Awards (Industry)

The Australian Postgraduate Awards (Industry) Scheme provides higher degree research training for high calibre 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 $5,000 in cash or kind for each year of the higher degree training course. On successful completion of their courses, APA(I) students are equipped to pursue research careers in industry or Universities or a

combination of both. Each year 125 new APA(I)s are given on the recommendation of the ARC. $7.3 million will be available in 1995-96 for the Scheme.

Research Infrastructure

The research infrastructure program provides the Commonwealth Government's contribution towards research infrastructure in higher education institutions. The central objective of the Program is to support high quality research by ensuring that areas of recognised research potential have access to the support necessary for their development, enhancing support for areas of research strength and remedying deficiencies in research infrastructure. The Program comprises two categories of grants:

- Research Infrastructure Blocks Grants Program
- Research Infrastructure Equipment and Facilities Program

The existing 1995-96 allocation for the Research Infrastructure Program is $58.7 million. An additional $35.6 million each year will be provided for Research Infrastructure Programs beginning in 1996. It is expected that the major part of the additional support will be allocated through the RIBG program. The enhancement will reduce deficiencies in the current level of support and allow Commonwealth competitive grant schemes to be adequately supported.

Research Infrastructure Block Grants Program
Grants under this programare allocated to members of the UNS 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). The existing 1995-96 allocation is $42.3 million.

Consistent with the 1994-96 funding report statement the former Research Infrastructure Program Mechanisms A and B have been amalgamated to form the *Research Infrastructure Block Grants Program*.

Research Infrastructure Equipment and Facilities Program
Research Infrastructure Equipment and Facilities Program Grants (formerly Research Infrastructure Co-operative Grants, Mechanism C) encourage institutions to develop co-operative arrangements among themselves, across the higher education system as a whole and with organisations outside the higher education sector. Although the Equipment and Facilities grants are intended primarily to support large scale co-operative initiatives involving two or more institutions, in 1994 the grants were opened up to applications from individual institutions for whom collaborative arrangements are impractical or inappropriate. The existing allocation for 1995-96 will be $16.4 million, inclusive of contributions to the Major National Research Facilities Program (see below).

In 1995, a total of $14.85 million will be distributed through the Equipment and Facilities Program which includes $1.2 million for projects with a national and international focus, such as the Ocean Drilling Program and international collaboration on high energy physics, and a $1.2 million for allocation to supercomputing infrastructure.

This portfolio will contribute $1.75 million in 1995 and $1.0 million in each of the years 1996 to 2002 from the Equipment and Facilities Program to the Major National Research Facilities Program. A further contribution of $0.75 million in each of the years 1996 to 2002 will be made from the National Priority (Reserve) Fund. This is a cross portfolio program administered by the Department of Industry, Science and Technology.

Overseas Postgraduate Research Scholarships

The Overseas Postgraduate Research Scholarships Scheme aims to attract top quality overseas postgraduate students to areas of research strength in higher education institutions and to support Australia's research effort. The scholarships offer students the opportunity to obtain a postgraduate qualification and to gain experience with leading Australian researchers. In 1995-96 $14.69 million will be available to the scheme. Three hundred new scholarships are provided annually.

Targeted Institutional Links Program (TIL)

The Targeted Institutional Links Program (TIL) aims to stimulate academic research cooperation between Australian universities and their counterparts in Asia. The program provides seed funding to Australian universities to support collaborative research links which foster internationally competitive research in Australia's national priority areas. Postgraduate scholarships are also awarded to scholars from Asian countries whose field of study directly complements the research links between institutions. In 1995-96, $0.76 million will be allocated under this program.

Research and Development Internships in Asia Program (RDIA)

The Research and Development Internships in Asia Program (RDIA) aims to promote Australian research and development capabilities through the development of long term collaborative links between Australian research institutions and commercial research organisations in the Asia Pacific region. It supports internships in international industrial research organisations by providing airfares, salaries and a package of allowances to

researchers from Australian institutions to undertake an industrial internship in commercial research organisations in Asia. A budget of $0.345 million is available in 1995-96.

Advanced Engineering Centres

DEET provides the Government's contribution to the operation of three Advanced Engineering Centres:

- 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.

The Advanced Engineering Centres have been operating for 2 years and will be reviewed in 1995. Each Advanced Engineering Centre received establishment funding of $1.4 million in 1992 and receives recurrent funding of $0.5 million annually. University and industry partners also contribute to operating costs.

Research activity in universities is supported by all of the above programs as well as funds from other sources including Commonwealth Government agencies, State Governments, business, private non-profit organisations and international sources. Any given group of researchers is likely to receive support from several sources, including more than one DEET/ARC program. The recent research achievements listed below have all benefited from DEET/ARC research support programs and are arranged by major field of research of the Australian Standard Research Classification. Given the increasingly multidisciplinary nature of research and technology, some activities would involve major inputs from more than one major field of research. Given that, in this instance, the researchers themselves have not had the opportunity to indicate the appropriate field of research classification, some editorial judgement has been exercised in classifying the achievements by attempting to identify the field in which the major part of the research has taken place.

Agricultural Sciences

Environmentally friendly industrial solvent
Research by chemists and biologists at Murdoch University has identified that high-cineole leaf oil from Eucalyptus oil mallees has industrial degreasing applications. A laboratory method of comparing degreasing rates of solvents has been developed. Full-scale practical trials have been carried out by Alcoa Australia Ltd. The oil is being used to replace environmentally unacceptable solvents in degreasing and other industrial applications.

Vaccine against blowfly strike in sheep
Scientists in the Centre for Animal Biotechnology at the University of Melbourne have identified and characterised antigens which can be used as vaccines to protect sheep from flystrike. Native antigens have been purified in small quantities from blowfly larvae and work is now underway to produce larger quantities using recombinant DNA technology. The project aims to assess the commercial feasibility of the vaccine by cloning recombinant DNA sequences to provide sufficient material for field trials. The vaccine has the potential to prevent three million sheep deaths a year. The project is a collaborative joint venture between the University and Cyanamid-Webster Australia Pty Ltd.

Sewage treatment by aquatic plants
Researchers at La Trobe University have discovered that a zinc-tolerant grass species, *Lemna milnor*, uses phytic acid for the deposition of insoluble zinc complexes in root tips, an important alternative to the binding of heavy metals by phytochelatins. Knowledge of the role of phytic acid with respect to toxic quantities of heavy metals in plants assisted applied research in toxic metal pollution and has led to the use of aquatic plants as a means of concentrating toxic metals from sewage wastes and industrial effluents.

Applied Sciences And Technologies

Detection of defects in glass panels
A University of Queensland research team has developed a way of detecting defects in the glass windows and balconies of high-rise buildings. The technique detects minute stones of nickel sulphide in the toughened glass panels of high-rise buildings. The stones, which range in size from 0.lmm to 0.5mm in diameter, are present in all types of window glass and may be rendered unstable by the special heat process used by the manufacturers for toughening glass. The technique for detecting the stones involves the use of a special instrument installed on a building's maintenance unit.

Space craft research
Large, highspeed wind tunnels are being designed and built in Australia to meet the demands of technology development for the next generation of launch vehicles and space planes. To retain this position of leadership, new

highspeed instrumentation for these facilities is being developed. Work by researchers at the University of Queensland has resulted in the development of systems for measuring lift, drag and pitching moment for flows which last less than one thousandth of a second at flow speeds in excess of 18,000 km/h. This technology is enabling the Australian Space Office and the University of Queensland to enter into collaboration with Japanese space agencies to Australia's scientific and economic advantage.

Refining base metals
Researchers at the Ian Wark Research Institute at the University of South Australia have developed new experimental and theoretical approaches to understanding bubble-particle interactions. The interaction of bubbles and particles is central to the process of mineral flotation, the critical concentration stage in the production of the valuable base metals, lead, zinc and copper. For the first time, atomic force microscopy has allowed the direct measurement of the fundamental forces controlling bubble-particle attachment.

Identity on the back of the hand
An interdisciplinary research group at Edith Cowan University has completed a two year research project on the use of back-of-hand vein patterns as a means of uniquely identifying individuals. A prototype biometric system has been developed. Matching involves the comparison of a given medial axis vein pattern against a library of patterns. A cross-matching experiment for a sample of 20 adults and more than 100 hand images has been undertaken including estimates of the false acceptance rate and false rejection rate. The results obtained for these and other images support the system's potential for unique verification of identity.

Environmentally friendly design
In collaboration with the Kambrook Group, Australia, the Key Centre for Design at RMIT is developing a system enabling the design of improved levels of environmental performance in small consumer products for domestic and international markets. This will lead to products and processes with reduced environmental impact. The first product was released in February 1995. The Key Centre has now extended its involvement to six other manufacturing groups under a program trade marked EcoReDesign.

Bubbles - a unique method of treating industrial waste waters and effluents
Research at University of Newcastle's Department of Chemical Engineering has demonstrated the important effect of introducing air or gas bubbles into particle separation in fluid mixtures. The research has shown that particles such as minerals cling to microbubbles and can be separated through a 'downcomer' pipe. Once released from the downcomer, the bubbles disengage and rise to the surface carrying the ore particles with them where they are separated and collected. The unwanted tailings sink to the bottom of the processing tank.

This industrial process, which is producing a competitive edge for Australian industry, has been patented as the Jameson Cell and is being introduced in the mineral processing industry.

Gas cooktops

Consumer awareness of energy consumption and concern about the production of greenhouse gases has provided incentive to gas cooktop manufacturers to search for a "cleaner" and more efficient product. In response, a University of NSW research team has taken an innovative approach to the study of domestic gas cooktop burners, with the aim of minimising undesirable combustion gases while maintaining or improving the efficiency of heat transfer to the saucepan and its contents.

A prototype burner has been produced that incorporates flame stabilisation ports into the main burner, significantly reducing nitrogen dioxide emissions. This burner design is now being optimised to further reduce nitrogen dioxide emissions, maximise heat transfer while maintaining a stable flame, and prevent production of carbon monoxide.

Sun protection and summer fabrics

Recent research has shown that summer weight textiles, particularly those made from 100% cotton and polyester/cotton, provide only relatively low protection from solar ultraviolet radiation. While unbleached cotton is more protective, Ultraviolet Protection Factors (UPF) for white 100% cotton summer garments can be as low as 5^+ or 10^+, providing less protection than a nominal Sun Protection Factor 15^+ sunscreen. However, research at the University of NSW has provided the manufacturers of summer clothing with a way of offering protection as well as style with their product. Researchers have developed and tested a range of ultraviolet absorbing compounds that covalently fix to cotton and other fibres. These compounds significantly increase the UPFs of 100% cotton fabrics and typically achieve UPFs of 50+. Fixed permanently inside the cotton fabric, they do not change its air permeability or moisture absorbing properties. Thus light weight 100% cotton garments remain cool and comfortable yet provide very high protection from solar ultraviolet rays.

The compounds and/or their application have been patented in 14 countries, and are commercially available from Sandoz Australia, under the trade names Rayosan C (cotton, viscose, wool and nylon) and Rayosan P (polyester).

Building fire research

Victoria University of Technology has achieved significant progress in research into the modelling of fire growth and spread and smoke transportation. A computational fluid dynamics (CFD) model has been developed from experiments at the Experimental Building-Fire Facility (EBFF) simulating realistic fire growth on solid polyurethane foam. This research allows the CFD model to predict mass release rate and heat release rate during building fires. The predicted results for realistic fires are in general agreement with the experimental results obtained from the EBFF.

Biological Sciences

Environmental factors affect brain development

This research from the University of New England has produced significant results showing that the development of visual neurones (nerve cells) is influenced by light stimulation. Using the developing chicken as a model, researchers demonstrated that the light-dependent development of the neurones is confined to a sensitive period and that the light stimulation establishes asymmetry in the brain. This is the first clear demonstration of environmental influences on the lateralisation of brain structure and function, previously considered to be determined by hormonal and genetic factors only. The result has enhanced understanding of the factors essential to nerve growth and repair.

Bio-diversity

Theoretical studies at the University of New England suggest that heterogeneity in the environment will help maintain genetic variation, particularly when different genotypes prefer different components of their habitat for feeding or for reproduction. Using a model system of *Drosophila* flies that breed and feed in cactus rots harbouring a variety of microorganism species, direct evidence has been obtained in laboratory experiments for genetic variation in such habitat preferences. In this case, females of different genotypes prefer different yeast species as sites on which to lay their eggs. This result has been extended in experiments done with support from the National Science Foundation under the US/Australian Science Agreement.

Short tails win the females

Sexual selection was first proposed by Charles Darwin (1874) and has ever since been a source of controversy. Researchers at James Cook University have during the past 12 months commenced a project that investigates how females select mates. The Golden-headed Cisticola, a small bird that displays unusual sexual dimorphism in the form of tail shortening during the breeding season, is the focal species of this study. The past field season has shown that females are preferentially selecting males with the shortest tails as their mates. Flight experiments in cooperation with researchers from the Institute of Zoology (London) and Cambridge University have shown that shorter tails hinder manoeuvrability during flight in a straight line but improve performance in fast tight turns. This suggests that females are selecting males on their ability to perform difficult courtship flights.

Coral genetics: theory and management

Researchers at James Cook University and the University of Wollongong have completed the first stage of a major analysis of the genetics of corals on the Great Barrier Reef. This represents the first comprehensive approach to sampling for genetic information along the main latitudinal axis of the reef. The results reveal that, for the dominant species of brooding corals, there are two major trends. Genetic variation within coral species is very high; there is as much variation over small distances (metres) as there is across large distances (hundreds of kilometres). Secondly for several coral species,

genetic variation decreases with an increase in latitude. These results provide an unusual example of a program that is significant both for theoretical biology and the management of coral reefs.

Fire management of Australian wildflowers

A joint project between Curtin University of Technology, the University of Melbourne and the Centre for Environmental Studies, Leipzig, Germany has taken the guesswork out of the appropriate fire management for conserving Western Australia's renowned wildflowers. Experimental plots set up at various times since fire in the species-rich sand-plain flora have been monitored since 1986 to build up an enormous data base. This has been fed into computer models used to predict the outcome of various fire regimes on population sizes. Results for *Banksia hookeriana*, the most popular item in Australia's burgeoning export wildflower trade, show the optimal fire interval is 16 years, considerably longer than currently practised.

New photosynthetic bacteria

Researchers from the Department of Microbiology at the University of Queensland have described a completely new species of photosynthetic bacteria from fresh water that differs from all other bacteria enough to be described as a new "genus". They have generated the 16S rRNA gene sequence from this bacterium. The discovery occurred while researchers were examining bacteria that can capture solar energy using special bacteriochlorophyll pigments. The bacteria are found in seawater and freshwater as well as in association with plants. These novel photosynthetic bacteria from Australian habitats may be used as future biotechnology resources, for example, as the basis for new types of solar energy collectors or bioelectronic devices based on photosynthetic pigments.

Detection of Legionnaires' Disease

Legionella bacteria are dangerous human pathogens causing epidemic outbreaks of the potentially fatal Legionnaires' Disease. It is important to be able to easily and rapidly detect the presence of such bacteria in the environment, especially in air and water connected with contaminated airconditioning systems, but also in such sources as potting mix soils.

Researchers from the University of Queensland's Microbiology Department have designed and developed a gene probe specific for legionella bacteria, especially for the detection of *Legionella pneumophila*, the most common cause of fatal human disease among *Legionella* species. The probe was designed to be used to stain legionella cells so that they could be directly detected using a special fluorescence microscope. The stain method produces results rapidly, making them available within hours rather than the days required for culture of the bacterium.

Water use by trees in tropical savannas

Savannas cover more than 30% of Australia, and are an important ecosystem worldwide. They are characterised by a strongly seasonal climate, and those in northern Australia are more seasonal than most. Although drought conditions develop every year during the dry season - a period of up to eight months with no rainfall - savanna trees are able to access deep ground-water

with the rates of transpiration being relatively undiminished for some species. Other savanna tree species are seasonally deciduous, and a wide range of responses by trees to seasonal drought has been observed.

Researchers at the Northern Territory University, in conjunction with CSIRO Divisions of Wildlife & Ecology and Water Resources, and the Northern Territory Power & Water Authority have been investigating water use by trees in tropical savannas with some surprising results. Initial results suggest that a very high proportion (up to 90%) of rainfall intercepted by catchments is transpired. This research has important implications for management of resources in the savannas, including water resources for domestic or agricultural use, and the impacts of tree clearing on the hydrology of savanna catchments.

Aestivation by freshwater crocodiles in the dry season

Aestivating crocodiles at their dry season refuge in northern Australia were studied over a six year period by researchers from the Northern Territory University. The crocodiles spent three or four months a year underground without access to water. The absolute size of body water pools declined proportionately with body mass and body solids, thus the crocodiles were not dehydrated even after three months without access to water. The results of this study do not indicate any specific adaptations for aestivation in this species, but given an adequate refuge, crocodiles can survive many months in aestivation.

Leaf growth promoted by carbon dioxide

The response of the world's vegetation, particularly crops, to rising atmospheric levels of CO_2 will greatly influence the quality of life next century, both in terms of climate and food supply. The potential for final yield increases of 20-40% in response to a doubling of CO_2 is established in the first few weeks after germination.

A research group at the University of Western Sydney's Hawkesbury campus has studied this response and found that production of the plant hormone ethylene, the ripening hormone, was strongly associated with CO_2 stimulated increases to leaf growth. Working with rice, they found that elevated CO_2 accelerated early leaf growth by 30%, ultimately leading to a 35% increase in rice grain production. If elevated CO_2 was applied later in the rice growth cycle, these yield increases were not recorded. An understanding of this mechanism will provide rice breeders with a blueprint for new rice plants for the next century.

Plant growth in CO_2 enriched climate

Carbon dioxide is the main nutrient used by plants to produce the primary food source for our planet. The atmospheric concentration of CO_2 is currently rising 0.5% per year due to the deforestation and burning of fossil fuels. The response of plants to these increased levels of CO_2 will largely determine the rate at which our climate will change in the future because plants alone have the capacity to ameliorate these changes in CO_2 by the "fertilisation effect".

Researchers at the University of Western Sydney, Hawkesbury campus have shown that plants will require different levels of the mineral nutrients nitrogen and phosphorus to make maximum use of increasing atmospheric levels of CO_2. Researchers have discovered that wheat and cotton plants can tolerate slightly lower levels of nitrogen in their leaves when grown at elevated CO_2 concentrations. In contrast to nitrogen, the phosphorus requirements of crop plants grown at elevated CO_2 may be slightly larger. This physiological research has provided the fundamental understanding necessary for global carbon models to estimate the magnitude of the fertilisation effect and for plant breeders to design crop plants for the 21st century.

Commercial application of gene technology

Researchers at the University of Adelaide have successfully undertaken a project aimed at developing and improving gene targeting technology. The project entailed the development of technology for the precise genetic modification of mice. It allows a previously unavailable precision to the investigation of biological problems. This work has resulted in a patent in addition to publications but the major benefit will be seen in the increase in sophistication of biological research through the widespread access to gene targeting technology. In addition, this technical and intellectual progress has enabled the establishment of significant commercial and academic collaborations with industry, such as Bresatec in South Australia, and has opened avenues for agriculturally important applications of this work.

Evolution and ecology of reptiles

Biologists generally assume that a high proportion of variation among individual animals in a population is due to genetic factors. Researchers at the University of Sydney have shown that this conclusion may sometimes be in error. By controlling incubation temperatures of lizard eggs in the laboratory, researchers have demonstrated that a very high proportion of variation in the measurable characteristics of the hatchlings, such as size, body shape, running speed, and general activity levels, are actually a result of the incubation temperatures experienced during development inside the egg. Thus, it may be possible to increase the efficiency of conservation efforts for endangered species by determining optimum incubation conditions to produce hatchlings that are most likely to be able to survive and reproduce when released into the wild.

Chemical maps of the peripheral nervous system

Nerve cells communicate with each other or with their target tissues via chemicals released from their endings. Each major functional class of nerves contains and releases characteristic combinations of chemical messengers. At Flinders University, a research team leads the world in identifying the chemical messengers used by the nerves regulating the activity of the internal organs. In the laboratory, they have employed state of the art microscopical techniques to make chemical maps of the nerves controlling the cardiovascular and respiratory systems, salivary glands, and the skin. These studies have shown for the first time how different nervous circuits are arranged to allow the specific regulation of each target tissue. By comparing the distribution of chemical messengers in the corresponding neuronal

circuits of different animals, this team has begun to see how these characteristic patterns have evolved. They have discovered several potentially important neuronal circuits that have previously been overlooked, not only in non-mammalian vertebrates, but also in common laboratory animals such as guinea-pigs. Taken together, the results of these studies have provided novel insights into the fundamental mechanisms underlying the nervous control of thermoregulation, water balance, and blood pressure.

Death of the cell
Researchers in the Department of Biochemistry at the University of Sydney have made major advances in understanding how the final stage (termination) of bacterial chromosome replication is achieved. A breakthrough occurred when the components of a replication termination system (a DNA terminator plus terminator protein) in the bacterium *Bacillus subtilis* were identified. Researchers have developed a model for how these two components interact to block movement of a replication fork at the first stage of termination. The system has now become the prototype termination system accessible to detailed chemical and biological analysis. The structure of the terminator protein discovered by this research, RTF, has recently been solved by a US group and will be of considerable value in understanding termination of chromosome replication in general.

Osteoporosis research
Research undertaken in the Department of Anatomy and Human Biology at the University of Western Australia has demonstrated new insights into bone structure and function using new linkages of a variety of computational methods. Differences in cancellous bone structure, well known in obvious osteoporosis, have been detected using these techniques in materials from many pre-menopausal asymptomatic women. The techniques have even shown absolute differences between the sexes as early as the second and third decades of life. Some of these differences (evident in individual women as young as 25 years) though anatomically more localised, mirror the widespread lesions found in older individuals especially those with osteoporosis. Such investigations are allowing development of inexpensive methods for much earlier prediction of incipient osteoporosis. Applied to these structural findings are biomechanical investigations that are indicating how normal cancellous bone bears stress and the mechanical inefficiencies of osteoporotic and pre-osteoporotic structures. Such studies are being applied to better prediction of the late fracture complications of overt osteoporosis.

Chemical Sciences

Reagents for removal of heavy metals
Researchers in the Chemistry Division at James Cook University of North Queensland have used original strategies for the design and preparation of a range of new chemical reagents that are capable of recognising and removing individual heavy metal ions from solution. The new reagents

incorporate a central cavity specially designed for taking up the metal of interest. The ability to remove selectively one metal in the presence of others is one outcome of the study which has industrial applications.

Isolation of toxins from avocado and Crofton weed

Collaborative work between researchers at the Australian National University and the National Research Centre for Environmental Toxicology has led to the identification of the chemical structures of two naturally occurring plant components which possess interesting biological activities. The first from the leaves of the avocado species *Persea americana* shows a specific necrotic effect on mammary cell tissue of lactating animals and is active against a number of tumour cell lines. A provisional patent is being taken out on the potential therapeutic use of this compound. The second compound, extracted from Crofton weed, causes specific damage to the small intra-hepatic bile ducts in mice and could be a contributor to the 'milk sickness syndrome' which was a principal cause of death in the central west of the USA during early settlement and resulted from humans drinking milk from cows that had grazed on a closely related plant.

Coral spawning

Research initiated at James Cook University and continued at Central Queensland University has focused on corals, hard and soft, which spawn on the Great Barrier Reef in late spring each year. The spawning process involves the release of eggs and sperm into the open ocean. Once released into the sea, sperm must find eggs from the same species to fertilise. They find the correct eggs from a trail of chemical attractants released into the surrounding water. These have been identified for the hard coral as *Montipora digitata* and the soft coral *Lobophytum crassum*. *Montipora digitata* uses a polyunsatutrated twelve carbon fatty alcohol as the sperm attractant, while the soft coral *Lobophytum crassum* eggs attract sperm using a diterpene alcohol, identical in structure to thunbergol, first isolated from Swedish pine trees. The identification of these compounds enables us to predict the effect of oil pollution and pesticides on the reproductive success of corals on the Great Barrier Reef.

The architecture of charged aggregates

Charged aggregates are formed when ions adhere to atomic or molecular partners. They are formed in combustion processes, in the upper and lower atmosphere, and in interstellar space. They are the central actors in electrolytic, solvation and nucleation processes in chemistry. Until now, it has been difficult to study the fundamental physical, chemical and spectroscopic properties of ions in a controlled way since they are difficult to isolate and are generally extremely reactive. A research team at the Griffith University Molecular Dynamics Laboratory has developed an apparatus that permits the first detailed experimental view of the vibrational "gymnastics" of atoms bound to large molecular ions. The Griffith team have determined the nature of the bonding and the structural properties of rare gas atoms bound to aromatic cations, in other words, the "dynamical architecture" of charged clusters that are of significance in a wide range of situations in chemistry and physics.

One of the applications of this research has been to elucidate the physical laws that determine the phenomenon of "wetting". This topic is currently receiving considerable attention in the field because of its role in a wide variety of technological applications, ranging from lubrication to the fabrication of ultra-thin coatings in microelectronics manufacture.

New automated wet chemical analyser
Researchers at La Trobe University have designed, constructed and tested new interface flow modules and detector units for an automatic chemical analyser. The project assisted in the development of a multipurpose analyser which is fast, robust and reliable and has wide analytical use in industrial, environmental and food industries. This analyser, an Australian invention by a small Australian company in Brisbane has made a significant contribution to Australian scientific instrumentation.

Earth Sciences

Investigation of past climate in the Australian region
Substantial effort has been directed this year to the development of techniques for the investigation of past climate in the Australian region using high resolution isotopic records recovered from massive corals. Work in the Environmental Geochemistry Group at the Australian National University has made use of oxygen isotope information to provide information on water temperature and on the intensity of monsoons and El Nino events. Carbon isotope records taken from the same samples indicate a significant change in the isotopic balance at the time of mass spawning on the coral reefs. Related work in the Geochronology and Isotope Geochemistry group has made use of the strontiumxalcium ratio in corals to provide a sensitive indicator of the temperature of the ocean water in which the coral has grown.

Marine quaternary record of Australian deep-sea sediments
Researchers in the Department of Geology and the Research School of Earth Sciences at the Australian National University have carried out an investigation of the marine Quaternary record of Australian deep-sea, sediments. Some 30 cores from the Australian region have now been investigated so as to determine the broad changes which occurred at sea for the last 150,000 years, a period which experienced a complete glacial to interglacial climatic cycle. Outcomes of the project include the identification of substantial changes to the warm Leeuwin Current offshore Western Australia over time; significant latitudinal shifts in the Tasman Front in the Tasman Sea through time corresponding to changes of atmospheric cells; three significant dissolution events during the last glacial/interglacial cycle resulting from a change in the pCO_2 of the eastern Indian Ocean and the Tasman Sea; and significantly higher temperature drops at the sea surface for all three oceans bordering Australia during the Last Glacial Maximum.

Past environments recorded in polar ice

Both Antarctica and Greenland are covered with three kilometres of ice which has accumulated over the past 250,000 years. Particles and gases are trapped from the atmosphere in snow which is converted to ice at depth, forming an archive of the Earth's atmosphere. A collaborative investigation of both ice caps by physicists at Curtin University of Technology and the University of Grenoble in France, has examined the quantity and source of lead isotopes in ice. The results of measurements on the upper section of the Greenland icesheet show that it is highly polluted with anthropogenic lead, principally from motor vehicle emissions in the Northern Hemisphere. The level of pollution has declined dramatically since the mid-1970s with the introduction of unleaded fuel. Measurements in Antarctica are more difficult to perform, because the lead concentrations are about one hundred times lower. However extremely sensitive methods have now been developed which confirm that recent Antarctic snow is also highly polluted with anthropogenic lead.

Atmospheric Research Facility

The Northern Territory University in collaboration with the CSIRO Division of Atmospheric Research and the Bureau of Meteorology has established an Atmospheric Research Facility on the Cox Peninsula, west of Darwin. The Facility is building a database for important atmospheric parameters in the northern Australian atmosphere to enable the definition of seasonal cycles and long term trends. The database at present includes methane, SO_2, NO_2, $(COOH)_2$ and surface ozone. Changes in these parameters can be linked to major point sources such as fires during the dry season and with the NW monsoon during the wet season which reflects the exchange of air from over the equator. An international project in collaboration with University of Sao Paulo, Brazil on the chemistry of aerosols has provided a database on total aerosol mass, soot carbon and major anions and cations.

Lithosphere mapping

The Centre for Petrology and Lithospheric Studies at Macquarie University has received ARC support to apply a new methodology known as four-dimensional lithosphere mapping to construct thermal and rock type profiles to 200km beneath the Earth's surface. Although the research is of global scale, it has immediate relevance to understanding Australia's geological structure and history. Working in collaboration with CSIRO, Centre researchers are providing a foundation for improving area selection techniques for mineral exploration resulting in funded collaborative projects and contractual research with major diamond exploration companies in Australia and internationally.

Deforestation areas experience low rainfall

A consortium of researchers from Flinders University, Murdoch University, CSIRO, the WA Department of Agriculture and the Leeuwin Centre for Space Sensing Technologies has found evidence that a 20% long term decline in winter rainfall in south-west Western Australia is linked to deforestation. The team has used a range of data to compare the regions of native vegetation with those replaced by agricultural use for winter growing species. In field observations convective cloud was routinely found forming over the areas of

native vegetation but not in the agricultural area, pointing to deforestation as a possible cause of low regional rainfall. These results will clearly have an impact on land management practices in the semi-arid zones of Australia.

Palaeomagnetism and tectonics of Australia
The Tectonics group of the University of Western Australia has redefined the Apparent Polar Wander Path for Australia and the former supercontinent, Gondwanaland, to show that Gondwanaland was derived from an older supercontinent, Rodinia, which existed from at least 1050 million years until 700 million years ago. The research shows that Gondwanaland did not form until 520 million years ago and that 320 million years ago it collided with North America and Laurussia to form Pangea - a supercontinent that contained all the major continental areas of the world. The work has strategic importance for mineral and petroleum resource exploration.

Seismic and fission track thermochronology study
The modern large-scale geologic structure of south-eastern Australia developed primarily in response to rifting, extension, separation and drifting apart of the Australian and Antarctic plates. Investigators at La Trobe University have applied state-of-the-art seismic reflection and fission track methods to chronicle the uplift, erosion, sedimentation, and faulting, that has occurred during and after the separation. Data have been used to develop a detailed history of the area, improving models of the mechanics of continental separation and assisting in the exploration for hydrocarbons.

Engineering

Weight-reductions in plastic fuel tanks
Researchers at the Australian National University, in collaboration with Ford, have undertaken a detailed study of the blow-moulding of Falcon fuel tanks in the Ford Plastics Plant aimed at reducing the cost and weight of the tanks. A pneumatically-driven parison- marking device has been constructed at the University and installed on the Ford B2 blow moulder. This electronically driven device allows parison control-points to be mapped directly onto the finished tanks and thus aids in the production of tanks with a more uniform distribution of wall-thickness. The overall wall-thickness of such tanks can be reduced, thus saving weight and reducing the cost of production.

West Gate bridge
Researchers from the Monash University Department of Civil Engineering have been investigating the nature and cause of fatigue cracks which appeared two years ago in the support steel framework of the West Gate Bridge over Melbourne's Yarra River. Their research into the capacity of innovative tubular steel framed structures under variable repeated load enabled the team to establish that the cracks were of no immediate concern. The scattering of cracks around the structure, which had appeared at around 11 years, was found to be in line with design-life predictions. Theory and test were in agreement, therefore no further investigation was required. As a

result, Vic Roads decided to modify all cantilevers by removing material that was making the deck too stiff. This process will cost relatively little and will eliminate future maintenance costs.

Fluid dynamics, drag and fuel bills

Numerical simulations of turbulence have shown the potential benefits of being able to control or manipulate turbulence in fluid flows, for example, over ship hulls or aircraft surfaces. Experimental studies at the University of Newcastle's Department of Mechanical Engineering have shown that riblets on hull surfaces can produce streamwise turbulent vortices which decrease the total drag despite an increase in the wetted surface area. Other studies have examined the effect of intense surface suction in reducing drag. This research used sophisticated laser Doppler systems to achieve small spatial resolution and accurate measurement very close to the surfaces being assessed. It has already produced a more reliable knowledge of the structure of turbulence, identified significant draft reduction and fuel savings for aircraft and ships and is likely to lead to further benefits in noise reduction and pollution dispersion.

Photovoltaic device research

Photovoltaic devices turn sunlight into electricity via solar cells. Research at the University of New South Wales has produced the world's most efficient silicon solar cells. UNSW has led the world in this area for more than a decade with the world record efficiency of 24%. This technology has been extended to suit large scale commercial production with high throughput, high yields, and low cost. The resulting "Buried Contact Solar Cell" technology has been licensed to most of the world's largest manufacturers.

Continuing work on the photovoltaic roof tile is also commercially significant. The innovative static concentrators enable virtually all light falling on the roof tile to be redirected laterally to adjacent solar cells. These concentrators have the potential to more than halve the costs of electricity generated by normal photovoltaic modules.

The research team that led the development of thin film crystalline silicon solar cells announced, in 1994, a break-through with the "multi-layer solar cell". This new design has the potential to produce solar cells that can compete directly with conventional energy sources for electricity generation. Essentially, the new solar cell can achieve similar efficiencies to the other cell designs, but with materials that are twenty times cheaper than those used in present commercial devices.

Surveying robots

Surveying robots are increasingly being used for the monitoring of the movements of unstable terrain and potentially dangerous structures. The remote-controlled robots are specially-equipped motorised electronic theodolites which can measure and survey autonomously by scanning reflective targets with the beam of the on-board distance meter.

Researchers at the University of NSW have developed systems which enable the robots to use cheap plastic reflectors rather than the expensive high quality glass prisms previously required. In particular, the research has concentrated on modelling and correcting errors associated with the use of the cheaper reflectors. In tests on the rockfill Mangrove Creek water storage dam, plastic reflectors were successfully used at distances of 500 metres. Tests over 100 metres with even cheaper tape reflectors established precisions of a few millimetres.

Information, Computer And Communication Technology

Machine knowledge

Expert systems are computerbased systems that capture and manipulate expertise. These systems have demonstrated significant commercial benefit in numerous applications. One of the main obstacles to the development of expert systems is the acquisition of the knowledge on which they are based. Two main approaches have been developed. Knowledge elicitation gains the knowledge from human experts. Machine learning gains the knowledge by computational analysis of examples. Both approaches have major strengths and weaknesses. Research at Deakin University has developed methods for the integration of the two approaches, enabling a human expert to collaborate with a machine learning system to develop a knowledge base. This is able to overcome many of the individual deficiencies of the two approaches employed in isolation. The new approach has been commercialised and the resulting computerbased systems are being marketed.

Lawn-mowing robot

A radio-controlled lawn mower has been developed by the Centre for Intelligent Robotics Research at Monash University. The lawn mower's speed and steering are operated by a joystick control panel and the unit uses a petrol engine mounted on a three-wheeled chassis with weak springs so that each time it runs over an uneven section of lawn, it immediately lifts or drops, maintaining a uniform cutting height. Autonomous robot navigation has potential application to road traffic fleet control, fire fighting, agriculture, mining, civil construction and forestry.

Extending the range for mobile communications

An Australian Postgraduate Award (Industry) scholar has been a member of a team in the University of Queensland's Department of Computer and Electrical Engineering which has designed and proven a high performance prototype antenna system for land vehicle satellite communications. The system is expected to provide communications for vehicles travelling in some of Australia's remotest areas. It also has potential for maritime and aircraft use.

Cutting the cost of reliable software
The cost associated with the development of highly reliable software is prohibitive. The Software Quality Institute at Griffith University has implemented a theoretical computational model, which has the potential to make a significant contribution to reducing the costs of producing reliable software. The system breaks new ground in that it is based on a formal computational model rather than a large number of rules and heuristics. This increases the generality of the system. The system has the capability to derive from rigorous mathematical specifications small program components.

Bionic vision
Imaging technology, including artificial vision is one of the hottest areas of research. Researchers at Edith Cowan University working with the Centre for Gallium Arsenide VLSI Technology at The University of Adelaide have fabricated a microchip based on insect vision. The microchip contains a single row of 60 photodetectors, 60 parallel processing elements, and a digital processor in order to detect the presence of objects and their motion including range and speed.

Making biscuits taste better
Making sure your favourite biscuits taste the way you like them is the result of a joint project between Macquarie University and Arnott's. Sophisticated computer technology takes the guesswork out of quality control by replacing fallible human judgment with more precise methods. An Australian Postgraduate Award supported PhD student is working on computer identification of the baking curve for different biscuit products. The researchers use neural networks to scan a range of biscuit samples and they can modify the production process to maintain quality. Digital images taken of the biscuits following the baking process give repeatable and durable standards against which the quality of the biscuits is judged.

Automated receptionist
Speech recognition technology developed by Macquarie University and an industrial partner, Syrinx Speech Systems, is helping service companies to respond around the clock to customer's needs. The project allows vocabularies to be created from a database of speech samples collected from a number of users and covering a range of accents and speaking styles. Speaker-independent recognition works by extracting the common features from the speech database and creating a statistical model for each vocabulary word. This software is being used in Syrinx's speech attendant systems which recognise the name of a person asked for when they telephone an organisation. The caller is then connected through to the correct telephone extension, all without human intervention.

Parallel computing
The Software Engineering Environments research group in the Department of Computer Science at Flinders University has completed work on a prototype software development environment which allows software developers to view and modify programs using a variety of views. This project, which has taken ten years to reach the point of constructing a

complete prototype, has investigated how these different kinds of views can be maintained concurrently, exploiting parallelism in modern computer workstations to improve responsiveness of the system.

Brain waves

Research undertaken at Flinders University has created improved methods for identifying and interpreting the patterns of electrical field activity that are conducted from brain to scalp during human mental activity. Electrical field activity was measured from scalp electrodes whilst subjects performed prescribed cognitive tasks. Artificial neural networks (ANNs) were simulated within computer programs to identify the relevant aspects of the spatiotemporal patterns of electrical field activity obtained during task performance. The study demonstrated the ability of ANNs to identify brain activity associated with private mental processes. This was demonstrated practically in a real time, human computer communication experiment in which scalp electrical field activity was obtained whilst a subject responded mentally and without overt behaviour to questions requiring a Yes/No answer. The ANN was able to identify the mental responses of the subject from the associated scalp electrical field activity with a better than 90% accuracy.

Advances in modem technology

The Institute of Telecommunications Research at the University of South Australia, in collaboration with JNS Electronics, has developed the DRFL 700 Modem which went on the market in March 1995. The new design enables the modem to transmit 2 Mbit/s of data in a 2 MHz bandwidth. This more than halves the bandwidth requirements for comparative modems currently available on the market. The bandwidth reduction has been achieved through the use of Advanced IQ Digital Modulation Techniques in conjunction with ultra linear RF circuits. The Digital Modulation design feature also enables the modems to be controlled and monitored from a central location, allowing better and more efficient management of equipment in remote regions.

Industrial applications of artificial neural networks

Artificial Neural Networks are computing devices modelled on the brain. They do not have to be programmed, but instead are "trained" to exhibit some desired behaviour. This means that they can be used to solve problems that cannot be solved analytically or algorithmically. Researchers at the Centre for Intelligent Information Processing Systems at the University of Western Australia have just completed a three year project that has developed solutions to a number of industrial problems using Artificial Neural Networks. The project involved two industrial partners, Alcoa and Gemco. For Alcoa, the researchers developed two image processing systems that will be used to monitor the Bayer process for the refinement of alumina. The work carried out for Gemco culminated in the development of a system for classifying flaws in railway tracks.

Managing the urban transport system
This project at the University of Sydney has developed a fully integrated travel, location and vehicle choice simulator for urban passenger transport. It is designed to evaluate the benefits and costs to the community of infrastructure and pricing policies for light rail, toll roads, congestion pricing, improvements to public transport services, carbon taxes and improvements in automobile technology. The software is now operating to identify the changes in vehicle use, government revenue, consumer surplus, emissions and energy for Sydney.

Mathematical Sciences

Optimising bus and rail schedules
University of Queensland researchers have developed new and improved algorithms for a range of practical problems in the scheduling of vehicles and crews for bus and rail transport. The researchers have successfully applied techniques such as linear programming, branch and bound, repeated matching and constructive and insertion heuristics to solve problems on a larger sealer than had previously been possible.

Mathematical breakthrough
An Australian Postgraduate Award holder at the University of Queensland has solved a mathematical problem which has eluded the experts for 40 years. The research student's PhD thesis on the mathematics of strategy, or "Games Theory", has resulted in a 12-dimensional mathematical model suitable for use in a flight computer and which has potential applications in air traffic control and jet combat aircraft.

Modelling and design of complex systems
Queuing networks and stochastic Petri nets are tools which are used to analyse complex systems subject to uncertain demand. Such systems occur widely in the modelling of telecommunications, computer hardware and software and industrial processing. A group of researchers in the Applied Mathematics Department of the University of Adelaide have been using recently discovered theoretical results in this area to provide algorithms which are very efficient and can be used to analyse larger systems than was hitherto possible. In conjunction with the Teletraffic Research Centre at the University of Adelaide, the algorithms have been implemented in software suitable for use by practitioners and applied to design of large telecommunication systems.

Railway scheduling and other problems
At the University of Western Australia new tools have been developed for problems involving network optimisation, such as railway scheduling, metropolitan water transport, pumping of fluids in refineries and foreign exchange transactions. The Mathematics Department has made one theoretical discovery of long-term importance called "Active Set Method". An immediately practical application of the group's work is to a new method

of railway scheduling, which has resulted in improved efficiency in a large Australian company and is currently being exported for installation in a major Asian railway.

Synergism
There is a large epidemiological literature on the problem of how to measure the joint and separate actions of two exposure factors in causing a disease, for example, smoking and exposure to radiation in causing lung cancer. Particular attention was given to the question of how to define the synergistic action of two causal factors. In the 1970s and 1980s many papers debated the question of whether synergism should be measured by multiplicative interaction or by additive interaction.

Research at the Flinders University of South Australia has shown how to define synergistic action in a statistical sense, and as far as it is possible to measure it. The researchers have shown that neither multiplicative nor additive interaction measure synergistic action. They have also shown that the opposite of synergistic action is not so much "antagonistic action", as has been assumed in the literature, rather "parallel action".

Medical And Health Sciences

The physiological significance of resistant starch
Research at Deakin University has revealed that undigested starch (ie resistant starch (RS)) acts in a similar way to dietary fibre in the gastrointestinal tract. The researchers developed an in vitro assay which measures RS in food. Short-term studies conducted in ileostomates (individuals who have had their bowel removed) confirmed that a high resistant starch breakfast meal results in large amounts of starch escaping digestion in the small intestine. A separate study found that individuals with an intact bowel produced significant increases in both breath hydrogen and serum acetate (both are commonly used as markers of colonic fermentation) following a high resistant starch diet. These results strongly suggest that resistant starch was both reaching the human colon and being fermented by colonic microflora.

Diabetes research
A model has been developed which allows a physician to estimate the actual secretion rate of insulin from the pancreas prior to its passing through the liver. This is the work of a group of researchers from the School of Mathematical Sciences and the School of Electrical Engineering at the University of Technology, Sydney, in cooperation with the Diabetes Research Unit of the University of Wales College of Medicine in Cardiff and the Diabetes Education Unit of the Prince of Wales Hospital at Randwick. The study involved more than 300 subjects who were studied during various glucose tolerance tests which are used in the definitive diagnosis of diabetes mellitus. The model is useful in determining the therapeutic regimen for a patient. It can be used on a computer, or with nomograms for those without ready access to a computer.

Implanting electrodes
Researchers at the University of Technology, Sydney have developed a model to optimise the path of an electric shock, delivered by an implanted defibrillator, through the heart. They have used finite element modelling techniques to produce a very fast simulation and optimisation computer mode. This model is portable to any 486 personal computer and maybe used by clinicians to assist in optimising the position and selection of implantable defibrillator electrodes in order to minimise energy required for defibrillation and minimise damage to the heart.

Burnout of young fast bowlers
Research in the Department of Human Movement at the University of Western Australia into the causes of the high incidence of abnormal radiological features in the lumbar spine of fast bowlers has clearly shown that the problem is predominantly a mechanical one. It was found that a group of young bowlers who counter-rotated their shoulders during the delivery stride, a characteristic of the mixed bowling technique, were more likely to show a progression of thoraco-lumbar disc degeneration (21% to 58% over 2.5 years) when compared to those who bowled with other techniques. This increase in the incidence of disc degeneration, a significant problem in itself, may also lead to more serious abnormal lumbar pathologies.

Research in hearing and deafness
Research in The Auditory Laboratory of the University of Western Australia has contributed to a new understanding of the way in which the inner ear of mammals (including humans), achieves the task of converting sound into meaningful patterns of nerve signals that can be interpreted by the brain. The research has employed a wide range of physical measurement techniques to show how one group of specialised cells within the inner ear acts in a manner analogous to the power assistance in a car's steering mechanism. These cells respond to the tiny vibrations set up by sound by making tiny, active, mechanical movements of their own to enhance the overall vibration of the inner ear structures and stimulate the nerve fibres connected to the brain. The research has revealed that in common forms of deafness caused by loud noise, various drugs and old age, the loss of this "power assistance" function is often responsible. A detailed understanding of the cellular power assistance mechanism could lead to new designs for hearing aids and new diagnostic methods for testing hearing.

Hypertension and diabetes
Research at the University of Tasmania shows a relationship between non-insulin dependent diabetes mellitus and high blood pressure. It was found that injection agents which cause constriction of the blood vessels in muscle will induce an acute state of diabetes in association with hypertension. Researchers had for a long time thought that hypertension was probably one of the consequences of diabetes, not a cause.

The basis of this discovery is that the blood-flow into muscles involves two separate vascular trees, one nutritive and the other non-nutritive. Hypertension makes the nutritive vessels constrict, causing blood to be

pushed through the non-nutritive ones instead. So the muscle or other organ is, in effect, starved of its necessary nutrition, with neither insulin nor glucose reaching all the muscle tissue. The results provide the basis for new therapies for combining treatment of diabetes, hypertension and possibly obesity and muscle cramps.

Physical Sciences

Measuring superlaminar flow
Significant advances have been made at the University of Wollongong into the experimental study of superlaminar flow in bearings. For the first time, a miniature Laser Doppler Anemometer, using a solid state laser, has been successfully tested at a flow of 175 microns. This miniature LDA probe is being used to test actual turbulent and transition flow in bearings. These measurements in thin film flow have enabled the team to develop a new theory that can be used accurately for transition flows.

Coastal ocean surface radar (COSRAD)
The development of ocean backscatter radar technology at James Cook University reached a mature stage in 1994 with a deployment in the Great Sands Region of Port Phillip Bay. Radar maps of surface currents were produced every hour over a two week period. The results show that tidal mixing and flushing of Port Phillip Bay is strongly inhibited by the matrix of sand bars and channels, and that flushing is affected by events which last longer than one day. A modification of the basic HF COSRAD system has also been developed to provide maps of current and wave parameters on a grid scale of 100 metres. Test deployments in the Geraldton Port have resulted in fine scale maps in and around Moore Reefs and the Port development area.

Inexpensive ultraviolet laser
A team of researchers from Monash University has produced a new laser tube which has low power needs, costs less and has a long life. The laser produces a highly focusable beam in the 200- to 300-nanometre ultraviolet range, just beyond visible light, and is suitable for a wide range of uses in biological science and technology including inscribing ultra-fine circuits on computer chips and very small scale surgery on individual cells or sections of DNA.

Observing the motion of electrons in materials
The structure of matter is determined by the motion of clouds of negatively-charged electrons that hold the positively-charged nuclei in position. Not only do the details of electronic motion and the details of nuclear positions determine each other, but the electronic motion gives matter properties that may form the basis of much of modern technology.

The electron motion has been directly and accurately observed for the first time in solid materials at the Electronic Structure of Materials Centre at Flinders University. Specifically, the numbers of electrons with specified values of energy and momentum are measured. Crystalline and amorphous

materials, mainly metals and semiconductors, have been studied and significant differences have been observed in electron motion for materials with quite subtle differences.

Developing a theory for electron-atom collisions
Physicists in the Laser Atomic Physics Laboratory at Griffith University have been investigating the interaction of atoms with both laser light and electrons. The team has developed a full quantum mechanical description of the behaviour of atoms in the presence of laser light which has been confirmed by a number of experiments. This theoretical model is now accepted as an accurate predictor of atomic response to laser radiation. The group has developed several techniques for studying collisions between atoms and electrons employing high resolution laser radiation. The data from these experiments are being used as stringent tests of current theoretical models.

The ultimate goal is to achieve a theory that can confidently predict processes involving electron-atom collisions such as those found in stars, lightning, gas lasers and light tubes.

Perfectly formed micro-holes
Using high power ultra-violet copper lasers, researchers at the Centre for Lasers and Applications at Macquarie University have refined a technique to "drill" perfectly formed holes less than the diameter of a human hair into materials as diverse as polymers, glass, ceramics and titanium. The process is being developed for an Australian medical company to use in extremely precise intravenous fluid delivery systems. Micro-orifices in plastic film ensure greater accuracy than is possible with existing intravenous drip kits controlled by a roller mechanism. This technology is superior to that previously available and at a lower cost.

Astronomy of small objects
A small astronomical object of great interest is the pulsar, which is formed when a star collapses on itself at the end of its life. A pulsar is a ball of solid neutrons only 20km across with the mass of the Sun and a strong magnetic field, which is spinning several times a second. The 14m radio telescope at the Mount Pleasant Radioastronomy Observatory of the University of Tasmania has been watching one pulsar, the Vela pulsar, for 18 hours every day for several years. It has been known for some time that this object speeds up its rate of rotation every few years. Data from the Hobart telescope, which caught it in the act twice in 1994, show that this speeding up takes place in a fraction of a second - remarkable behaviour for an object with the mass of the Sun. Studying the behaviour of this extraordinary object is revealing a great deal about the nature of matter at densities far beyond those achievable in a laboratory on Earth.

Gaseous electronics
Research into the theoretical modelling of electrical discharges and low temperature plasmas at James Cook University has a wide range of applications, from basic research in atomic/molecular physics to applied electrical engineering. Software developed at JCU is currently being used at

Heidelberg in the determination of electron molecule scattering cross sections. At Keio University in Japan research is more industrially orientated and software developed at JCU finds application in the modelling of plasma processing devices for the microelectronics industry. It also has application in the design and interpretation of data from wirechamber detectors used in highenergy physics. CERN which uses such detectors has also requested software developed by the project. There has been a significant series of exchange visits between JCU staff and students and workers from these overseas laboratories, with sponsorship coming mainly from overseas sources.

Superconducting materials
Researchers of the superconductivity team at the University of Wollongong have developed special thermomechanical techniques including sandwich rolling and atmosphere controlling for fabrication of long length superconducting wires. These techniques enable them to eliminate the formation of "bubbles" and undesirable "sausaging" in the wires and ensure the uniformity and high critical current density over long lengths of superconductors. This team, in collaboration with a research team at the Ohio State University, has demonstrated that a continuous tube forming process is advantageous over the conventional powder-in-tube process and more suitable for industrial development.

Social Sciences And Humanities

Sociological impediments to the application of agricultural biotechnologies in Australia
Research undertaken at the Central Queensland University has helped to identify the emerging issues, types of research being undertaken, and the changing nature of science (including the perceived effects of collaboration with private industry).

The vast majority of scientists believed the new biotechnologies in agriculture would: increase agricultural productivity; improve the quality of the environment; increase the sustainability of agriculture and assist farmers to remain in agriculture. Farmers agreed in the majority with only the first assertion, being very uncertain about the new technologies and their likely effects upon farming systems.

In an era where 'technology transfer' between science and farming is viewed as a key to Australia's agricultural future, farmers remain wary of biotechnologies, and scientists do not appear to have the time to devote to explaining the new technologies and products. Agrobiotechnologies may never realise their potential in circumstances where farmers - as the main 'user' group - remain unconvinced that major benefits will result from the work being undertaken by scientists.

Measuring conservation values
Members of Charles Sturt University's Johnstone Centre of Parks, Recreation and Heritage, together with colleagues in the USA, have examined the validity of contingent valuation methodology in measuring nonmarket economic values of national estate forests in east Gippsland. The study found that Victorian households had a median willingness to pay $52 for reserving the forest, contributing to a net present value of $543 million. The data suggest that use of the east Gippsland unreserved national estate forests for timber production does not constitute a socially optimal or economically efficient allocation of resources. The study also indicated the existence of nonmarket values related to the productive activity of logging; however it was small and people considered their budget when answering questions about *willingness to pay* to preserve national estate forests.

Development of intelligence
Educational psychologists at Murdoch University have established quantitative evidence of intellectual growth spurts in early adolescence. Quantitative evidence has been difficult to obtain because test results do not generally provide the same unit of measurement across a wide range of ability. The researchers used computer technology and modern test theory to overcome the problem with a non-verbal test of intelligence.

Every six months they tested a group of 200 students ranging in age from eight years to fourteen years in a part longitudinal and part cross-sectional study lasting five years. The timing of the spurt coincides with transition from primary to secondary school and with the shift to abstract reasoning beginning to be required in secondary school. The significance of the result is that the onset of the spurt can range anywhere from age ten to fourteen, and therefore in assigning students to programs of study, schools need to be aware that a child may or may not have yet entered his or her intellectual growth spurt. No gender differences were found in the timing of this growth spurt, although it was more obvious for boys than for girls.

Sense of smell
The Centre for Advanced Food Research of the University of Western Sydney, Hawkesbury has achieved major insights into the perception of complex odour mixtures by humans. Odours encountered in the home, workplace or outdoors, are usually complex mixtures of dozens of chemicals, yet humans can rarely identify more than three or four of the constituents. This project is investigating two mechanisms derived from recent biochemical and physiological findings that may explain the reasons for this limited capacity.

The project has demonstrated that one of the fundamental mechanisms by which humans perceive and identify odours in mixtures is by a process of temporal coding. In addition, the project has demonstrated a second fundamental mechanism. This mechanism shows that odorants that stimulate odour cells in the nose by different biochemical processes tend to be easily differentiated in mixtures, but not in cases where the nose is stimulated by similar biochemical processes. These two major findings provide fundamental information about the human sense of smell and

provide a basis for determining how and which odorants in mixtures influence our liking for the aromas of foods and dislike of odorous air pollutants.

Development of the sense of taste

The primary aim of a project undertaken at the Centre for Advanced Food Research at the University of Western Sydney, Hawkesbury was to establish the age at which the sense of taste attains full adult function in humans. Specifically it aimed to map the responses of areas of the tongue of eight year old children and adults to the commonly encountered sour tasting substance citric acid to determine the areas where function differed for the two groups. The researchers demonstrated that sensitivity to sour taste on some of the regions of the tongue of eight year old children is greater than that found with adults. Some of these regions in children contained greater numbers of taste papillae. However, their sense of taste was unable to integrate this increased information about sourness at different regions as efficiently as that of adults, suggesting that full functional maturity had not been achieved. The study also demonstrated for the first time that eight year old children have both the cognitive and sensory ability to analyse taste mixtures into their components, opening the way for studies of children's perception of individual components in foods that cause children to like/dislike foods and affect their diet and nutrition.

Urban and regional studies inner city gentrification project

The effect of inner city gentrification on resident Aboriginal populations has been studied by researchers at the University of Technology, Sydney's Jumbunna Centre for Australian Indigenous Studies, Education and Research funded through DEET. The research produced important results which will benefit Australian society and assist the formation of government policy directed at helping the Aboriginal community. The research results have shown that the Aboriginal people are dramatically underemployed in the Redfern area; consequently they are extremely marginalised by the progress of gentrification in the area. The Redfern Aboriginal community itself is the largest employer of Aboriginal people in the area, mainly funded by government, though many of the positions are short term. The research leads to the conclusion that it is incumbent upon businesses in the area to capitalise on the goodwill that exists in the Aboriginal community if social relations are to be improved.

Memory performance in ageing adults

Researchers at Flinders University have made important discoveries about memory performance and beliefs about memory in ageing adults. Although there were instances of age related memory decrements, the researchers have shown conditions under which the performance of ageing adults was on par with that of much younger adults. This is important in debunking the view that ageing is exclusively a time of loss and decline. Furthermore, by examining peoples' beliefs about their memory abilities, the researchers showed not only that beliefs could be changed, but that memory performance can affect beliefs in positive ways. In the course of doing a series of memory tasks, older and younger adults improved their perceptions of their memory abilities and the amount they remembered. At a societal level,

these findings indicate that engaging older, and younger, adults in activities that require them to use their memory will be beneficial. Improving actual memory performance and beliefs about memory ability might also improve overall quality of life.

Development and differentiation of cognitive abilities
Researchers at La Trobe University have conducted research into the structural modelling of the genetics of child and adult cognition in providing new insights into the development and differentiation between abilities. Anderson's model of cognitive architecture was assessed using longitudinal data from the La Trobe Twin Study and extended to Fragile X syndrome to identify which components of the model were effected in this common disorder. Outcomes of this research have been fundamental to the application of cognitive science to children and adults, especially in predicting the outcomes of intervention programs. A particularly important outcome has been that for the first time an indication of the degree of genetic abnormality and intellectual deficit can be made. This can be used in the assessment of pre-natal diagnosis.

Improving teaching skills
A study at the Queensland University of Technology School of Mathematics has developed a computer simulation system which facilitates the development of high-level diagnosis and remediation skills in novice teachers. It provides teacher educators with an effective new tool to overcome one of education's main problems; most teachers do not seem to be able to diagnose and plan effective remediation programs for children manifesting error patterns in mathematics. The simulation system further provides an educational context where novice teachers are required to link theory to practice.

Reference source for music of the fourteenth century
A project at La Trobe University has produced an integrated reference for the music of the fourteenth century by bringing together the research products of two previous projects, Decoration, Text and Music in Medieval Choirbooks (Manlon and Stinson 1984-86) and The Fourteenth Century Music Recording Project (Griffiths, Stinson, Carsaniga et al). The first project produced a computer program SCRIBE, used to encode the annual cycle of Dominican chants from an early fourteenth century source. The second project compiled the first comprehensive inventory of polyphonic music of the fourteenth century by revising and translating the texts of all secular music, and rescored some 150 works which are being released on compact disc. The integration of the two previous projects has documented for the first time all European music, ie written music extant or known to have existed in the fourteenth century, which provides .a comprehensive reference book to all known musical works.

Antiquity of the colonisation of Australia
Using luminescence dating techniques on a number of Australian sites, members of the Department of Prehistory at the Australian National University have obtained results to indicate an unexpected antiquity for the colonisation of Australia - 50 000 to 60 000 years in several cases. Similarly

exciting advances were made in the extraction of organic residues from archaeological and other fossil sources. The first haemoglobin and DNA have been isolated from remains of extinct Australian marsupials opening the way to identification and dating of the residues.

The Anglo-Australian Telescope Board

Role *Operating under an agreement between the Governments of the United Kingdom and Australia, the Anglo-Australian Telescope Board maintains facilities which enable British and Australian Astronomers to undertake research for the advancement of scientific knowledge.*

These facilities include the Anglo-Australian Telescope (AAT) and the UK Scmidt Telescope (UKST) at Siding Spring Observatory outside Coonabarabran, NSW, and a laboratory in the Sydney suburb of Epping.

Recent Achievements

Death of a Comet

In July 1994, amid extraordinary public and media interest, the fragments of periodic Comet Shoemaker-Levy 9 impacted with Jupiter, the largest planet in the Solar System. A network of ground and space-based telescopes was trained on this collision, including the Anglo-Australian Telescope (AAT). Using the acclaimed infrared instrument IRIOS on the AAT, astronomers were successful in obtaining excellent data including many images of the fragment impacts.

AAT observations of the comet fragments on their approach to Jupiter had been made in February and May 1994. At that stage the comet had broken into more than 20 fragments, the result of an earlier encounter with Jupiter. The comet fragments ranged in size from perhaps as large as 1 to 2 Km in diameter down to particles the size of dust grains. These AAT observations helped to refine the fragment orbits and improve estimates of the collision times.

The impacts in July proved to be visually spectacular, and scientifically intriguing, especially as scientists had never had the opportunity to study such a collision. Early data reduction has revealed a great deal about the chemical composition of Jupiter's atmosphere. One compound that was conspicuously absent was water. Several explanations have been put forward to account for this but, on investigation, it appears that Jupiter's atmosphere must be much drier than most models had predicted. This also indicates that the lower cloud layer on Jupiter is not composed of water ice. Analysis of the data will continue for some time.

ENVIRONMENT, SPORT AND TERRITORIES

Science and Technology in the Portfolio Budget

The Australian Antarctic Division has a total budget allocation of $61.7 million in 1995-96 ($62.7 million in 1994-95). The Division both undertakes and supports scientific research in the Australian Antarctic Territory, the Southern Ocean and subantarctic islands, with priority on the study of global climate change and protection and monitoring of the Antarctic ecosystems.

The Division's 1995-96 funding will support two major marine science voyages during the year. The RSV *Aurora Australis* will undertake coordinated studies of oceanography, sea ice and marine biology studies during the Antarctic winter. The second voyage will examine the oceanographic conditions and biology of the waters off the Australian Antarctic Territory during summer. One aim of this study is to determine krill abundance and distribution so that the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) can set a precautionary limit on the krill fishery in this area.

The Commonwealth Bureau of Meteorology has been given a total budget allocation of $129 million in 1995-96 ($117 million in 1994-95). The Bureau's research priorities for 1995-96 include climate research embracing greenhouse studies, numerical weather prediction modeling, tropical meteorology, background air pollution monitoring, remote sensing and marine meteorology. The Department coordinates research into the greenhouse effect. The Government has allocated $17.1 million to this activity over the 1993-94 to 1995-96 triennium. The priorities for the greenhouse research program are developing the capacity for regional prediction of climate change, climate modelling, and monitoring of sea level rise and assessment of potential regional impacts.

The Department (Environmental Strategies Directorate and Environment Protection Agency), and the Land and Water Resources Research and Development Corporation (LWRRDC) are developing the National River Health Program (NRHP) over a 5 year period. The Program incorporates the $10m Monitoring River Health Initiative (MRHI) which was announced in the December 1992 Prime Minister's Environment Statement, and LWRRDC is contributing over $2 million.

The NRHP includes nationally coordinated biomonitoring by the states and territories ($3.5m) which is designed to lead to predictive models for river health. Supporting this biomonitoring are research and development projects ($3.5m) of which 18 have so far commenced. The NRHP also covers research into environmental flow requirements of rivers ($2.6m) and

10 projects have commenced so far. Other expenditure includes remote monitoring systems, information delivery and communication, several reviews on Specific issues and administration and program support.

The National Strategy for Rangeland Management and Action Plan (NSRM) is being developed by a joint Working Group established by the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). Funding of $1 million over 1993-94 and 1994-95 has been allocated under the Rangelands Rescue Program to prepare the Strategy. It is planned to release the draft Strategy for public comment in late 1995 and it is expected that the final document will be ready for consideration by the Council of Australian governments in the first half of 1996. It is anticipated that the NSRM will provide the framework for a national approach to the ecologically sustainable management of Australia's rangelands, an area approximately three quarters of the continent.

To implement the Commonwealth Coastal Policy, the Department has been allocated funds for development of a coastal monitoring program to support coastal managers and contribute to the Global Ocean Observing System; establishment of an electronic Coastal Atlas to make available to coastal planners and managers the coastal data holdings of Commonwealth agencies; and funds for a coastal scholarship scheme for post-graduate research targeted at coastal management issues.

The Environmental Resources Information Network (ERIN) is establishing a network of environmental information systems for environmental planning, decision making and education. During 1994-95 major achievements included:

- *the development of systems to provide environmental information through the international electronic network (the Internet);*
- *development of information system education and training materials;*
- *conclusion of phase 1 of the Cape York Peninsula Land Use Strategy.*

Work will continue on the implementation of Australia's obligations under the draft National Strategy for the Conservation of Australia's Biological Diversity as well as under the Convention on Biological Diversity. For example, work to initiate long term monitoring of Australia's biological diversity, support the development and implementation of innovative techniques and technologies to improve the management of Australia's biological diversity, development of collaborative projects with relevant interests, and consideration of establishment of a biodiversity information clearing house.

The Forests Branch provided funding for a number of major research projects including old growth surveys and disturbance mapping of other forest areas in Queensland, a major component of the Queensland Comprehensive Regional Assessment (CRA) program.

Under an initiative of the National Forest Policy Statement (NFPS) the Branch provided an amount of $50,000 for the production of a State of the Forests Report. The Report is a requirement of the Ecologically Sustainable Development Strategy and will inform the public on the current state of Australian forests. Also under the NFPS an amount of $44,290 was provided to continue funding a project on the long-term monitoring of the effects of management-imposed fire regimes on old growth vegetation in Kakadu National Park. Knowledge gained from this project will be Useful for fire management programs within Australia and will provide results on the effect of differing fire regimes on old growth forests.

The Australian Heritage Commission has been given a total budget allocation of $14 million in 1995-96 ($12 million in 1994-95), including the state and territory components of the National Estate Grants Program (NEGP), for ongoing identification of Australia's natural and cultural heritage and associated activities related to its conservation and presentation.

MAJOR RESEARCH ACTIVITIES

Australian Antarctic Division

Role *To contribute to knowledge of the global environment through research in the Antarctic region, provide scientific knowledge for the effective management of the Antarctic environment, and increase Australia's influence in Antarctic matters by participating in international scientific programs and by contributing to international scientific forums.*

Recent Achievements

Light Detection and Ranging

An atmospheric LIDAR (Light Detection and Ranging) developed by the University of Adelaide is currently being upgraded, tested and prepared for Antarctic operation. By early 1997 this sophisticated instrument will routinely monitor the structure and dynamics of the stratosphere and mesosphere above Davis. Importantly, this instrument will provide new data in a sparsely sampled region that is significant in the context of understanding global atmospheric dynamics. This facility will complement recent optical and radar instruments deployed at Davis during this summer to assist understanding of the response of the middle and upper atmosphere to natural and human-made perturbations.

Australia's contribution in CCAMLR

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) at its 1994 meeting used data collected by the Antarctic Division's Biology Program to set precautionary limits (based on revised assessment methods developed at the Antarctic Division) on any future fish catches around Heard Island. This is the first time that any nation within CCAMLR has carried out the required research in advance of a fishery so that the conservation principles of CCAMLR can be fully taken into account in fishery management.

Research by the Antarctic Division resulted in new analytical techniques for estimating krill recruitment and for utilising the results from trawl surveys. These have both been adopted as the standard methodologies for management within CCALMR.

Substantial refinements to the equipment and major software development has been undertaken to enable rapid and effective analysis of the huge volumes of hydroacoustic data obtained during krill abundance surveys. This new data management system will be used for the first time on the 1995-96 CCALMR endorsed survey.

Bechervaise Island, near Australia's Mawson station, has been the site of an innovative ecosystem monitoring program, which has been operational since 1991, designed to provide information required by CCALMR. The program utilises technology developed by the Antarctic Division, which allowed researchers to automatically detect a catastrophic event that occurred in the summer of 1994 when the main penguin food source, krill, failed to appear. The automatic penguin monitoring system proved that it is a sensitive indicator of such natural catastrophes and it will continue to provide valuable information on the general state of the Antarctic ecosystem.

Global Change and Antarctica

The return survey along a 2250km route around the hinterland of the Lambert Glacier, the world's largest ice stream, was completed in February 1995. Preliminary analysis of the extensive data on ice thickness, ice velocity and snow accumulation collected during the surveys suggests that this major drainage basin may be in a state of positive balance with more mass presently accumulating.

Sea ice plays a major role in modifying the exchange of heat and water between the ocean and the atmosphere, but the ice thickness, a major factor in this role, is very poorly known for the Antarctic. The sea ice thickness distribution and ice characteristics in Prydz Bay were investigated during a cruise of RSV *Aurora Australis* in September 1994.

Geophysical Research

A new Antarctic Digital Acquisition System (ADAS), developed at the Antarctic Division, is being used to record variations in the earth's magnetic field and ionosphere in the Antarctic. The data being transferred via satellite link to the Academic and Research Network (AARNET) making it readily available to national and international researchers.

A digital ionospheric sounder has been installed at Casey to probe the ionosphere for irregularities. The conditions in this medium have an impact for both HF and satellite communication.

Bureau of Meteorology

Role *To observe and understand Australian weather and climate and provide meteorological, hydrological and oceanographic information, forecast, warning and advisory services in support of Australia's national needs and international obligations.*

Most research within the Bureau is conducted by the Bureau of Meteorology Research Centre (BMRC) in the general areas of short and medium range weather prediction, climate, mesoscale meteorology, satellite meteorology and climate change modeling.

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

Recent Achievements

International comparison of rainfall estimation from satellites
In 1992-93 the Bureau played a major role in the execution of the international Coupled Ocean-Atmosphere Response Experiment (COARE) in the western Pacific region. That four month field program produced a vast amount of data on the physical processes controlling seasonal fluctuations in climate in our region. The Bureau of Meteorology Research Centre (BMRC) has now coordinated an international project using this data to compare the accuracy of techniques for estimating rainfall from satellite data.

El Nino predictions
An intermediate level coupled ocean-atmosphere model has been developed in BMRC to predict changes in the sea surface temperature of the Pacific Ocean associated with the El Nino phenomenon, which has a marked impact on Australian climate. In the past, such models have been driven only by observations of the wind near the sea surface. The BMRC model predictions have been improved by the use of a novel technique to assimilate data taken from instruments below the ocean surface. The model provides support for the seasonal outlook service of the National Climate Centre.

Contribution to IPCC
The BMRC is coordinating the chapter on observations of climate change for the Second Scientific Assessment of the Intergovernmental Panel on Climate Change (IPCC). Throughout 1994, BMRC scientists contributed significantly to the chapter on model validation as well as to the assessment of issues covering tropical cyclones and model simulations of future climate change.

Model simulation of climate change
The BMRC coupled ocean-atmosphere model has been used to simulate global climate change under conditions of steadily increasing concentrations of carbon dioxide. A 100 year control run has been completed with the concentration of carbon dioxide fixed at present levels. These results have been compared with a "transient" run in which the concentrations increased by 1% per year. One impact of the higher concentration of greenhouse gases is a reduction in the diurnal temperature range over much of the land areas of the globe; that is, the increase in the overnight minimum temperature tends to be greater than that in the daytime maximum.

Great Barrier Reef Marine Park Authority (GBRMPA)

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

Recent Achievements

Monitoring of Reef Health
As part of a broad program to monitor the long-term health of the Great Barrier Reef, a comparison of recent photographs of reefs with those taken in the period 1890 to 1960 has been undertaken. The comparisons show that reef-flat communities in the inshore central Great Barrier Reef have declined markedly in coral cover since the mid 1950s. Research into the cause of this decline continues, with sediment and nutrient runoff from coastal land-use a possible suspect.

Australian Nature Conservation Agency (ANCA)

Role *The ANCA administers programs which contract, sponsor and award grants for scientific research and technological developments in a broad array of disciplines as part of the Agency's role as the principal nature conservation agency of the Commonwealth Government.*

The agency is responsible for a number of research programs which include the following:

- The States Cooperative Assistance Program (SCAP) involves ANCA in cooperative nature conservation programs of national or international significance related to the wildlife and the protected areas in the States and Territories. In 1994-95, $0.95 million was provided for projects in the States and Territories.
- The Research and Surveys Program (RSP) addresses the collection and maintenance of scientific and cultural information. Funding totalling $1.5 million was provided for projects during 1994-95.
- The Feral Pest Program (FPP) aims to limit the impact of feral or other introduced animal pests on native species and/or landscapes, particularly those in those areas important for the recovery of endangered or threatened species. Projects are implemented in cooperation with the States and Territories. During 1994-95, a total of $1.86 million was allocated to 51 projects.
- The Endangered Species Program (ESP) funds research and management projects aimed at the recovery of species and ecological communities, threat abatement and education programs to increase the awareness of endangered species issues. Most of this activity is in cooperation with the States and Territories.
- The Australian Biological Resources Study (ABRS) aims to document the biological diversity of Australia. The ABRS Participatory Program funds grants which stimulate taxonomic research to fulfil this aim. During 1994-95, $2 million was awarded in support of 68 projects. Also, the ABRS GOPHER, BIOSERVE, was established on the INTERNET to make available appropriate ABRS data. The first dataset to be made available was a revised version of the Census of Australian Vertebrate Species (CAVS).

Recent Achievements

Interim Biogeographic Regionalisation of Australia (IBRA)
In cooperation with the States and Territories, the Commonwealth developed the Interim Biogeographic Regionalisation of Australia (IBRA) as a means of identifying priorities for the establishment of protected areas. The IBRA comprises a total of 80 "natural" regions based on existing State and

Territory data. The Commonwealth provided access to continental datasets and its role was to match region boundaries and descriptions across State and Territory borders.

Australian Heritage Commission

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

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

Recent Achievements

Wild Rivers
The Australian Heritage Commission is working jointly with the Centre for Resource and Environmental Studies, ANU, States and Territories, and other parties to identify rivers in relatively undisturbed condition. This is being done using GIS techniques, by compiling a national rivers database with relevant environmental parameters.

Forest regional assessments
Joint regional assessments with the Victorian Department of Conservation and Natural Resources have been conducted in the Central Highlands and East Gippsland regions of Victoria. A draft report has been published on national estate values in the Central Highlands and public submissions are being considered for the final report.

Australian Sports Commission

Role *The Australian Sports Commission undertakes and funds various research projects to identify methods to improve athlete performance and to improve the quality of participation in sport.*

Recent Activities

In 1995-96 research will continue into preparation of athletes for competition in hot humid conditions, further refining talent identification methods and the investigation of indicators, diagnosis and recovery from overtraining. A priority area also for 1995-96 is the development of injury surveillance techniques, prevention and rehabilitation of sports injuries.

In the area of technology development, a biomechanical golf swing analysis system is being developed to assist golf coaches and teachers, the Superoo bicycle frame is being refined and techniques to provide immediate, real time feedback on athlete performance is being investigated.

National Greenhouse Research Program

Recent Activities

Over the last year, the National Greenhouse Research Program has made significant progress in reducing key uncertainties in climate change prediction. These include: completion of the field component of the Southern Ocean Cloud Experiment, which has illuminated the role played by natural sulphur emissions in cloud formation and the way clouds influence warming; a major multi-institute field experiment, known as OASIS, at Wagga Wagga which will provide a much better understanding of the exchange of greenhouse gases from the Australian landscape, leading to new information relevant to the compilation of the National Greenhouse Gas Inventory; the analysis of oceanic observations which show a statistically significant warming of the Indian Ocean over recent decades and the inclusion of improved land surface schemes in climate models. The first Australian simulations of the climatic response to gradually increasing atmospheric greenhouse gas concentrations were also completed.

Forward plans for greenhouse research through to the 1998-99 financial year have been developed and are reported in the document "Foundations for the Future" produced by the National Greenhouse Research Committee. The success to date of the National Greenhouse Research Program and the directions outlined in "Foundations for the Future" are making unique contributions to the better understanding of climate change in the southern hemisphere and in particular its impact on Australia.

FINANCE

Science and Technology in the Portfolio Budget

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

The Australian Government Analytical Laboratories (AGAL) operate through the DAS Business Services Trust Account on a fee-for-service basis. AGAL plays a strategic role in the protection and promotion of Australian public health and safety and agricultural trade through its quality analytical services in chemistry and microbiology.

IPS Radio and Space Services (IPS) is budget-funded at $3.4 million for 1995-96. Inline with a Government directive, IPS has recently introduced an annual service charge to all customers and also offers consultancy services. IPS provides support and advice for high frequency (HF) and satellite communications, and geophysical organisations.

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

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

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. This is to identify and manage risks to the safety of workers or potential hazards to the community or environment associated with the genetics of manipulated organisms. GMAC is supported by a Secretariat within the Department and its funding for 1995-96 is expected to be around $0.4 million.

MAJOR RESEARCH ACTIVITIES

Australian Government Analytical Laboratories (AGAL)

Role *To develop analytical methods of suitable precision, accuracy and efficiency to meet demands from the Australian Government for emergency testing services involving the health or safety of the community or threatening Australia's export market for agricultural produce.*

Recent Achievements

Analytical advances for public health and the environment
Within its activities aimed at decreasing the costs of analytical preparation for the benefit of the Australian analytical community, AGAL has completed two separate projects. The first is an analysis of all "white powder" drugs of abuse using minimal solvents by employing the capillary electophoresis technique. In the second, illicit drugs have been profiled to compare identities of seizures and determine geographic origin by analysing levels of trace metals.

AGAL is seeking to identify means by which ozone-depleting solvents used in many chemical processes can be eliminated. During the year, the Laboratories extended the use of supercritical carbon dioxide as a separating solvent in sample preparations with the aim of replacing the significant use of chlorinated solvents.

AGAL has been researching the use of DNA technologies for analytical measurements and has used these technologies to assist in species comparison and identification, and for micro-organism identification and detection.

IPS Radio and Space Services (IPS)

Role *To provide timely radio propagation and space environment advice that customers will rely on to perform their operations; that is appropriate to the needs of the Australasian community; and that uses best technical and business practices.*

Recent Achievements

Solar spectrograph
Events on the sun can cause disturbances to the geomagnetic field and the ionosphere of the earth, off which high frequency radio waves are reflected. IPS has installed a modern solar spectrograph comparable to the best in the world, at Narrabri, NSW which will allow IPS to assess the likelihood that a solar event will cause a disturbance here on Earth, and if relevant, estimate its time of occurrence.

KEL Aerospace, a Melbourne-based company, was contracted with IPS to help in the design and construction of a similar spectrograph for the Indonesian Space Research Centre (LAPAN). IPS has also helped in the training of LAPAN's scientists in the solar-terrestrial field.

Scientific Services Laboratory (SSL)

Role *To provide the Department of Administrative Services with a research and investigation capability in relation to its design and construction and maintenance operations, and to provide a commercial scientific service to external clients in the construction and related industries.*

Recent Achievements

CERTIFIRE
The first compendium of certified products and contractors meeting certification requirements for passive fire protection systems has been released and a Memorandum of Understanding signed with the Australian Fire Protection Association of Australia. This has been developed in a joint venture between SSL and Warrington Fire Research, The scheme is called CERTIFIRE and is being promoted in Asia to support Australian exporters.

Appraisal and accreditation
The SSL national accreditation service for fire protection equipment continues to expand and now includes categories of equipment including valves, pipework and fittings, and gaseous systems. The SSL Register of Accredited Products has been recognised in the Building Code of Australia and SSL has recognition by the Hong Kong Fire Services and Factory Mutual Research Corporation (USA). A network called FIRENET has been formed under the Auslndustry Business Networking Scheme to promote the SSL Listing throughout Asia in support of Australian exports.

DAS Centre for Environmental Management (DASCEM)

Role *To satisfy customers' environmental management needs for independent specialist advice and cost-effective solutions in the areas of: management of ozone depleting substances (halons and CFCs); energy management services; site assessment and remediation; environmental assessments and audits; and workplace health and safety.*

Recent Achievements

Halon Bank
The Halon Bank established in 1993 to collect ozone depleting halons from fire suppression units had, by the end of February 1995, collected approximately 250 tonnes of Halon 1211 and 48 tonnes of Halon 1301.

The successful establishment of the Halon Bank led to an approach by ODS Reclaim Limited (representing the Association of Fluorocarbon Consumers and Manufacturers) to operate a CFC management facility along the lines of the Halon Bank. In January 1995, DASCEM signed a twelve-month contract with ODS Reclaim to manage non-reprocessable CFCs.

Genetic Manipulation Advisory Committee (GMAC)

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

Recent Activities

During 1994-95 the assessment of thirteen proposals for the planned release of genetically modified organisms was finalised. The majority of these were for modified plants. The Committee advised that one release proposal should not proceed.

GMAC also released the revised guidelines for large scale genetic manipulation work and commenced work on the revision of guidelines for small scale work.

HUMAN SERVICES AND HEALTH

Science and Technology in the Portfolio Budget

This portfolio includes several agencies dealing with research and scientific services. These are the National Health and Medical Research Council (NHMRC), the Australian Institute of Health and Welfare (AIHW), the Australian Radiation Laboratory (ARL), the Chemicals Safety Unit (CSU) and CSL Limited. AIDS research and health research programs are also funded through the portfolio.

Medical and public health funding through the NHMRC will increase to $129.7 million in 1995-96 ($125.5 million in 1994-95). The AIDS research budget will be $12.1 million ($12.1 million in 1994-95).

The appropriation to the Australian Institute of Health and Welfare for 1995-96 is $6.96 million (1994-95 was $8.1 million).

In 1995-96, ARL expects to spend around 50% of its total budget of $7.0 million (includes $1.7 million of POE money) on research and development.

The appropriation to the Australian Institute of Health and Welfare for 1995-96 is $7.0 million (1994-95 was $8.1 million)

MAJOR RESEARCH ACTIVITIES

National Health and Medical Research Council (NH&MRC)

Role *The objective of the National Health and Medical Research Council is to advise the Australian community on the achievement and maintenance of the highest practicable standards of individual and public health and to foster research in the interest of improving these standards.*

The Council is currently providing support to 1604 research projects, as well as providing block funding for five major research centres and institutes.

Recent Achievements

Blood pressure gene cloned
There are several causes of high blood pressure, including a congenital condition in which patients with defective cortisol metabolism are severely hypertensive. An enzyme, HSD2, plays an important role in inactivating steroids, particularly glucocorticoids (GCs) such as cortisol, which occupy the aldosterone receptor. Aldosterone is a steroid which regulates the salt and water balance in the body. Dr Z. Krozowski's group at the Baker Medical Research Institute has cloned the gene for HSD2, and the high potency enzyme derived from it has been demonstrated to reduce the concentrations of GCs to very low levels, effectively eliminating their biological activity.

Breast cancer inducing gene found
The discovery that a gene called cyclin Dl plays a critical role in the growth of breast cancer has been made by scientists at the Garvan Institute in Sydney. Research showed that cyclin Dl, which codes for one of a group of cell cycle-regulating enzymes called cyclins, are 'over-expressed' or more abundant in 45% of breast cancers when compared to normal tissue.

The recent research centred on the question as to whether changes in cell division rates in breast cancer were caused by or were the result of changes to the level of cyclin Dl. The group found that abnormal quantities of the gene cause cells to divide and multiply more rapidly. The level of the gene determined the rate of growth of cancer cells and, more importantly, it was discovered that if levels were high enough, cyclin Dl was sufficient to stimulate dormant cells to divide and multiply. The work provides a potential new marker of disease development and a target for therapeutic intervention.

Asthma risk identified in study
Dr John Hopper, a Senior Research Fellow of the NHMRC at the University of Melbourne's Department of Health and Community Medicine, has carried out a study on the predisposition of children with asthma to suffer continuing symptoms into adulthood.

The study involved 1500 people, aged 30 to 32 years, who were originally surveyed as seven year olds. Of the children surveyed who demonstrated asthma symptoms, 75% were without symptoms in their early 30s. In contrast, one in every nine without childhood asthma did have asthma as an adult. The study found that children are more likely to have asthma when adults if they are female, or have eczema, poor lung function, parents with asthma or had asthma themselves as a child. The study concluded that a child had a 7% chance of developing asthma in adulthood with none of the risk factors present, but a child with four or more factors had in excess of a 35% chance. The study will assist in identifying high risk groups in childhood, and targeting those groups with preventive and educational health programs.

Observing cell division in embryos
Using 8-day old mouse embryos and funded by the NHMRC, Dr Patrick Tarn and his embryology unit at the Children's Medical Research Institute (CMRI) have traced the movements of cells removed from the womb for up to 48 hours. The changes in a mouse embryo at this time are similar to those which occur in the 4th to 6th weeks of human pregnancy when the head and face are formed.

This period is a crucial one, as it is when the 'master plan' is designed, and it is likely to be the best opportunity to undertake any therapy to correct an existing genetic error. One of the most significant aspects of Dr Tarn's contribution to the understanding of early embryonic development is his development and use of a procedure known as fate mapping, in which embryos containing a heritable transgenic marker are isolated from a donor pregnant female mouse. Cells containing the marker are transferred to another embryo and their development tracked as they divide and differentiate over a two-day period.

Multiple Sclerosis prevented in rats
Researchers at the Centenary Institute of Cancer Medicine and Cell Biology at the Royal Prince Alfred Hospital in Sydney used a drug derived from human antibodies to successfully prevent the development of an experimental model of multiple sclerosis (MS) in rats.

Overseas research suggested that a molecule produced by immune cells known as TNF could cause cell destruction. Degenerative diseases involving the immune system, such as rheumatoid arthritis, have also been linked to the presence of the TNF molecule.

Dr Sedgwick's team tested a drug that acts as an antidote to TNF. Rats with a disease similar to MS were trialed. Untreated rats developed paralysis, whereas the disease was completely prevented in rats which received the treatment. The drug is already undergoing trials on patients with rheumatoid arthritis.

Anti-malaria drug developments
Collaboration between scientists at the Walter and Eliza Hall Institute and LaTrobe University is leading to an understanding of the problem of malarial resistance to existing drugs and may lead to the development of a new, more effective, vaccine.

Despite its use for forty years as the most common anti-malarial drug, scientists remain ignorant of the way chloroquine kills malarial bacteria. The most severe type of malaria kills between one and three million people per year and is caused by the parasite *Plasmodiumfalciparum*.

The research team is investigating the way chloroquine and other anti-malarial drugs operate, to enable them to enhance the effectiveness of current drugs or to perhaps develop new, improved drugs. A synthetic compound has been developed which operates in a similar fashion to chloroquine and is activated by light. This compound is introduced to

malarial cultures, which are then subjected to intense ultraviolet light. Using this technique, scientists are able to view the way the compound acts on malarial parasites at a molecular level, opening the way for more effective treatments to be developed.

Commonwealth AIDS Research Grants Program (CARG)

Role *To foster research aimed at preventing the spread of human immunodeficiency virus (HIV) infection and minimising the personal and social impact of HIV infection.*

In 1995, the CARG is providing 128 grants across all major research disciplines, as well as support for three national research centres in: HIV Virology Research; HIV Epidemiology and Clinical Research; and HIV Social Research.

Recent Achievements

In order to develop rationally designed drugs which are effective against the regulatory proteins produced by the AIDS virus (HIV), it is necessary for researchers to have detailed knowledge of the three dimensional structure of these proteins and their mechanism of action. The Biomolecular Research Institute (BRI) has produced sufficient quantities of the HIV Nef protein for structural studies to begin. This availability of highly purified Nef protein has also led to the discovery of a number of novel functions that provide clues to what will be required to inhibit the Nef function.

The BRI has also discovered that another of the HIV proteins, Vpr is highly toxic to host cells, resulting in growth arrest and abnormal enlargement of cells. These functions have been mapped by BRI to a small area of the Vpr molecule. Findings suggest that this region is an appropriate target for therapeutic intervention.

CSL Limited

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

Recent Achievements

Genital wart cancer vaccine being developed
Uniquest, the Brisbane-based technology company for the University of Queensland has signed an agreement with CSL to advance the development of a vaccine designed to prevent genital warts and cervical cancer caused by the sexually-transmitted Human Papilloma Virus (HPV).

HPV is a very prevalent virus, affecting approximately one in three people sometime in their lives. Researchers are attempting to develop a vaccine using virus-like particles, one of the first in the world. The initial research leading to this development was funded by the NHMRC. The team hopes to have an HPV vaccine ready for human trials within two to three years.

Australian Radiation Laboratory (ARL)

Role *ARL is concerned with all aspects of radiation which have implications for public or occupational health. It provides advice and services on many different forms of radiation and undertakes research to support these activities and enhance its fundamental knowledge.*

ARL is concerned with all aspects of radiation which have implications for public or occupational health. It provides advice and services on many different forms of radiation and undertakes research to support these activities and enhance its fundamental knowledge.

Recent achievements

Radiation protection standards
Revised Australian radiation protection standards developed since the publication of revised recommendations by the International Commission for Radiological Protection in 1990 are currently available for public comment. These comments are currently being reviewed and it is anticipated that the new recommendations will be put before the NHMRC for approval by the end of the year.

Neutron calibration facility

Neutrons are hazardous nuclear particles. An instrument with a neutron source is widely used in Australian agriculture for measuring soil moisture content. Neutrons are also generated in accelerators, including those used in medical radiation therapy. As part of occupational radiation protection, neutron fields need to be monitored so that protection in the form of shielding may be put in place if necessary. The first neutron calibration facility established in Australia has recently been constructed at ARL to ensure that instruments used for measuring neutrons correctly report their presence and determine their intensity. All three internationally recognised standard calibration techniques will be available by the end of 1995.

INDUSTRY, SCIENCE AND TECHNOLOGY

Science and Technology in the Portfolio Budget

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

There are also agencies and programs supporting technological development in industry through the provision of grants, concessions and services. For example, the Industry Research and Development (IR&D) Board, which includes both industry and government representatives, is concerned with promoting the development and improving the efficiency and international competitiveness of Australian industry by encouraging research and development activities.

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

Innovation;

- *Tax Concession Scheme* which provides for registered R&D performers to claim R&D related expenses at 150%.
- *Competitive Grants for R&D* provided to assist firms to:
  - develop internationally competitive and internationally traded goods, services and systems;
  - adopt new products, materials and methods to improve manufacturing capability, productivity and quality;
  - strengthen linkages between technology developers and technology users;
  - develop technologies, including emerging and enabling technologies, that are likely to have wide application in Australian industry; and
  - foster collaboration between firms and research institutions.
- *Concessional Loans for Commercialisation of Technological Innovation* aimed at supporting small high technology oriented firms in the early stages of commercialisation,
- *AusIndustry-Development and Application of Technology in Industry* aims to encourage firms to adopt and adapt appropriate technology. Its first element provides financial assistance to projects which accelerate the development or diffusion of strategic technologies which would not proceed without assistance. The second provides funding to improve the institutional sources of technology and technical advice available to industry.

- *The Australian Technology Group Limited (ATG),* a small commercially focused company, evaluates research with commercial potential, particularly, but not limited to, research from the public sector.
- *Australian Industrial Property Organisation* provides industrial property rights services in inventions, trade marks and designs. Legal protection given with the rights encourages industry to develop and exploit new technology as well as facilitating the transfer of overseas technology to Australia. The organisation operates on full cost recovery.

Industry development;

- *National Space Program* aims to improve the competitive position of Australian firms to supply space-related goods and services, and to provide support for the application of space-related science and technology by the Australian public and private sectors.
- *The computer bounty* provides assistance for the production of computer hardware, certain assemblies, electronic microcircuits, printer circuit boards, modems and multiplexors, and certain operating software (due to end on 31 December 1995).
- *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 fisted on the Pharmaceutical Benefits Scheme in return for increased activity in Australia, including new investment, production, research and development.
- *The Information Technology Development Program* aims to assist the development of companies in the information technology industry by providing information on, and access to, leading edge methodologies and approaches to product development, manufacturing and service provision. The program has been enhanced through the inclusion of the *Information Technology Standards Program* which aims to streamline the information technology standards environment in Australia by improving the development of new standards, and testing, certification and accreditation infrastructure.
- *Partnerships for Development and Fixed Term Arrangement Programs* encourage international companies in the information technology and telecommunications industries to undertake strategic investment, R&D and export activities in Australia which are integrated into the global marketplace. Partnerships for Development and *Fixed Term Arrangement Programs* encourage international companies in the information technology and telecommunications industries to undertake strategic investment, R&D and export activities in Australia which are integrated into the global marketplace.

- *Telecommunications Industry Development Plans* encourage the licensed telecommunications carriers and key suppliers to undertake strategic investment, R&D and export activities in Australia which are internationally competitive.
- *Marine Science and Technology Program* aims to align marine R&D more closely with industry requirements and to play a key role in international cooperation in marine science and technology- Closer links between the marine industry, government and research agencies will be enhanced through the newly created Australian Marine Industries and Sciences Council.

Science, technology and industry linkages;

- *Cooperative Research Centres (CRCs) Program* provides support for long term collaborative ventures linking research and research users from universities, Commonwealth- and State - funded research organisations and business enterprises. It promotes high quality cooperative research and education programs through centres of research concentration, strengthening the links between research and its commercial and other applications.
- *The Major National Research Facilities 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.
- *The Space Industry Development Centres (SIDC) Program* is a component of the National Space Program and is directed at the development of an Australian commercial space industry. The objective of the program is to encourage industry to divert R&D funds from more traditional areas of technology to space related activities through collaborative ventures with University based space research centres. At present, three SIDCs have been established at Griffith University, Queensland University of Technology and the University of South Australia.
- *International Science and Technology Program* aims to stimulate Australian involvement in international research collaboration and generate awareness of Australian S&T capabilities. A longer term aim is to build commercial opportunities through collaborative research.
- *The Renewable energy Development Program* aims to remove impediments to the development of this industry to ensure its integration into mainstream energy markets.
- *Science and Technology Awareness Program* aims to increase awareness and understanding of the central role which science and technology play in Australia's economic and social wellbeing.

Program or agency	*Estimated expenditure 1994-95 $m*	*Budget estimate 1995-96 $m*
Factor (f) Pharmaceutical Industry Development Program	94.5	136.6
AIMS	16.5	16.6
ANSTO	66.2	65.6
CSIRO	461.1	416.8
Industry Innovation Program grants	47.4	63.1
CRG Program	112.7	126.6
Computer Bounty	77.1	75.8
Enterprise Development Program		
NIES - Commonwealth	15.6	26.4
- State	11.1	12.8
Other	8.6	5.3
Enterprise Networking Program	3.3	10.1
National Space Program	7.6	6.1
Science and Technology Awareness	1.7	1.7
International S & T Program	5.5	5.6
National Research Facilities	-	15.3
TOTAL	928.9	984.4
PORTFOLIO TOTAL (Outlays)	2694.9	2806.0

- Policy advice for the establishment and delivery of Government services in science and technology is provided through the Science and Technology Policy Branch (Science and Industry Policy Division), the Ministerial and Portfolio Co-ordination Division, the Bureau of Industry Economics and other Divisions of the Department of Industry, Science and Technology.

Firm capability and management skills;

- *The National Industry Extension Service (NIES)* is a joint Commonwealth/State program which provides extension services to firms in the traded goods and services sectors to increase internal efficiency and international competitiveness.
- *The Enterprise Networking Program* is designed to encourage small to medium sized enterprises cooperate with other firms in strategic areas of business to exploit opportunities beyond the reach of the individual firms. Support is available to establish networks, including customer-supplier, innovation and lead firm networks.

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

MAJOR RESEARCH ACTIVITIES

The Australian Institute of Marine Science (AIMS)

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

Recent Achievements

Research output from the northwest
AIMS has now established a facility in the Dampier-Karratha area to support its research initiative in the northwest of Western Australia. The research conducted during 1993-94 made significant observations of the coastal ecosystems. Researchers at the Institute have observed the spawning of two species of reef-building coral *(Acropora millepora* and *Acropora nobilis)* on nearshore reefs following the full moon in October. This is a different time of year to previous reports of spawning on these WA reefs and is similar to the spawning period for inshore corals of the Great Barrier Reef. This suggests that annual patterns of coral recruitment derived from the northern outer reefs may be more complex than indicated in previous data.

Recruitment of coral reef fish
The results of a 9-year study along the length of the Great Barrier Reef, recently published in *Science,* has shown for the first time that coral reef fish populations fluctuate as a direct result of variable replenishment with juveniles recruited from the plankton. This has important consequences for the conservation of fish stocks on the Great Barrier Reef and justifies present enquires into the production and dispersal of larval fishes in the ocean. The study incorporated the development of a new type of fish trap that has allowed researchers to map the distribution and abundance of a wide range of larval fishes including those of commercially important stocks.

Monitoring the Great Barrier Reef

AIMS began monitoring the Great Barrier Reef in 1985 to determine the effects of the crown-of-thorns starfish. The AIMS program monitors several important ecological variables annually on representative reefs over most of the GBR. In addition sixty reefs are surveyed each year. This year's data indicated increasing numbers of crown-of-thorns starfish on some reefs in the northern part of the GBR. The management agency (the Great Barrier Reef Marine Park Authority) is now undertaking a detailed examination of these reefs.

Age of fish

Researchers developed a technique for ageing coral reef fishes using increments deposited in their otoliths. This new knowledge resulted in the first accurate demographic records for any non-commercial reef fish and showed that these small species may live for long periods, with some individuals of 4-5 cm being almost 20 years old. Similar studies of a number of species of commercial and recreational importance have also indicated that many of these fish may live as long as 30 years and mature at a late age, making them particularly vulnerable to heavy exploitation.

Mobile computing and interfaces

In developing computing equipment for underwater use AIMS has designed and built interfaces (using software and hardware) that have a much wider application to the field of mobile computing and to the mechanisms for controlling sophisticated machines. The Institute has lodged three patent applications and is currently exploring the potential for commercialisation.

Coral drought records

An investigation of the frequency of droughts in Eastern Australia has been undertaken using cores drilled from massive corals. The corals from northeast Australia point to a return period of about 30 years for dry spells, similar to the current one, but a frequency of about one in 350 years for decade-length droughts. This knowledge can assist planners in alleviating the effect of droughts.

The 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

SYNROC

Two contracts have been completed with Lawrence Livermore National Laboratory and the Pacific Northwest Laboratory, both aimed at establishing Synroc as a wasteform for the immobilisation of US defence wastes. Current initiatives by the US government may accelerate the potential for commercialisation of Synroc technology.

Treatment of arsenic wastes

For the last three years, ANSTO has undertaken research into the treatment of arsenic wastes which are often generated during the processing of uranium, copper, lead and gold ores. This research has been funded through the CRC for Waste Management and Pollution Control Ltd of which ANSTO is a major partner. The ANSTO-led arsenic waste treatment group has developed patented technology for the photo-oxidation, removal and immobilisation of arsenic. The US Environment Protection Agency has agreed to allocate US$650,000 to demonstrate the technology in Montana, under its Mine Waste Technology Pilot Program. In addition, the technology is being transferred to Australian industry.

The Australian National Beamline Facility

The Australian National Beamline Facility (ANBF) is a general purpose hard X-ray beamline operated at the Photon Factory, in Tsukuba Japan, to provide Australian scientists with routine access to synchrotron radiation. The ANBF operated throughout 1994, accommodating 23 Australian research teams performing a wide range of experiments in physics, chemistry and biology. The main diffractometer, installed in late 1993, was commissioned for powder and triple axis diffraction during 1994. It is unique in utilising Image Plates (re-useable storage phosphor plates which have replaced photographic film in many X-ray applications) to acquire the entire powder diffraction pattern simultaneously, cutting the acquisition time from many hours to 10 minutes or less. This very high rate of data acquisition also allows time resolved powder data to be measured.

The ANTARES AMS Spectrometer

The new high intensity ion source, recently installed on the ANTARES AMS spectrometer at ANSTO, is fully operational and has been used to analyse several hundred radiocarbon samples. This computerised sputter source allows high precision and throughput necessary for studies in global climate change and quaternary science. The ANTARES AMS spectrometer and the new ion source have been also applied to the ultrasensitive detection of I^{129}, a long-lived fission product useful for nuclear safeguards monitoring. It has also been used to analyse samples of waters and sediments, collected by the International Atomic Energy Agency inspectors at various distances from a reprocessing plant.

Ovarian cancer

The first stage of the clinical evaluation of a radiolabelled monoclonal antibody used for the monitoring of ovarian cancer has been completed. Comparison of the results with other procedures indicates that the agent, developed in collaboration with Agen Biomedical Ltd, has potential in the care of ovarian cancer patients.

The Australian Space Office

Role *To implement the National Space Program in support of the activities of the Australian Space Council, including the promotion and development of commercially viable industries based on space technology and the encouragement of local industry participation in space R&D.*

National Space Program aims to improve the competitive position of Australian firms to supply space-related goods and services, and to provide support for the application of space-related science and technology by the Australian public and private sectors.

Recent Achievements

Endeavour Telescope

The Australian space telescope Endeavour is the most sophisticated space payload built in Australia to date. The payload consisted of a demonstration/evaluation model of an ultraviolet light telescope and was successfully flown aboard NASA's space shuttle STS 67. The telescope was commissioned by the National Space Program and built by Australian industry. The lead contractor was Auspace Pty Ltd and about 100 Australian firms were employed as sub-contractors. The building of the telescope "space qualified" Australian firms to allow them to compete for ensuing space contracts, such as the Along Track Scanning Radiometer (ATSR-2) and its follow-on contract for Advanced Along Track Scanning Radiometer (AATSR).

Along Track Scanning Radiometer (ATSR-2)

The surface of the sea has a dominating influence over the heat flow in and out of the atmosphere. The European Space Agency's (ESA) second Remote Sensing Satellite (ERS-2), launched in April, will provide continuity of data and a replacement for ERS-1 which was designed primarily to study the ocean surface and its interactions with the atmosphere. The National Space Program let contracts to Australian industry for the manufacture of components for ERS-2.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Role: *To give Australians a better future. Its main role is the conduct of strategic research to:*

- *Improve the export and import replacement performance of Australia's primary and manufacturing industries;*
- *Develop ecologically sound management principles and practices for the use and conservation of Australia's natural resources;*
- *Achieve sustainable development in production systems and develop technologies to minimise environmental damage from economic development;*
- *Provide leverage for Australian enterprises that add value to goods and services through innovative use of information technology and telecommunications, or that contribute to reducing the trade deficit of the information and communication industries;*
- *Enhance productivity and effectiveness in provision of infrastructure and services, particularly health and construction.*

CSIRO is recognised nationally and internationally for its contributions to science and Australia's development. The organisation will build on this reputation through our strong commitment to multi-disciplinary research, and collaboration with researchers in other organisations including Cooperative Research Centres, to ensure that the nation derives the maximum benefit from our research.

Structure and Organisation

CSIRO is governed by a Board comprising up to ten members, one of whom is the Organisation's Chief Executive. The research carried out by CSIRO's 7400 staff is undertaken in six research institutes which have the following objectives:

- *Institute of Animal Production and Processing*
  To enhance the global competitiveness of Australia's animal-based and food industries, the health and well-being of all Australians and the wise long term use of the nation's natural resources for these purposes.
- *Institute of Industrial Technologies*
  To increase the international competitiveness, efficiency and scope of Australia's manufacturing industries and to be a leader in strategic research for those industries.

- *Institute of Information Science and Engineering*
  To be a leader in strategic research on information and communications technologies and the integration of systems based on these technologies for the benefit of Australia.

  To help increase the international competitiveness and export orientation of Australian information and telecommunications industries.

  To assist other industry sectors to improve their competitiveness through process improvements and the use of advanced computer and communications systems.
- *Institute of Minerals, Energy and Construction*
  To play a major contributing role in the development of sustainable and competitive minerals, energy and construction industries in Australia and in the creation of a better living and working environment for all Australians.
- *Institute of Natural Resources and Environment*
  Provide the scientific knowledge required for the effective management and conservation of Australia's natural resources and environment, particularly in relation to the conservation and protection of natural heritage and sustainable use of natural resources.
- *Institute of Plant Production and Processing*
  To enhance sustainability, competitiveness and growth of Australia's field crop, horticultural, forestry and pasture-based production and processing industries, and to improve the knowledge of Australia's indigenous plants, insects and soils leading to the development of technology for the better management of its natural resources.

While CSIRO is funded primarily by direct appropriations from the Commonwealth, an increasing proportion of the Organisation's funds come from external sources. These include collaborative ventures with industry, granting schemes funded by both industry and government, and earned revenue. In 1995-96, it is estimated that $256 million of CSIRO's $673.6 million budget will come from these external sources.

Planning and Reporting

CSIRO has adopted the Socio-Economic Objectives (SEO) classification of the Australian Bureau of Statistics' (ABS) Australian Standard Research Classification as the basis for strategic planning and reporting outcomes of the Organisation's research. This classification provides a framework for describing the purpose for undertaking research in terms of economic and social benefits. The following achievements are reported on this basis.

Recent Achievements

Plant Production and Primary Products

More vigorous wheats
CSIRO's Division of Plant Industry has improved the early growth of wheat - a breakthrough which could benefit the wheat industry by $35 million a year. Compared with other cereals, wheat develops its leaf canopy very slowly. Scientists have bred lines with faster developing leaves which soon shade the soil, reducing evaporation of water and increasing the amount of water available for crop growth. This will result in higher yields and better use of water resources. The development will also mean a reduction of weeds and the use of herbicides and will help to tackle the problem of herbicide-resistant weeds, with a positive impact on the environment.

Brassicas - natural soil fumigants
CSIRO scientists have shown that brassicas have the potential to control pests and diseases in both agricultural and horticultural crops. They have shown that pieces of Brassica root can reduce the growth of *take-all* fungus in the laboratory. The research has shown that compounds known as isothiocyanates (ITCs), which are produced by decaying crop residues of Brassica plants, suppress the growth of some soil diseases, including *take-all* (the most serious root disease of wheat). The scientists have coined the term biofumigation to describe the effect of the naturally occurring ITCs in Brassicas, which achieve the same result as commercial chemicals sold as soil fumigants. Biofumigation will have great potential for pest control without synthetic chemicals. The scientists will now work to identify Brassica types with ITCs effective in controlling the important pests of agriculture and horticulture.

Breakthrough in flowering
The CSIRO Division of Plant Industry recently announced a major breakthrough in research into flowering. Scientists have discovered the first step towards understanding the control of flowering. They have identified a chemical treatment which can replace the treatment required for some crops to flower. One of the most important stages in a plant's development is the change from vegetative growth to flowering. Understanding and managing flowering could advance agriculture worldwide.

Insect-resistant peas
The CSIRO Division of Plant Industry has recently announced a breakthrough in genetically transforming peas to provide them with resistance to seed eating weevils - a major insect pest in pea crops. Many insecticides have become less effective because insects have developed pesticide-resistance. This breakthrough will help satisfy consumer demands for clean food, and will be of great benefit to the Third World, where

insecticides are not readily available to poor farmers. The scientists hope that similar methods will make other important food legumes, such as chickpeas, cowpeas and mungbeans, resistant to insect attack.

Bushfire simulator
The CSIRO bushfire spread simulator, SiroFire, makes use of local geographic, weather and fuel information. SiroFire enables a fire controller to enter a reported fire on an IBM personal computer and to predict its perimeter at any future time. The CSIRO Division of Forestry was assisted in the final stages of the development of the model by the Rural Access Program, which is administered by the Department of Primary Industries and Energy.

Animal Production and Primary Products

The horse virus mystery - equine morbillivirus
A large team of scientists at CSIRO Australian Animal Health Laboratory (CSIRO AAHL) backed up the Queensland Department of Primary Industry's investigation of the mystery horse virus that killed Mr Vic Rail and fourteen horses. Within six days a virus was isolated in samples from four horses. Transmission trials confirmed that this virus was the cause of death. Later the same virus was found in samples from the late Vic Rail. Genetic analysis has shown that the virus belongs to a group known as morbilliviruses, but it is only distantly related to other members of the group which include measles, rinderpest and canine distemper. Suggestions of an unidentified 'killer disease of horses and people' could have damaged Australia's export meat markets. The Cannon Hill area includes an export meat works. The speed of diagnosis also helped protect other industries.

Toxicity antidote for sheep
An antidote has been found by the CSIRO Division of Animal Health against annual ryegrass toxicity (ARGT). Reported sheep deaths due to ARGT cost Australian farmers more than $10M annually, although many producers do not report the deaths. The antidote was tested with the assistance of four WA farmers during a recent outbreak of ARGT. The antidote complements a vaccine also developed by the Division. Commercial partners are now being sought for these two products. Both products are the result of many years of research by CSIRO with support from wool producers through the International Wool Secretariat.

No wind
The CSIRO Division of Animal Health has developed a new compound for livestock that may take the wind out of any proposed Greenhouse gas emission tax, boost production and save farmers money. This non toxic compound reduces the amount of methane gas animals release to the atmosphere. Methane production is suppressed for as long as the additive is given. It is especially suitable for cattle production systems because it can be delivered as a feed additive, or by an intrauminal controlled-release device. There are also production benefits. Trials in cattle at the Tropical Beef Centre

in Rockhampton have increased live weight gains by up to 20%. Sheep are being tested at the Division of Animal Production in WA. The work is backed by farmers through support from the International Wool Secretariat and the Meat Research Corporation.

Coughing chooks

The CSIRO Division of Animal Health has identified new strains of infectious bronchitis virus responsible for outbreaks of coughing in poultry flocks. Infectious bronchitis virus (IBV) is a major cause of respiratory disease in poultry flocks. It has been a problem to producers since the 1960's. The discovery of the new strains could lead to improved management of the disease. This research was supported by poultry and egg farmers through the Chicken Meat and Egg Research and Development Councils.

Reduction of methane gases

The CSIRO Division of Animal Health has developed a treatment which alters the activity of fauna, such as protozoa, present in the forestomach (rumen) of sheep and cattle. Removal of microfauna (protozoa) in the rumen may improve the ability of animals to utilise protein in poor pasture conditions. The new treatment also has the potential to reduce ruminal production of methane, an important green-house gas. CSIRO has submitted a patent for this treatment and is continuing the research with the support of a major company in the field of veterinary and agricultural products.

Modification of milk fat

Specialised supplements when fed to dairy cows reduce the saturated fats present in milk. In conjunction with Rumentek Industries, the CSIRO Divisions of Animal Production, Food Science and Technology, and Human Nutrition are using this fat modified milk to develop a range of healthier dairy products including cheese, butter and icecream. The specialised supplements are based on oilseeds, such as canola, that have been treated to protect the oils from breakdown in the animal's stomach. A 200-cow feedlot dairy, constructed by Rumentek Industries, in collaboration with the University of Western Sydney, is now in full production and is conducting trials with these supplements. Human nutritional tests conducted this year using the modified milk and products have been very successful and have led to significantly lower cholesterol levels than conventional dairy products.

Natural flavours of seafood

The CSIRO Division of Food Science and Technology has found that some ocean fish and crustaceans possess flavours that are characteristic of the species or the location in which they were caught. These flavours, described as 'briney', 'fresh ocean', and 'iodine-like', are caused by chemicals known as bromophenols. There is evidence that these compounds are of environmental origin and are part of the diet. Species of fish with a high dietary intake of algae or worms have the highest concentration of bromophenols and the strongest flavours. This new information may enable aquaculture operations to improve the flavour of seafoods produced in intensive fisheries.

Mineral Resources

Airborne mineral mapping

The CSIRO mid-infra-red airborne CO_2 laser spectrometer (MIRACO_2LAS) developed by the Division of Exploration & Mining has been used for mineral mapping. Test flights over areas of current exploration interest showed, for the first time that silicate minerals can be mapped from the air using this high resolution sensing system. In the next few years, the Division plans to incorporate this new technology into operational remote sensing instruments

Unlocking the secrets of ore formation

Minute samples of ancient ore fluids, trapped as tiny inclusions in minerals, hold the key to understanding the transport of ore metals and the formation of world-class ore deposits. These secrets are being unlocked at the CSIRO Division of Exploration & Mining using a unique microanalytical method, based on focussed high-energy proton beams. The division's proton microprobe is capable of analysing single fluid inclusions only a few micrometres in diameter. Already, the method has yielded new insights into the transport of gold and copper in hydrothermal systems and provides a powerful exploration tool for targeting hydrothermal ore deposits.

Mine safety

Engineers from the CSIRO Division of Exploration & Mining have designed and built a seismic system for monitoring the seismic response of the earth to mining activities. The system, which can operate continuously without the need for site services or personnel, was successfully tested at the new Gordonstone Mine in the Bowen Basin in 1994. This showed how the ground overlying the working seam has moved and fallen and has led to an understanding of the mine's interactions with the stress field.

Safety in mining beneath reservoirs

Extensive, good quality resources of hard coking coal exist beneath the major water reservoirs of the Southern Coalfields of NSW and provide a challenge for economic extraction. Instruments designed by the CSIRO Division of Exploration & Mining for tectonic strain monitoring of the San Andreas fault have been deployed at three sites at the Cataract reservoir to measure deformation and strain associated with longwall mining. Precision is such that the response to the shearing operation is easily monitored from distances in excess of several kilometres. The system allows evaluation of strains at the reservoir floor to be compared with expectations from the mine design as a method for safe design optimisation. The equipment also has great potential in the sphere of large scale stability of designs for very deep pits and highwall mining systems.

Improved synthetic rutile process

In keeping with a world wide trend towards lowering impurity content RGC Mineral Sands Ltd sought a process to remove naturally occurring radionuclides from synthetic rutile product obtained from its Western Australian mineral deposits. CSIRO has assisted RGC to develop a process to

remove naturally occurring radionuclides such as thorium and uranium. Trials at the Narngulu synthetic rutile plant in July 1994 demonstrated that the concentration of uranium and thorium had been significantly lowered. Additionally, the new process produces a higher quality synthetic rutile in terms of a higher titanium dioxide content that will help offset any additional operating costs associated with the new process.

Energy Resources

Oil saturation in rocks

CSIRO's Fluid History Analysis project at North Ryde has devised a novel measurement that indicates the maximum oil saturation in rocks. This measure correlates with permeability and has applications for oil exploration in positive identification of residual oil zones (where an oil column formerly existed) and for oil production where conventional methods for characterisation of the reservoir are inadequate. Most oil reservoirs have a residual oil zone. Recognition of these residual zones in a hole that is dry or intersects a gas zone indicates proximity to oil and allows a strategy to be devised to make further tests for oil.

Measuring oil well flow

Extracting hydrocarbons from their geological reservoirs involves pumping multiphase mixtures of crude oil, water and gas from each well. The mining industry is seeking new, more economical ways of measuring flow rates of multiphase mixtures produced from oil wells. The flow rate of each phase needs to be known to manage and optimise total oil production. To address this important industry issue CSIRO has developed an oil well flow meter which has been installed at ESSO Australia's West Kingfish platform in Bass Strait. The meter utilises gamma-ray technology developed in CSIRO and is an advanced prototype undergoing long term trials. CSIRO is currently negotiating with oil service companies to market and service the gamma-ray meter.

Binderless coal briquetting

The CSIRO binderless briquetting process has been successfully demonstrated in a US pilot plant. Briquetting offers a method of utilising the increasing amount of coal fines generated by the Australian coal industry and, at the same time, reducing their impact on the environment, where they form a high percentage of the material in spoil heaps and tailings. The twelve month study tested fines from Australian high rank coking coals at a 2 tonne per hour pilot scale plant. The tests confirmed that the CSIRO briquetting process, which does not use expensive binders, could be applied in a large scale operation. In addition, the tests gave researchers and the industry partner a better knowledge of the factors and costs involved in scaling up to a commercial operation and, more immediately, in building a pilot facility in Australia. The process also has particular potential for West Australian sub-bituminous (Collie) coals in proposed new steel making processes and as an alternative fuel to wood and kerosene in several Asian countries.

Recycling transformer oils
In a $2.3 million project, CSIRO and Pacific Power are developing a new process to recycle degraded transformer oil. The new process is technically simple and economic and will enable the oil to be renewed on site at power stations and electricity substations. Ninety-nine per cent of the oil can be recovered and re-used and the electrical properties of the recycled oil are excellent. An added benefit of the process is that it destroys polychlorinated biphenyls (PCBs) present in some older transformer oils, converting them to harmless chloride salts. Currently a fully-integrated prototype unit capable of processing one tonne/day of degraded and contaminated oils is being commissioned and expressions of interest are being sought to develop the technology.

Rural Based Manufacturing

Rapid measurement of wood properties for pulp production
The CSIRO Division of Forest Products has developed technology for measuring morphological characteristics of pulp wood samples by a combination of X-ray and image analysis. The first instrument is built to process *Pinus radiata* wood, Silviscan-P, and is fully operational and available for analysis of experimental and industrial samples. A second instrument to measure eucalypt wood samples, Silviscan E, is being constructed. The instruments will enable pulp mills to quickly determine the characteristics of batches of timber so that processing can be tailored accordingly.

The potato that does not brown
In a project led by the Divisions of Horticulture and Plant Industry and funded by the Gene Shears initiative, CSIRO has recently developed potatoes which do not brown when the tubers are cut. Enzymic browning is a widespread problem in the food industry and is currently controlled by chemical treatments (many of which are becoming unacceptable) or by heat treatments (which are energy expensive). Researchers at the CSIRO have achieved this by down-regulating the browning enzyme polyphenol oxidase (PPO) by more than 95% in the main crisping potato, *Atlantic*. Pending GMAC approval, the Division of Horticulture plans to test Atlantic potatoes in the field and to try the technology on Russet Burbank, the main chip potato as well as table potato. It is expected this technology will apply to a wide range of fresh and processed plant crops - fruit, vegetables, timber, pasta etc. CSIRO has filed international patent applications for PPO and is considering potential commercial partners.

Measuring style
The CSIRO Division of Wool Technology's instrument for the measurement of greasy wool style was given its first public display at the Division's Woolspec '94 seminar. Style is a parameter based on a number of visual characteristics of greasy wool, such as crimp frequency and definition, colour and staple shape, and is currently manually assessed. The Division's instrument uses advanced image analysis techniques to provide an objective

measurement of style. The objectivity of this instrument and other existing commercial instruments, previously developed by the Division, places greasy wool on the same footing as other textile fibres. It also provides new opportunities for marketing of greasy wool.

Salinity reduction in hides processing
Work being conducted at the CSIRO Division of Wool Technology's Leather Research Centre aims to reduce the salinity of tannery effluent, a particular problem in inland areas. A mixture of two environmentally compatible substances as alternatives to sodium chloride for the control of swelling during processing have been found. Commercial interest in these substances has been obtained from a chemical manufacturer which supplies chemicals to the tanning industry. The anti-swelling formulation is now undergoing commercial trials in a wet-blue tannery. In addition, a pilot scale system which concentrates dilute chrome tanning solutions and improves the effectiveness of recycling has been developed. The system has been shown to produce high quality leathers.

Manufacturing

Anti-Flu Drug
An anti-influenza drug stemming from long-term strategic research by the CSIRO Division of Biomolecular Engineering is undergoing advanced human clinical testing by the international drug company, Glaxo. The research led to the characterisation, by X-ray crystallography, of the three-dimensional structure of neuraminidase, one of the surface proteins on the influenza virus and the identification of an invariant region in the active site of this protein. This enabled the design of a new drug which blocks this site and which has the potential to treat all strains of influenza. Other key players in this research have been Biota Holdings, an Australian company, which provided research funding and the Victorian College of Pharmacy which synthesised the new drug. Benefits to Australia will primarily flow through royalties to the various Australian parties.

Isolutrol
A process to synthesise Isolutrol from readily available materials has been developed by CSIRO. Isolutrol is a compound which until now has only been available from the gall bladders of sharks. The main value of Isolutrol is that it is useful in the treatment of acne because it normalises excessively oily skin. The CSIRO process is now being trialed on a small scale and, based on the success of these trials, Macfarlane Laboratories plans to manufacture synthetic Isolutrol. Macfarlane has signed a non-exclusive supply agreement with one of the world's leading cosmetic companies and is negotiating with two others.

Magnesium ingots
The magnesium foundry project has developed a 3 tonnes per hour magnesium ingot casting machine for the Australian Magnesium Research and Development Project. The casting machine is unique in that 8kg ingots

of pure magnesium are cast under a sulphur hexafluoride cover gas in such a way that skimming of the top surface of the ingot is not required. The metal delivery device was designed at QCAT after extensive water modelling and a provisional patent is being prepared. The ingot mould design is unique in that it allows a good cover gas seal, resulting in reduction of expensive cover gas consumption by two-thirds. The mould design is also the subject of a provisional patent application. In addition, the machine only requires one operator, has low maintenance requirements and produces ingots that are very consistent in mass.

Transport

Rostering staff for changing service demand
Better rostering of airport staff has been achieved by a team from CSIRO's Division of Mathematics and Statistics and The Preston Group. Airport services staff rostering is complex. It depends on aircraft arrival and departure times and is regulated by hundreds of business and industrial relations rules. CSIRO provided mathematical models and optimisation algorithms for the rostering software. The Preston Group, a Melbourne-based firm specialising in simulation, scheduling and optimisation software, developed links to airport staff and flight schedule databases and to the industrial regulations rule base. As a result of this work airport staff can be confident of fair, reliable rosters.

Information and Communication Industries

Respirator advisory system
Selecting the correct respirator is important in managing exposure to breathing contaminants in many industrial environments. In collaboration with 3M Australia, the CSIRO Division of Information Technology has developed an expert Respirator Advisory System (RAS) that leads respirator users through the complex decision making process. 3M Australia has found that the RAS has significantly improved the productivity and reliability of respirator use. The RAS has generated a great deal of international interest, and planning is now underway to adapt the system to the conditions and standards of international markets.

High-speed mobile phone link
Engineers from Microwave Networks Australia (MNA) have teamed with the CSIRO Division of Radiophysics to produce row-cost 38GHz digital microwave links for use in mobile telephony. Cellular telephone infrastructure needs high-speed data links to connect base station cell sites. Microwave links, the latest technique for this, enable fast service roll-out and are cost-competitive with cable. The new technology uses CSIRO expertise in antennas, waveguide design and gallium arsenide monolithic microwave

integrated circuits. A prototype link is now running at 8 Mbits per second over 2 km, and a production version is being developed for commercial release later this year.

Real-time identification system
CSIRO, in conjunction with the Cooperative Research Centre for Robust and Adaptive Systems, has developed SQIS, a real-time system to match images from a videocamera or other source against a large image database. This has significant application in face recognition for security systems, and to telecommunications services which require an ability to browse through libraries for desired images and image sequences. SQIS has recently been tested on a database of 10,000 images, with recognition of a given image taking less than one second on a low-end personal computer.

Economic Framework

Asia-Pacific Metrology
The National Measurement Laboratory (NML) within the CSIRO Division of Applied Physics is playing a leading role in Asia Pacific Metrology. NML, with a long established history and a high reputation in international metrology, has recently accepted the Secretariat and Regional Coordination role for the Asia-Pacific Metrology Programme (APMP) for the period 1994-98. The APMP has 22 member countries or territories, and works to improve regional competence in metrology at the primary measurement level. Its aim is to gain international recognition of measurement standards within the region and within the broader international system. APMP has been recognised by the Asia-Pacific Economic Cooperation (APEC) Forum as a specialist body capable of contributing to APEC's objective of free trade within the region by increasing recognition and credibility of physical standards and conformance. The National Measurement Laboratory is also involved in a number of bilateral collaborations within the region, including one to gain international recognition for Indonesia's national standards.

Health

Iron status of young Australians
In recent years, there has been an increasing recognition that, in the midst of a plentiful food supply, there are still potential areas of nutritional deficiency in Australia. A survey conducted this year by the CSIRO Division of Human Nutrition showed that over one third of young Australian women had low iron stores with one in ten young males being at risk. Low body iron stores were linked to lower meat consumption and to a high degree of concern with related environmental issues and body weight. A second study of iron status in infants and young children from the Port Pirie region, however, showed little evidence of impaired iron stores at this age. This indicates that the links

previously seen in this group between lead ingestion and cognitive development were not due to impaired iron status, a known determinant of cognitive development.

Preventing heart attack
Several cardiovascular risk factors including high cholesterol, high blood pressure, smoking and ageing lead to diseased blood vessels due to endothelial cells dysfunction. The diseased vessels show an inability to relax and also are more prone to contract abnormally due to an enhanced production of a constrictor factor(s). The production of such pro-constrictor compounds can make blood vessels more vulnerable to vasospasm. Vasospasm in the coronary vascular bed can pre-dispose the heart to ischaemia and result in a heart attack. Therefore, any strategy to 'preserve' or 'restore' proper endothelial cell function would have a positive influence.

Recent findings by the CSIRO Division of Human Nutrition indicate several naturally occurring phenolic antioxidants possess vascular protective actions. For instance, several plant compounds including quercetin and kaempferol as well as the supplementation of the diet with vitamin E (a-tocopherol) have been found to be effective in restoring the impaired endothelial cell dependent relaxation of blood vessels in hypertensive animals. These results suggest the previously reported protective effects of dietary antioxidants against the development of coronary heart disease may be mediated, at least in part, through their ability to preserve the functional integrity of vascular endothelium. Further experiments are clearly warranted to identify and characterise the mechanism of action and also to discover other dietary constituents with similar protective actions.

Nutrition and Cancer
Increasing recognition that oxygen-related free radical damage represents a primary cause of cancer in humans has led CSIRO's Division of Human Nutrition to investigate the naturally occurring protective, antioxidant substances in plant food. An integrated system for the assessment of the total functional antioxidant capacity of a- particular food has been developed. Application of this technique will allow potent antioxidant food sources to be identified and incorporated into dietary health strategies. Evaluation can now also be made of the effect of food processing and preparation on the final functional antioxidant capacity of food stuffs.

Environmental Knowledge

Tuna Tag
CSIRO Division of Fisheries scientists have developed a 'smart' tag for the highly valuable Southern Bluefin Tuna. The tag is placed in the body cavity of the fish to record such factors as body temperature, water depth and temperature as well as the geographic location of the fish. The information collected by the tag will help improve long-term strategies for a sustainable fishery.

Environmental Aspects of Economic Development

Monitoring land condition changes using satellite data

Monitoring change in land condition and productivity is a priority for the understanding and management of land and vegetation resources. Methods have been developed by CSIRO's Division of Mathematics and Statistics for processing sequences of satellite imagery to detect subtle change. An operational system for calibration, to remove variations in the satellite data due to sensor, sun angle or atmospheric effects, was a key development. Map products have been produced for use by land managers. Applications have included changes in rangeland and remnant vegetation condition, and monitoring of land degradation problems such as salinity and wind erosion inWA.

Land degradation assessment study

CSIRO's Division of Wildlife and Ecology has completed trials and cost benefit studies of a grazing gradient method for assessing land degradation. The remote-sensing based method is capable of providing comprehensive, objective and repeatable analysis of grazed country after future significant rainfalls have been taken into account. It also offers the significant additional advantage of immediate information about landscape condition through analysis of archived remotely-sensed data.

Air pollution measuring device

The CSIRO's Division of Atmospheric Research has developed an inexpensive air sampler which gives scientists, environmentalists, engineers and others a simple, accurate way of measuring selected pollutants in air. Based on a Swedish design, it is small and requires no electricity, so is ideal for remote use. Nitrogen dioxide, sulfur dioxide, ammonia and other acid-forming gases can be measured with the new device. Nitrogen dioxide, as well as contributing to acid rain, is a major pollutant associated with photochemical smog.

Chlorine-free shrinkproofing process for wool

Conventional processes for producing superwash wool relied on the use of chlorine in order to modify the fibre surface to impart shrink-resist properties to wool, especially knitwear. Whilst very successful, the use of chlorine poses some environmental problems with the effluent from current shrinkproofing operations around the world. The CSIRO Division of Wool Technology and the International Wool Secretariat have developed a chlorine-free process that eliminates the environmental problems. The process has been successfully trialled at pilot plant and commercial scale.

Effects of coal mine pitwater on beef cattle

Studies to determine the effects of coal mine pitwater on beef cattle by the CSIRO Division of Tropical Animal Production have demonstrated that there is little or no effects of the mineral components of this water on the health, growth and reproductive function of these animals. This study has also defined the tolerance of cattle to ingestion of minerals, especially sulphates, in drinking water and makes recommendations about safe guidelines.

Water purification

Conventional water purification processes do not effectively remove the naturally-occurring coloured organic matter known as fulvic acid. A collaboration between the CSIRO Division of Chemicals and Polymers, ICI Watercare and the South Australian Engineering and Water Supply Department has led to a cost effective recycling process for removing fulvic acid based on a magnetic ion exchange resin. The estimated increase in cost to the consumer is about 1%, for a much higher quality water. After successful pilot trials at the SA State Water Laboratory the process is now being demonstrated in a 600 cubic metre per day plant at Adelaide's Hope Valley treatment works.

Pirat - sewer probe

The Pirat system, which is being developed with CSIRO's Divisions of Manufacturing Technology and Building Construction and Engineering and Melbourne Water, has demonstrated its ability to assess sewer condition much more reliably than current operator-based TV systems. A robotic probe has been developed to measure the interior surface of the sewer using laser or sonar scanners. This has inspected 4km of live sewer and given previously unavailable data for assessing condition and evaluating repair options. The probe integrates advanced scanner, communications and data processing technology to identify and rank important types of defects with a reliability unachievable by current techniques.

Advancement of Knowledge

Close encounter between a pulsar and a star

The pulsar PSR B1259-63 was found a couple of years ago with CSIRO's Parkes radio telescope. It is unique, as it is the only pulsar we know of that orbits a massive, 'mainstream' kind of star. The pulsar is in a highly elliptical orbit around its companion and passes close to it every three and a half years. The last encounter in January 1994, was closely watched with the CSIRO's Australia Telescope. The observations show that the pulsar has slowed down as a result of passing close to its companion; this is the first time that this has been seen.

A black hole

In July 1994 an object in our Galaxy called GRO J1655-40 suddenly burst into life, emitting X-rays and then radio waves. The Australia Telescope and many other radio telescopes in Australian were swung into action to watch the outburst. Working together, they made images'of the object that show two 'jet'-like structures zooming away from each other, moving apart faster than the speed of light. These jets are probably powered by a black hole in the centre of the object.

The Cooperative Research Centres (CRCs) Program

The objectives of the Program are:

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

The Cooperative Research Centres Committee, which is appointed by the Minister, provides advice on the Program. Under the Program, new Government funding, rising to $140 million annually by 1996-97, will be provided to support up to sixty one Centres. During 1994-95, a selection process for ten new Centres was completed. The successful Centres were:

- Landscape Evolution and Mineral Exploration
- The Sustainable Development of Tropical Savannas
- Diagnostic Technologies
- Black Coal Utilisation
- Sustainable Sugar Production
- Weed Management Systems
- International Food Manufacture & Packaging Science
- Conservation and Management of Marsupials
- Quality Wheat Products and Processes
- Water Quality and Treatment
- Aerospace Structures (Extension)
- Premium Quality Wool (Extension)

Cooperative Research Centres are established under formal contracts, normally for seven years, with the Commonwealth to undertake long-term strategic research with a primary focus on the natural sciences and engineering and their application. By their very nature, CRCs do not achieve significant results in their early years. In a number of cases the benefits of the research will not be apparent for many years, if not decades. Nevertheless, some of the early Centres are now reaching the point where promising achievements are in evidence.

Recent Achievements

Fibre optics
The Australian Photonics CRC is engaged in the development of optical fibre and photonic technology - the use of light to process information - an enabling technology of the information superhighway. Its research outcomes include dispersion compensators that enable buried fibres to carry the ever increasing communications traffic; new components based on UV treated glass which enable cheap optical fibre interconnection to computers; optical current monitors for the power industry to make switchyards safer and billing more accurate; new switching technologies to cope with the communications traffic expected from multimedia communications; CAD programs to design the photonic networks of the future; and blue fibre lasers to store video information on CD's. These advances have arisen through a focused program which encompasses basic research and understanding, student training and community education, and product development. The Centre has established its own technology transfer company to cope with the growing demand in turning its R&D into products, and is in the process of establishing a spin-off company to retain that development in Australia.

Growth factors
The CRC for Tissue Growth and Repair recently constructed a hightech manufacturing facility capable of producing genetically engineered growth factors for the international market". Growth factors are small hormone-like compounds that are essential for the growth of cells in animals and humans.

GroPep Pty Ltd, the commercial arm of the Centre, presently markets and sells sixteen novel growth factors, two of which will be manufactured for the pharmaceutical industry at the new plant to meet stringent international standards, Good Manufacturing Practice (GMP) and ISO 9000.

New potential for pest control
The CRC for Tropical Plant Pathology has identified diagnostic DNA sequences for some of the most important pathogens, such as *Phytophthora* which is a cause of lost production in such areas as citrus and tropical fruits and native forests. These sequences will be used to develop improved diagnostics, which will lead to better disease management through use of disease-free planting material, and reduce the need for the use of chemicals.

Training eye technologists in Asia

Technical training in developing countries such as India and China is an important activity in the CRC for Eye Research and Technology. The method of education is seen as an entrepreneurial breakthrough where the technical training is the link between research and commercialisation. This training aims to educate new and existing contact lens practitioners and technicians in Asia. In countries such as China this training includes a one year certificate program. The training aids and the inclusion of interpreters in the teaching program are seen as an excellent way of advancing Australia's reputation in the technology field.

Passenger comfort in high-speed ferries

In July 1992 Western Australian high-speed ferry builder Austal Ships approached the Perth node of the Australian Maritime Engineering CRC (AMECRC) to investigate comfort improvement of passengers when ferries were operating in adverse conditions. Motion stabiliser systems had been developed in other countries, but there was an opportunity for an Australian product which would perform comparably with overseas products. AMECRC staff assisted in the development of an automatic system. Vessel motions have been reduced by over 50% through an on board computer which receives signals from motion sensors and sends signals to hydraulic pumps which continually adjust the fin and flap angles so as to produce forces which oppose the ship motion. The first two systems were installed on ferries bound for the Chinese market just 9 months after the contract with AMECRC was signed. The system is now fitted to vessels operating in China, Indonesia, Tahiti and Japan, with further orders for vessels in UK and Turkey.

Computer control in tropical pest management

The CRC for Tropical Pest Management is achieving major successes in tackling key pest problems in tropical Australia, including woody weeds and insect pests of tropical horticulture. The Centre has developed innovative virtual plant software for crop research and has produced four commercial software products for education and decision support in industry. Results from the implementation of the Centre's software products have included saving the pecan industry over $1 million. In the past year, the Centre has also increased its international activities, particularly in the AsiaPacific region, through training courses and collaborative research projects.

Industry Research and Development Board

Role *Through the operation of various programs, to facilitate wealth creation by the development of internationally competitive Australian industries through the encouragement of successful innovation and improving Australian firms' awareness of the role of innovation in business growth.*

The Industry Research and Development Board was established on 1 July 1986 under the *Industry Research and Development Act 1986*. Under this Act the Board has responsibility for administering several innovation programs which are the Tax Concession for Research and Development, Competitive Grants for Research and Development and Concessional Loans for Commercialisation of Technological Innovation.

Innovation Programs

Tax Concession for Industrial R&D

The tax concession for industrial research and development is designed to encourage Australian companies to become more innovative and internationally competitive by increasing their R&D activity. The program is effectively market driven, being structured in a manner which is neither industry nor product specific, allowing companies to determine both the area of innovation and the direction of their R&D activities. Syndication enables access to critical mass finance for new R&D for firms which would otherwise be unable to use the tax concession.

The 1994 Working Nation White Paper introduced a number of initiatives to the tax concession which came into effect during the 1994-95 year. The initiatives were:

Syndication - Lowering the R&D expenditure threshold for participation in R&D syndication from $1.0 million to $0.5 million. Access to scarce capital for R&D has been identified for some years as a critical factor constraining the growth of most SMEs. This change will significantly improve the scope for SMEs to attract critical-mass financing through syndication.

R&D Expenditure Thresholds - Removing the $50,000 R&D expenditure threshold and making expenditures of $20,000 or more eligible for the full 150% concessional deduction. This tax concession initiative clearly targets smaller businesses opening the way for a significant boost for R&D activity in Australia's small business community.

Overseas R&D Activities - Allowing certain overseas R&D activities to be eligible for the concession subject to prior discretionary approval by the Industry Research and Development (IR&D) Board. This change benefits both large and small companies. At present only R&D activities that are undertaken in Australia are eligible for the concession.

To preclude the exodus of R&D offshore, there are eligibility guidelines. In addition, the value of overseas R&D expenditure allowable is restricted to 10% of total R&D expenditure on the particular project. In this way companies will have greater scope and assistance in locating the best source of R&D facilities and expertise either in Australia or overseas but with the clear preference being for the development of indigenous R&D capabilities

Recent Achievements

Effectiveness

The Bureau of Industry Economics (BIE) completed two major reviews of the concession during 1994-95.

1. *Spillovers*

Spillovers arising from industrial R&D occur when the actions of an innovating firm affect any other party either positively (and this effect is not paid for) or negatively (and this effect is not compensated for). Spillovers are of interest to governments because their existence represents the strongest justification for subsidisation of private industrial R&D. This is because innovating firms base their R&D investment decisions on the expected private returns to R&D, but fail to take account of the un-paid effects on other parties.

In addressing the nature of spillovers from industrial R&D, the BIE study focused on three major benefits: knowledge spillovers, increases in consumers' surplus, and community benefits; the increased value that benefits downstream user firms and consumers from innovative products; and benefits identified which flow broadly to society.

2. *Syndication*

R&D Syndication induces significant new R&D in the companies that use it. The program acts to stimulate the supply of critical mass R&D funding for relatively sophisticated, but capital poor firms and to embed a commercial focus in the resulting R&D program. The BIE found that the program has an inducement rate of around 2.6.

There are many facets to successful commercialisation. Syndication plays a very significant role in accelerating and bringing forward R&D, with the result that innovations are earlier to markets than they would otherwise be. On average, firms estimated that the loss in commercial value by being late to market by one year was around 50 per cent - so the value of being early can be very great. Firms also suggested that syndication plays an important role in increasing the ease with which finance was available for the production

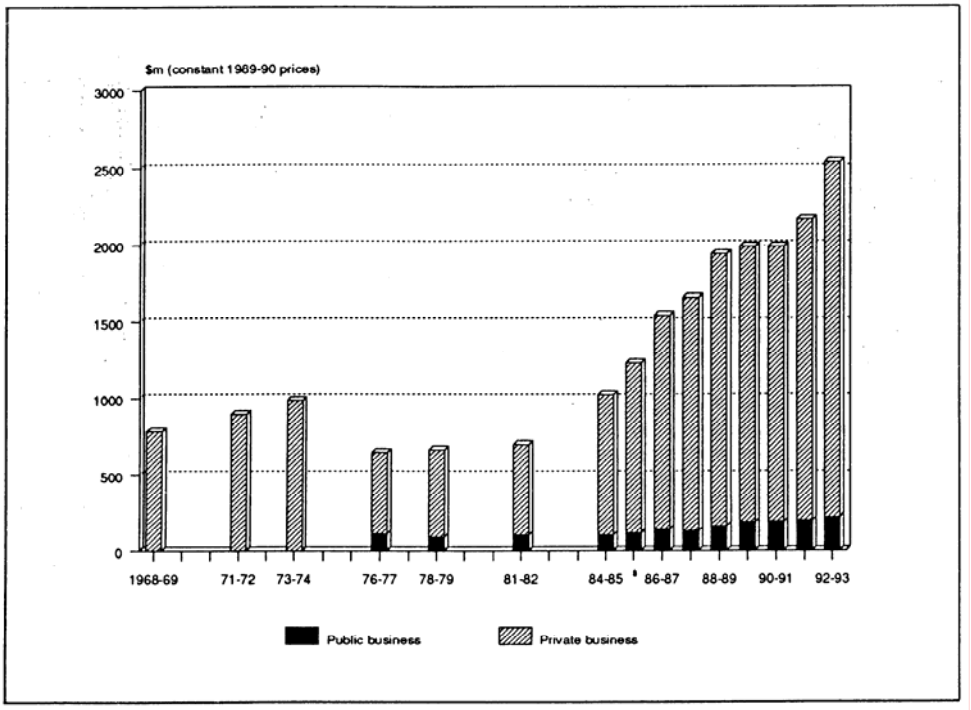
and commercialisation phases following R&D. As well, research managers thought that syndication eased switching between projects with lower compared to higher commercialisation prospects.

For a wide variety of parameter settings, the BIE found that the program generated net social benefits. The report found that 114 syndicates involving 81 research enterprises had conducted $825 million worth of R&D under the program up to August 1994.

Approximately 1000 firms consistently perform R&D each year and claim the concession, with about 2300 firms registering for the scheme in recent years. In 1992-93 the estimated gross cost to revenue of the incentive in terms of company tax forgone is $540 million. The trend in total R&D expenditure by the business sector is shown in Figure 8.

Figure 8

BUSINESS EXPENDITURE ON R&D



Source: DIST based on ABS data

Telecommunications multiplexer
Under syndication, JNA Telecommunications Ltd accelerated development of the AS200 multiplexer for supply to telecommunications carriers. The product is expected to generate about $60m internationally and $30m domestically over the next three years. At the time of syndication, JNA was a private company (established in 1960) with limited access to capital. With the intellectual property gained from the AS200 multiplexer, the company was able to float on the Sydney Stock Exchange in July 1992, raising $12 million in share capital. Since then, JNA has increased employment and is expanding internationally.

Health diagnosis products
ABCL is a manufacturer of advanced laboratory instruments that assist in the processing of tissue and smear samples used to diagnose various illnesses, including cancer. The company is strongly export oriented with about 95 per cent of sales being offshore. Four products have been developed under syndication and are generating exports.

Defibrillator
Nucleus Ltd used syndication to finance the development of the defibrillator, a high technology implantable medical device. The defibrillator project would have proceeded more slowly in the absence of syndication. This would have reduced the ability of the company to compete for a world market estimated at about $1.5 billion by the year 2000. The post syndication expected share of this market for Nucleus ranges from 10 to 14 per cent.

Concessional Loans for Commercialisation of Technological Innovation
Concessional loans support small firms in the early commercialisation of technological innovation of goods, systems or services.

Recent Achievements

Underground paging device
Mine Site Technologies, a small innovative company employing 10 people, received a concessional loan to assist with commercialisation of an innovative paging device which transmits messages directly through the earth. This will replace enormous lengths of phone lines and elaborate networks of aerials for radio communication. Mine Site Technologies will offer its improved product to the 380,000 underground miners in Australia, North America and South Africa. Growing export opportunities also exist in the large mines in China and South America.

High quality kit homes for export
Tasmanian Timber Engineering received one of the first concessional loans to support the company's efforts in producing high quality kit homes for the Japanese market. The development of a second prototype will allow Tasmanian Timber Engineering to address the $10 billion opportunity

presented by the Japanese housing market. The firm's Japanese partner has estimated that the export demand could see Tasmanian Timber Engineering having to expand their current product output by up to twenty times.

Competitive Grants for Research and Development
Grants for Research and Development provide support for a range of research and development projects, including:

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

Recent Achievements

Secure data transfer
Intellect is a fast growing technology company which has established significant local and international markets for its unique products. Intellect has developed a security encrypton processor to enable fast and secure customer credit, charge and smart card transactions at checkout counters. The processor also enables safe transfer of data between and within banks (ie inter-bank and intra-bank). Intellect's clients are major multinational computer companies including Unisys, AT&T, GIS, IBM, Siemens-Nixdorf and Fujitsu/ICL. The company was recently named 1994 Australian Exporter of the year.

Multiple-core Optical Fibre Devices (MOFD)
Siemens Ltd, in collaboration with the University of Sydney, the University of New South Wales, and the Australian National University have developed MOFD. MOFD equipment uses the special properties of optical fibres which contain two optical cores within the same fibre cladding. This will reduce the use of expensive optical devices such as splitters, filters and switches. The implementation of this new technology will allow transmission of extremely high speed data for high-resolution graphics and moving video.

Integrated building automation system
Sydney based Vanoco Pty Ltd has been active in software development and systems integration since its inception in 1988 and has recently entered the lucrative information technology markets of South East Asia. The company was able to successfully develop Real Time Integrated Building Automation System (IBAS). This system optimises energy use aimed at minimising the operational costs of large commercial buildings, and at the same time, provides security access via security cards. In addition to its use in building management, Real Time IBAS has been adapted to financial applications such as banking.

PRIMARY INDUSTRIES AND ENERGY

Science and Technology in the Portfolio Budget

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

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

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

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

Research Bureaux

The Department maintains three research bureaux:

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

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

$105.4 million in 1995-96. Research is generally directed to areas where the external benefits are high, at the more basic lines of research, in research that may have a wide social impact, and where user pays funding is not generally cost effective. In addition, the Bureaux undertake research on a contract basis for other agencies and industry.

R&D Corporations and Councils

R&D Corporations and Councils were established to encourage greater end user participation in research, to work with industry and research organisations to facilitate and actively pursue the commercialisation of research and the realisation of industry opportunities and to promote and become involved in technology transfer.

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

- Cotton R&D Corporation
- Dairy R&D Corporation
- Fisheries R&D Corporation
- Forest and Wood Products R&D Corporation
- Grains R&D Corporation
- Grape and Wine R&D Corporation
- Horticultural R&D Corporation
- Meat Research Corporation
- Pig R&D Corporation
- Sugar R&D Corporation
- Wool R&D Corporation
- Chicken Meat R&D Council
- Dried Fruits R&D Council
- Egg Industry R&D Council
- Honeybee R&D Council
- Tobacco R&D Council

It is proposed that as of 1 July 1995 the Tobacco R&D Council will become the Tobacco R&D Corporation and the Chicken Meat and Egg Industry Councils will be merged with the Rural Industries R&D Corporation.

Provision is made for Commonwealth funding of these bodies based on dollar for dollar matching of industry determined research levies up to a maximum of 0.5 percent of gross value of production (GVP) of the industry (up to 0.2 percent GVP matching and 0.5 GVP percent Government appropriation for the fishing industry). The Government's matching contribution is designed to provide an incentive for the primary sector to increase its R&D funding and to become more responsible for its own R&D priority setting.

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

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

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

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

MAJOR RESEARCH ACTIVITIES

Australian Bureau of Agricultural and Resource Economics (ABARE)

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

Recent Achievements

Model of world markets for iron ore and steel

A world iron ore and steel trade model was developed by ABARE. The model was used to examine the implications of continued growth in the Chinese economy for iron ore and steel industries worldwide. China is becoming an

increasingly important player in the world iron ore and steel market. The prospects for the Chinese steel industry are closely linked to the outlook for the Australian iron ore industry.

MEGABARE
ABARE continued to develop its global macro-economic general equilibrium model (MEGABARE). The model has been refined significantly over the past year to allow time paths for economic variables to be mapped and the ability to analyse regional trade arrangements, such as, APEC, has been enhanced. MEGABARE is currently being used to quantify the impacts of greenhouse response policies on trade and industry structure at the international and domestic levels.

Projecting feed grain demand
A model was developed to link average ration demands from various livestock sectors to estimate aggregate demand for feed grains in Australia over the next five years. Analysis of outputs from this model is being used by the grain industry for strategic planning purposes.

Northern prawn fishery
Abioeconomic model was developed to assess the relative benefits likely to accrue from alternative management options in the northern prawn fishery. Results from a number of simulations have enabled the economic assessment of policy options in the fishery. Implications for the long term management of the fishery will be detailed in future ABARE research.

Bureau of Resource Sciences (BRS)

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

Recent Achievements

Fishery status reports -1993
Resource assessments of Australian Commonwealth fisheries were released in September 1994 in one volume entitled *Fishery Status Reports 1993*. The reports contain a statement of the current status, relevant background and research needs for all major Commonwealth fisheries. The reports provide

an excellent reference for a range of fisheries issues and are widely used by government, fishers and the general public. BRS is currently updating these reports for 1994.

Review of seedborne diseases
BRS conducted an extensive review of diseases of concern that may be introduced on seed of 24 crop genera. Crops covered include grain legumes, oilseeds, tropical pasture legumes, tropical grasses, tomato and temperate pasture legumes. The work was an important part of Australia's contribution to recent international developments in pest risk analysis. This work was summarised in a publication entitled *Summary Review of Seedborne Diseases for 24 Crop Genera in Australia*.

Technology transfer
BRS has established the Advanced Systems Institute to provide focused training in advanced computing technologies for decision makers and others involved in sustainable development programs. The Institute provides, in cooperation with hardware and software vendors, a range of general, advanced and specialist courses in technologies and their application to natural resource analysis and management. A key achievement for the year was the development and presentation of a two-week course in coastal zone information management for representatives from the ASEAN countries.

Objective criteria for exceptional circumstances declarations
An objective framework to assess when Drought Exceptional Circumstances exist was developed within the Department of Primary Industries and Energy (DPIE) in consultation with the States and endorsed by the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). BRS, the Australian Bureau of Agricultural and Resource Economics (ABARE) and the Rural Division of DPIE assisted the Rural Adjustment Scheme Advisory Committee (RASAC) to use these criteria to assess applications from the States and the Northern Territory for Drought Exceptional Circumstances.

Australian Geological Survey Organisation (AGSO)

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

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

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

Recent Achievements

New energy source
AGSO research has demonstrated that a hot dry rock resource that could supply all of Australia's energy requirements at current usage for the next 7 500 years resides within the top 5kms of Australia's crust, mostly beneath the Eromanga Basin in western Queensland and north east South Australia. As a result of this research project an industry research consortium has been formed to trial the concept.

Improving exploration efficiency
In a joint research project with a petroleum exploration company, AGSO has achieved a significant insight into the timing and controls on hydrocarbon migration in the Timor Sea and developed a powerful exploration tool for improving exploration efficiency.

Renewed focus on Cooper-Eromanga
Results from the Queensland portion of AGSO's joint National Geoscience Mapping Accord Sedimentary Basins of Eastern Australia project have been completed. The project influenced the Queensland government to focus its effort on evaluating the Cooper-Eromanga Basin. The results of the project suggest that there are not sufficient petroleum resources in Bowen-Surat to supply Queensland's growing energy demands.

Understanding Australia's fisheries
Following a swath mapping survey to the south west of Tasmania using the advanced technology aboard the French research vessel *L'Atalante,* AGSO has released in consultation with CSIRO and State Fisheries several bathymetry maps identifying new sea mounts which have led to the identification of additional fishing resources. The maps have been well received by the Southern Trawl fishing industry and conservation

arrangements for two of the fisheries are now underway. This work has also supported Australia's claim to territory outside the 200 mile Economic Exclusion Zone under the United Nations Convention on the Law of the Sea.

Groundwater mapping
The hydrogeological map series over the Murray Basin was completed in 1995. This cooperative AGSO and State agency project has produced 26 map sheets of detailed groundwater quantity and quality information. These will be used to determine long term sustainability of the groundwater resource and the Basin's environmental and production based eco-systems.

Port Phillip Bay
AGSO was awarded a contract to examine the impact of human activity on estuarine and coastal systems in Port Phillip Bay. Geochemical results from that study resulted in the adoption of a new model for water - sediment - nutrient interaction in the Bay which will impact on the development of future management strategies.

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 managing research and development programs; and facilitating the dissemination, adoption and commercialisation of the results of research and development.*

Its mission is to increase economic and social benefits for the fishing industry and the people of Australia, through planned investment in research and development in an ecologically sustainable framework.

The National Research Advisory Network, which comprises of committees in each State and the Northern Territory, advises the FRDC on priorities for fisheries R&D and the relevance and priority of specific applications, thus minimising duplication and ensuring maximum returns on investment.

Recent Achievements

Seafood Catering Manual
This is the seafood industry's first national catering manual. It was published jointly by the FRDC and the Agribusiness Marketing Services Unit of the Queensland Department of Primary Industries. The manual is aimed at caterers, seafood distributors, exporters, overseas importer's, retailers,

trainers, and researchers; it is a 'hands-on' book designed for use 'on the job'. The book describes species and alternatives and includes quality assurance and assessment procedures, information on buying, storage, hygiene, preparation, cooking, and marketing.

Grains Research and Development Corporation (GRDC)

Role: *The GRDC is a statutory corporation funded jointly by a levy on grain growers, and matching Commonwealth contributions. At present, there are 25 leviable crops spanning temperate fuel tropical cereals., oilseeds and grain legumes. The Corporation has a mandate to plan, develop and oversee research and development in the industries which encompass these crops. The Corporation's primary goal is to invest in research, development and related activities to benefit Australian grain growers, within a wider grains industry and community context.*

Recent Achievements

Asian consumer preferences
Asia is the premium market for Australian wheat with noodles being the major food produced. This year, with assistance from the GRDC, a study was undertaken to assess Asian consumer preferences for noodles. The study concentrated on the preferences of Korean women for noodles made from different types of Australian wheat. The research showed that there is an Australian taste preference, which is quite different from indigenous Korean preferences and that the preferences of Koreans resident in Australia for long periods of time, change to reflect Australian taste preferences. Koreans resident in Australia can only be used to test Korean tastes in the first two years of residence. Next year's research in this project will focus on Japanese consumers.

Healthy grains
Chickpeas could be a protein wonder-food matching the protein levels of dairy food and with lower cholesterol levels. This follows GRDC-funded research at the CSIRO Division of Human Nutrition into pulse grains including chickpeas, peas, lentils and f aba beans. The research showed blood cholesterol levels declined significantly in test rats on pulse diets, compared with those on casein (dairy) diets. For athletes, the research showed

combining pulses with cereals boosted body weight gain. Cereals are a superior source of sulfur-amino acids and compensate for the deficit in pulses. Breakfast and snack-food manufacturer All-gold, based in Leeton, NSW, is now evaluating combining pulses and cereals in breakfast and snack foods.

Rust breakthrough
The scientists at CSIRO Plant Industry and at the Cooperative Research Centre (CRC) for Plant Science have isolated, for the first time, a gene which can give plants rust-resistance. These scientists have for years been unravelling the relationship between the disease-causing fungi and the plants. Isolation of flax rust resistance genes has opened the door for scientists to insert a range of resistance genes into vulnerable crops, without otherwise altering their strengths. The breakthrough provides techniques that may be used to isolate resistance genes in wild grasses and allow their transfer to elite wheat cultivars. This was not possible before because the species could not be cross-bred.

Golden bullets hit bullseye - transformed wheat
This year with GRDC support CSIRO scientists have successfully introduced new genes into wheat - the last of the large-scale cereal crops to have undergone this process. CSIRO's Division of Plant Industry has confirmed the presence of an introduced bacterial gene for herbicide resistance in progeny of transformed wheat plants. The key to this success has been a new method of introducing DNA into plant tissue. Tungsten or gold microparticles are coated with DNA which holds the genes, in this case for herbicide resistance. The particles are shot at high velocity into young wheat embryos. The benefit of gene transfer is that traits such as improved dough-making and starch qualities, disease or herbicide resistance can quickly be introduced with little or no change to the otherwise superior qualities of the cultivar. This technology provides plant breeders with a simple method for producing a wide cross which normally requires years of back-crossing to bring an altered cultivar back to it's original quality.

Grape and Wine Research and Development Corporation (GWRDC)

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

Recent Achievements

Grapevine development
A major review by Dr Peter May, of the role of rootstocks for grapevines has been concluded, addressing issues such as adaptability to sites, pests and disease, soil salinity, drought and grape quality. Published as a 62 page document and citing over 270 references, this publication will become a key source of information in the development of Australia's winegrape, dried grape and table grape industries.

Oak Barrels and Wine Quality
A longer term study of the origin, type and means of seasoning wine barrel oak has provided very valuable information on the influence of these characteristics on wine style and quality. Differences were found between the same French wood, seasoned in Australia compared with France. The level and degree of control of coopering heat significantly influenced wine quality, more so than oak origin or seasoning. More precise control of coopering heat offers considerable potential to better influence and manage wine quality.

Horticultural Research and Development Corporation (HRDC)

Role *To faster efficient, competitive and adaptable horticultural industries with a view to improving their overall performance and well-being of horticulturalists and the community at large.*

Recent Achievements

Import substitution of gherkins
The Corporation has continued to assist the development of the pickled vegetable industry in the Riverina area. This industry now efficiently produces a high quality product that has replaced the use of imported gherkins used in the fast food market. The production of gherkins is now expected to reach a turnover of $10 million ex-factory and $3.5 million ex-farm by June 1996. Export markets in New Zealand and South East Asia are now being developed.

Storing peeled potatoes
An integrated system for extending the shelf life of pre-peeled whole potatoes from 2-3 days to 3-4 weeks has been developed. The system eliminates the need to use sodium metabisulphate as a preservative. It will allow the industry to value-add while at the same time addressing consumer demands for product variety and convenience.

Control of seed borne diseases of flower seeds
Steam-air treatments to control diseases borne by flower seed have been developed to replace hot water treatments. The treatment produces a number of benefits including easier handling of seeds because of dry conditions after treatment, a higher percentage of germination and better disease control. Steam air treatments also significantly reduce fungicide usage and minimise operator risk and environmental concerns. Growers have expressed interest in the purchase of a commercial model of the treatment unit.

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:

Sugar genes
Genetically transformed sugarcane plants were established in the field for the first time in 1993-94. Spectacular progress in the technology of microprojectile transformation in the past two years has established Australia as the world leader in sugarcane transformation. Rapid progress in improving the efficiency of the transformation system, isolation and testing of useful genes and promoters for disease and cane grub resistance, and the application of gene marker technology to sugarcane breeding and testing of germplasm integrity has made the commercial application of biotechnology an achievable goal in the medium term.

Pest management of the sugar field
Integrated pest management of rodents has been introduced to sugarcane producing areas. Annual surveys indicate that damage by rodents extends to over 50% of Australian sugar producing areas and results in annual losses of between $2 million and $4 million. A further $0.6 million is expended on annual baiting programs. Prior to 1987, the only strategy to control rodents in sugarcane involved widespread application of rodenticide which was

inefficient and not cost-effective. Projects conducted by the Bureau of Sugar Experiment Stations (BSES) and the Queensland University of Technology (QUT) partly funded by SRDC have provided an understanding of the processes responsible for rodent damage. More attention to in-crop weed control, the modification of non-crop areas to make them less suitable as refuges for rodents, and the strategic use of baits are all important components of an integrated control program.

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

Processing of dried vine fruit
The development of metering equipment to enable a constant flow of fruit into the processing line has provided efficiency gains, reduced processing costs, and improved product quality by eliminating fruit surges that lead to the sub-optimal operation of processing and packaging equipment. The development of the "front end" equipment compliments the modification of other processing equipment aimed at improving the quality of the final product.

Energy Research and Development Corporation (ERDC)

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

- Reduce the amount of energy required to be supplied;
- Reduce customer energy costs.

ERDC was established in 1990 to facilitate and stimulate effective energy innovation for the benefit of Australia. It has an annual appropriation of approximately $12 million. In the financial year 1993-94, ERDC committed $15.9 million to 66 projects which have a total project cost of $39 million. Since its establishment, ERDC has committed $46 million to projects which have a total project cost of $150 million.

Recent Achievements

Biomass in the energy cycle
A major report for the renewable energy sector, *Biomass in the Energy Cycle*, was released in February 1995. Biomass-based energy has the potential to reduce significantly Australia's greenhouse gas emissions by reducing our reliance on coal-fired electricity and by the development of alternative liquid fuels. The report provides an action plan for the industry in Australia, based on identification and analysis of the main strategic issues. Various projects were proposed to develop and promote the biomass-based energy industry in Australia, based on:

- heat and electricity generation from waste streams, including municipal solid wastes, food processing and animal/human wastes; and
- liquid fuel production from food processing wastes and lignocellulose.

High temperature heat pumps
Water heating in the industrial and commercial sectors in Australia costs $1.5 billion each year and comprises about 10% of the nation's annual energy consumption. The successful technical and commercial viability of high temperature heat pumps (HTHP) for water heating in the range of 60-80°C was demonstrated at a Brisbane hotel, with considerable savings provided to the owners. The electricity industry now has a product which can compete with other methods of water heating, such as gas or resistance heating. Increased efficiencies mean that less electricity is used, and there is potential for reducing greenhouse gas emissions produced from heating water.

International collaboration
Through the ERDC, Australia has recently increased its involvement in the activities of the International Energy Agency (IEA). The benefits of this involvement include the sharing of research information, providing a platform for Australia's activities in energy research, and contributing to the directions of IE A priorities and activities. ERDC has signed the following IEA Implementing Agreements, on Australia's behalf:

- Solar Heating and Cooling;
- Greenhouse Gas R&D;

International collaboration
Through the ERDC, Australia has recently increased its involvement in the activities of the International Energy Agency (IEA). The benefits of this involvement include the sharing of research information, providing a platform for Australia's activities in energy research, and contributing to the directions of IEA priorities and activities. ERDC has signed the following IEA Implementing Agreements, on Australia's behalf:

- Solar Heating and Cooling;
- Greenhouse Gas R&D;
- Solar Power and Chemical Energy Systems;
- Demand Side Management;
- Energy Conservation in Buildings and Community Systems;
- Energy Technology Data Exchange.

Land and Water Resources Research and Development Corporation (LWRRDC)

Role *To improve the long-term productive capacity, sustainable use, management and conservation of Australia's land, water and vegetation: resources through a directed, integrated and focused research and development effort.*

Recent Achievements

Monitoring of pesticides
The CSIRO Division of Plant Industry developed new Enzyme-Linked ImmunoSorbent Assay "ELISA" kits to detect and monitor pesticides in water in field situations. Costing only a few dollars per sample, the kits are contributing to safer water recycling, storage and discharge practices, especially in the cotton, rice and horticultural industries.

Effluent disposal on land
The Queensland Department of Primary Industries has programmed a series of "user-friendly" computer software modules to improve the design of land-based effluent treatment systems for specific rural industries. Feedlots, piggeries, abattoirs or even sewerage treatment plants can use the "Model of Effluent Disposal for Land Irrigation" (MEDLI) to ensure that land disposal of effluent is done in a sustainable way.

Algal blooms

A research project into the cause of algal blooms found in New South Wales, Victoria, South Australia and Queensland has been completed by the Murray-Darling Freshwater Centre. As a result, a set of physiological assays has been developed to determine the relative importance of nitrogen and phosphorus limitation to algal growth.

The Research Centre also demonstrated that algal "grazers", such as water fleas and other zooplankton, are as important as nutrients in limiting algal blooms in some freshwater dams. The research will assist in using biomanipulation of zooplankton to control algae in lakes.

Sharing water

The Centre for Water Policy Research at the University of New England produced an integrated economic model of supply, demand and distribution of irrigation water to the cotton industry in the lower Gwydir Valley of New South Wales. Water managers are using the model and its decision support systems to produce benefits for both irrigators and wetlands through capacity sharing, trade in water entitlements and strategic timing of water releases.

Controlled waterlogging

A farmer-designed "alley farming" vegetation system, with the potential to pay for itself within three years, was further developed by the Western Australian Department of Agriculture to slow the rise of water tables and to maximise production. Commercial trees and semi-commercial salt tolerant species are used in combination with forage and perennial pastures to reduce waterlogging.

Rural Industries Research and Development Corporation (RIRDC)

Role *To manage research and development investments on behalf of government and industry for the benefit of the people of Australia.*

This will be achieved by:

- enhancing innovation in the rural and related sectors;
- fostering the development of new industries; and
- addressing strategic issues facing the rural sector.

The Corporation organises and funds research to support small, emerging and new rural industries such as Asian foods, spices and herbs, wildflowers, ostriches and emus. RIRDC also addresses broader issues which affect most if not all agricultural industries: such as agroforestry, agribusiness,

extension and rural education. The Corporation also provides services for the five semi-independent research and development councils, i.e. Chicken Meat, Dried Fruits, Egg, Honeybee and Tobacco.

The establishment of a new national equine research and development program, which incorporates a Research Advisory Committee and a RIRDC-funded research program coordinator, to facilitate the management of the research program and to guide its future direction was launched in January 1995.

Recent Activities

Asian foods
Three reports on Asian foods were completed as follows:

- *Asian Food - Getting a Bigger Bite* has determined demand for Asian processed foods and has surveyed the domestic industry. The report recommends ways in which RIRDC, government and industry can take steps to encourage more investment in the domestic industry, to replace imports and promote export growth.
- *Food Distribution in China and Hong Kong - Market Profile and Directory* provides a detailed insight into the structure and workings of selling within these competitive markets. It also provides a list or the key import distributors and agents.
- *The Market for Processed Food and Beverage Products in Urban China* is the result of interviews with over 5000 shoppers in four major Chinese cities during May-June 1993 to survey and analyse expenditure patterns, consumer profiles and market size.

Wildflowers and native plants
The most comprehensive baseline study of the Australian wildflower industry has been completed. This study provides much needed data on the industry; analyses its markets, economics and capabilities; and identifies future industry options and strategies. The production of wildflowers in Australia is valued at an estimated $40 to $45 million a year, with exports value at about $20 million in 1992-93.

PRIME MINISTER AND CABINET

Science and Technology In the Portfolio Budget

Expenditure on science and technology policy and programs through the Office of the Chief Scientist was $2,0 million in 1994-95 and is expected to remain the same ($2.0 million) in 1995-96.

MAJOR POLICY ACTIVITIES

Prime Minister's Science and Engineering Council (PMSEC)

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

The Prime Minister chairs the Council and the Minister Assisting the Prime Minister for Science is the Deputy chair. The Chief Scientist is a member of the Council and is also the Executive Officer. Membership includes Ministers with primary responsibility for science and technology matters, and representation at the most senior level from the business and science and technology communities and from the trade union movement.

PMSEC has played a valuable role in involving senior Ministers in discussions of current issues in science and technology, with a particular emphasis on the application of research to economic and social objectives. It has assisted greatly in the development of policy, with many of its discussions giving new impetus to the resolution of issues within Government.

PMSEC has the following terms of reference:

- to address important issues in science, technology, engineering and relevant aspects of education and training
- to examine the contribution of science, technology and engineering to the economic and social development of Australia
- to enhance awareness in the community of the importance of science, technology and engineering for Australia's economic and social development
- to examine Australia's science and engineering resources and the effectiveness of their organisation and utilisation
- 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

At the June 1994 meeting, the Council heard presentations on issues arising from the rapid development of information and communications services and technologies, including the work of the Broadband Services Expert Group (BSEG), and the ASTEC study of research data networks.

The BSEG report is a wide-ranging discussion of the impact of broadband and other networked services on Australia, and the issues arising from their development. Partly as a response to the report, the Prime Minister has announced the formation of a high level National Information Services Council under the auspices of PMSEC, and has indicated the Government's intention to address the issues arising from information services over coming months drawing on advice from that Council. The issues raised in the ASTEC report will be considered as part of that process.

The reports on *High Performance Computing and Communications*, (HPCC) and *Research for a Healthy Society*, considered at the Council meeting in December 1994, contained a number of recommendations for further action by government, including the development of a National HPCC Action Plan, additional funding for HPCC initiatives, and the development of Centres of HPCC Expertise. These matters were referred to the relevant Ministers for action who have been asked to report back to Council at its next meeting.

Coordination Committee on Science and Technology

Role *To allow departments and agencies with an interest in science and technology to share information about their programs, policies, problems and work plans. This helps ensure coherence and consistency in the implementation of Government policy for science and technology, and allows an overview by the Committee of that policy.*

The CCST's Terms of Reference, adopted in 1994-95, are:

- to provide coordinated advice to the Government through the Minister Assisting the Prime Minister for Science 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.
- to exchange information among departments and agencies on domestic and international science and technology programs, policies, work plans, issues and opportunities.

Recent Achievements

The Coordination Committee has, during 1994-95:

- contributed to the development of the Government's forthcoming Innovation Statement;
- undertaken a review of the implementation of the recommendations of a 1992 paper to PMSEC on Australia's science and technology links with the Asia-Pacific region, and advised the Minister Assisting the Prime Minister for Science on these links, in the context of the development of the Innovation Statement;
- advised the Government on responses to an ASTEC report on research and technology in tropical Australia, and a paper to PMSEC on gene technology;
- discussed the draft report on research and development by the Industry Commission;
- contributed to developing the Major National Research Facilities Program and advised Government on proposals which should be funded under the Program
- published a paper on the national goals for science and technology, and how science and technology performing and funding agencies build these goals into their priority setting processes.

Office of the Chief Scientist

Role *To provide policy advice, briefing and support directly and through the Chief Scientist, to the Prime Minister and Minister Assisting for Science; coordinate S&T policy advice and development across portfolios, both directly and through the Prime Minister's Science and Engineering Council (PMSEC) and the Coordination Committee on Science and Technology (CCST); and supports the Chief Scientist and the Australian Science and Technology Council (ASTEC)*

The Office of the Chief Scientist:

- provides advice and information on issues relating to S&T, directly and through the Chief Scientist, to the Prime Minister and the Minister Assisting for Science.
- consults with Ministers, their offices and departments and agencies to ensure effective policy development and coordination on S&T-related issues.
- provides secretariat support and advice to the Prime Minister's Science and Engineering Council, the Coordination Committee on Science and Technology, and the Australian Science and Technology Council.
- initiates and develops new policy proposals where appropriate, in cooperation with other departments.
- advises on the work of Cabinet Committees, such as the Structural Adjustment and Trade Committee, as appropriate.
- consults with key stakeholders and the broader science and technology community, informs them of the roles and impacts of PMSEC, ASTEC and the CCST, helps identify key S&T-related issues, and brings a wide range of views and experience to bear on the development of policy advice.
- provides support for the Chief Scientist in his interactions with governments, researchers and business.

Recent Developments

Women in Science and Technology

The Office of the Chief Scientist has supported the work of the Women in Science and Technology (WISET) committee, which was established in December 1993 as an expert group to advise the Government on ways to encourage greater participation and retention of women in science and

engineering careers. WISET issued a discussion paper in December 1994. A final report is expected to be completed in April 1995, for consideration by the Minister Assisting the Prime Minister for Science.

Access to Australia's Genetic Resources
During 1994-95, OCS has continued to work with all States and Territories to develop a national approach to managing access by scientists and industry to Australia's biological resources.

A Commonwealth-State Working Group on Access to Australia's Genetic Resources, supported by the Office of the Chief Scientist, has been established. The Working Group is to investigate and report on action required to develop a national approach to access to Australia's genetic resources. This will include the identification of benefits for the Australian community, including protection and promotion of Australia's commercial, nature conservation and scientific interests; and appropriate mechanisms to govern access, collection, processing, development and export of Australia's genetic resources.

Other Initiatives
The Office of the Chief Scientist has played a major role in coordinating government activity on information and communications services and networks. Since mid 1994, it has chaired an interdepartmental committee focusing on the government's role in information services and networks, including the development of best practice in its own use of these services and networks, and the use of networks to deliver services to its clients. This has catalysed a number of initiatives in departments.

During 1994-95, the Office has consulted with the Australian scientific community on the state of our greenhouse-related science, and possible future directions for research. This led to advice to Government on the role of science and research in addressing greenhouse concerns.

Australian Science and Technology Council

Role *ASTEC is a principal source of independent advice to Government on a wide range of policies and programs related to science and technology, and of concern to Commonwealth departments and agencies, higher education institutions and private enterprise.*

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 and technology, including;

- the advancement of scientific knowledge;
- the development and application of science and technology in relation to the 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

The Networked Nation
ASTEC's ten-month investigation of Australia's future requirements for research data networks culminated in the tabling of its report *"The Networked Nation"* in Parliament on 21 September 1994. This report:

- examines the history of research data network developments in Australia and overseas,
- outlines the benefits of such networks, and
- provides a plan whereby future requirements identified in the report can be met.

The report links access to global information resources to international competitiveness and a knowledge-based society and then outlines a vision for the future which gives Australia the opportunity to enter the twenty first century with unprecedented capacity to use and benefit from networked information.

Four major requirements are identified;

- a national high-speed backbone service
- universal, affordable network access
- promotion of Australian development of information network services
- improved network management.

These requirements are needed not only by the research and higher education communities but increasingly by the broader community. Five recommendations set out how Australia can meet these requirements. *Recommendation One* calls for the establishment of a more coordinated approach to research data network delivery through the establishment of a consortium to provide high-speed backbone service. *Recommendation Two* addresses more timely provision of network access in higher education institutions. *Recommendation Three* outlines how business and industry in

Australia can increase its access to global networking. *Recommendation Four* sets out a strategy for government to use these networks and *Recommendation Five* addresses networking in schools.

Matching science and technology to future needs

Australia will face many new challenges in the 21st century - growing environmental concerns, an aging population, changing employment patterns and our evolving role in Asia. ASTEC's current study, *Matching Science and Technology to Future Needs: 2010*, is exploring Australia's needs for science and technology into the next century - focussing out to the year 2010. ASTEC believes this study has the potential to be of great benefit to our economic and social future and our capacity to maintain a healthy environment.

The study is intended:

- to foster communication within the science community, and between the scientific community and users of research and the wider public;
- to generate consensus about needs and opportunities; and
- to raise awareness among the science and technology community (both in the science base and in industry) of the long term potential of areas of technology and markets.

The Minister for Industry, Science and Technology and Minister Assisting the Prime Minister for Science, Senator Peter Cook, launched the study at the Powerhouse Museum in Sydney on 8 September 1994. At the launch, the Minister urged all Australians to think about their future and Australia's ability to meet that future in terms of science and technology.

The terms of reference for the study commit ASTEC to provide an information base which can assist government and industry to make better informed decisions on the development and application of science and technology. The study will only succeed with widespread co-operation. ASTEC has therefore sought to involve all interested parties with a stake in science and technology.

ASTEC is facilitating five separate collaborative foresighting studies called partnerships. These are in the areas of urban water life cycle, information and communications technology, health, shipping, and a study of the attitudes of youth to science and technology and its effect on shaping the future. Together, these studies form a central element of the Future Needs study by testing foresight techniques in sectoral areas with the relevant research and user organisations. The benefits to partners include:

- knowledge of foresighting techniques for long-term planning;
- networking between sector research users and performers;
- strategic planning out some 15 years;
- identification of issues for the sector in 2010; and
- identification of science and technology requirements to realise the preferred future for 2010.

TRANSPORT

Science and Technology 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, transport sector research by the Bureau of Transport and Communications Economics, the Australian Road Research Board and the Department of Transport's involvement in the introduction of Intelligent Transport Systems into Australia. Expected expenditure outcomes are $5.5 million for 1994-95 and $4.4 million for 1995-96.

MAJOR RESEARCH ACTIVITIES

Federal Office of Road Safety

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

The 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 to ensure that resources are directed towards achieving the most appropriate, cost effective measures to achieve the ongoing objective of positively addressing and minimising the national road toll.

Recent Achievements

Fatal crashes
Considerable attention has been devoted over the past year to the development of more reliable and detailed databases and the identification of appropriate analytic methods. A monthly fatality statistics database has been established. This should allow the more timely monitoring of road fatalities on a national basis.

Four wheel drive and light commercial vehicle occupant protection

In recent years, the use of four wheel drives and, to a lesser extent, light commercial vehicles to carry passengers has increased. Following a recent review, the level of occupant protection provided by these vehicles is to be improved. The first step is to bring the Australian Design Rule (ADRs) requirements for these vehicles up to those for passenger cars. These requirements were determined as national standards in December 1994 and begin to come into effect from July 1996. The second and third steps will look at applying ADR 69/00, the new passenger full frontal crash standard, which comes into effect July 1995, and new dynamic side and offset frontal crash requirements to these vehicles.

Bus safety

FORS has managed a consultancy, in conjunction with the National Road Transport Commission and with the support of the Australian Bus and Coach Association, to develop guidelines for improving the safety of existing buses. They provide guidance for the modification of existing buses to improve occupant protection in the areas of:

- seat and partition padding;
- emergency exit signing;
- seat and seat anchorage strengthening; and
- seatbelt installation.

Vehicle emission standards

Air pollution from motor vehicles is a major community concern. Vehicle emission standards introduced over recent years have resulted in a gradual and sustained improvement in urban air quality, but further work is needed to counter the effects of an ever-growing vehicle fleet, and the potential impacts of rapidly growing commercial vehicle numbers. A new Australian Design Rule for diesel engine emissions came into force on 1 January 1995. A much tighter standard for petrol engine vehicles has been approved and is to take effect from 1997.

Australian Road Research Board

Role *The Australian Road Research Board (ARRB) is the principal centre for road and related transport research in Australia. It is a non-profit public company which was established in 1960.*

Its members comprise the eight State and Territory road transport and traffic authorities, the Federal Department of Transport and the Australian Local Government Association. It has an annual budget of some $10 million of which the Federal Department of Transport currently contributes $2.2 million annually.

Recent Achievements

Measuring paved surfaces
ARRB has developed a Walking Profilometer. This invention will revolutionise the way paved surfaces are measured. Surveys that previously took days can now be completed in hours. Not only saving time and money, the Walking Profilometer will provide new opportunities for managers, engineers, surveyors and contractors responsible for building and assessing paved surfaces. ARRB has lodged a world-wide patent for the device, which has significant export potential.

BUREAU OF TRANSPORT AND COMMUNICATIONS ECONOMICS (BTCE)

Role *To assist policy development and informed public debate on transport and communications issues through relevant, high quality and timely research.*

Recent Achievements

Greenhouse gas emissions
The BTCE has undertaken research into greenhouse gases with funding allocated from the Prime Minister's December 1992 Environment Statement. This research has developed long-term forecasts of greenhouse gas emissions from the Australian transport sector, and work is now proceeding on modelling behavioural responses to mitigation instruments.

This Statement was prepared by the Science and Technology Analysis Section, Department of Industry, Science and Technlogy, based on contributions from many Commonwealth agencies.

The Section also produces a number of other publications designed to promote informed public discussion on science, technology and innovation issues. If you require more information on these publications, please contact the Section on (06) 276 1252.

Each year, the Government compiles this record of publicly funded scientific achievements. Information on the diverse range of current research and development projects is presented, including 'golden bullets' that implant genes giving herbicide resistance to wheat, advances in bionic vision, and new high-speed wind tunnels for the development of the next generation of space vehicles.

This publication provides many useful insights into our national research accomplishments and the Government funding arrangements which underpin them. It will be of interest to all members of the community, including students, academics, business leaders, government officials, scientists and engineers.

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