



Science and Technology Budget Statement 1999 - 2000



Senator the Honourable Nick Minchin
Minister for Industry, Science and Resources

C O M P E T I T I V E A U S T R A L I A

SCIENCE AND TECHNOLOGY
BUDGET STATEMENT
1999-2000

CIRCULATED BY
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MINISTER FOR INDUSTRY, SCIENCE AND RESOURCES

DEPARTMENT OF INDUSTRY, SCIENCE AND RESOURCES
CANBERRA 1999

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WORLD WIDE WEB

AUSTRALIAN SCIENCE AND INFORMATION PAGES

Science and Technology

Anglo-Australian Observatory	www.aao.gov.au/
AusIndustry.....	www.ausindustry.gov.au/
Australian Antarctic Division	www.antdiv.gov.au/
Australian Broadcasting Corporation, Science Programs	www.abc.net.au/science/
Australian Geological Survey Organisation (AGSO).....	www.agso.gov.au/
Australian Institute of Marine Science (AIMS).....	www.aims.gov.au/
Australian Nuclear Science and Technology Organisation (ANSTO)	www.ansto.gov.au/
Australian Research Council	www.deetya.gov.au/nbeet/arc/arc.htm
Bureau of Meteorology.....	www.bom.gov.au/
CSIRO	www.csiro.au/
Cooperative Research Centres.....	www.isr.gov.au/crc/index.html
Defence Science and Technology Organisation (DSTO)	www.dsto.defence.gov.au/
Department of Industry, Science and Resources.....	www.isr.gov.au/
Great Barrier Reef Marine Park Authority (GBRMPA)	www.gbrmpa.gov.au/
IPAustralia.....	www.ipaustralia.gov.au/
National Health and Medical Research Council (NHMRC).....	www.health.gov.au/nhmrc/
Rural R&D Corporations.....	www.affa.gov.au/affa/statutory-authorities.htm
Science and Technology Advisory Bodies	www.isr.gov.au/science/bodies/bodies.html

General Information on Australia

Australian Bureau of Statistics	www.abs.gov.au
Australian Federal Government Entry Point.....	www.fed.gov.au
Australian Universities	www.deetya.gov.au/highered/unis.htm
Major Australian Newspapers:	
<i>Australian Financial Review</i>	www.afr.com.au/
<i>Sydney Morning Herald</i>	www.smh.com.au/
<i>The Age</i>	www.theage.com.au/
<i>The Australian</i>	www.theaustralian.com.au/home/

HIGHLIGHTS

In 1999-2000 Commonwealth support for major science and innovation programs is expected to be almost \$4 billion in accrual terms*, with a dollar increase over 1998-99 of about \$50 million on a cash basis.

Financial highlights include real increases of:

- 7% in total support for industrial R&D and innovation in the business sector, to \$664 million in 1999-2000, and
- 9% for scientific research in medical fields, to \$195 million, including the establishment of a new National Institute of Clinical Studies.

Australia's consistent support for research in the public sector now puts us third in international rankings of research levels in government laboratories and universities.

Impressive outcomes from Australia's publicly funded research continue:

- The discovery of 'nanobes' in sandstone 3-5km below the Australian seabed promises to be a major scientific advance that may give clues to the origins of life on earth. These tiny organisms, as little as 20 nanometres long, appear to be not only the smallest living organisms ever found on earth, but to represent a whole new life form.
- A new low cost process developed by researchers in the University of Melbourne School of Forestry can turn sawdust and forestry wastes into chemicals worth over US\$1500 per tonne, with no added energy input and little risk to the environment.
- The Macquarie University Centre for Lasers and Applications has conducted successful pre-clinical trials using their newly-developed laser technique that 'welds' severed nerves and blood vessels.
- South Australian-based international pharmaceutical and health care company, FH Faulding, is using a \$900,000 *Start Plus* grant for the next stage in their development of an innovative treatment for prostate cancer. The treatment uses a special virus patented by CSIRO.
- The CSIRO has solved the intractable problem of bonding plastic and paint in a process that eliminates the need for damaging solvents and ozone-depleting chemicals, and enables recycling or waste polyethylene. The new SICOR technology, also being used by Australian industry, is the subject of a \$16 million licensing agreement with a US company.
- No more TV remote to lose down the back of the couch! Severely disabled people are trialling a 'mind switch' developed by the Sydney University of Technology. The 'switch' uses brain signals to control electrical devices.

* Note that accrual accounting is used in presenting the 1999-2000 Commonwealth Budget. This represents a major change in the Government's financial reporting practice. Box 3.1 in Section 3 of the Statement provides a simplified explanation that compares accrual principles with those of the cash accounts that were used up to the end of 1997-98.

SUMMARY NOTES

SUPPORT FOR SCIENCE AND INNOVATION IN 1999-2000

- In 1999-2000, Commonwealth support for major science and innovation programs is expected to be \$3953 million in accrual terms, approximately at the same real level as in 1998-99 but with a dollar increase in cash terms of about \$50 million.
- Total support for industrial R&D and innovation in the business sector, including both direct support through appropriations and the estimated effects of tax revenue forgone, is expected to be \$664 million in 1999-00. This is a real increase of 7 per cent overall, resulting from an estimated real increase of 10 per cent through the industrial R&D tax concession, together with a real increase of 3 per cent in direct support for innovation through the R&D Start program and smaller support measures.
- Support for general science and technology programs will rise to \$500 million, a real increase of about one per cent. These programs include the Cooperative Research Centres, rural science, energy research, environment R&D, transport studies – and health and medical research, where funding increases substantially.
- Medical science - where the Government's strong record of support since its election has provided a real increase of 25 per cent over three years - sees a rise to \$195 million in 1999-00. This represents an overall real increase of more than 9 per cent over the 1998-99 estimate. The funding boost will enable the National Institute of Clinical Studies to begin operations.
- Targeted research in universities (mostly funded on the advice of the Australian Research Council) will receive \$438 million, an estimated decrease of 5 per cent. Other funds for university research are estimated to decrease by about 2 per cent in real terms.
- In accrual terms, a total of \$1153 million will be provided to the major research agencies in 1999-00, including \$234 million for defence R&D. Budget support for CSIRO will see out the current triennium with a 3% increase in real terms over the previous triennium. CSIRO will receive \$604 million, but external earnings will raise this to over \$870 million. Healthy increases for other research agencies are masked by a substantial drop in capital funding for AGSO following the completion of its new building.
- In common with trends in many countries with high levels of government R&D, Australian policy over a long period has sought to encourage greater reliance on external earnings, particularly those resulting from productive interactions with industry. In this context, the latest international data show that combined R&D expenditure within Australian public sector agencies and universities - when considered relative to GDP - is now third highest in the world.
- Budget support is provided in the expectation of useful outcomes and outputs, 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 AND INNOVATION

	1997-98	1998-99 est \$m	1999-00 accrual* \$m	cash adj. real change#
TARGETED HIGHER EDUCATION R&D ¹	420.4	451.2	437.6	-5.5%
OTHER HIGHER EDUCATION R&D.....	1215.5	1204.5	1197.3	-2.3%
COOPERATIVE RESEARCH CENTRES.....	146.9	145.2	139.7	-5.5%
R&D START.....	91.2	127.9	160.5	+23.3%
OTHER INNOVATION SUPPORT.....	64.2	117.9	97.7	-18.5%
IR&D TAX CONCESSION	336.0	363.0	406.0	+9.9%
RURALR&D.....	140.5	155.7	151.0	-4.7%
NHMRC	158.9	176.0	173.2	+8.1%
OTHER HEALTH R&D	14.7	17.9	22.1	+21.3%
OTHER R&D GRANTS ²	27.2	12.9	14.2	+8.3%
CSIRO ³	472.9	481.5	603.6	-0.5%
DSTO ⁴	245.5	247.0	233.8	-2.3%
OTHER R&D AGENCIES.....	253.9	252.5	315.9	-1.2%
TOTAL	3588	3753	3953*	-0.4%
	Real change	+ 3.8%[†]		

* The 1999-2000 Federal Budget saw the introduction of accrual accounting to replace the former cash accounts. Support shown for the year 1999-2000 is therefore on an accrual basis.

The real changes shown are based on adjusted 1999-2000 estimates, provided by agencies, in approximately comparable form to the 1998-99 estimates of cash expenditure. See Tables 2, 3 and Box 3.1.

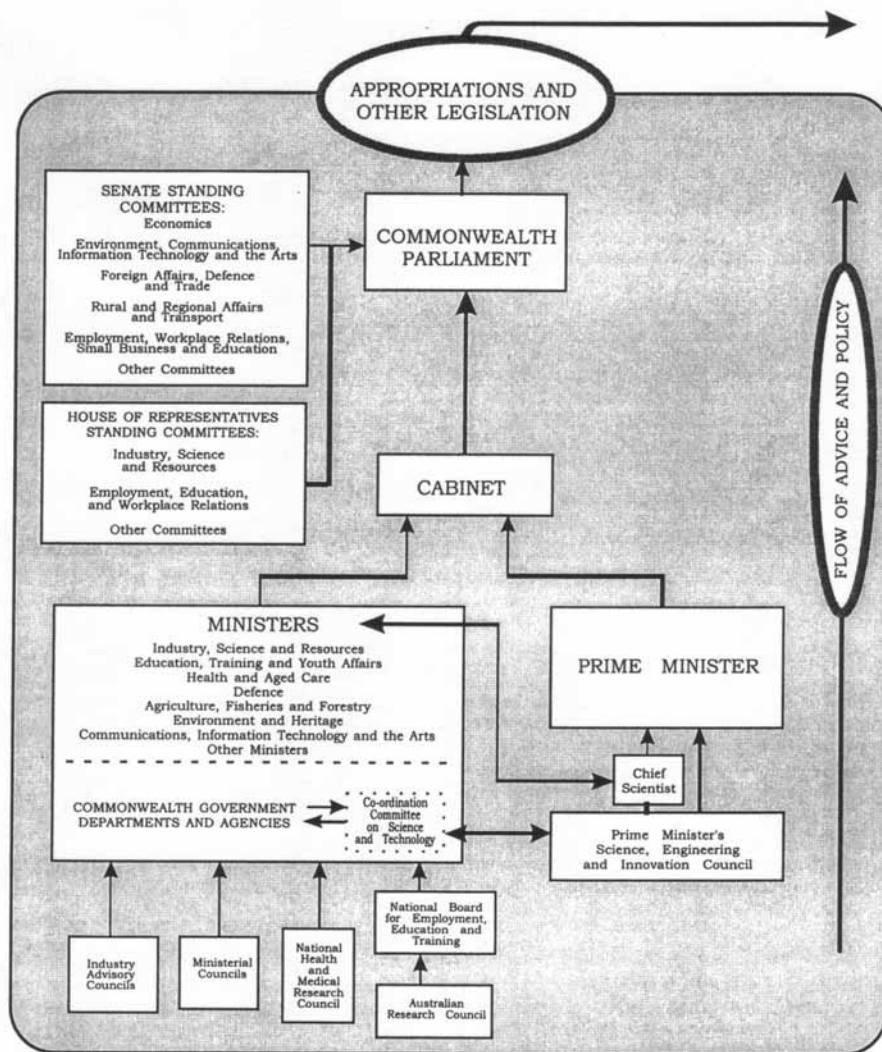
† There is a substantial revision to the 1998-99 estimates, resulting in a growth of 3.8% in real terms (compared with the estimate of -0.5% published in the 1998-99 *Statement*).

- 1 Represents the total of Budget and HEF Act funding and incorporates funds allocated on the advice of the Australian Research Council (ARC).
- 2 Australian Biological Resources Study, Greenhouse research grants, Energy R&D and Australian Road Research Board.
- 3 Includes funding through AFFA for the Australian Animal Health Laboratories. In addition to the budget funding shown, CSIRO expects to earn about \$267 million from external sources in 1999-2000.
- 4 These figures include components funded through appropriations to other parts of the Defence portfolio. (See note 1 to Table 4.)

For more detailed information see Tables 2 to 6

Figure 1

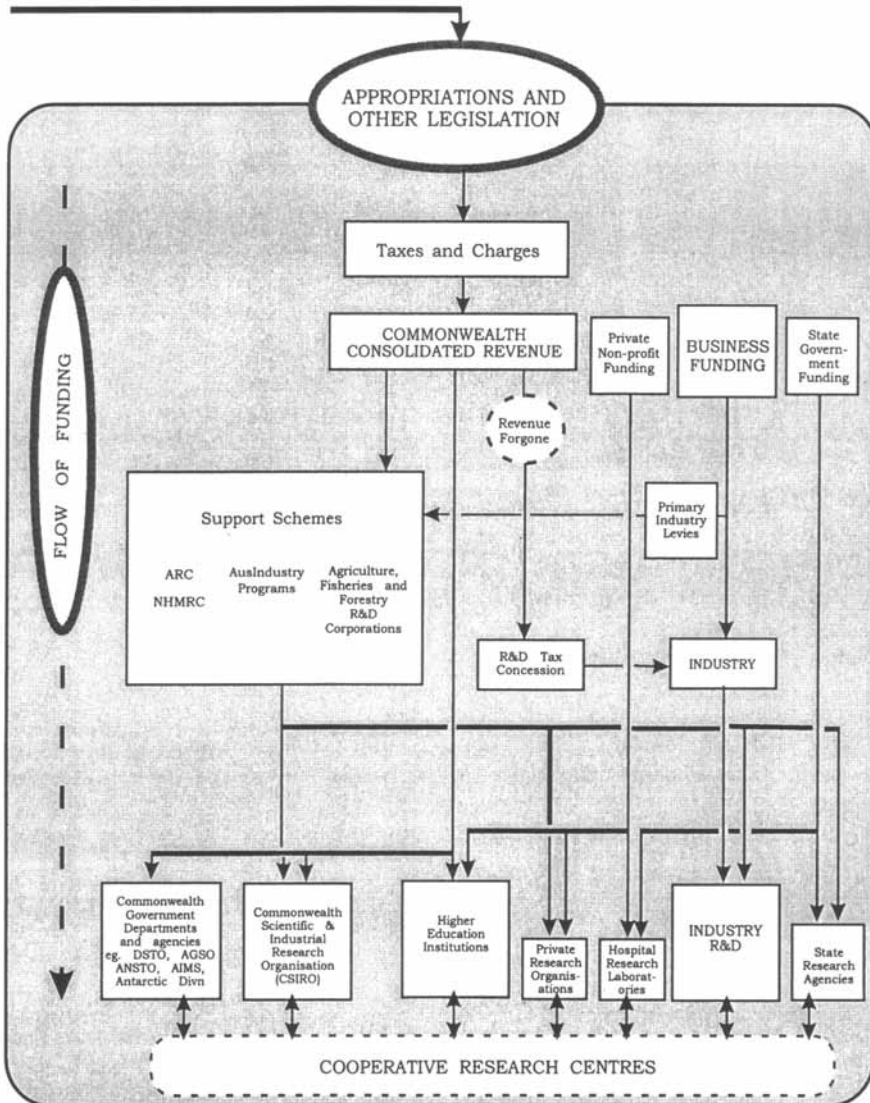
MAIN CHANNELS OF ADVICE FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY



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.

SECTION

1

Science, Innovation and the Knowledge Based Economy

This section discusses the opportunities offered
by the emerging knowledge based economy, and
how best to position Australia.

Introduction

On the new accrual basis (see Box 3.1 on page 3.2), the 1999-2000 Budget provides an estimated \$3.95 billion for Government programs supporting science and innovation.

Innovation is widely recognised as the central driver of growth and wealth creation. The creation of new products and processes, often based on sophisticated scientific and engineering research, is spawning new industries, and transforming traditional sectors of the economy to such an extent that it is challenging our understanding of the nature of economic activity and its relationship with science and technology.

Land, labour and capital, the traditional elements of economic analysis, have been joined by knowledge as the *knowledge-based economy* becomes a focus of attention. Industries that are highly knowledge-intensive, such as Pharmaceuticals and information and communication technologies and services, are becoming major income generators, while the 'knowledge' inputs in 'traditional' industries, such as mining, textiles, and agriculture, are themselves becoming a major source of value — with sophisticated mineral exploration techniques; fashion design and marketing; gene technologies and new water management techniques.

In the new knowledge-based economic environment, economic leadership increasingly passes to those who are capable of developing highly innovative products or services that can command a temporary monopoly in a new market. Firms that possess these capabilities are tending to surpass or displace those who focus solely on the reduction of costs and the production of generic products that can compete only in price. And the most significant gains often come to those involved in the development of new 'enabling technologies': component items, devices or techniques that become indispensable across a broad spectrum of industries.

But innovation is not only concerned with products and physical processes. It is also about patterns of behaviour and forms of organisation and management that enable access to and transfer of knowledge and thus more effective production and delivery of goods and services. More broadly, innovation is about being able to exploit opportunities and adapt to a rapidly changing global environment. These changes demand new ways of thinking and organisation. And for those who are unable to be at the leading edge, survival may well depend on being able to follow quickly.

Dimensions of knowledge: from information to learning

The revolution in information and communications technologies

The knowledge-based economy is founded on the phenomenal advances we have seen in information and communications technologies (IC&T) over the past few decades — its recent emergence being driven not only by the much greater ease and speed of communication, but also the very substantial falls in its cost.

For some time now computers and increasingly sophisticated software have been able to cut down the time we need to spend on routine activities. We now have the capacity to process large quantities of data and extract relevant information quickly and easily; and software-controlled machines can perform repetitive mechanical functions. We are able to communicate and diffuse information, and search for and access it, to an unprecedented degree.

We are seeing two almost contradictory effects:

- Information and communication technologies are changing the way we do almost everything — from e-mail, the Internet and the World Wide Web, to monitoring and controlling automated manufacturing processes. With a ripple-like effect, changes in one area open up new possibilities in others: those who are able to think creatively are exploiting these new possibilities by turning them into reality. Creative foresight, as much as efficiency, is the key to flourishing in these new conditions.
- Ironically, the very technology that promises so many benefits if we can be flexible and think freely can also threaten to drown us in a vast sea of information. Focusing primarily on the details of information we may miss broader implications and opportunities.

Knowledge and its transferability

While ready flows of information and widespread ease of access to it are pre-conditions for the development of a knowledge-based economy, these are not sufficient by themselves.

Knowledge takes different forms — and it is particularly important to distinguish between explicit and implicit forms. Explicit knowledge (*codified knowledge*) ranges from very basic information with very little explanation or detail, such as data on the heights and weights of the population, or a telephone book or catalogue, to much more complex forms of information, such as technical manuals, text books, or academic papers. But any form of explicit knowledge requires at least some degree of implicit knowledge (*tacit knowledge*) if it is to be absorbed, understood, and used effectively. At one end of the information spectrum even a sign post requires a person to know the meaning of an arrow shape. At the other end, it will commonly take the highly developed design skills of an industrial engineer to put an innovative idea into effective practice — no matter how explicitly it may be described. Similarly, implicitly possessed creative skills are required for the effective implementation of good ideas for new and improved services.

Explicit knowledge, whether information or more complex codified knowledge, is relatively easy to transfer physically through the new electronic means that are now available. Many issues concerning the knowledge-based economy centre on the development of capabilities to exploit this potential, or on mechanisms to restrict access to this 'free-flowing' codified knowledge through the control of intellectual property. Box 1.1 shows some of the possibilities that the new technologies have unleashed within this 'information economy' component of the broader knowledge-based economy

Implicit or tacit knowledge, however, is less easy to transfer. It resides in people's heads, is expressed in the application of their skills, and becomes embedded within the capabilities of organisations through the systems and collective patterns of behaviour that evolve within them. It often takes considerable time and effort to develop. Tacit knowledge commonly comes from experience so that transfer often occurs through demonstration and performance, for example, through apprentice-type training rather than 'book learning'. Moreover, because this form of knowledge is often invisible it can be easily overlooked — thus, in a few cases, firms have relied on weak assessments of their human capital so that when downsizing they have effectively stripped themselves of valuable skills and capabilities. Similarly, outsourcing in a careless way has the potential to remove the implicitly held skills necessary for effective management of an outsourced service. A more common result from overlooking the significance of tacit knowledge is a general neglect of training issues and opportunities for skill development across an organisation.

The relative difficulty of acquiring or transferring tacit knowledge means that it is often a source of competitive advantage. The best firms will be aware of the need to build their workforce skills, embed collective capabilities across all their staff, and value them sufficiently to prevent their movement to competitors. Conversely, to achieve an effective knowledge-based economy many highly capable firms are needed — and reasonable degrees of mobility may need to be encouraged so as to develop economy wide capabilities. The movement of people between the research and industry sectors is a particularly effective way of diffusing tacit knowledge and developing capabilities throughout the economy.

Globalisation of information and localisation of application

Deregulation and the explosion in the use of new information and communication technologies means that *information has become globalised* to an unprecedented degree. Businesses and individuals operating in many professions are now able to include a wide range of interactions and regular contacts overseas — and these connections are transforming the way they operate. For the most part, the information that forms the content of these rapid global communications can be characterised as simple codified knowledge.

BOX 1.1:

Changes to service delivery in the new information environment

<i>Service</i>	<i>Traditional form of delivery</i>	<i>Delivery in the new information environment</i>
Banking	<ul style="list-style-type: none">• Over the counter• ATM in major street	<ul style="list-style-type: none">• Home banking via PC with smart card loading facility
Books and reports	<ul style="list-style-type: none">• Bookshop purchase	<ul style="list-style-type: none">• Download from WWW, print locally
Databases	<ul style="list-style-type: none">• Proprietary networks• Hard copy reports	<ul style="list-style-type: none">• Available on WWW
Encyclopaedias	<ul style="list-style-type: none">• Hard copy volumes	<ul style="list-style-type: none">• CD ROM, on-line updates• WWW publishing
Facsimile	<ul style="list-style-type: none">• Telephone company	<ul style="list-style-type: none">• Internet fax
Gambling	<ul style="list-style-type: none">• TAB outlets	<ul style="list-style-type: none">• Gambling sites on WWW
Games	<ul style="list-style-type: none">• Specialised games computer	<ul style="list-style-type: none">• Download from WWW• Compete with other players via WWW
Mail services	<ul style="list-style-type: none">• Post Office service	<ul style="list-style-type: none">• Email
Music (audio)	<ul style="list-style-type: none">• CD, cassette tape	<ul style="list-style-type: none">• Audio available from WWW sites, burn CD locally
Newspapers	<ul style="list-style-type: none">• Hard copy sheets	<ul style="list-style-type: none">• Published on WWW site
Photographs	<ul style="list-style-type: none">• Transfer by post or courier	<ul style="list-style-type: none">• Transfer via the Internet
Share trading	<ul style="list-style-type: none">• Telephone stockbroker	<ul style="list-style-type: none">• Orders placed via access to WWW sites
Sheet music	<ul style="list-style-type: none">• Purchase hard copy from music store	<ul style="list-style-type: none">• Download from WWW and print locally
Software	<ul style="list-style-type: none">• Purchase box of discs	<ul style="list-style-type: none">• Download from WWW to PC
Telephone	<ul style="list-style-type: none">• Telephone company	<ul style="list-style-type: none">• Converse via audio Internet link
Television	<ul style="list-style-type: none">• Analogue transmission	<ul style="list-style-type: none">• WWW-enabled, available on demand
Tickets	<ul style="list-style-type: none">• Purchase over the counter, by phone or by post	<ul style="list-style-type: none">• On-line order, print on smart card via buyer's PC
Travel booking	<ul style="list-style-type: none">• Travel agent in a shopping centre	<ul style="list-style-type: none">• Bookings via access to WWW site, smart card becomes ticket
Video	<ul style="list-style-type: none">• Video tape or photographic film	<ul style="list-style-type: none">• Video delivery via WWW

Source: CSIRO Mathematical and Information Sciences

But information can only be applied to some purpose where sufficient tacit knowledge is available in the appropriate field. *Tacit knowledge tends to be localised*. There are many reasons for this. Firstly, tacit knowledge exists in the heads of individuals and in the collective capabilities developed within business enterprises and other organisations, which, in general, reside in specific locations. Tacit knowledge is often transferred through person to person contact, again a localised activity. Another important reason is that those with high degrees of tacit knowledge prefer congenial localities where they can interact with others of like abilities. Clusters of highly capable firms are often found in such environments where physical proximity is a major factor in facilitating productive personal interactions and linkages. Silicon Valley, Massachusetts, and Austin in the US, discussed further below, are classic examples of high technology clustering.

It is the *local* presence of tacit knowledge that allows us to reap the benefits of global connectedness, and is thus of key importance in determining the effectiveness of the local or national system of innovation.

Opportunities and risks in the new information environment

The new information environment — the information highway — permits many companies to transform the way they do business. By creating particular opportunities in accessing new markets, and new ways of accessing old markets, it is not only changing the way firms relate to customers, suppliers and competitors, but changing the way markets themselves operate. Customers can more readily tap into a whole new range of information about products and alternative suppliers to the extent, for example, that conventional advertising is becoming obsolete in some markets. Businesses can also gain access to large amounts of commercial and technical information from around the world. The codification of knowledge facilitates the spread of best practice and new ideas, and increases the speed of innovation.

These developments also influence the ways businesses are organised and how they conduct their operations. For example, the new information environment has accelerated the trend towards new forms of organisations such a 'virtual companies'. There is also evidence of changes in the way firms are organising their internal operations.

However, these developments are only part of the story. There are many opportunities in the information economy, but in a world where whole markets can be transformed, traditional ones destroyed in some cases, and completely new ones created there are also many risks for the unwary. Box 1.1 shows several examples. There are particular risks in overlooking the crucial importance of tacit knowledge, as has been indicated above. Great opportunities are available to those who recognise the full implications of the shift to a knowledge-based economy — the importance of learning and creativity — and are not limited to being a consumer in the information economy, the risk of a sole focus on the simple 'information' end of knowledge.

Developing patterns of learning

The risks of an excessively narrow focus on information, as outlined above, can be partly addressed through proper attention to the development of human capital and organisational capabilities. Both individuals and organisations need to establish patterns of behaviour that keep them searching for and absorbing new ideas — so learning and developing tacit knowledge and capabilities.

Individuals, organisations and nations are increasingly recognising that high levels of knowledge, skills and competence are critical to success. A particular emphasis of the 1994 OECD Jobs Study, reinforced in the 1998 report *Technology, Productivity and Jobs Creation - Best Policy Practices*, was the importance of investment in people, within a framework seeking to extend lifelong learning for all. Evidence shows that in OECD countries overall:

- a substantial proportion of national income is devoted to investment in human capital — public and private spending on formal education and training are on average about 6 per cent of GDP;
- there is considerable private investment in human capital (eg enterprise based training) though it is not fully accounted for;
- there are significant social and economic returns to investment in education - at least in the case of relative earnings of employed individuals with different levels of education; and
- human capital is not equitably distributed within countries.

The growing importance of human capital to competitiveness is also reflected in the changes in the occupational distribution of employment in OECD countries. During the 1980s, employment in member economies grew fastest in high-skilled jobs, while it was slowest or even declining in low-skilled jobs.

Upskilling has been observed across all industries rather than being simply the result of changes in the industrial composition of economies. However, it has occurred faster in industries that have higher than average R&D expenditures and growth rates in the number of patents. Similarly, human capital has accumulated faster in those sectors that, at the beginning of the 1980s, were more intensive in the use of high-skilled workers. Thus, human capital accumulation and innovative efforts are mutually reinforcing.

Towards an Australian knowledge-based economy

Key elements

There are a number of requirements if Australia is to take full advantage of opportunities in the global information environment. Most importantly, we need the capacity to successfully create and exploit scientific knowledge and technology. Fundamental to this are:

- world class science and education systems;

-
- top-ranking framework conditions in terms of physical, legal and financial infrastructure
 - a culture of entrepreneurship and innovativeness;
 - business capabilities at levels that match our scientific capacities;
 - patterns of behaviour that promote continuous searching and learning by organisations and individuals and hence the widespread diffusion of new technologies and ideas; and
 - linkages and dynamic interactions that build all these elements into an effective national system of innovation.

We have many strengths in these areas.

The development of public education and research over the past half century has endowed Australians with an excellent scientific base. On the latest available international comparisons (see Section 4), Australia stands third in the world in terms of expenditure on public scientific research as a proportion of gross domestic product (GDP). And our share in the world's output of science, measured as our share in overall numbers of scientific publications, has recently shown an increase (see page 4.2). The Government is determined that these strengths should be maintained and enhanced.

We have very well developed infrastructure in a number of other areas. For example, the Australian telecommunications system is first rate, and we are a leading user of new information and communication technologies. According to the most recent survey of Internet hosts, Australia ranks among the most 'connected' nations in the world. We have a policy and regulatory environment that encourages competition and entrepreneurship, with recent changes in intellectual property regulation further enhancing the environment for innovation (see Section 2). The Government has also taken a number of initiatives to establish an Australian venture capital industry to provide finance for research commercialisation and other innovative activities.

To multiply the benefits flowing from this infrastructure we need to increase the linkages between our research base and industry by creating a dense web of both formal and informal interactions.

Linkages and symbiosis between science and industry are critical

Given that we have an excellent science system, the apparently low rate of research commercialisation by Australian companies raises many issues.

It is sometimes suggested that industry is not receptive because research is irrelevant to commercial realities, with the implication that more research should be directed according to industry goals. The problem with directed research is that, in the rapidly changing circumstances of the global knowledge economy, it is becoming more and more difficult to predict *what* kind of research will be relevant. Firms at the frontiers of the knowledge economy are finding that open-ended exploration is not just about knowledge for knowledge's sake, but can also yield valuable new technologies and business ideas. Leading firms, rather than seeking to tie research to short-term

industry goals, are open to new discoveries and able to adapt new ideas, from research or from other industries, to make them relevant to their own work; or to change the direction of their own work to take advantage of opportunities offered by new knowledge.

As discussed earlier, the ability of firms to absorb and use knowledge is as important as the availability of knowledge. This receptive capacity is to a large extent dependent on prior tacit knowledge within these firms: knowledge developed by doing, and by interaction with other 'doers'. In a knowledge-based economy, learning and creativity need to happen at all points. While a strong science system is critical to the generation of new knowledge, gaining the full benefits from this knowledge requires entrepreneurship, innovative management, eagerness to search for new ideas and keep on learning at all levels of business, and a flair for spotting new customer needs and fresh business opportunities. This challenge is applicable to all industries, not merely new or 'high tech' industries. Businesses in all sectors need receptive mind-sets to exploit new sources of competitive advantage and respond rapidly and flexibly to change.

Search and learning strategies — which are fast becoming a necessary part of business survival — may involve searching databases and reading academic journals, but personal contacts and networking are also very important. International experience shows that success in the knowledge-based economy is significantly driven by the co-existence of competitive behaviour and inter-firm co-operation and networking. Benefits stem from sharing of costs/infrastructure, reduced search costs and knowledge spillovers. Research collaboration and cooperation with other firms and research institutions are an invaluable way of keeping 'in the loop'.

All this has important implications for the relationship the research community has with the business community. It suggests that basic research should not be cordoned off. While basic research should not be *driven* by immediate concerns of business, strong efforts need to be made to establish regular patterns of communication between the two communities. The dynamism of the relationship relies on the constant movement between open-endedness and focus — a dynamism that is lost when operating at either extreme. Without setting the agenda, business concerns can nevertheless offer direction and stimulus for basic research. Indeed the application of research by industry can also further understanding. But for this to happen, scientists involved in basic research need to be willing to communicate with business about their work, and even explore potential applications.

The importance of close relationships between the research and business communities is borne out by overseas experience. A study by Scottish Enterprise, the public agency responsible for economic development in Scotland, showed that the close integration of business and research has a profound effect on commercialisation rates in the USA. For example, the study suggests that the enormous technology-driven growth relatively recently achieved in Austin, Texas, is underpinned by 'an unusually close working relationship between the University of Texas at Austin, the

Chamber of Commerce and the public sector'. The study attributes the success of Silicon Valley in part to 'its extensive informal social and business networks... Information and ideas are disseminated rapidly. Networks allow resources to come together; collaboration and competition exist side by side'. Similar networking patterns were observed in the growth of the high technology industry in Massachusetts centred on a strong partnership between the Massachusetts Institute of Technology (MIT) and the financial community, with the creation of networks in the wider business community occurring later.

These studies show that the relationship between research and business is far from linear, or one sided, with business the only beneficiary. The Scottish Enterprise study suggests that university involvement in regional economic development was 'normally based on a recognition of long term self interest'. The University of Texas, for example, has become one of the leading universities in the US. Likewise, Stanford (located in Silicon Valley), and MIT in Massachusetts, have substantial international reputations. Far from waiting for business to develop their capabilities on their own, university involvement was often directed towards helping create a corporate base capable of using academic research: 'Academia has not taken the local environment as given but has actually sought to change it'.

The Government's forward agenda

The importance of raising levels of business R&D has long been recognised. What is becoming increasingly clear is that business R&D plays a vital role in the development and maintenance of the expertise industry players need to understand and adapt the findings of complex scientific research performed in specialised institutions. R&D capabilities act as a bridge that enable regular communication with researchers, providing early access to new ideas — a significant source of competitive advantage. Government initiatives to support and increase business R&D, such as R&D Start and the R&D tax concession play an important role in building these bridges (for further information on the programs see Section 5).

The Government has also recognised that a lack of a developed early stage venture capital industry in Australia inhibits the commercialisation of R&D. In response the Government has implemented the Innovation Investment Fund (IIF) Program. Under this program, the Government invests in venture capital funds which will be matched by the private sector on a 2:1 basis (see Sections).

The IIF Program aims to provide equity capital to encourage new technology start-up companies. Private sector fund managers are being licensed to manage the funds, giving them the opportunity to develop the specialist tacit knowledge necessary in this field. In this way, the program can also have an effect on the skills base of the Australian venture capital industry.

The investments made by the fund managers, by demonstrating the gains to be made from investment in high technology start-up companies, are intended to stimulate further private sector participation in Australian venture capital markets. A new *Venture Awareness* program aims to help other Australian

institutional investors, such as superannuation funds, to evaluate potential venture capital investments (see Section 2).

To address capabilities at the other end of the investment relationship, a new *Investment Ready* program will provide information to start-up companies about the requirements of potential investors and help them build the management skills needed for successful commercialisation (see Section 2).

Another important task for the Government is to facilitate the development symbiotic relationships between research and business of the kind outlined earlier. It is doing this in a number of ways. For example, the Government is helping position Australia to capitalise on developments in Biotechnology by supporting the establishment of an Institute of Molecular Bioscience in Queensland (see Section 2). The Institute will bring together a number of research groups, some of whom involve private sector participants, and lease research space to private companies in incubator type arrangements. Similar public/private sector research collocation will occur in the new Technology Park in the Melbourne Docklands area, and the CSIRO Riverside Park (both described in Section 2), stimulating the creation of high technology clusters.

Other Government programs working to build linkages include the Cooperative Research Centres, the Strategic Partnerships with Industry Research and Training (SPIRT) Program, the Technology Diffusion Program (Sections 2&5). By creating opportunities for interaction between the research and business communities they facilitate the flows of knowledge and expertise that underpin innovation. It is only through processes and interactions of these kinds that we can build a truly knowledge-based economy.

The knowledge-based economy demands new ways of thinking and the establishment of patterns of interactions and behaviour that promote innovation. It is not just about having more of some 'thing' called knowledge, or the simple exploitation of new communications technology, but about developing the capabilities to understand, share and apply knowledge. The Government is doing this by maintaining the excellence of public research, while at the same time stimulating business innovation and encouraging linkages between the two. The National Innovation Summit (see Section 2), to be held in collaboration with the Business Council of Australia, will aim at developing a broad national consensus on the strategies to be pursued by government, industry and the research community in strengthening our innovation system.

SECTION

2

Recent
Major
Developments

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

Science and Technology Advice

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

The Prime Minister's Science, Engineering and Innovation Council (PMSEIC) is the Government's principal source of advice on science, engineering and innovation.

The Council is chaired by the Prime Minister, and is made up of Ministerial members, representatives of the business and scientific community, and personal members. The Minister for Industry, Science and Resources, Senator Nick Minchin, is Deputy Chair of the Council, and the Chief Scientist is its Executive Officer.

The most recent meetings of PMSEIC, held in May and December 1998, addressed the following topics:

- strengthening interactions between universities and industry;
- profiting from agricultural biotechnology;
- the nexus between science and its applications;
- opportunities to produce a vibrant Australian software industry;
- the conclusions and recommendations of the Strategic Review of Health and Medical Research;
- dryland salinity and its impacts on rural industries and the landscape;
- Australian greenhouse science; and
- Australia's involvement in international science facilities.

In December 1998, PMSEIC absorbed the functions of the former Australian Science and Technology Council (ASTEC). While the full membership of PMSEIC normally meets two times a year, the non-Ministerial members meet on a monthly basis. In effect, the meetings of non-Ministerial members have taken up much of the role of the former ASTEC.

PMSEIC papers are available on the World Wide Web at www.isr.gov.au/science/pmseic/pmseic.html.

Coordination Committee on Science and Technology (CCST)

The Coordination Committee on Science and Technology acts as a forum for the exchange of information among departments and agencies with an interest in or responsibility for scientific and technological matters

continued. Matters receiving attention in the past financial year have included:

- the role and terms of reference for CCST and its forward work plan;
- interactions between industry and universities;
- coordination of Commonwealth policy and funding for major research facilities;
- developments in the proposed World Intellectual Property Organisation (WIPO) database treaty;
- OECD Megascience projects;
- biotechnology opportunities;
- matters arising from multilateral international forums for science and technology (APEC, OECD, UNESCO);
- Near earth asteroids; and
- possible topics for PMSEIC agendas.

Innovation in Industry

Innovation Strategy Development

National Innovation Summit

Following a comprehensive review of programs providing support to business, the 1997 Industry Statement, *Investing for Growth*, sought to build on the strengths of Australia's Innovation System and address its weaknesses.

As part of its commitment to further developing policy for improving Australia's performance, the Government has announced that a National Innovation Summit to be held in near future, in partnership with the Business Council of Australia. The aim of the Summit will be to develop consensus strategies for Government, industry and the research community, to strengthen innovation and improve the level of commercialisation of Australian research and development. In the lead up to the Summit, the Government will encourage a stronger and more informed debate on innovation, examining the impediments to innovation and identifying ways of overcoming them. This policy development will build on the achievements of the Government's activities and programs supporting innovation.

Research Commercialisation Forum

A Research Commercialisation Forum was held in Melbourne on 9-10 November 1998. It brought together an invited group of 75 people representing a cross-section of public and private sector research managers,

business innovators, venture capitalists and policy makers, to focus on how Australia can do better at commercialising the results of research.

The Forum produced a clear consensus on the major issues we need to address, among them the importance of an internationally competitive taxation regime for improving the availability of venture capital for small, high growth technology-based firms, and the need for greater recognition by business and government that innovation is a key driver of economic growth and job creation.

The Forum's outcomes will form a valuable input to the National Innovation Summit to be held shortly.

R&D Tax Workshop

An R&D Tax Workshop was held in Sydney on 24 March 1999 as a lead-in event to the Innovation Summit. The Department's primary objective in holding the Workshop was to provide an opportunity for industry and research community stakeholders to canvass views on innovation aspects of tax reform. The Workshop was attended by nearly 100 people from a wide range of industries, the research community, industry associations, government departments and consultants. Discussions at the workshop focused on the Review of Business Taxation, the Government's innovation agenda, the R&D Tax Concession and Capital Gains Taxation. The outcomes of the workshop will be used to inform the Government's response to the Review of Business Taxation and to identify non-tax issues for consideration at the Innovation Summit.

Innovation Discussion Paper

In November 1998 the Department of Industry Science and Resources released a discussion paper, *A New Economic Paradigm?*, which introduces a range of theoretical work on innovation. The publication has attracted attention in the industry, research and policy communities, and is serving to inform and stimulate debate on innovation in the lead up to the Innovation Summit.

Innovation Investment Fund (IIF)

The IIF provides access to equity capital to encourage new technology companies to improve the commercialisation outcomes of Australia's strong research and development capabilities and to create a self-sustaining, early-stage technology-based venture capital market. Together with private sector funding, the \$230 million provided by the Government over the two ten year rounds of the program will create an overall investment pool of about \$345 million for early stage venture capital investments.

Through the use of private sector funds managers the IIP is also creating new equity management skills in the Australian business community. The first five fund managers were licensed in 1998: A&B Investment Management (\$41.25m); AMWIN Management (\$41.25m); Momentum Funds

Management (\$30m); Rothschild Bioscience Managers (\$42.5m); and Coates Myer(\$41.25m).

Renewable Energy Equity Fund (REEF)

The Renewable Energy Equity Fund (REEF) announced in the Government's statement *Safeguarding the Future: Australia's Response to Climate Change*, is based on the existing IIP model and will provide venture capital to small, innovative companies for the development of renewable energy technologies. By assisting in funding further growth of the renewable energy industry, it will help reduce Australia's greenhouse gas emissions.

As with the IIF, the Government will provide two-thirds (approximately \$20 million) of the agreed level of capital for the REEF fund, with at least another third to be sourced from private capital raised by the fund manager. A call for applications was made in April, and the fund will become operational later in 1999.

New Programs to Enhance Commercialisation

In its pre-election statements the Government announced two new initiatives:

- a Venture Awareness Program under which up to \$1 million per annum will be spent over three years on measures to increase information to Australian investors about the advantages of investing in early stage firms; and
- an Investment Ready Program under which \$30 million will be spent over three years to help Australian firms build the management capabilities needed to attract equity capital.

Technology Diffusion Program

The Technology Diffusion Program (TDP), which commenced on 1 July 1998, supports activities aimed at building international science and technology links, domestic science and industry alliances, and initiatives in technology diffusion.

Due to changes to the Administrative Arrangements Orders following the federal election in October 1998, the **Online Business** component of the TDP was transferred to the Communications, Information Technology and the Arts portfolio, with a budget of approximately \$17 million.

The **Technology Alliances** and **Technology Transfer** components remain as integrated elements of the TDP, with an overall budget of about \$90 million over four years. To date the program has supported a number of successful innovative projects, which include:

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- the Collaborative Health Informatics Network, which aims to coordinate the diffusion of overseas technological advances and domestic research and development to the information technology and healthcare industries, has already begun to create a simple one-stop access point for SMEs into the complex healthcare industry;
 - an initiative with a large company with international linkages using technologies acquired overseas to conduct intense technology training workshops and mentoring of about a hundred companies, concentrated on SMEs potentially in the supply chain;
 - support has enabled Australian industry to participate in the Republic of Korea's privatisation and upgrading of its waste water infrastructure; and
 - the Euro-Australian Co-operation Centre (EACC) project which is administered by the University of Western Sydney. This project enhances co-operation among European and Australian companies, universities, research centres and other non-profit organisations (eg industry associations, chambers of commerce), by supporting the development of collaborative activities and disseminating their results.

Commonwealth Technology Park Initiative

The Government has committed \$22.5 million over four years towards the establishment of a Technology Park at the Melbourne Docklands. The Commonwealth contribution will be made available through the Federation Fund. The Technology Park will commercialise innovation, and create new technology driven industries and higher value added products and services. Target areas for commercial development will be those with high growth and high potential returns including information technology, communications, multimedia, biotechnology, manufacturing, mining and energy.

Shipbuilding Innovation Scheme

The Government has allocated \$68.8 million to maintain the competitiveness of the world-leading Australian shipbuilding industry. A five year Shipbuilding Innovativeness Scheme (SIS) will encourage product research and development and design innovation in the industry. Eligible shipbuilders will receive assistance at a rate of 50 per cent of innovation expenditure for up to a total of 2 percent of eligible production costs. The scheme will run for five years from 1 July 1999.

Intellectual Property

An appropriate intellectual property regime is important for the facilitation of innovation and research commercialisation.

Review of IP Legislation

In conjunction with the Attorney General's Department, IP Australia has established a committee to review Australia's intellectual property legislation. The review forms part of the Commonwealth and State Governments' *Competition Principles Agreement*.

Reduction in Fees

Productivity improvements achieved by IP Australia contributed to a 10 per cent reduction in its fees in November 1998. This brought the total fee reduction for the calendar year to 23 per cent.

Intellectual Property Laws Amendment Act

The *Intellectual Property Laws Amendment Act 1998* received Royal Assent in July 1998. The Act contains a number of changes that support research and innovation. It provides an extension of term scheme for pharmaceutical patents, which encourages R&D by lengthening the period of return on investment. It has also revised the regulatory regime for patent and trade marks attorneys, which, by opening the profession to competition, improves the access of inventors to assistance when applying for patents. Administrative changes made by the Act revise the procedures for the payment of certain patent fees and provide a higher level of service to customers.

Higher Education Research

Increased funding for higher education research infrastructure

Investment in higher education research infrastructure underpins Australia's strong performance in research. In this Budget the Government is delivering on its election commitment to provide additional funding for higher education research infrastructure, by providing \$93.3 million over three years. Of this, \$36.8 million will be provided this financial year. This support for infrastructure builds on the Government's prior investment of \$90 million over three years in 1997, and will assist in maintaining Australia's position in the international research community.

Additional funding for science education

In line with its election commitment, the Federal Government is also providing an additional \$25 million over three years for science education, including \$5 million for 1999-2000.

After consultation with key stakeholders in industry and the science and academic communities, the Government will invite national tenders for

projects involving university course development and lectureships with industry partners.

Funds for large projects, in the order of \$500,000 per year for three years, will be allocated on a competitive basis. These projects will involve partnerships between universities and industry, with industry contributing funding in cash or in kind.

Increased funding for SPIRT

Increasing collaboration between universities and industry is a priority of the Government. In line with its election commitments, in late 1998 the Government provided an additional \$58.9 million over the next three years for the Strategic Partnerships with Industry Research-Training Scheme (SPIRT), which will build and maintain stronger linkages within the national innovation system.

Australian Partnership for Advanced Computing

In 1998 the Government announced the allocation of \$19.5 million to establish the Australian Partnership for Advanced Computing (APAC), to strengthen Australia's supercomputing infrastructure, and provide the computing power which is now necessary for scientific disciplines such as biotechnology, molecular chemistry, materials science, structural engineering, astronomy and environmental science.

APAC will establish a peak computing facility at its host institution, the Australian National University, which will be at least five times larger than any facility currently available at Australian universities.

Program reviews of higher education targeted research

The Department of Education, Training and Youth Affairs (DETYA) and the Australian Research Council (ARC) have continued to implement a monitoring and evaluation strategy for the higher education targeted research program through the Research Evaluation Program (REP). The following reviews have been taking place in 1998-99:

Impact of educational research

This study has been commissioned to provide information on the impact of Australian educational research on educational policy and teachers' professional practice. The aim of the study is to assist the Government and funding agencies to enhance the effectiveness of educational research funding.

Four groups of consultants have been engaged to study research-based policy formulation; classroom practice; bibliometric analysis of educational research; and the role of education faculties in the production and dissemination of knowledge.

Valuing university research: international experiences in monitoring and evaluation of research outputs and outcomes

This project studies the methods and approaches used to monitor and evaluate research outcomes and outputs in comparable Australian and international research funding bodies / agencies. The study will also identify and describe examples of best practice in evaluating research and advise on the efficacy and applicability of the various methodologies and approaches with reference to evaluating research outputs and outcomes; relevance to national research priorities; and different types of research.

Study of higher education research infrastructure

This study examined how research infrastructure is currently funded in universities, both in Australia and overseas, and proposed a number of possible models for future funding of research infrastructure.

Australian Research Council key developments

Joint Strategic Workshop on Genomics and Gene Technologies

In 1998, the ARC and the Research and Development Corporations (RDCs) held discussions to identify potential joint activities. An agreement was reached to sponsor a series of workshops for researchers in genomics and gene technologies. The first workshop was held in April 1999.

ARC presentation to PMSEIC on university-industry links

At the first meeting of the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) in May 1998, the Chair of the ARC led a presentation on university-industry linked research in Australia. The presentation emphasised the importance of basic research for Australia's economic competitiveness and the success of targeted industry linkage programs - and in particular, the importance of skills transfer and personnel movement in linking science and technology.

Subsequently, the ARC was invited to convene a working group for the Coordination Committee on Science and Technology to consider the wider aspects of university-industry research interaction. The ARC is also convening a PMSEIC working group to assess the merits of Australian participation in a series of proposed international research facilities and the potential benefits to Australia of hosting these facilities.

Community awareness

As an integral part of its strategic planning in 1998, the ARC developed a community awareness strategy. The objective of the strategy is to increase community awareness of the role and importance of research in Australian society, the outcomes (in terms of benefits to the community) of research activities supported by programmes referred to the ARC, and the role of the ARC within the national innovation system, in research training, and in fostering linkages between universities, industry and research institutes.

Australian Research Council discipline research strategies

Management research

In response to the 1997 discipline research strategy report on management research, the ARC has allocated \$150,000 under the Special Research Initiative Program to a project that will enhance collaboration, networking and the strategic development of management research in Australia. The project will comprise four seminars over three years, and a program to establish and coordinate support for the growing number of doctoral students in the field.

Information technology

The ARC discipline research strategy *Information Technology: Sink or Swim?* was developed by the Australian Academy of Technological Sciences and Engineering and was launched in September 1998. The final report of the strategy and the Council's response is being published in 1999.

Australian Research Council innovative projects

The commercialisation of research and technology transfer in the higher education system

In 1998 the ARC commissioned a study to assess technology transfer effectiveness and commercialisation performance at a number of selected universities. The ARC's interest arose from a 1995 report, *Maximising the Benefits: Joint ARC/HEC Advice on Intellectual Property*, which identified the necessity for further work to explore the role of university commercial arms or other university bodies in maintaining a productive dialogue between industry and the higher education research sector. The final report for the commercialisation of research and technology transfer in the higher education system is being published in 1999.

Assessment of cross-disciplinary research proposals

The ARC has commissioned a report on the assessment of cross-disciplinary applications for funding under ARC referred programs to assist it to develop options for enhancing support for cross-disciplinary research. The final report for the assessment of cross-disciplinary applications is being published in 1999.

Career paths of PhD graduates

The ARC is examining the relationship between the PhD and subsequent employment, towards the wider objective of assessing the nature and scale of research training in Australian universities and its subsequent use and value in the context of current demand for PhD graduates in industry, government and the higher education sector. As a first step, the ARC has commissioned a scoping study to determine the nature and extent of information that is already available about the destination of research trained graduates, establish what further information is needed and identify the most

appropriate methodologies for obtaining it. The final report for this scoping study will be published in 1999.

Information Technology

New arrangements

As part of the new administrative arrangements following the 1998 Federal Election, the Government's information and communications industries development activities have been moved from the Industry, Science and Resources portfolio to the Communications, Information Technology and the Arts portfolio. Similarly, the Office for Government Online (OGO) became part of the Department of Communications, Information Technology and the Arts and the National Office for the Information Economy (NOIE) was moved back under the umbrella of the Department. The Online Business element of the Technology Diffusion Program including responsibility for the Information Technology Online grant program is now administered by NOIE. The new arrangements are designed to increase opportunities for cooperation between IT-related Government functions previously operating in separate departments.

Information and communications industries development

Software Engineering Quality Centres (SEQC) and Testing and Conformance Infrastructure (T&CI) initiatives

The December 1997 Government statement *Investing for Growth* allocated \$28 million (including running costs) over four years from July 1998 to be used for both the SEQC and T&CI initiatives. The split of funds between the two programs was not specified, but has since been nominally allocated as \$20 million over four years for SEQC and \$8 million of T&CI.

Funding to set up centres or nodes of Software Engineering Australia (SEA) and an initial set of national projects, was provided in the 1997-98 financial year from the Technology Support Centres Program (operated by the Department of Industry, Science and Resources). The call for the first round of SEQC program proposals was made in October 1998. SEA nodes are currently submitting to the Department of Communications, Information Technology and the Arts proposals for Round One SEQC funding.

The Testing and Conformance Infrastructure program began operating in November 1998. A two-stage evaluation process was established following consultation with industry. Advertisements were run over two weeks calling for expressions of interest, closing on 18 December 1998. The final proposals will be assessed and successful projects selected by the end of May 1999.

The Office for Government Online

Year 2000

Following the 1998 Federal Election, the Government brought responsibility for the Commonwealth's Year 2000 Industry Program and the Government's own Year 2000 Project Office within the Communications, Information Technology and the Arts portfolio. This is providing a strengthened and more coordinated response to the issue.

Approximately \$600 million is being spent to ensure that Commonwealth agencies are Year 2000 compliant by the target date of July 1999. Cabinet receives quarterly reports on the state or readiness of these agencies and its business enterprises. These reports are published on a portfolio basis, and from this quarter onwards, will be published at an agency level in line with world's best practice. As at March 1999, nearly 60 per cent of Commonwealth Government business-critical systems have been remediated and are back online.

In February 1999, Parliament enacted Year 2000 Information Disclosure legislation. Its purpose is to encourage greater voluntary disclosure and exchange of information. This will assist organisations to check their supply chains and will encourage large companies to assist in the remediation of smaller firms - the so-called "Good Samaritan" effect. The limited protection from civil liability in the legislation is restricted to Year 2000 statements that are made in good faith, but does not prevent consumers, for example, for taking action in the event of Year 2000 product or service failure.

As well as ensuring that its own agencies and key utilities are Year 2000 compliant, the Australian Government has an important role in assisting the private sector. In the 1998-99 Budget, it was announced that most Year 2000 software expenditure, including on initial diagnosis, software modification, remediation and testing, would be immediately tax deductible.

The Government has also recognised the need to raise awareness and encourage action within the business community, particularly by SMEs. Working with the States and Territories, the Commonwealth has allocated some \$10 million to a national industry awareness strategy that was launched in July 1998. This campaign includes a national inquiry hotline, national media advertising, brochures, seminars, websites and a Year 2000 Register of products, systems, tools and service providers.

A national survey of 8,000 businesses released in December 1998 found a very high level of overall awareness as well as widespread action already undertaken by larger businesses. However, a significant proportion of small businesses are yet to take action, and as a result, SMEs will be heavily targeted in the next phase of the industry campaign. This campaign will be complemented by a national communications strategy addressing the concerns of the general public about the risks or otherwise of service failures emanating from the Year 2000 problem.

Gatekeeper

The difficulty of ensuring the security and integrity of messages and the authenticity of users is one of the primary barriers to the take-up of electronic commerce by government and business.

The Gatekeeper Program, launched in May 1998, is a strategy for the use of public key technology to support the development of government on-line information and services.

Public key technology, a relatively recent development in cryptography, is an encryption mechanism that allows identification of an individual, an organisation or a role; non-repudiation of messages; and secure transfer of information.

The Gatekeeper strategy provides a clear framework for those agencies that choose to use public key technology, and ensures there is consistency across the Commonwealth. The strategy is an important enabling factor in the development of electronic commerce as a means for the exchange of government information and the procurement of government services.

Australian Government Locator Service (AGLS)

The AGLS, a joint initiative for the Office for Government Online (OGO) and the National Australian Archives, will play an important role in helping people to access government services and resources on the Internet.

The AGLS has established metadata standards that can be used to 'catalogue' government information that appears on the Internet, making it easier to find. The proposed standards are outlined in an exposure draft of the *Australian Government Locator Service (AGLS) Manual for Users*.

AGLS is already being used by some major information management projects, such as the Business Entry Point (BEP) and the HealthInsite Project, to describe and index government information and services relevant to business and the community.

When combined with the authentication services provided by the Gatekeeper strategy, AGLS will form a critical element enabling the delivery of government online information and services.

Australia is regarded as one of the world leaders in metadata work. OGO is promoting AGLS as a key opportunity for industry development in information technology infrastructure and is actively supporting work in resource discovery and search engine development being undertaken by Distributed Systems Technology Centre.

Health and Medical Research

Health and Medical Research Strategic Review

In March 1998, the Minister for Health commissioned a major strategic review of health and medical research, under the chairmanship of Mr Peter Wills AM. The terms of reference for the review focused on the future role of health and medical research up to the year 2010, and emphasised the need to maintain a broadly-based research capacity, including a research workforce able to support future research developments. In December 1998, the Minister released a discussion document prepared by the review committee. The document was widely circulated for comment and a series of briefings were held across Australia. The report of the review was finalised in April 1999.

Medical Research Investment Fund initiative

In October 1998, County Investment Management Ltd announced a proposal to establish a Medical Research Investment Fund which will make additional funding available to recipients of NHMRC grants. Recipients of the proposed investment funding will be required to contract a proportion of the intellectual property arising from their NHMRC grants to the Fund, so that the Fund may take advantage of the opportunity to capitalise on the commercial potential which arises, or receive a proportion of royalties which are received, following realisation of commercial potential.

The proposal is based on the premise that, across the great range of research which NHMRC funds, from time to time significant discoveries with great commercial value will occur. The fund will not attempt to 'pick winners', but rely on the fortuitous nature of medical research. If the Fund is successful it will significantly boost business sector support of health research in Australia which in 1996-97 was about 12% of a total expenditure on health research of about \$850 million.

Biotechnology

Biotechnology Strategy

The Government will provide \$17.6 million over the next two years to fund the establishment of an office of biotechnology, Biotechnology Australia, in the Department of Industry, Science and Resources; and a statutory Office of the Gene Technology Regulator, in the Health and Aged Care Portfolio.

Biotechnology Australia

Biotechnology Australia (BA) will report to a new Commonwealth Biotechnology Ministerial Council consisting of five Ministers, with others co-opted as appropriate, which will be chaired by the Minister for Industry, Science and Resources. Receiving \$10 million over two years (\$6 million in 1999-2000 and \$4 million in 2000-01), BA will: develop a national strategy for biotechnology; a public awareness program to provide information about biotechnology and gene technology; training in the effective management of intellectual property; and secure better access to genetic resources and gene collections.

Office of the Gene Technology Regulator (OGTR)

The Health and Aged Care Portfolio has received \$7.6 million for the establishment of a statutory Office of the Gene Technology Regulator. It will operate under regulatory powers conferred through an inter-governmental agreement and associated Commonwealth, State and Territory legislation, and report to a Commonwealth/State Gene Technology Ministerial Council.

A Commonwealth-State Consultative Group began extensive consultations for the development of a framework for gene technology regulation in December 1997.

The regulation of gene technology and its applications will operate in close collaboration with existing systems for the regulation of food, agricultural and veterinary chemicals, industrial chemicals and therapeutic goods.

New Institute of Molecular Bioscience

Institute of Molecular Bioscience

In addition to the Biotechnology Strategy, the Commonwealth will contribute \$15 million of Federation Funds over four years to the establishment of the Institute of Molecular Bioscience (IMB) at the University of Queensland (UQ). The IMB is a joint venture of the Commonwealth and Queensland State Governments, the UQ and a private benefactor. Total cost is estimated at \$55 million, with the Federation Fund, Queensland Government and UQ each contributing \$15 million, and the balance coming from the private benefactor.

The IMB will bring a number of research organisations under one umbrella, including the Australian Genome Research Facility (AGRF), the Centre for Molecular and Cellular Biology (CMCB), the Drug Design and Development Centre (3D Centre), the Centre for Microscopy and Microanalysis (CMM), the CSIRO Molecular Animal Genetics Centre (MAGEC), and the QDPI Agricultural Biotechnology Centre (QABC).

The IMB will share a building complex and infrastructure development totaling 35,000 square metres with the CSIRO Division of Tropical Agriculture (valued at \$45 million) bringing the total development value to \$100 million. The IMB will employ about 450 scientists while a further 250

will be employed by the CSIRO, giving a total employment in the complex of

some 700 researchers.

Marine Science and Technology

Oceans Policy

On 23 December 1998 the Government released Australia's Oceans Policy, the first comprehensive national policy to protect and manage Australia's oceans. At the core of the Policy is a commitment to ecosystem-based management of our marine jurisdictions, which will be implemented through a new approach — the development of integrated Regional Marine Plans — based on large marine ecosystems.

Marine Science and Technology Plan

The Government is developing a Marine Science and Technology Plan that will identify national issues and priorities in marine research; and in building our marine science, technology and engineering capability. The Plan nominates a series of strategies to further our understanding and sustainable use of the Australian marine environment, and provides a foundation for the conservation and resource development efforts encompassed by the Oceans Policy.

National Marine Science Centre

The Coffs Harbour National Marine Science Centre (MSC) is a Federation Fund project with a total cost estimated at \$12 million, spread over the four year period to the end of financial year 2001/02. It is a joint initiative of the University of New England and Southern Cross University. When completed, the Centre will provide much needed research and teaching facilities for temperate climate marine science, particularly in reef forming corals and species, in a biologically important location at the overlap of the northern and southern biotic regions.

Joint Australian Facility for Ocean Observing Systems

CSIRO and the Bureau of Meteorology Research Centre have established a Joint Australian Facility for Ocean Observing Systems (J AFOOS). The facility will focus on designing and developing a suite of marine observing systems in the Indian and Pacific Oceans. The Australian Ocean Observing System will use advanced instruments and satellites, as well as systems such as the long-standing voluntary program adopted by commercial shipping, to collect information on surface and sub-surface ocean temperatures. It will

contribute to Australia's international responsibilities to understanding and monitoring the Exclusive Economic Zone, and is a timely response to the increasing national and international interest in the role of the oceans, especially related to climate prediction and climate change.

Nuclear science and technology

Replacement Nuclear Research Reactor

On 3 September 1997, the Government announced a major upgrade to Australia's nuclear science infrastructure with the decision to construct a replacement nuclear research reactor at a cost of \$286 million. The new reactor will replace the technologically obsolete High Flux Australian Reactor (HIFAR). It will provide the Australian medical, industrial, scientific and engineering communities with access to a modern, multi-purpose reactor that can maintain and enhance Australia's nuclear science and technology capabilities. A Draft Environmental Impact Statement (EIS) was prepared, and released on 17 August 1998 for public review and comment. Some 935 submissions were received as a result of the 12-week public exhibition period, with approximately 10 per cent originating from the local community area around the Lucas Heights Science and Technology Centre. A Supplement to the Draft EIS was prepared and submitted to Environment Australia on 18 January 1999, in response to issues raised in submissions on the Draft EIS. Following this the Minister for the Environment made a series of recommendations, which have been accepted by the Minister for Industry, Science and Resources and will be implemented to ensure the replacement reactor at Lucas Heights is built and operated in accordance with best international practice.

Accelerator enhancements

In support of efforts by international organisations to strengthen nuclear safeguards, ANSTO has developed ultra-sensitive environmental monitoring methods. The techniques involve the use of a new tandem accelerator beamline that was built for the detection of actinides and long-lived fission products. The capabilities of the Australian National Tandem Accelerator for Applied Research (ANTARES) were also enhanced through the addition of a high energy heavy ion microprobe, which is being used in a research project to study the immobilisation of waste materials using cement pastes.

Integrated solutions

The recently commissioned small angle neutron scattering instrument forms part of an integrated technology platform being used by ANSTO to address a number of important questions, posed by Australian research and industry communities, about properties of materials as determined by their microstructure — such as porosity, purity, surface characteristics and crystal formation. The range of materials explored includes polymers and polymer blends important in the design and manufacture of products made from

recycled materials; and rock, the porosity of which, for example, controls the flow of oil to a well-head. A multi-disciplinary team has adopted a problem-solving strategy to bring the full benefits of nuclear-based science and technology to ANSTO's stakeholders.

Nuclear Safety Culture

ANSTO is undertaking a strategic research and development project into Nuclear Safety Culture. This employs a safety culture survey developed in collaboration with the School of Psychology at the University of New South Wales and trialled at ANSTO. The survey is now being applied in nuclear research institutes in Indonesia, Japan, Korea, Vietnam and Thailand; an agreed set of safety culture activity indicators is also being trialled in nine regional countries. The results of these activities will be studied at a workshop in May 1999, which is planned by ANSTO and will be hosted by the Malaysia Institute of Nuclear Technology.

Federal Sector Science Programs

Cooperative Research Centres (CRC) Program 1998 selection round

The 1998 CRC selection round was formally launched on 31 May 1998, following the decision by government in the 1998-99 Budget context that the program would continue at the level of the then current forward estimates. Applications closed on 30 September 1998.

Fifty nine applications were received. On the basis of extensive reviews by two expert panels and independent referees and assessors, a short list of 43 applications were selected for interview. The final recommendation was considered by the Committee on 18 March 1999, and the Minister announced funding for 26 CRCs on 16 April 1999.

Contracts with the successful proponents are being negotiated. The total value of program funds to be committed in those contracts is about \$397 million. Industry will contribute \$419 million in additional funds, and other CRC participants, including universities and research organisations, will contribute about \$1050 million.

<i>Cooperative Research Centre</i>	<i>Level of Funding (\$ Millions)</i>
AJ Parker for Hydrometallurgy	11.5
Asthma	11.5
Australian Cotton	13.4
Australian Photonics	27.4
Australian Telecommunications	14.8
Biological Control of Pest Animals	13.9

Bioproducts	13.7
CAST Metals Manufacturing	21.0
Catchment Hydrology	16.2
Cattle and Beef Quality	16.0
Clean Power from Lignite	14.1
Coastal Zone, Estuary and Waterway Management	14.7
Cochlear Implant and Hearing Aid Innovation	14.2
Enterprise Distributed Systems Technology	20.0
Freshwater Ecology	14.0
Great Barrier Reef World Heritage Area	16.4
Intelligent Manufacturing Systems and Technologies	13.6
MicroTechnology	17.4
Polymers	15.0
Sensor Signal and Information Processing	13.2
Terrestrial Carbon Accounting	15.3
Tropical Plant Protection	13.9
Tropical Rainforest Ecology and Management	16.7
Vaccine Technology	13.4
Viticulture	13.6
Welded Structures	11.5

Major geospatial information initiatives

Australia's national mapping agency, AUSLIG, has the lead responsibility within the Commonwealth for development and implementation of the Australian Spatial Data Infrastructure (ASDI). The ASDI aims to provide better access to essential geographic information about Australia to Government, the private sector and the broader community. This increased accessibility is necessary to improve decision making in such areas as environmental assessment, natural resources management, socio economic studies and physical infrastructure development such as mobile communications networks, roads, railways, power grids and airports.

Online Web Mapping

Australia has made substantial gains in the field of online mapping. We have been nominated as the lead nation on Web Mapping within the Global Spatial Data Infrastructure technical community. Online Web mapping will enable access to geospatial information from a variety of Internet sources and the ability to compile this information into a map product. AUSLIG has become a sponsor of the Open GIS Consortium (OGC) "Web Mapping Technology Testbed", joining the US Federal Geographic Data Committee, US Army Topographic Engineering Centre, and the US Department of Defence National Imagery and Mapping Agency. As a full 'Testbed' member, AUSLIG has secured industry, research and government partners for a newly formed Australian WWW Mapping Consortium to coordinate Web Mapping and associated inputs into OpenGIS nationally.

Major geophysical initiatives

Offshore petroleum frontiers promotion

As part of the National Geoscience Survey Initiative, additional funding of \$33.3 million over four years was identified for the Australian Geological Survey Organisation (AGSO) in the Government's 1998 Budget to help identify possible new offshore petroleum zones in frontier areas of Australia's Exclusive Economic Zone. AGSO is currently undertaking a series of major studies drawing on the funding initiative to demonstrate petroleum exploration opportunities.

Australian National Seismic Imaging Resource (ANSIR)

A new seismological facility designed to image structures inside the Earth was unveiled in December 1998 by the Parliamentary Secretary to the Federal Minister for Industry, Science and Resources, the Hon Warren Entsch MP. ANSIR was assembled over three years using a grant of \$5 million provided by the Commonwealth Government under its Major National Research Facilities Program. This program was established to strengthen Australia's research and education base so as to ensure Australia remains internationally competitive. Seismic images of the Earth generated by ANSIR will provide vital insights into the geology of the Australian continent.

Greenhouse science

The National Greenhouse Research Program

The Government is providing an additional \$14 million over four years for Greenhouse Science through the National Greenhouse Research Program (NGRP). The NGRP aims to support, through targeted research, the development of policies and activities to deal with atmospheric change and greenhouse-induced climate change. It consists of a core component providing funding to the CSIRO, Bureau of Meteorology and National Tidal Facility, and a component supporting research projects and activities on the science and impacts of climate change undertaken by various institutions. The measure will provide for continued investigation of climate systems, improving climate change models, detecting regional climate change and support for international climate change science.

Advancing greenhouse science

The Greenhouse Science Advisory Committee submitted its report, entitled *Advancing Greenhouse Science Strategy & Business Plan 1999 to 2004*, to the Minister for the Environment and Heritage in December 1998. The Plan was prepared following an extensive round of focus group meetings and consultations involving scientists from a range of research institutions including CSIRO, the Bureau of Meteorology and universities. The Plan outlines strategies, activities, outcomes and performance measures for an effective Australian greenhouse science research program over the next five years. It does this for the priority areas of Greenhouse and the Climate System, Climate Variability and Trends, Impacts and Adaptation,

Mitigation, and Tracking Emissions and Sinks. The Plan also stresses the importance of communicating the results of research to contribute to policies aimed at mitigating and adapting to climate change.

Refining the National Greenhouse Gas Inventory

Since the agreement of the Kyoto Protocol, the Framework Convention on Climate Change has increased its focus on improving the quality and the level of certainty of greenhouse gas inventories. The Australian Greenhouse Office has planned a program of inventory development and research aimed at providing direct improvements to the Australian National Greenhouse Gas Inventory over the short to medium term. The immediate focus is on reducing uncertainties in the land use change and forestry sector. The Australian Greenhouse Office is also participating actively in a series of workshops conducted by the Inter-governmental Panel on Climate Change to develop guidelines on good practice in inventory preparation and a framework for estimating and communicating uncertainties.

New environmental research centre

In August 1998, the Minister for the Environment, Senator Hill, announced that a National Centre for Tropical Wetlands Research would be established in the Northern Territory. The centre will build on the internationally recognised expertise of the Environmental Research Institute of the Supervising Scientist (ERISS), with formal links to the Northern Territory University, the University of Western Australia and Townsville's James Cook University.

Major Antarctic report

The Government has accepted the broad thrust of the report Australia's Antarctic Program beyond 2000: a framework for the future as providing an appropriate basis for the development of a focused and effective Australian Antarctic Program for the next twenty to thirty years. In particular, the Government has accepted the Antarctic Science Advisory Committee's recommendations that the future achievement of Australia's Antarctic objectives will require more flexible uses of resources and the provision of more cost effective and responsive transport and infrastructure arrangements.

Meteorological and related advances

International collaboration in ocean monitoring

The Global Ocean Data Assimilation Experiment (GODAE) is an international initiative, based on recent scientific and technological advances, aimed at establishing a long-term monitoring system for the global oceans. In 1998, the international project office for GODAE was set up in the

Bureau of Meteorology Research Centre (BMRC). Through some 3,000 sub-surface floats across the world's oceans, providing routine measurements of the temperature and salinity structure, GODAE will provide data input to computer models that predict the future behaviour of the global oceans.

Southern Ocean Atmospheric Photochemistry Experiment

A major international project, the second Southern Ocean Atmospheric Photochemistry Experiment (code-named SOAPEX2) was conducted during January and February 1999. The experiment was based at the Cape Grim Baseline Air Pollution Monitoring Station in Tasmania, and involved participants from the Bureau of Meteorology, the CSIRO and three British universities.

One of the largest and most comprehensive studies ever conducted into the chemistry of the lower atmosphere, SOAPEX2 is part of a major international effort to understand more about the chemistry of our atmosphere and its impact on climate.

Improved rainfall estimates for tropical storms

The Generalised Tropical Storm Method (GTSM) for estimating Probable Maximum Precipitation (PMP) for tropical regions of Northern Australia will be reviewed under a new three-year project with an estimated total budget of \$1.5 million. The objective of the project is to improve the quality of PMP estimates in those regions of Australia affected by tropical storms. The project was jointly undertaken by the Bureau of Meteorology and a number of State Water agencies.

Rural R&D Corporations

Meat Research

On 1 July 1998 the functions of the Meat Research Corporation were subsumed within a new industry owned company established under Corporations Law, Meat and Livestock Australia Pty Ltd. Under a Memorandum of Understanding between the Government and the company, the Government maintains its contribution to meat R&D under the same formula — matching industry R&D levies on a dollar-for-dollar basis up to 0.5% of the industry's gross value of production — as is applied to other rural R&D Corporations within the Agriculture, Fisheries and Forestry – Australia (AFFA) portfolio.

International science and technology links

APEC

The Government supports participation by the Australian research community in APEC science and technology activities, through the APEC Industrial Science and Technology Working Group (IST WG). Australia is 'Lead Shepherd' guiding the 1ST WG for 1999.

The 3rd APEC Ministers' Conference on Regional Science and Technology Cooperation was held in Mexico in October 1998 on the theme of 'Facilitating Networks and Partnerships'. Australia was closely involved in the *Mexico Declaration* endorsed by Ministers at this meeting.

The activities of the Working Group for 1999 will focus on implementation of the *APEC Agenda for Science and Technology Industry Cooperation into the 21st Century*, the *Cleaner Production Strategy* and the *Mexico Declaration*.

Information about the Working Group and its activities can be found on the APEC Science and Technology Web site (ASTWeb), located at www.apecst.org. ASTWeb contains a web-based directory of links to science and technology sites throughout APEC, information on science and technology activities throughout APEC and member economies, discussion forums and a calendar of APEC science and technology events.

OECD

Over three decades, the OECD has made a substantial contribution to the study and discussion of policy issues in science, technology and innovation through the OECD Committee for Scientific and Technological Policy (CSTP) and its various working groups. This work has greatly facilitated the exchange of policy experience between member countries and had a major influence on the directions of science and technology policy in all developed countries.

CSTP work focuses on the following areas:

- **The development and analysis of science and technology indicators**, to provide a consistent international approach to the measurement of science and technology activity so as to provide an empirical base for comparing member countries' performance;
- **Innovation and technology policy**, which includes the exploration of new policy approaches, national innovation systems, technology diffusion, and issues relating innovation to productivity;
- **The science system**, looking at, for example, trends affecting university research and education, public understanding of science and technology, and how results of the science system contribute to economic growth and employment;

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- **International cooperation in relation to large facilities and projects** — Australia has been particularly active in relation to possible new international facilities for biological informatics and radio astronomy;
 - **Biotechnology studies** related to human health, intellectual property, technology transfer and genetic resources, water use and conservation, and food safety.

Australia continues to be very active within the CSTP and its subgroups and has taken a leading role in some areas. A meeting of the OECD Working Group on Technology and Innovation Policy (TIP) was hosted by Australia in Canberra during November 1998, the first time the group had met outside OECD headquarters in Paris. A number of associated workshops were organised, concentrating on the Knowledge-Based Economy, innovation and commercialisation of research. These workshops involved participation from APEC member economies and some other countries. Over 120 Delegates, representing some 35 economies, participated in this series of meetings.

Bilateral activities

- China

- Australia and China successfully conducted a number of collaborative activities in the 1998-99 financial year, including:
 - In September 1998 Australia sent nine people, led by the Chief Scientist, John Stocker, to "China Water '98". The visit was organised by the Ministry for Science and Technology (MOST) in Beijing;
 - A delegation led by Professor Shang Yong, Director General, Department of Policy, Regulation and Reform, MOST, visited Australia in November 1998 to learn about Australian science and technology policy;
 - Ten Chinese were invited to a workshop on S&T collaboration between Australia and China held as an adjunct to the Australian Waste Water Association (AWWA) Conference and Water Industry Trade Show/Convention in April 1999;
 - A workshop to showcase Australian technologies focusing on odours and air pollution was held in Chengdu, China, in May 1999; and;
 - A workshop to coincide with the Fifth International Union of Materials Research-Societies International Conference on Advanced Materials (IUMRS - ICAM '99) will be held in Beijing in June 1999.

- European Union

- Australia was involved in 37 research projects with European partners, under the EU's Fourth Framework of Research and Development, which concluded in December 1998. Projects were in

the fields of biomedicine, environment and climate, telematics, energy and measurement standards.

- The Department of Industry, Science and Resources hosted the fourth meeting of the Joint Science and Technology Consultative Committee in Canberra in March 1999. This meeting reviewed the achievements and events for collaborative research and discussed benefits to be gained through international collaboration. It looked to the EU's Fifth Framework Program, which commenced in March 1999, as an opportunity to progress the relationship through new projects. The relationship entered a new phase when agreement was reached in October 1998 to amend the 1994 S&T Agreement so as to allow Australian researchers to participate in all the thematic research and technological development programs. The previous agreement had restricted Australian participation to six sectoral areas.

DISK and the EU jointly funded a workshop in clean coal technologies in Brussels in May 1999.

- France

- The French Australian Industrial Research (FAIR) program supported a range of collaborative follow-up activities, between Australian and French research organisations and companies, resulting from the FAIR Workshop on Food Processing Technologies. The Australian side hosted the FAIR Workshop in April 1999, on the topic of Water and Wastewater Treatment. The meeting of the Joint Steering Committee, held in Adelaide, discussed strategies for future bilateral cooperation under the FAIR Arrangement.

- Germany

- Australia is partnering with Germany in biotechnology, water and environment technologies. Major projects are underway to enhance these partnerships and to form research and industry consortia to access the EU's Fifth Framework Program for Research and Development and jointly address wider markets.

- India

- A workshop with local government R&D institutions, universities and regional industry groups was held in the Indian state of Kerala (south-west coastal region) in April 1999. The aim of the workshop was to brainstorm areas of interest for collaborative R&D projects and to showcase Australian technologies appropriate for local needs as a platform for on-going industrial linkages.

- Indonesia

- Collaboration in S&T with Indonesia continues to progress under the Agreement on Science and Technology Cooperation between our nations. The Collaboration on Science and Technology Australia:Indonesia (COSTAI) Joint Steering Committee meeting was held in February 1999. This meeting set the strategic directions for activities in collaborative science and technology research for 1999-2000. The priority research areas of biotechnology, mining/mine site rehabilitation and clean water were agreed as areas of mutual interest by the Joint Steering Committee.

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- Strategic forums in biotechnology and mining/mine site rehabilitation are scheduled for September 1999, and are to be followed by a clean water strategic forum in March 2000. It is anticipated that these forums will involve experts from both countries in focusing research interests within these broad priority areas.
 - A number of collaborative projects with Indonesia have been funded under the Targeted Research Alliances component of the Technology Diffusion Program.

- Italy

- The Memorandum of Understanding (MoU) for Cooperation in Scientific Research and Technology between Australia and Italy was renewed in the first half of 1999. This MoU will form the basis for future workshops and expanding collaborative research.

- Japan

- The Department of Industry, Science and Resources funded two collaborative workshops in early 1999:
 - a mariculture workshop concerning the propagation of lobsters was held in Fremantle, Western Australia, in January 1999, involving research scientists from Australia and Japan and lobster industry organisations; and
 - a renewable energy workshop was held in Perth, Western Australia, in February 1999, involving key experts from Australia and Japan's New Energy and Industrial Technology Development Organisation.
- Japan hosted the 9th Joint Science and Technology Consultative Committee meeting in Tokyo in May 1999. The meeting discussed priority areas for collaboration and expects to endorse a number of projects out of session.

- Korea

- The S&T relationship between Australia and Korea has been growing steadily, and a Treaty-status Agreement between the two countries is now ready for signing.
- A number of collaborative research projects in the fields of biotechnology, energy, the environment and photonics are currently in progress.
- There have also been two major collaborative workshops during the past twelve months. The first of these was the Korea-Australia Joint Symposium on Biotechnology, held in Seoul in November 1998 and attended by representatives of the Australian and Korean research communities and private sector bodies. The second was a symposium and series of workshops, held in Pusan and Ulsan, aimed at showcasing Australian environmental technology and management expertise.

- Malaysia

- A joint science and technology meeting for senior government officials will be held in Kuala Lumpur in early June 1999 to discuss policy developments, review bilateral activities and to endorse new collaborative proposals.
- Prior to this meeting, Malaysia hosted a biotechnology workshop which will focus on vaccine technology and food nutrition. New collaborative activities will be developed as a result of this workshop.

- Mexico

- Australia's science and technology relationship with Mexico has been strengthened by Workshops in Water and Waste Water Treatment and Technology for the Beef Industry. These were supported under the Technology Research Alliances element of the Technology Diffusion Program.

- United Kingdom

- The Department of Industry, Science and Resources and the British Council (Sydney) managed the Partners in Innovation Program for facilitating research collaboration for enhanced industry innovation and technology diffusion. Under this program, the British Council brought out a group of Welsh research scientists from a wide range of innovative areas for visits/workshops with groups with similar interests from New South Wales, in Sydney in October 1998. The Department will be supporting reciprocal visits to Wales in 1999.
- Also under the Partners in Innovation Program, the Department of Industry, Science and Resources funded a water and waste management workshop in Sydney in November 1998, and a sludge management and waste water treatment workshop in Perth in April 1999.

Other initiatives in support of science and technology

- in industry, science and technology

- R&D Scoreboard' 98 was released by the Industry Research and Development Board and AusIndustry. This is the fourth in a series of reports on business expenditure on R&D at the firm level. Scoreboard aims to raise awareness of the importance and benefits of R&D. It shows that a select group of Australian companies have a strong commitment to R&D, and that they are playing a major role in determining Australia's technological progress, thus ensuring the future prosperity of Australian business. In contrast to most studies of R&D, the Scoreboard series provides R&D data on individual firms, which can provide unique insights for investors, policy makers and firms.
- A Memorandum of Understanding (MoU) between the Commonwealth and CSIRO regarding the National Measurement Laboratory (NML) was signed on 4 September 1998. Among other

things, **the MoU declares NML a National Facility within CSIRO.**

- United States company Tadiran Microwave Networks has **extended and expanded the scope of research and development** being carried out by CSIRO in a move that could lead to the establishment of a significant millimetre-wave microwave industry in Australia. The first objective is to develop a new range of radios.
- In November 1998, **the Australia Telescope opened the first part of the upgrade** that will allow it to receive higher frequencies and thus get finer details of observed objects such as our galaxy, stars being born, other galaxies and gas clouds. The work is being funded by the Major National Research Facilities Program and CSIRO's Capital Investment Plan.
- **CSIRO and British Aerospace Australia have signed a research relationship agreement** worth up to \$20 million to develop advanced materials and processes for the global aircraft industry of the early 21st century. Research to be carried out under the new agreement will involve the development of tougher composite materials for building lighter aircraft structures, and devising more effective and environmentally-friendly ways to monitor and extend the life of aerospace parts.
- **Riverside Corporate Park, North Ryde**, a CSIRO initiative to self-fund the replacement and refurbishment of aged and obsolete research facilities and infrastructure, is moving into Stage III. Sound planning processes and sophisticated marketing techniques have successfully guided the development through Stages I and II. The objective to re-accommodate in excess of 500 researchers in high-quality accommodation by early next millennium is likely to be achieved.
- In February 1999, Australia's National Mapping Agency, AUSLIG, introduced a **new pricing and delivery scheme for key Commonwealth digital map data**. This initiative will improve access to fundamental mapping data using technology from the Internet and has resulted in a 66 per cent reduction in the price of selected data. This will ensure that digital data is readily available and affordable to industry and the community for use as planning and management tools.
- AUSLIG's SPOT-LITE product was launched in November 1998 enabling satellite imagery to be obtained with a moment's notice of placing an order through the Internet.
- The ASDI Grant Partnership Program being conducted by AUSLIG is a fundamental part of the Government's Australian Spatial Data Infrastructure (ASDI) implementation strategy. This program aims to assist groupings of agencies and companies to release existing spatial data holdings into the public arena.
- To encourage mineral exploration and facilitate the discovery of economically significant mineral deposits, **the Australian Geological Survey Organisation (AGSO) produces a range of new geoscience information products** as part of the National Geoscience Mapping Accord (NGMA). The NGMA is a cooperative Commonwealth, State and Northern Territory initiative to produce a new generation of

geological maps and information for onshore Australia drawing on new data collection, processing and analysis techniques.

- In conjunction with the Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRCLEME), AGSO is applying computer modelling techniques to map and visualise the subsurface characteristics of regolith in 3D. Integrated geochemical modelling and 3D regolith mapping are important inputs in assisting geoscientists to improve regolith-landscape evolution models. These models in turn will help promote the development of enhanced geochemical models for resource exploration and landscape models for environmental management.

- in science and technology awareness:

- The 1999 Australia Prize was awarded in the field of energy science and technology to two scientists - Professor Martin Green and Professor Stuart Wenham - both from the University of New South Wales for their work in photovoltaics, the conversion of sunlight into electricity. Professors Green and Wenham have invented or co-invented seven distinct solar cell technologies over the past 15 years. Their 'Buried Contact Cells' technology currently holds the world efficiency record, at 24.5 per cent, for converting sunlight into electricity.
- **The 1999 Michael Daley Awards for Science, Engineering and Technology Journalism**, outsourced to the Australian Museum, were presented in May 1999, as part of National Science Week, in conjunction with the Eureka Awards.
- In 1998-99, the Science and Technology Awareness Program continued to manage **grants** awarded to individuals and organisations for activities which aimed to increase the science and technology awareness of Australians. The projects target regional and country areas of Australia and industry groups, emphasising the importance of engineering and mathematics to Australia's economic well-being.
- In May 1999, the Commonwealth supported a highly successful **National Science Week** featuring activities coordinated and arranged by the Australian Broadcasting Corporation (ABC), the Australian Science Teachers Association (ASTA) and the Australian Science Festival (ASF). National Science Week 1999 featured over 800 events involving schools, businesses, museums, science centres and industry.
- The Government continued funding the **Science Broadcasting Development Project** at the ABC. Since its launch in July 1997, The Lab web site has continued to generate intense interest. Its companion site, Labnotes, extends the ABC's science output to Australia's classrooms with specific curriculum content. The Lab has also formed a content-sharing relationship with the Dutch Elsevier science news channel, allowing more Australian science news stories to reach an international audience.
- The Government continued as a major sponsor of the **Australian Science Olympiads**, providing funding of \$250,000 for 1998-99.

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- The quarterly newsletter for science and technology communicators, **FACETS**, continued publication in 1998-99. Distributed to 1,900 communicators, it has a national coverage of projects and activities in science and technology awareness to provide opportunities for cooperative ventures.
 - The 5th edition of the **Register of Science and Technology Communicators** was published in December 1998 and has been widely distributed. The Register contains contact information on people and projects interested in science and technology matters and, by facilitating networking, seeks to enhance cooperation and stimulate ideas.
 - The Cooperative Research Centres Program and the Technology Diffusion Program jointly **sponsored the Cooperative Research Centres Association inaugural Awards for Excellence in Technology Transfer**. The three award winners were: A J Parker Cooperative Research Centre for Hydrometallurgy; Cooperative Research Centre for Tissue Growth and Repair; and Cooperative Research Centre for Catchment Hydrology.
 - **The *Ingenious!* CD-ROM won the 1998 AIMIA Award for best entertainment/game CD-ROM**. This CD-ROM was developed by the National Science and Technology Centre (Questacon), the ABC and Radiant Productions under the Australia on CD program.

- in international science and technology collaboration

- ANSTO is contributing to three International Atomic Energy Agency (IAEA)-sponsored coordinated research programs. These cover the use of biological processes to remove sulphates in the treatment of mine and mill effluents, the characterisation of technologies used in environmental restoration activities and the improvement of safety assessment methods for near-surface waste disposal facilities, a key component in the siting, design and establishment of Australia's proposed low-level waste repository.
- ANSTO has become **a preferred supplier to the IAEA of nucleonic equipment** for the South-East Asian region, and has recently won orders from the IAEA to supply a number of South American countries.
- Through ANSTO, **Australia has been appointed by the IAEA as lead country for the sub-project "Management of Marine Coastal Environment and its Pollution"**, which is a component of the three-year United Nations Development Program/International Atomic Energy Agency/Regional Cooperative Agreement project 'Better Management of the Environment, Natural Resources and Industrial Growth through Isotope and Radiation Technology'. Training facilities will be used at both ANSTO and the University of New South Wales. The participating countries are Australia, Bangladesh, China, India, Indonesia, Korea, Malaysia, Myanmar, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand and Vietnam.
- In collaboration with the Department of Foreign Affairs and Trade and IDP Education Australia, Questacon developed **Innovative Australians, an exhibition designed to showcase Australian**

capabilities as an innovator of sophisticated science and technology expertise, promote economic opportunities for Australia and raise awareness of the contribution Australia is making to improving the quality of life in our region. The exhibition is touring in India, Thailand, the Philippines, Malaysia, Singapore and Taiwan.

- Questacon hosted the SpaceQuest exhibition, developed by the National Space Development Agency of Japan (NASDA) to celebrate Questacon's tenth birthday. The exhibition and associated activities were a feature of the Australia Japan Friendship Anniversaries 1996-98. **SpaceQuest explored recent developments in Japanese space travel and research** and featured the Alflex, an experimental space vehicle developed by NASDA and tested at Woomera in South Australia in 1996.
- Questacon has been selected to host the Third World Congress of Science Centres, to be held in 2002.
- **International Agreements signed by CSIRO:**
 - A collaborative agreement has been signed with the Institute of Molecular Agrobiolgy at the University of Singapore for agricultural research.
 - CSIRO and Australian industry have signed an agreement giving them access to \$1.6 million worth of Japanese magnesium research through Japan's Mechanical Engineering Laboratory at Tsukuba and the National Industrial Research Institute of Nagoya.
 - AgrEvo, one of the world's leading crop production companies, and CSIRO have signed a five-year strategic research alliance to collaborate in specific areas of agricultural biotechnology. The new partnership involves CSIRO, a research group from the Australian National University, Hoechst Schering AgrEvo GmbH (Germany) and its Australian subsidiary, AgrEvo Pty Ltd.
 - Several agreements have been made with government and research institutes in Japan to further joint coal research. These include Memoranda of Understanding with Japan's Ministry of International Trade and Industry and JCoal on underground mining; with the Central Research Institute for the Electric Power Industry on coal utilisation; with the Centre for Coal Utilisation Japan on ultraclean coal; and with the Research Institute for Innovative Technologies for the Earth on carbon dioxide recycling and gas separation.

- in environment

- **The National River Health Program is providing crucial information to support implementation of the COAG Strategic Water Reform Framework** and meet the commitment to give priority to research to progress the Framework, in particular the determination of consistent methodologies for establishing environmental flow requirements. Under the Natural Heritage Trust, the Government has allocated \$15.8 million to the program for the period 1996-97 - 2001-02. There are two major components of the program: Environmental Flows Management and Australia-Wide Assessment of River Health. The program operates as a partnership

between the Commonwealth, the States and Territories and research organisations.

- A number of research projects in native vegetation research, funded jointly by Environment Australia and the Land and Water Resources Research and Development Corporation were completed. The aim of the program is to **assist government agencies, community groups and land holders to better manage and protect native vegetation** through the application of improved knowledge and understanding gained from research.
- The Marine Group of Environment Australia is providing \$100,000 to the Queensland Environment Protection Authority from the Clean Seas Program, and \$32,500 to Antifouling Solutions Pty Ltd and the Defence Science and Technology Organisation Australia from the Introduced Marine Pests Program, for three projects to support Australia's commitment to ban the application of tributyltin (TBT) antifoulants.
- Reports resulting from the study of the radiological situation at the former French nuclear sites at the Mururoa and Fangataufa atolls were published. The study found that **no remedial action at the Mururoa and Fangataufa atolls was needed** on radiological protection grounds.
- ANSTO's experience and technology in radiotracing is underpinning the **design, development and verification of a model to measure the fate and transport of sediments and contaminants** in the coastal zone. Carried out with the assistance of Sydney Water and the Hunter District Water Board, and in collaboration with the Water Research Laboratory of the University of New South Wales, the model will provide a three-dimensional model of the turbulence experienced at depths of up to 70m.
- As part of Global Climate Change studies in collaboration with Monash University, University of Tasmania, University of Adelaide and University of Wollongong, a project **investigating the timeframes for climate and environmental change over the past 200,000 years** in Australia is nearing completion. This study was carried out using analytical techniques on ANSTO's Accelerator Mass Spectrometer coupled with uranium series geochronology. Data taken from the three pole-equator-pole transects for this study will be used for a global database as part of the international geosphere/biosphere program. The final report for this project is due to be released in July 1999.
- A study involving the deployment of a radon detector at Cape Grim Baseline Air Pollution Station has established that **40 per cent of the fine particles in the air sampled were from man-made sources**. This information is being fed into the international models of global climate change being developed by CSIRO, Atmospheric Research.
- ANSTO's three-year Managing Mine Waste Project, launched last year, has established a number of test sites, enabling the key aims of the project, reducing acid mine drainage, to be satisfied. The project has developed an ecological risk assessment software package that has been used at one of the test sites. This package is being developed further so it can be used at more generic sites. Collaborations have

been established with and between CSIRO, Australian and overseas universities, environmental consultants and mine operators.

- ANSTO, through its collaborative link with the CRC for Waste Management and Pollution Control Limited, has demonstrated the **application of its patented technology in the treatment and removal of arsenic from tube well water**, which is used in Bangladesh villages for drinking. The demonstration, which was funded by AusAID, proved successful in removing arsenic to below the levels accepted by the World Health Organisation.
- ANSTO researchers began a study of the poisoning mechanisms of automobile catalytic converters, with the aim of increasing the converters' life expectancy. Samples from used catalytic converters were studied, using ion beams from ANSTO's 3 MV Van de Graaff accelerator. This work was undertaken as a commercial project for the NSW Environmental Protection Agency.

- in meteorology

- A three-year research and development program, involving the Bureau of Meteorology, CSIRO and NEC, and based around the NEC SX-4 supercomputer operated by the joint Bureau of Meteorology-CSIRO High Performance Computing and Communications Centre (HPCCC), was established. One focus of the program is to upgrade the major systems used by the Bureau of Meteorology for research and operations. Key projects include the exploitation of the full computational power of supercomputer architectures for atmospheric and oceanographic prediction, and the development of effective data-management facilities for accessing and visualising results from models run on the supercomputer.
- Improvements to meteorological services were achieved through the development and introduction on the $\langle \text{World Wide Web} \rangle$ World Wide Web (www.bom.gov.au) of a graphically displayed tropical cyclone threat map covering the northern areas of Australia. During tropical cyclone Rona in February 1999, the threat maps, combined with real-time weather observations and forecast information, led to hits on the Bureau of Meteorology's web server peaking at more than 3.5 million hits per week.
- The Bureau of Meteorology's **atmospheric transport and prediction system was enhanced to operate at finer scale** and its capabilities were extended to cover volcanic eruptions in support of the advisory service to aviation. In June 1998, the National Meteorological Operations Centre participated in an international intercomparison of predictions of volcanic debris dispersal for a hypothetical eruption of Mt Hekla in Iceland.
- The Bureau of Meteorology works with AusAID to support National Meteorological Services in the Asia Pacific region. Under an AusAID-funded project, the Bureau **developed a seasonal rainfall outlook scheme for Fiji tailored to local conditions** and implemented the scheme in the Fiji Meteorological Service. The transparency of the underpinning theory and the availability of a thorough assessment of the skill of the outlooks, makes the scheme an attractive support tool suited to the needs of many other nations in

the Asia-Pacific region also influenced by the El Nino and Southern Oscillation phenomena.

- To strengthen the technological capability of ASEAN countries to deal with transboundary smoke haze caused by forest fires, an AusAID-funded project was announced by the Minister for Foreign Affairs on 28 July 1998. This project is being implemented by the World Meteorological Organization (WMO) in conjunction with the Economic and Social Commission for Asia and the Pacific (ESCAP), with the Bureau of Meteorology assisting its coordination.
- The Bureau of Meteorology's Reference Climate Station (RCS) network was pivotal in **identifying 1998 as Australia's warmest year on record**. Maintenance of this network, at the necessarily high standards required for climate change detection, is supported by funding provided by Government in response to the 1996 Review of the Operation of the Bureau of Meteorology.
- SILO, an agro-meteorological web site that is a joint initiative of the Bureau of Meteorology and the Queensland Centre for Climate Applications, gained a Highly Commended award at the 1999 Sydney Easter Show's Agricultural Software Competition, the only competition of its type in the world. This competition brings together the best of Australian innovation in agricultural information technology, with participants from all States competing. **SILO was recognised for its ability to facilitate agro-meteorological monitoring and modelling**. It is jointly funded by the parent organisations and the Land and Water Resources Research and Development Corporation and the Rural Industries Research and Development Corporation.
- **Significant progress in the development of the Generalised Southeast Australia Method (GSAM) for extreme rainfall estimation** resulted in the completion by the Bureau of Meteorology of two key reports, one addressing temporal distribution of large and extreme design rainfall bursts over south east Australia, while the other detailed the methodology used to analyse rainfall data antecedent to the extreme events. The results are an important input to the design of spillway capacity for large dams.

- in defence

- The Minister for Defence announced in March 1999 that the Australian Defence Department will cooperate with the United States to assess the operational utility of a revolutionary, unmanned aerial surveillance and reconnaissance system known as *Global Hawk*. *Global Hawk* has the potential to significantly enhance Australia's ability to monitor our territory and maritime approaches. The aircraft carries high-resolution radar, optical and infrared sensors, and a satellite communications and navigation system. DSTO, with industry, will work on a maritime mode for *Global Hawk's* sensors. It is planned that Australia will host *Global Hawk's* first operational trial outside the United States early in 2001.
- In March 1999, the Minister for Defence opened the **new Explosives Ordnance Experimental Complex** at the DSTO laboratory in Salisbury, South Australia. The opening marked the establishment of a state-of-the-art facility for research into explosives, pyrotechnics

and propulsion systems. It will contribute significantly to Australian self-reliance in "energetics" aspects of weapons systems effectiveness, safety and service life.

- A **new closed-circuit, continuous flow transonic wind tunnel** was commissioned at DSTO's Aeronautical and Maritime Research Laboratory in Fishermens Bend, Victoria in March 1999. With a test section 0.8m square, it operates over a Mach number range of 0.3 to 1.4 and can be pressurised up to 2.0 atmospheres or depressurised to 0.3 atmosphere. The tunnel will be used for research into the aerodynamics of military aircraft and missiles.
- In support of Defence's commitments under the *Defence and Industry Strategic Policy Statement*, **DSTO will periodically release information on its future research programs and priorities**. New ways will be devised to make future research directions clearly visible to a wide range of industry and other interests.
- DSTO has revised its **industry interaction policy framework** to reflect better the evolving capabilities of industry and an increased Defence reliance on industry. DSTO has continued to promote interaction with industry through existing arrangements and by placing over 900 new research contracts, two research agreements and four collaborative research agreements with industry, universities and other research organisations. Nine licences for DSTO technology were also signed.
- DSTO plays an important role in the Government's initiative to **engage industry as partners in capability development**, which includes expanding the capability and technology demonstrator (CTD) program. (CTDs demonstrate how new technology may be exploited to enhance military capability in a previously unexplored manner.) The Minister for Defence announced that CTD funding could be increased to up to \$20 million per year, depending on the quality of proposals. DSTO's support of the CTD program includes promoting greater industry involvement.
- The **CTD program** continues with five CTD proposals being approved. These CTDs demonstrate the defence applications of advances in sonar, radar and bio-sensor technologies. They support Australian research initiatives and source considerable work from Australian industry, with strong industry commitment to, and co-investment in, several of the approved proposals.

- in health

- On 19 March 1999, the Minister for Health and Aged Care announced 14 grants for research into evidence-based medicine. Evidence-based clinical practice is one of the most important movements in modern medicine. It challenges health professionals to make decisions based on science rather than habit. It asks them to take account of the best available evidence in their treatment choices. There was an overwhelming response to the National Health and Medical Research Council's (NHMRC) call for expressions of interest in research into evidence-based clinical practice. More than 340 research groups replied to the NHMRC's advertisement. Thirty-five were invited to submit full applications and 14 were selected for funding. The research projects, to be funded through the NHMRC, aim to identify,

trial and sustain better ways of managing patient care. The diversity of the research projects selected proves that evidence-based medicine has a place in all areas of health. For example, the studies look at better ways of preventing heart disease, improving asthma management, caring for premature babies, detecting breast cancer, treating indigenous diabetes and other critical issues.

One project will apply principles of evidence-based medicine to the growing problem of youth suicide. The researchers, from the South Eastern Sydney Area Health Service, plan to build on an earlier study which improved continuity of care, referral and follow-up of young people hospitalised after a suicide attempt. Chief investigator for the project, Dr Margaret Tobin, wants to find out how to maintain the gains achieved so far and compare methods of incorporating new ideas into routine clinical practice.

- The NHMRC, in association with the Department of Health and Aged Care, hosted a one-day workshop on 25 March 1999 on the topic of **health and economic research**, chaired by Dr John Best, chairperson of the Strategic Research Development Committee (SRDC). The workshop involved some 40 invited experts, and were conducted largely as an interactive roundtable discussion.

The goal of the workshop was to discuss the applicability of economic analyses in health, and to consider the implication for health research priorities. The workshop aimed to canvass a future research agenda in this important area.

- The Aboriginal and Torres Strait Islander Health Research Working Group (RAWG) is a joint working group of the SRDC and the Office of Aboriginal and Torres Strait Islander Health Services (OATSIS) of the Department of Health and Aged Care. It was established to develop and implement evidence-based mechanisms for **priority setting of research activity between different health issues and types of research in Aboriginal and Torres Strait Islander health**.

One of the priority research areas identified by the RAWG was *otitis media* (middle ear infection), a disease that is pervasive and chronic in many indigenous communities. As well as causing hearing infection and loss, it can result in the long-term effects of educational and social disadvantage. An innovative draft methodology for Aboriginal and Torres Strait Islander strategic health research has been developed, and trialled on the issue of *otitis media*. The steps involved in the methodology are:

- a review of the existing evidence base and an analysis of current programs and approaches, presented as a systematic review;
- identification of the priority research/s that need to be answered to achieve health gain at a workshop of relevant experts and stakeholders. (Prior to the workshop evidence from the systematic review was mapped onto a research framework to assist with the process of identifying priority gaps that needed to be addressed);
- calling for research; and
- implementation of the results of the research into action via policy and programs.

Currently full applications are being considered by the Otitis Media Research Committee prior to making recommendations for funding to the Minister. It is expected that this methodology will be applied to other research issues for which funding has been allocated such as diabetes and substance misuse.

- A study was undertaken by Butler, Biglia and Bourke of the Research School of Social Sciences at the Australian National University in Canberra to evaluate the publication output of Australia's health sector, particularly the papers supported by funding through the National Health and Medical Research Council (NHMRC).
- The results of that study, presented in the report *Australian Biomedical Research: Funding Acknowledgments and Performance*, shows that NHMRC publications have a strong presence in the published scientific world. They appear at approximately twice the expected rate in the top 1 per cent of most highly cited publications and the top 5 per cent in many fields. NHMRC hopes to build upon the information in this study over time, by undertaking more detailed analysis of the data collected through annual funding rounds and by employing continuing data analysis techniques. The study also highlights the value of and potential for joint funding with other research funders. Work which draws support from multiple sources tends to have a high citation rate. This may be because NHMRC prestige draws extra funding and so enlarges the project. Multiple funding is also encouraged as a way to enlarge the research sector.
- The peer review process for NHMRC project grants has been enhanced in 1999 with the introduction of Discipline Panels. Along with some additional functions, the Discipline Panels will replace the Assigners' Panels, which were responsible for assigning applications to appropriate assessors and assisting with re-assignment. As in the past, each application must be independently assessed by appropriate assessors before the interview of applicants by a Regional Grants Interviewing Committee (RGIC). The Discipline Panels are expected to overcome a number of perceived problems with the previous peer review process.
- ANSTO continued to make an **important contribution to healthcare in Australia through the manufacture and commercial distribution of radiopharmaceuticals**. Radiopharmaceuticals have a significant diagnostic impact in areas such as thyroid disease, cardiology, kidney disease, bone disease and cancer. They are also used for cancer therapy, including pain palliation. These products have been either developed by ANSTO or manufactured by ANSTO under licence. They are also exported to New Zealand and Asia. The National Medical Cyclotron, which is located at the Royal Prince Alfred Hospital, Sydney, continued to routinely produce relatively long-lived isotopes (including thallium-201, gallium-67 and iodine-123), which are having a significant impact in cardiology, cancer diagnosis and diagnosis of thyroid disease. The cyclotron continued to produce short half-life isotopes used at the hospital for diagnostic applications and medical research using positron emission tomography (PET) imaging.
- Commercial radiopharmaceutical production is supported by research to **develop products to meet specific health care needs** and

to improve products and production processes. Strategic research efforts have been focused on developing agents for the diagnosis and therapy of cancer, the diagnosis or improved management of neurological disease and improved particle-based isotope delivery systems for cancer therapy. Exploratory work on the use of sol-gel matrices for controlled release led to the defining of a new strategic research project on the development and optimisation of silica and titania-phosphate gels for the encapsulation and controlled release of radiopharmaceuticals and other drugs. A sol-gel route for bonding silicon and bonding crystalline alumina was developed.

Significant statements, reviews and reports

Over the past year, a number of statements, reviews and reports dealing with major issues relating to innovation, science and technology have been published. These are listed below. Highly specialised scientific reports are not included in the list. These are normally listed in Annual Reports, which are also omitted from the list presented here.

Industry, Science and Resources Portfolio

- Minister for Industry, Science and Resources
 - *Science and Technology Budget Statements 1998-99 and 1999-2000*
- Department of Industry, Science and Resources
 - *A New Economic Paradigm?: Innovation based Evolutionary Systems*
 - *Regulation of Gene Technology*
- CSIRO
 - *CSIRO Operational Plan 1998-99*
 - *A Guidebook to Environmental Indicators*
 - *Beyond Science: Managing Projects for Success*
 - *Commitment, Collaboration and Impact: CSIRO Minerals and Energy Research*
 - *Recent Outcomes of CSIRO Research for Australia: A Briefing to Government*
- Australian Institute of Marine Science
 - *Long-Term Monitoring of the Great Barrier Reef- Status Report Number 3, Australian Institute of Marine Science, 1998.*
- Australian Nuclear Science and Technology Organisation (ANSTO)
 - *ANSTO Operational Plan 1998-99*
 - *Environmental Impact Statement for the Replacement Nuclear Research Reactor*
 - *E Report: Environmental and effluent monitoring at Lucas heights Science and Technology Centre, 1997*
 - *ANSTO's Radioactive Waste Management Policy - Preliminary Environmental Review*
 - *ANSTO Ethics & Conduct - A Code for ANSTO Staff*

Education, Training and Youth Affairs Portfolio

- Department of Education, Training and Youth Affairs
 - McCann D, Christmass J, Nicholson P and Stuparich, J, *Educational Technology in Higher Education*, Higher Education Division Occasional Paper, DETYA, Canberra, 1998

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- Reader L, *Engineering Training Opportunities into the Future - An Examination of the Recent Workplace Reforms and Their Impact on Future Training Opportunities in the Water, Electricity and Road Sectors*, DETYA, Canberra, 1998
 - Australian Research Council
 - *Discipline Research Strategies - Challenges for the Social Sciences in Australia*, ARC, July 1998
 - *Comments on Discipline Research Strategies - Challenges for the Social Sciences in Australia*, ARC, September 1998
 - *Discipline Research Strategies - Information Technology: Sink or Swim?*, ARC, March 1999
 - *Comments on Discipline Research Strategies - Information Technology: Sink or Swim?*, ARC, March 1999

Environment and Heritage Portfolio

- Australian Antarctic Division
 - Budd WE (ed), *Antarctica and global change: interactions and impacts*, Annals of Glaciology Issue 27, International Glaciological Society, Cambridge, 1998
- Australian Greenhouse Office
 - *Adaptation of the insurance industry to climate change and consequent implications*, Australian Greenhouse Office, Canberra, 1998
 - *Climate change scenarios and managing the scarce water resources of the Macquarie River*, Greenhouse Science Series, Australian Greenhouse Office, Canberra, 1998
 - *The impact of global warming on the distribution of selected Australian plants and animal species in relation to soils and vegetation*, Greenhouse Science Series, Australian Greenhouse Office, Canberra, 1998
 - *Australasian impacts of climate change — an assessment of vulnerability*, (an extract from an Intergovernmental Panel on Climate Change special report), Australian Greenhouse Office, Canberra, 1999
- Bureau of Meteorology
 - *Temporal distributions of large and extreme design rainfall bursts over south-east Australia*, Hydrology Report Series 5, Bureau of Meteorology, Melbourne, 1998
 - *GSAM Antecedent Rainfall Project Report*, Hydrology Report Series 6, Bureau of Meteorology, Melbourne, 1999
 - *Research in the BMRC*, Bureau of Meteorology, Melbourne, 1998
 - *Coupled climate modelling: abstracts of presentations at the tenth annual BMRC Modelling Workshop*, 12-13 October 1998, BMRC Research Report 69, Bureau of Meteorology, Melbourne, 1998

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- Great Barrier Reef Marine Park Authority
 - Lucas PHC, Webb T, Valentine PS and Marsh H, *The outstanding universal value of the Great Barrier Reef World Heritage Area*, Great Barrier Reef Marine Park Authority, Townsville, 1998
 - Wachenfeld DR, Oliver JK and Morrissey JI (eds), *State of the Great Barrier Reef World Heritage Area 1998*, Great Barrier Reef Marine Park Authority, Townsville, 1998
 - *Preliminary study of potential impacts on the GBRWHA from coastal urban development: a scoping study to identify projects suitable for future funding proposals*, Report to the Great Barrier Reef Marine Park Authority, 1998
 - Biodiversity Group
 - Gill AM, Woinarski JCZ and York A, *Australia's biodiversity - responses to fire: plants, birds and invertebrates*, Biodiversity Technical Paper No. 1, Biodiversity Group, Canberra, 1999
 - *Introduction*, Flora of Australia Vol 1, 2nd edition, Australian Biological Resources Study, ABRS/CSIRO Publishing, Melbourne, 1998
 - *Ferns, Gymnosperms and Allied Groups*, Flora of Australia Vol 48, Australian Biological Resources Study, ABRS/CSIRO Publishing, Melbourne, 1998
 - *Vegetation of Tasmania*, Flora of Australia Supplementary Series No. 8, Australian Biological Resources Study, ABRS, Canberra, 1999
 - *Lichens of rainforest in Tasmania and South-eastern Australia*, Flora of Australia Supplementary Series No. 9, Australian Biological Resources Study, ABRS, Canberra, 1999
 - *Introduction, Species Plantarum: Flora of the World*, Australian Biological Resources Study, ABRS, Canberra, 1999
 - *Irvingiaceae, Species Plantarum: Flora of the World*, Australian Biological Resources Study, ABRS, Canberra, 1999
 - *The Global Taxonomic Initiative: shortening the distance between discovery and delivery*, Australian Biological Resources Study, Environment Australia, Canberra, 1998
 - Marine Group
 - *Australia's Oceans Policy*, Volume 1, Environment Australia, Canberra, 1998
 - *Australia's Oceans Policy: Specific Sectoral Measures*, Volume 2, Environment Australia, Canberra, 1998

Agriculture, Fisheries and Forestry Portfolio

- Bureau of Resource Sciences
 - *State of the Forests Report 1998*
 - *1998 Fisheries Status Reports*
- Grains Research and Development Council:
 - *Australian Grains Industry 1998/1999*

Health and Aged Care Portfolio

- National Health and Medical Research Council
 - *Report on Maternal Deaths in Australia 1991-93*
 - *Acute Pain Management: Scientific Evidence*
 - *Australian Biomedical Research: Funding Acknowledgments and Performance*

Treasury Portfolio

- Australian Bureau of Statistics (ABS)
 - *Research and Experimental Development, Business Enterprises, Australia, 1996-97, Cat No 8104.0,9 July 1998*
 - *Research and Experimental Development, General Government and Private Non-Profit Organisations, Australia, 1996-97, Cat No 8109.0,13 August 1998*
 - *Research and Experimental Development, All Sector Summary, Australia, 1996-97, Cat No 8112.0, 20 August 1999*
 - *Innovation in Mining, Australia, 1996-97, Cat No 8121.0,11 September 1998*
 - *Use of the Internet by Householders, Australia, November 1998, Cat No 8147.0,1 March 1999*

SECTION

3

Science and Innovation
in
the Budget

BOX 3.1

INTRODUCTION OF ACCRUAL ACCOUNTING

The 1999-2000 Commonwealth Budget is different from all previous budgets. It has been developed according to accrual, rather than cash accounting.

Accrual appropriations will provide agencies with the full financial resources they need to deliver their outcomes and outputs. This includes costs that accrue over time, such as depreciation, superannuation and long service leave. Hence, agencies are no longer seeking cash to fund programs and activities.

Generally, the level of funding provided for research grants under accrual accounting will be very similar to that provided under the previous cash regime. However, under accrual accounting, expenses are recognised when they occur rather than when the cash is paid, and this may not always occur at the same time during the financial year.

The other main reason for changes between 1998-99 and 1999-00 in Commonwealth agencies' estimates is the introduction of the Capital Use Charge on the agencies' net assets. Agencies have received additional revenue equal to the expected charge that will be paid back to Government at the end of each financial year.

Note that the financial information in this Statement has been provided by the agencies and departments with responsibility for the programs. Further information is available from the *Portfolio Budget Statements* of each department. These can be accessed through the Federal Government entry point on the World Wide Web (www.fed.gov.au).

Australia's national R&D expenditure

Table 1 provides a broad outline of recent data on R&D expenditure in Australia, based on surveys by the Australian Bureau of Statistics (ABS). The most recent data showed that Australia's gross expenditure on R&D (GERD) stood at \$8693 million in 1996-97, corresponding to 1.68 per cent of gross domestic product (GDP). Broadly, about 47 per cent of Australia's R&D expenditure, corresponding to 0.80 per cent of GDP, was undertaken within business enterprises in that year.

TABLE 1 Australia's expenditure on R&D, by sector of performance, 1992-93 to 1996-97*

Sector of performance	1992-93			1993-94			1994-95			1995-96					
	\$m	%GDP	% real annual increase	\$m	%GDP	% real annual increase	\$m	%GDP	% real annual increase	\$m	%GDP	% real annual increase			
Business	2862	0.70	17.4	3119	0.72	6.4	3499	0.76	11.6	4321	0.88	20.6	4124	0.80	-7.4
Government	1824	0.45	0.4	na	na		1983	0.43	2.9	na	na		2090	0.40	0.7
- Cwltth	1155	0.28	2.5	na	na		1197	0.26	0.3	na	na		1266	0.25	1.6
- State	669	0.16	-3.1	na	na		786	0.17	7.4	na	na		825	0.16	-0.7
Higher educ.	1695	0.43	8.9	na	na		1830	0.41	1.8	2039	0.43		2308	0.46	11.1
Priv non prof.	102	0.02	5.7	na	na		156	0.03	22.9	na	na		171	0.03	1.8
TOTAL	6483	1.59	8.1	na	na		7467	1.62	5.7	na	na		8693	1.68	10.6

Source: ISR based on ABS data.

* It is expected that ABS business sector R&D data for 1997-98 will become available in June 1999.

The other principal R&D sectors include higher education, where 27 per cent of R&D expenditure (0.46 per cent of GDP) was undertaken, and Commonwealth agencies, which accounted for 24 per cent of R&D expenditure and 0.25 per cent of GDP.

At 1.68 per cent of GDP, GERD in 1996-97 stood at an all time high and had increased from 1.62 per cent in 1994-95 and 1.38 per cent in 1990-91. The substantial increases in GERD since 1990-91 mainly reflect substantial increases in the level of R&D in the business sector. Business sector R&D expenditure increased sharply from 0.76 per cent of GDP in 1994-95 to 0.88 per cent in 1995-96, but decreased to 0.80% in 1996-97.

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

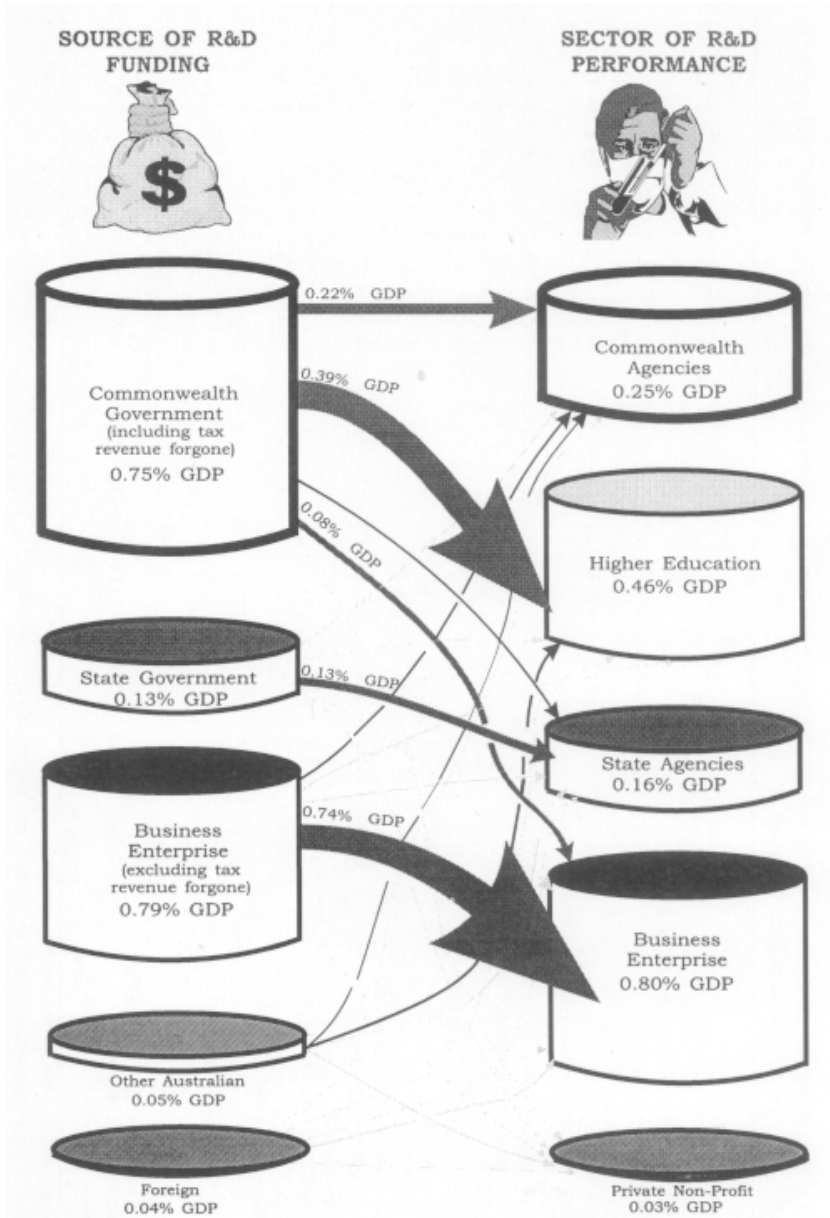
Commonwealth support for R&D in a national perspective

As is seen from Table 1, Commonwealth agencies are significant performers of R&D, but undertake only 24 per cent of total R&D expenditure. As a funding source, however, the Commonwealth Government provides about 40 per cent of R&D funds directly, and has provided an additional 5 per cent 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.

Figure 3

COMMONWEALTH R&D SUPPORT IN A NATIONAL PERSPECTIVE



The figure illustrates major flows of funding support between sectors, based on ABS 1996-97 data. It places Commonwealth funding of R&D in a national perspective.

TABLE 2 Summary of Major Commonwealth Support for Science and Innovation, through the Budget and other Measures - \$m at constant 1996-97 prices

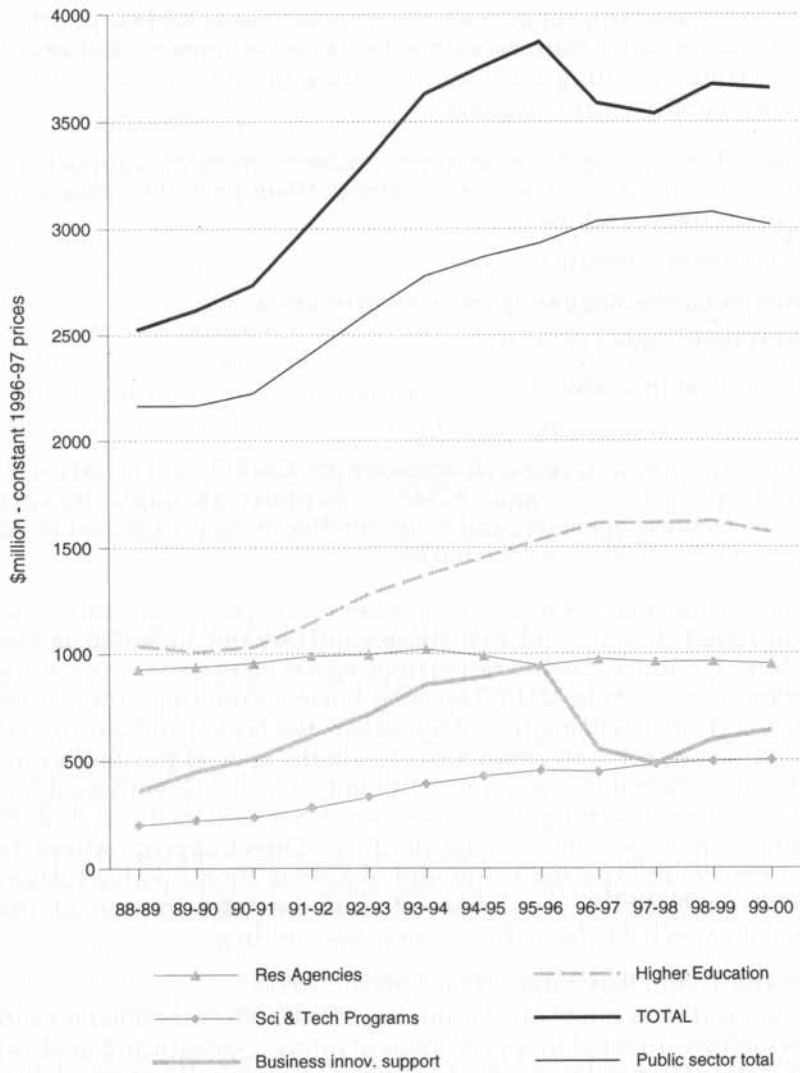
	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	1999-00
										<i>est</i>	<i>est cash*</i>	accruals [#]
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	270.3	260.5	261.5	256.6	282.7	260.0	273.0	254.9	242.1	241.6	236.1	224.8
• Civil	667.8	695.0	725.6	737.2	735.5	727.8	669.4	717.4	716.6	718.1	712.8	884.1
SUB-TOTAL	938.1	955.5	987.2	993.8	1018.3	987.8	942.3	972.3	958.7	959.7	948.9	1108.8
SCIENCE AND TECHNOLOGY BUDGET PROGRAMS												
• Health and Medical	103.4	119.3	135.9	141.0	149.9	159.5	166.3	166.1	171.2	189.5	207.3	187.8
• Cooperative Research Centres	-	-	19.7	48.2	95.4	108.9	135.4	143.2	144.8	142.1	134.3	134.3
• Rural	94.3	90.3	101.9	117.4	123.2	137.1	129.1	126.0	138.5	152.3	145.2	145.2
• Energy and environment	21.2	25.0	21.5	21.1	20.1	20.0	20.0	11.4	24.8	10.7	11.7	11.7
• Transport	2.3	2.4	2.4	2.3	2.3	2.3	2.2	2.0	2.0	2.0	1.9	1.9
SUB-TOTAL	221.2	237.0	281.4	330.1	390.9	427.9	453.1	448.6	481.4	496.7	500.4	480.9
BUSINESS INNOVATION SUPPORT												
• IR&D tax concession	336.9	395.5	466.1	544.0	716.1	742.8	795.8	407.1	331.3	355.1	390.3	390.3
• R&D Start	-	-	-	-	-	-	-	56.4	89.9	125.1	154.3	154.3
• Other innovation support	111.5	113.3	145.3	169.2	136.1	145.8	144.2	88.0	63.3	115.3	93.9	93.9
SUB-TOTAL	448.4	508.8	611.5	713.1	852.1	888.6	940.0	551.4	484.5	595.6	638.6	638.6
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	143.0	200.5	263.7	279.6	311.1	325.4	356.4	399.2	417.0	443.9	419.3	422.9
• Specific R&D support	140.3	147.2	152.1	154.1	153.7	154.4	153.0	152.0	148.9	146.7	145.2	145.2
• Est. general research support	723.3	683.3	726.2	843.6	903.5	970.8	1026.3	1062.2	1047.1	1029.2	1003.7	1003.7
SUB-TOTAL	1006.7	1030.9	1142.0	1277.3	1368.3	1450.7	1535.8	1613.4	1613.0	1619.8	1568.2	1571.8
TOTAL COMMONWEALTH SUPPORT												
AT ESTIMATED 96-97 PRICES	2614	2732	3022	3314	3630	3755	3871	3586	3537	3672	<i>3656</i>	3800
EST. REAL % INCREASE/DECREASE		4.5	10.6	9.7	9.5	3.5	3.1	-7.4	-1.3	3.8	-0.4	-

Basis differs from earlier years. See Box 3.1.

* Estimated to approximate cash accounting expenditure of earlier years.

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

Commonwealth support for science and innovation through major programs

In the new accrual terms, Commonwealth support for major science and innovation programs is expected to stand at an estimated \$3953 million in 1999-2000 (see Table 3), essentially at the same level as in 1998-99 (see Table 2). Broadly, support generally increased over the period from 1986-87 to 1995-96, with revenue forgone from the Industrial R&D Tax Concession Scheme providing particular stimulus from the mid-1980s. Omitting this, the rise in total Commonwealth support results from increased R&D support to the higher education sector coupled with a steady rise in amounts disbursed through the various granting schemes, including the introduction of the Cooperative Research Centres Program.

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 :

- R&D in Commonwealth agencies
- science and technology support for specific areas
- support for business innovation.
- higher education research

- 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 \$1153 million in 1999-2000, on an accrual basis.

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 licensing fees, disposal of assets etc.) and additional Commonwealth support won competitively via the special purpose grant schemes. To encourage improved links with industry, the Government has set a target for external earnings (ie, funds from other than its direct Budget appropriations) of 30 per cent of total funding. Direct appropriations to CSIRO for 1998-99 are expected to amount to \$598 million (with a further \$6 million through AFFA, see Table 4) , but the total income of the Organisation is expected to be in the region of \$870 million.

- Science and Technology Support for Specific Areas

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

Support for R&D through these special purpose research grant schemes and programs is estimated to increase to \$500 million in 1999-2000, representing a real increase of about 1 per cent.

- *Support for Business Innovation*

Support for R&D and innovation in the business sector through the industrial R&D tax concession is estimated to be \$406 million in 1999-2000, an increase of 10 per cent in real terms.

The R&D Start scheme will increase substantially by a real 23 per cent to \$161 million. Together with smaller schemes, total direct support for R&D and innovation in the business sector increases to \$500 million.

- *Higher Education Research*

Support for research in the higher education sector (excluding support from special purpose grant schemes) is estimated to be \$1635 million in 1999-2000, a real decrease of about 3 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.

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 the research and research training component of the general operating grant for universities.

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 from 1987-88 to 1998-99. (But note that their external earnings — not shown in the figure — have increased over the same period.) Over the same period, the special purpose science and technology support schemes have increased significantly.

Over past years, significant increases in funding in the higher education sector have been accompanied by a substantial change in arrangements so that the proportion of funds allocated on the advice of the ARC is now much higher than in the mid-1980s.

Detailed data

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

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

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

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

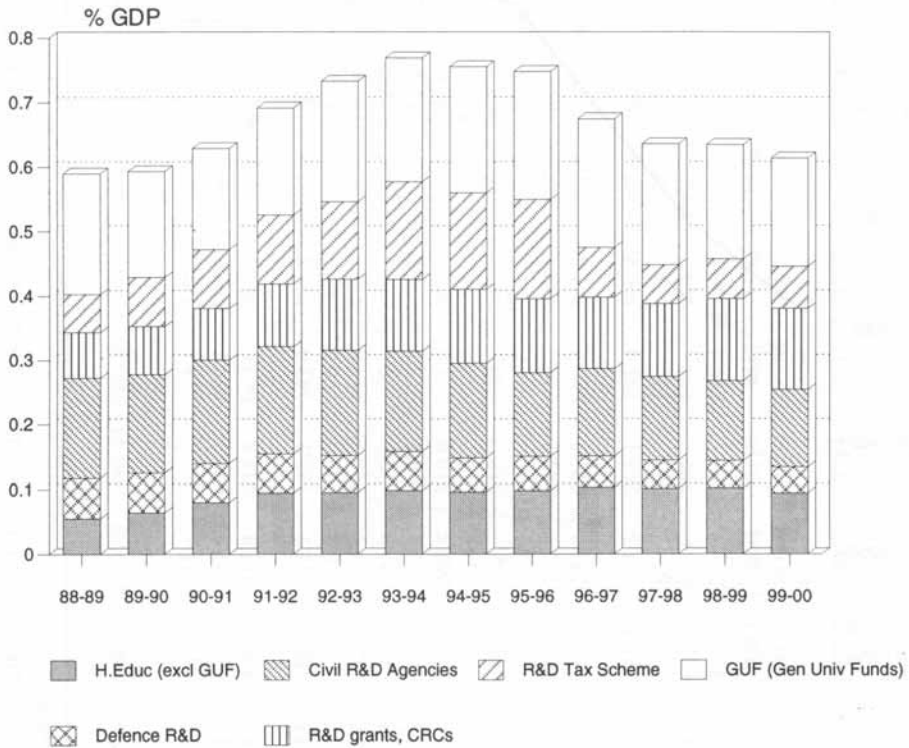
Over the past three decades there has been considerable international effort to reach agreed definitions of R&D. The resulting definitions have been applied with some rigour in periodic surveys conducted within most OECD countries. This so-called "Frascati" methodology has been applied in Australia since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

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

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

are broad similarities between trends in what is described here as 'science and innovation' and R&D expenditures as reported by ABS.

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

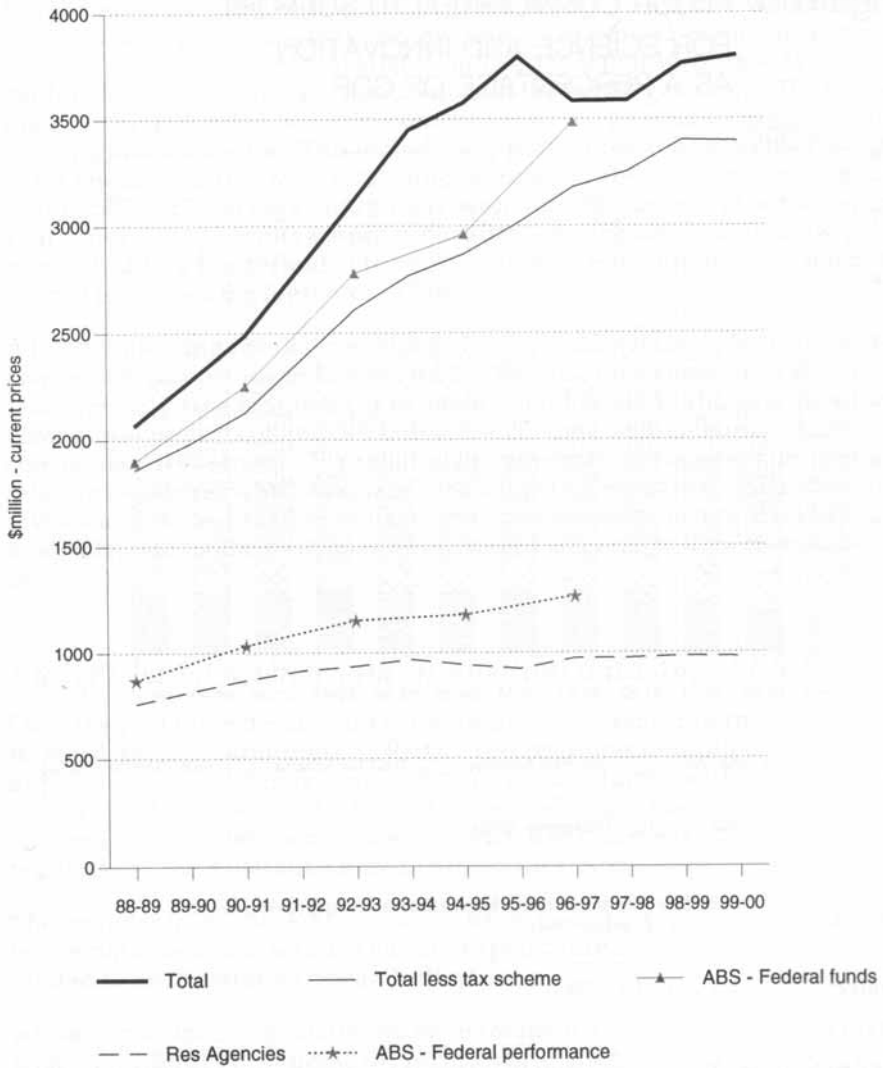


* For 1999-2000, the data for the chart has been adjusted to approximate the cash accounting basis of earlier years.

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: ISR and ABS

**TABLE 3 Summary of Major Commonwealth Support for Science and Innovation, through the Budget and Other Measures
- \$m actual cost in year incurred**

	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	<i>est</i> 1998-99	<i>est*</i> 1999-00	accruals* 1999-00
MAJOR SCIENTIFIC RESEARCH AGENCIES												
Defence	235.0	237.1	242.4	241.5	268.5	247.4	267.6	254.9	245.5	247.0	245.6	233.8
Civil	580.7	632.7	672.5	693.8	698.5	692.8	656.1	717.3	726.8	734.0	741.4	919.5
SUB-TOTAL	815.7	869.8	914.8	935.3	967.0	940.2	923.6	972.2	972.3	981.0	987.6	1153.3
SCIENCE & TECHNOLOGY BUDGET PROGRAMS												
Health and Medical	89.9	108.6	125.9	132.7	142.4	151.8	163.0	166.1	173.6	193.9	215.6	195.3
Cooperative Research Centres	-	-	18.2	45.3	90.6	103.7	132.7	143.1	146.9	145.2	139.7	139.7
Rural	82.0	82.2	94.5	110.5	117.0	130.5	126.5	126.0	140.5	155.7	151.0	151.0
Energy and environment	18.5	22.8	19.9	19.9	19.1	19.1	19.6	11.4	25.2	10.9	12.2	12.2
Transport	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.0	2.0	2.0	2.0	2.0
SUB-TOTAL	192.4	215.7	260.8	310.6	371.3	407.3	444.1	448.6	488.2	507.7	520.5	500.2
BUSINESS INNOVATION SUPPORT												
IR&D tax concession	293	360	432	512	680	707	780	407	336	363	406	406
R&D Start	-	-	-	-	-	-	-	56.4	91.2	127.9	160.5	160.5
Other innovation support	96.9	103.2	134.7	159.2	129.2	138.8	141.3	87.9	64.2	117.9	97.7	97.7
SUB-TOTAL	389.9	463.2	566.7	671.2	809.2	845.8	921.3	551.3	491.4	608.8	664.2	664.2
HIGHER EDUCATION RESEARCH												
ARC and related grant schemes	124.4	182.5	244.3	263.1	295.4	309.8	349.3	399.2	422.9	453.7	436.1	439.9
Specific R&D support	122	134	141	145	146	147	150	152	151	150	151	151
Est. general research support	629	622	673	794	858	924	1006	1062	1062	1082	1044	1044
SUB-TOTAL	875.4	938.5	1058.3	1202.1	1299.4	1380.8	1505.3	1613.2	1635.9	1655.7	1631.1	1634.9
TOTAL COMMONWEALTH SUPPORT	2273	2487	2801	3119	3447	3574	3794	3585	3588	3753	3803	3953
% GDP	0.593	0.629	0.692	0.733	0.769	0.755	0.748	0.675	0.636	0.635	0.614	0.639
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 1996-97 PRICES	2614	2732	3022	3314	3630	3755	3871	3586	3537	3672	3656	3800
EST. REAL % INCREASE/DECREASE		4.5	10.6	9.7	9.5	3.5	3.1	-7.4	-1.3	3.8	-0.4	-

SOURCE: See Tables 4, 5 and 6. * Approximates cash accounting basis of earlier years. #Basis differs from earlier years. See Box 3.1.

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

	1988-89	1989-90	1990-91	1991-92	1992-93	Outlays		1995-96	1996-97	1997-98	est	accruals [#]
						1993-94	1994-95				1998-99	1999-00
AGRICULTURE, FISHERIES AND FORESTRY												
Contribution to CSIRO for Aust Animal Health Labs ¹	4.7	4.9	5.3	5.5	6.0	5.9	6.2	5.8	6.0	6.1	6.1	6.1
DEFENCE												
DSTO ²	219.0	235.0	237.1	242.4	241.5	268.5	247.4	267.6	254.9	245.5	247.0	233.8
EDUCATION, TRAINING & YOUTH AFFAIRS												
Anglo-Aust Telescope	2.5	2.7	2.9	3.0	3.1	3.1	3.0	3.2	3.3	3.5	3.6	3.7
ENVIRONMENT & HERITAGE												
Antarctic Division	46.3	57.7	62.8	67.3	65.4	61.0	61.3	63.1	59.4	61.9	64.7	95.3
Bureau of Meteorology												
Research Centre (BMRC)	2.2	2.4	2.8	3.3	3.3	3.6	3.6	4.0	4.4	4.5	4.4	7.2
Supervising Scientist -including ERISS	6.6	7.6	6.7	7.5	7.6	6.6	6.5	6.0	5.4	4.3	4.2	6.0
HEALTH & AGED CARE												
Australian Institute of Health & Welfare	4.2	4.4	4.2	5.0	6.8	7.2	8.1	7.1	7.6	7.7	7.7	8.1
CSL ³	16.6	9.4	3.0	13	6.9	16.7	-	-	-	-	-	-
INDUSTRY, SCIENCE & RESOURCES												
Aust Nuclear Science & Technology Organisation	54.3	57.5	62.6	64.3	68.2	64.2	66.2	65.6	63.7	72.7	74.5	110.6
Australian Institute of Marine Science	11.0	11.4	13.6	14.2	14.2	16.9	16.5	16.6	16.4	16.4	18.5	25.0
CSIRO ¹	348.1	375.2	414.4	446.3	456.2	460.4	460.8	416.7	433.9	466.8	475.4	597.5
Kraft Pulp Mill study (CSIRO)	0.0	0.5	1.4	1.9	1.9	1.9	-	-	-	-	-	-
AGSO (<i>note capital works in 96-97 & 97-98</i>)	42.9	47.0	52.9	52.9	54.2	50.9	60.5	68.0	117.1	82.9	74.9	60.0
TOTAL	758.4	815.7	869.8	914.8	935.3	967.0	940.2	923.6	972.2	972.3	981.0	1153.3

Basis differs from earlier years. See Box 3.1.

(1) Note that these data are added together in the Summary Table at the front of this *Statement*.

(2) DSTO expenditure shown here includes overhead components funded under other Defence programs, such as salaries for service personnel, FBT, superannuation and some administrative support costs. These have been added to the DSTO figures published in the Budget Papers. For 1996-97, 1997-98 and 1998-99, DSTO funding included additional one-off provisions to cover the costs of voluntary redundancies, a redirection of administrative savings and supplementation for a 6% salary increase.

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

TABLE 5 Major Programs Supporting Science and Innovation through the Budget (\$m)

	1988-89	1989-90	1990-91	1991-92	1992-95	Outlays 1993-94	1994-95	1995-96	1996-97	1997-98	est 1998-99	accruals [#] 1999-00
AGRICULTURE, FISHERIES AND FORESTRY¹												
Wool Research	21.7	20.8	11.7	13.8	13.2	120	15.1	11.7	10.4	7.2	14.3	10.5
Meat Research	11.9	13.8	13.6	20.8	22.9	22.1	25.1	22.6	21.1	22.8	21.4	20.5
Fishing Industry Research	5.4	8.1	8.4	6.6	7.5	8.5	9.2	10.4	11.3	11.2	11.4	12.4
Grains	11.1	13.3	14.4	14.8	15.7	21.2	23.3	21.3	29.1	33.8	36.2	35.3
Horticulture Research	0.6	1.2	3.1	4.4	8.3	9.6	10.7	11.4	12.0	11.4	14.3	15.2
Land & Water research	10.4	9.9	13.3	13.3	13.7	11.8	11.3	10.6	9.8	10.8	10.9	11.1
Rural Industries R&D Corporation	4.0	5.0	6.0	8.4	10.5	10.5	10.5	10.5	5.6	10.8	11.0	11.1
Other rural research,	8.0	10.1	11.7	12.4	18.8	21.3	25.5	28.0	26.7	32.5	36.2	34.9
COMMUNICATIONS, INFORMATION TECH & THE ARTS												
Business Online (e-commerce)	-	.	-	-	-	-	-	.	.	.	3.0	3.0
Info & Communication Industries Devel	-	-	-	-	.	-	-	.	-	.	3.5	3.0
ENVIRONMENT & HERITAGE												
Aust Biological Resources Study	1.3	1.6	1.2	2.0	2.3	2.3	2.0	1.8	1.3	1.0	1.4	1.6
Greenhouse research (NGRP)	0.8	5.7	5.7	6.1	6.0	5.8	6.0	6.0	3.5	3.6	3.5	3.7
EDUCATION, TRAINING & YOUTH AFFAIRS												
Research evaluation and Academies	-	-	1.6	2.0	2.0	2.0	2.1	2.1	2.2	2.0	2.5	2.3
ARGS & ARC grants/fellowships (including marine R&D grants) ²	50.7	35.6	1.2	-	-	-	-	-	-	-	-	-
Post-graduate Awards ²	21.7	11.3	-	-	-	-	-	-	-	-	-	-
Targeted Institutional Links Program	0.0	0.2	1.0	2.0	1.1	1.4	1.4	0.8	0.5	0.5	-	-
HEALTH & AGED CARE												
AIDS Research	3.5	5.0	7.1	10.8	10.5	11.6	12.1	12.1	11.7	12.0	12.0	12.0
NH&MRC Research Grants ³	73.4	84.9	96.5	105.1	112.2	120.8	126.7	141.3	152.4	158.9	176.0	173.2
Capital Works for Medical Institutes	-	-	5.0	10.0	10.0	10.0	13.0	9.6	2.0	2.7	5.7	7.8
National Institute of Clinical Studies												2.3
INDUSTRY, SCIENCE & RESOURCES												
Industry Innovation (incl. R&D Start)	-	-	-	-	-	-	-	-	56.4	91.2	127.9	160.5
Industry Innovation Program grants	-	-	-	-	43.5	40.3	45.6	50.4	-	-	-	-
Innovation Investment Fund	-	-	-	-	-	-	-	-	-	4.0	25.0	34.5

TABLE 5 Major Programs Supporting Science and Innovation through the Budget (\$m) — *continued*

	1988-89	1989-90	1990-91	1991-92	1992-95	Outlays					est	accruals [#]
						1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00
Advanced Manufacturing Tech Program	-	-	.	0.1	-	-	-	-	-	-	-	-
Technology Development Program	1.1	1.9	3.0	3.2	-	-	-	-	-	-	-	-
National Procurement Development Program (NPDP)	3.9	5.6	4.2	4.4	-	-	-	-	-	-	-	-
IR&D Act 1986 (GIRD)	31.8	32.0	29.6	32.2	-	-	-	-	-	-	-	-
IR&D Incentives Act 1976												
• Commencement grants	0.1	-	-	-	-	-	-	-	-	-	-	-
• Project grants	2.8	0.3	-	-	-	-	-	-	-	-	-	-
• Public interest projects	0.3	-	-	0.1	-	-	-	-	-	-	-	-
Technology Diffusion Program	-	-	-	-	-	-	-	-	-	-	12.5	27.0
Technology Support Centres	-	-	-	-	-	-	3.9	12.2	7.2	13.7	-	-
International S&T Program	1.0	4.1	5.0	5.1	5.3	5.4	5.5	5.6	5.6	5.6	-	-
Malaria Vaccine Joint Venture	1.2	0.8	2.3	9.4	-	-	-	-	-	-	-	-
Motor Vehicle R&D	8.3	4.7	2.3	-	-	-	-	-	-	-	-	-
Australian Technology Group Pty Ltd	-	-	-	-	30.0	-	-	-	-	-	-	-
National Research Facilities	-	-	-	-	-	-	-	6.4	17.0	20.9	10.2	5.1
Cooperative Research Centre Grants	-	-	-	18.2	45.3	90.6	103.7	132.7	143.1	146.9	145.2	139.7
Assistance under the Bounty [†]												
(Computers) Act 1984	31.1	45.0	51.3	74.5	75.0	78.0	74.8	64.1	56.5	19.5	58.6	-
National Space Program	5.4	2.4	5.5	5.7	5.4	5.4	9.0	2.7	1.7	0.5	1.5	-
Renewable Energy Grants	-	-	-	-	-	-	-	-	-	-	4.4	6.9
Energy research	9.6	11.2	15.9	11.8	11.6	11.0	11.1	11.8	6.6	20.6	1.5	-
Biotechnology Australia	-	-	-	-	-	-	-	-	-	-	-	6.0
Shipbuilding Innovation Scheme	-	-	-	-	-	-	-	-	-	-	-	9.1
TRANSPORT & REGIONAL SERVICES												
Payments to Austroads/												
ARRB Transport Research Ltd	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.0	2.0	2.0	2.0
TOTAL	322.8	336.4	322.7	399.5	473.0	503.9	549.6	588.4	595.6	646.1	752.4	750.7

Basis differs from earlier years. See Box 3.1.

FOOTNOTES TO TABLE 5

- (1) 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 in cash accounting terms)

	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	est 1998-99	est 1999-00
Wool	14.21	19.63	17.11	14.05	12.32	12.45	19.50	10.94	12.79	13.09	10.53	9.57
Meat ^a	11.58	13.30	15.17	25.60	25.55	24.65	23.52	22.40	23.13	24.50	12.31	14.19
Grains												
- Grain ^b	2.53	3.99	4.27	5.31	9.36	12.61	8.51	17.18	19.48	20.39	17.97	22.17
- Wheat	8.35	9.84	8.45	12.92	18.35	19.95	16.28	33.65	35.17	32.02	31.64	32.41
Coal ^c	15.02	17.05	14.95	13.88	16.10	1.48	-	-	-	-	-	-
Special Rural	0.00	0.20	0.30	0.15	0.99	1.03	1.32	1.57	1.39	1.87	1.80	2.41
Fish	-	-	0.50	1.12	1.01	2.01	2.41	2.46	2.52	2.88	3.30	3.58
Horticulture	0.20	1.62	3.26	4.94	7.24	3.12	3.61	4.28	8.04	9.06	8.86	9.91
Other Rural												
- Chicken Meat	0.38	0.46	0.55	0.78	0.65	0.67	0.71	0.71	0.79	0.82	0.79	0.79
- Cotton	1.55	1.87	2.66	3.87	3.89	2.57	2.13	2.90	4.30	5.48	5.57	5.64
- Dairying	1.57	2.94	4.82	5.21	5.65	6.20	6.13	5.75	8.36	10.94	11.86	12.13
- Dried Fruit	0.29	0.39	0.45	0.78	0.92	0.46	0.49	0.39	0.79	0.41	0.70	0.70
- Grape & Wine	0.94	1.28	1.25	0.96	1.60	1.70	2.08	1.91	2.62	2.37	4.60	5.04
- Honey	0.10	0.12	0.14	0.07	0.12	0.15	0.15	0.15	0.20	0.16	0.18	0.19
- Pig Industry	1.37	1.95	2.58	2.67	2.88	3.61	3.75	3.57	3.42	3.46	3.47	3.50
- Egg Industry	0.37	0.30	0.45	0.57	0.68	0.67	0.63	0.68	0.76	0.77	0.71	0.68
- Sugar	1.40	1.37	1.48	1.28	3.40	4.48	4.89	5.46	5.99	6.17	6.04	5.98
- Tobacco	0.94	0.77	0.59	0.59	0.92	0.64	0.33	0.49	0.57	0.83	0.63	0.63
- Forestry	-	-	-	-	-	-	0.38	1.00	1.72	2.53	2.56	2.56
Total	60.82	77.09	78.98	94.75	111.62	98.45	96.84	115.49	132.05	137.77	124.16	132.08

(a) Industry contributions for meat R&D to the Australian Meat Research Corporation.

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

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

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

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

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

TABLE 6 Major Programs and Incentives supporting Science and Innovation outside the Budget (\$m)

	1988-89	1989-90	1990-91	1991-92	1992-95	1993-94	1994-95	1995-96	1996-97	1997-98	est 1998-99	accruals [#] 1999-00
COMMUNICATIONS, INFORMATION TECH & THE ARTS												
Support from the Federation Fund												
- Commonwealth Technology Park	-	-	-	-	-	-	-	-	-	-	1.0	2.0
EDUCATION, TRAINING & YOUTH AFFAIRS												
Higher Education Funding Act: special research assistance ^{1,2}	12.1	77.3	178.7	240.3	260.0	292.0	306.3	346.4	396.5	420.4	451.2	437.6
Funding for ANU Institute of Advanced Studies ³	108	122	134	141	145	146	147	150	152	151	150	151
Estimated research & research training component sourced in the operating grant ^{4,5,6}	656	629	622	673	794	858	924	1006	1062	1062	1052	1044
INDUSTRY, SCIENCE & RESOURCES												
Tax Concession ⁷ for industrial R&D	201	274	326	432	512	680	707	780	407	336	363	406
Tax Deduction for equity subscriptions in Management Investment Companies (MICs) ⁸	7	19	34	-	-	-	-	-	-	-	-	-
Support from the Federation Fund												
- National Marine Science Centre	-	-	-	-	-	-	-	-	-	-	2.0	3.0
- Institute of Molecular Bioscience	-	-	-	-	-	-	-	-	-	-	0.5	5.0
TOTAL	984	1121	1295	1486	1711	1976	2084	2282	2017	1969	2016	2039

Basis differs from earlier years. See Box 3.1.

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

- (1) Includes ARC/DETYA funding for research grants, fellowships, centres, postgraduate awards and infrastructure.
- (2) Until 1996-97, included funding for the Advanced Engineering Centres which were originally funded under HEFA but shifted to funding under the operating grant from 1996 onward.
- (3) This is an estimate of funds for research and research training provided to the Institute of Advanced Studies (IAS) of the Australian National University (ANU) through the operating grant. Funding for the John Curtin School of Medical Research (JCSMR) of the ANU was transferred to the Health Portfolio in 1992, returning to the ETYA portfolio in 1997-98 (JCSMR funding made up \$18.7 million of the total IAS funding of \$153 million in 1997-98) but is here included from

1992-93 to 1996-97 for comparative purposes. For 1999-2000, the IAS block grant is estimated to be \$151 million. Within this amount, the University estimates that \$40-45 million annually can be regarded as being attributable to the IAS in respect of University overheads, major equipment and such campus-wide costs as the library, information technology and central administrative activities.

- (4) The sum of the estimates in the previous row and this row of figures is an estimate of the research and research training component of the university operating grant. It does not include funds spent on research by the former advanced education sector institutions prior to the 1989 amalgamations.
- (5) A new methodology for estimating research and research training is used for 1993-94 onwards due to changes in ABS data collection introduced in *1994 Research and Experimental Development - Higher Education Organisations* (8111.0). The methodology prior to 1993-94 uses estimates for 1984-85, 1986-88, 1988-89, 1990-91 and 1992-93 based on ABS R&D surveys in the calendar year in which each of these financial years commences. From 1993-94 onwards, the estimate is based on the ABS survey of research expenditure of universities by source of funds. One of the sources identified by the ABS is General University Funds (GUF). The operating grant component is the major part of GUF, and can be estimated by using the operating revenue figures from *DEETYA Selected Higher Education Finance Statistics*. A research and research training component of the operating grant can then be calculated by multiplying the proportion of GUF attributable to the operating grant, by the R&D funds sourced from GUF (this latter is obtainable from ABS Higher Education R&D surveys for 1994, 1995 and any subsequent years). For example, the estimate for 1993-94 is based on 1994 data; with adjustment for 1993. The estimates for 1994-95 and 1995-96 are the most accurate, as they are based on existing 1994, 1995 and 1996 ABS data respectively. Estimates for 1996-97 and beyond are based on the 1996 data, using forward projections of the non-capital unified system operating grant for subsequent years.
- (6) The apparent decline between 1992-93 and 1993-94 may therefore be attributable to the break in the data series due to the introduction of the new methodology.
- (7) A 150% company tax deduction for eligible industrial R&D expenditure applied from 1 July 1985 to 20 August 1996, when the rate was reduced to 125%. The data series in Table 6 comprise estimates by the Department of Industry Science and Resources based both on information provided in registrations for the concession and from the Treasury. They do not account for any recoupments arising from the dividend imputation system. Since the policy rationale for the tax concession scheme is to increase business expenditure on R&D, the data in the table are estimates relating to the year when companies undertake the R&D for which they subsequently claim the concession – that is, they are the estimated cost to revenue that would have occurred if companies had claimed the tax concession in the same financial year in which the R&D expenditure was incurred. In fact, some claims are not made until subsequent years (not necessarily in the next financial year). The estimated revenue forgone for the years when claims for the concession are lodged with the Australian Taxation Office is, from 1988-89 to 1999-00, as follows: \$160m, \$195m, \$200m, \$275m, \$305m, \$400m, \$465m, \$685m, \$675m \$710m, \$440m, \$370m and \$380m. Figures published here are revised over those published previously. While these data represent best estimates at the time of publication, they may require further revision as more information becomes available.
- (8) Licensed Management and Investment Companies invested in approved high technology/growth activities. The equity subscription in these companies attracted a 100% income tax deduction in the year that subscriptions were made. The scheme concluded in June 1991.

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

<i>THEMATIC PRIORITIES</i>	<i>1989-90</i>	<i>1990-91</i>	<i>1991-92</i>	<i>1992-93</i>	<i>1993-94</i>	<i>1994-95</i>	<i>1995-96</i>	<i>1996-97</i>	<i>1997-98</i>	<i>1998-99</i>	<i>1999-00*</i>	<i>%Total</i>	<i>%GDP</i>
Primary products	191.5	207.9	232.1	254.2	277.6	287.1	278.9	277.9	298.2	316.6	313.3	8.2	0.054
Industrial development	480.7	547.4	653.9	753.0	879.8	903.9	964.2	671.0	634.9	757.9	809.6	21.3	0.128
Energy	61.7	73.3	77.7	87.0	108.8	109.2	118.9	83.4	96.6	84.3	91.6	2.4	0.014
Transport & telecommunications	34.4	38.5	42.1	38.9	34.7	35.6	47.6	33.6	33.7	34.8	36.0	0.9	0.006
Urban and rural planning	0.5	0.6	0.8	0.5	0.5	0.9	1.3	0.3	0.2	0.3	0.3	0.0	0.000
Prevention of pollution	40.3	49.9	59.6	60.5	61.8	68.9	56.8	52.5	57.3	59.3	60.5	1.6	0.010
Identification & treatment of pollution	21.3	22.3	28.5	27.5	32.6	36.7	37.3	31.8	31.9	33.2	38.2	1.0	0.006
Health	122.0	136.6	159.9	181.1	212.5	210.1	228.5	219.5	230.1	253.7	276.4	7.3	0.043
Social development & services	5.1	12.3	13.3	13.1	12.0	14.4	11.8	10.2	10.6	10.9	11.2	0.3	0.002
Mining, earth & atmosphere	92.7	100.2	100.1	117.9	118.9	130.1	128.8	188.6	158.4	148.8	133.7	3.5	0.025
Advancement of Knowledge													
- targeted research funding	347.6	426.0	502.6	524.8	556.5	574.4	623.2	678.3	710.2	734.9	721.0	18.9	0.124
- general university funding	629.0	622.0	673.0	794.0	858.0	924.0	1006.0	1062.0	1062.0	1052.0	1044.0	27.4	0.178
Defence	246.7	250.1	257.2	266.9	293.0	278.9	291.1	276.1	263.5	266.3	267.0	7.0	0.045
TOTAL	2273	2487	2801	3119	3447	3574	3794	3585	3588	3753	3803	100	0.635

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

* Estimated to approximate cash accounting expenditure of earlier years.

Thematic Priorities

Table 7 presents a re-arrangement of aggregate outlays from Table 3 according to 'thematic priorities' following a recommendation by the Chief Scientist.

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

Industrial development, for which the tax concession and the R&D Start Program are the major components, accounts for 21 per cent of total support. Support for activities relating to primary products (mostly agriculture) account for almost 8 per cent, while health research and defence R&D are the other substantial categories, each at around 7 per cent of the aggregate.

SECTION

4

Australia in an
International
Context

AUSTRALIAN SCIENCE AND TECHNOLOGY – KEY FACTS –

In 1996-97, Australia's total R&D expenditure stood at Aus\$8.7 billion. This corresponds to 1.68% of GDP, the highest recorded level.

In 1996-97, the annual investment of Australian business in R&D was 0.80% of GDP, though it had decreased from 0.88% in 1995-96. Though still significantly lower than most other developed countries, it has increased markedly since the early 1980s. Over 1991 to 1997, Australia's growth rate in business R&D was the fourth highest in the OECD.

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

In 1996-97, R&D expenditure in Australian public sectors (government agencies and universities) was 0.86% of GDP, the third highest in the OECD. In fact, data for nonOECD countries (but not published here) indicate that Australia currently ranks third in the world on this indicator.

Australia has about 90,500 people in its R&D workforce. These include 42,700 in universities (including 23,800 postgraduate research students), 26,100 in the business sector and 19,500 working in Federal and State Government laboratories.

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

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

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

Australia ranks tenth in international scientific effort normalised by population - by publishing some 970 scientific papers per million population per year.

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

This information is an update of information from *Australian Science and Technology at a Glance 1997*. A new edition is expected to be released later in 1999. See also Table 1 (p. 3.3), Figure 3 (p. 3.5) and the associated text.

Broad international comparison of R&D levels

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

Table 8 shows the latest available GERD/GDP data for twenty OECD and four 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

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

	GERD (est. 1996 US\$m)	GERD/GDP	Change	Period 1984 to 1991		Period 1991 to 1997		
				Average annual real increase in GERD	Average annual real increase in GDP	Change	Average annual real increase in GERD	Average annual real increase in GDP
United States (1997)	202,486	2.64	0.09	2.5	2.6	-0.17	1.9	3.1
Japan (1996)	82,817	2.83	0.38	6.7	4.6	-0.21	1.3	1.1
Germany (1997)	42,683	2.39	0.10	4.5	3.9	-0.23	-0.3	1.6
China (1996)	33,469	0.49	0.05	9.8	7.5	-0.21	4.5	13.9
France (1997)	27,972	2.26	0.20	4.3	2.9	-0.15	0.2	1.6
United Kingdom (1996)	21,088	1.94	-0.08	1.8	3.0	-0.17	0.7	2.6
Korea (1996)	17,252	2.79	0.79	0.0	9.6	0.86	12.7	6.0
Italy (1997)	12,186	1.05	0.22	5.9	2.9	-0.18	-2.0	1.3
Canada (1997)	11,013	1.64	0.12	3.2	2.8	0.11	3.6	2.5
India (1992)	7,928	0.74	-0.03	5.0	5.7	0.00	4.1	4.3
Netherlands (1996)	6,787	2.09	0.11	3.6	3.0	0.05	3.1	2.6
AUSTRALIA (1996)	6,487	1.68	0.37	7.3	2.9	0.31	5.4	3.7
Sweden (1995)	6,008	3.59	0.33	1.7	2.0	0.65	6.6	1.5
Spain (1997)	5,346	0.89	0.38	13.1	4.2	0.01	1.3	2.1
Chinese Taipei (1996)	5,020	1.84	0.74	18.8	8.7	0.15	8.1	6.4
Switzerland (1996)	4,946	2.74	0.44	2.6	2.0	-0.09	1.0	0.5
Belgium (1995)	3,392	1.59	0.02	2.8	2.8	-0.05	0.3	1.6
Finland (1997)	2,828	2.73	0.58	7.0	2.7	0.66	7.3	3.2
Austria (1997)	2,700	1.52	0.24	5.3	2.8	0.03	2.3	1.9
Denmark (1997)	2,456	2.02	0.48	6.7	1.6	0.32	5.8	2.7
Norway (1997)	1,721	1.56	0.26	3.0	0.4	-0.09	2.7	3.9
Ireland (1995)	868	1.39	0.23	7.1	4.4	0.42	17.1	8.3
Singapore (1994)	667	1.25	0.50	15.2	7.0	0.21	11.4	5.9
New Zealand (1995)	601	0.97	0.06	5.1	0.6	-0.03	3.6	3.5
Average (24 economies)		1.86	0.28	6.6	4.0	0.09	4.8	3.1
Average (20 OECD only)		1.97	0.24	4.5	2.9	0.10	3.6	2.2

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

1996 prices converted at purchasing parities). The Table also shows the change in the GERD/GDP ratio between 1984 and 1991, and between 1991 and 1997 (or nearest years), and the average annual real growth rates over each period both for GERD and GDP.

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

GERD is, however, made up of R&D expenditure undertaken in quite different sectors (principally, the business sector, government agencies and universities). There are wide international differences in the relative contribution of these sectors to GERD and policy issues may differ substantially between research sectors. Figure 7 indicates the relative sizes of the research sectors for the economies listed in Table 8, but re-orders the list according to level of GERD/GDP.

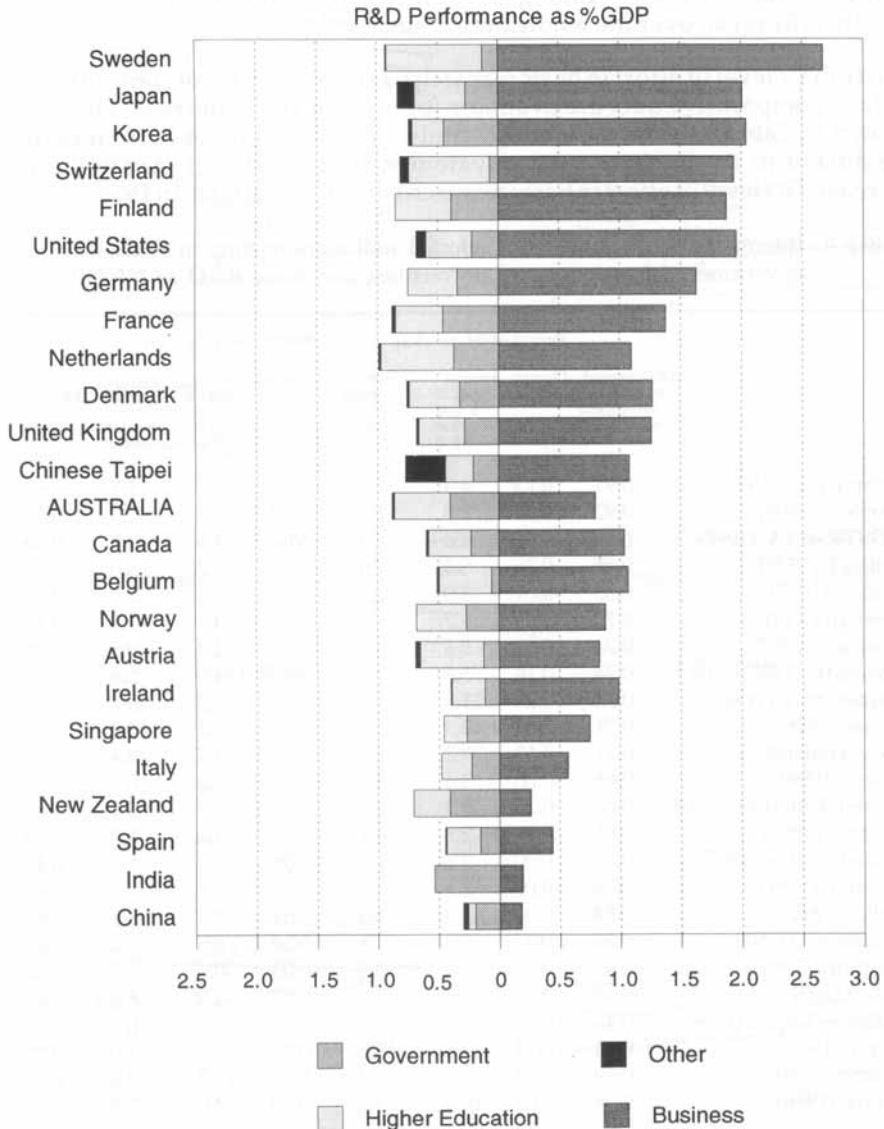
There is much advantage in comparing the sectors separately. A complication, however, is that there is great variation internationally in the scope of R&D activities and institutional structures in the government and academic sectors. The type of research or function typically undertaken in government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

- (i) R&D in government agencies and universities combined; and
- (ii) R&D in the business sector.

R&D expenditure in government agencies and universities

Table 9 shows comparative international data for combined R&D expenditure within government agencies and universities. In this list, the arrangement is in order of R&D expenditure as a percentage of GDP. The Table also shows changes in this ratio for the periods 1984 to 1991 and 1991 to 1997, as well as the average annual real growth rates. Added to these indicators is the growth rate in government Budget appropriations in support of science and technology activities.

Figure 7 R&D EXPENDITURE AS A PERCENTAGE OF GDP
- INTERNATIONAL COMPARISONS



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

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 0.65% for all twenty four economies listed. The change in this ratio for Australia was negative between 1984 and 1991, but over the period since 1991 was larger than the OECD average increase. Among all countries, there was some convergence towards the mean over the whole period since 1984.

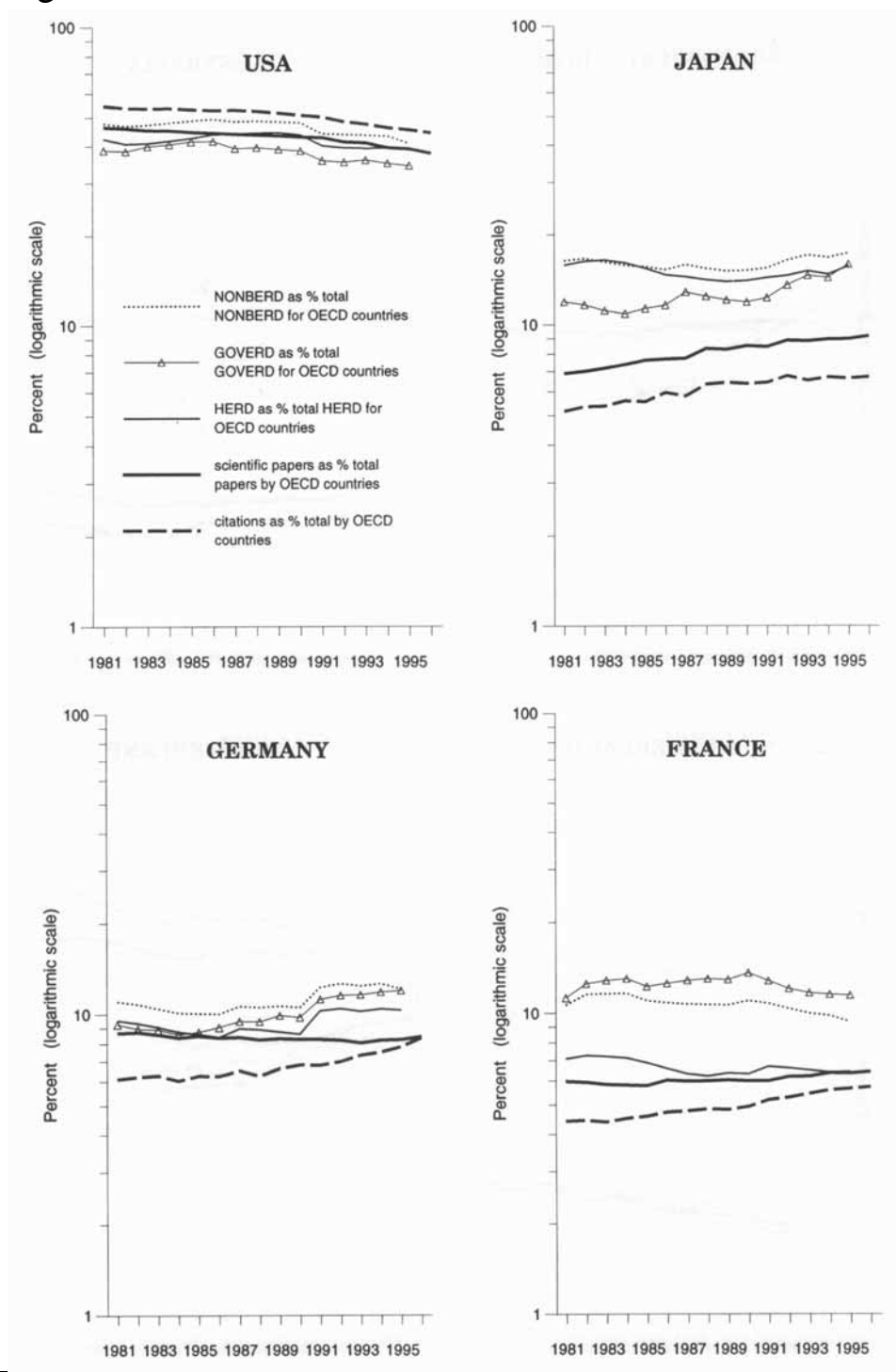
Australia's level of effort in basic research has been a matter of some interest. In fact, comparative data are available for only eleven countries. These are shown in Table 9. (The data also include small amounts of basic research conducted in the business and private non-profit sectors.) Australia has increased its level of effort in basic research from 0.33% of GDP in 1978-79, to

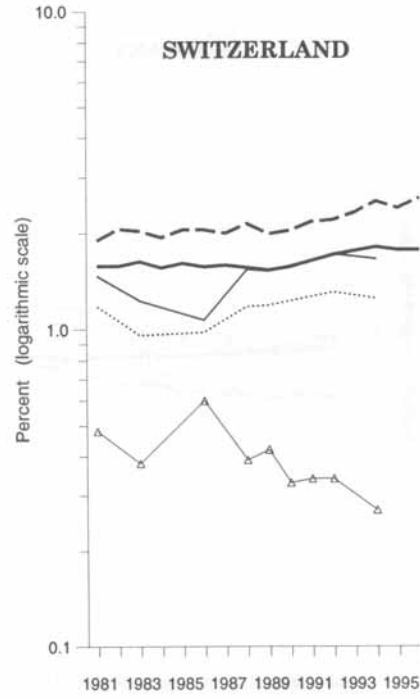
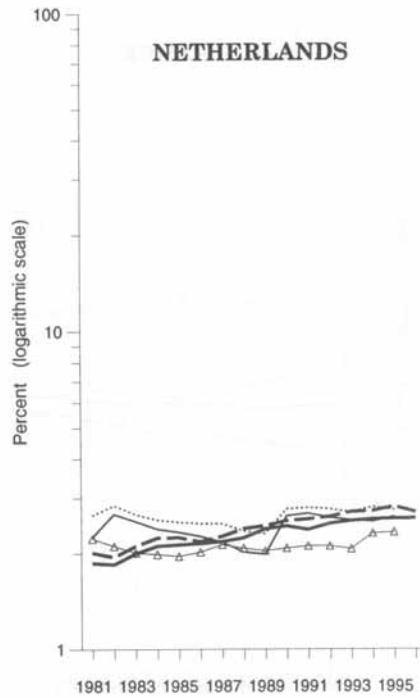
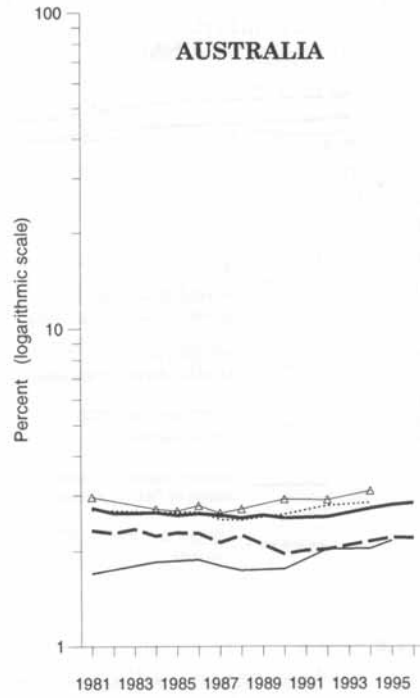
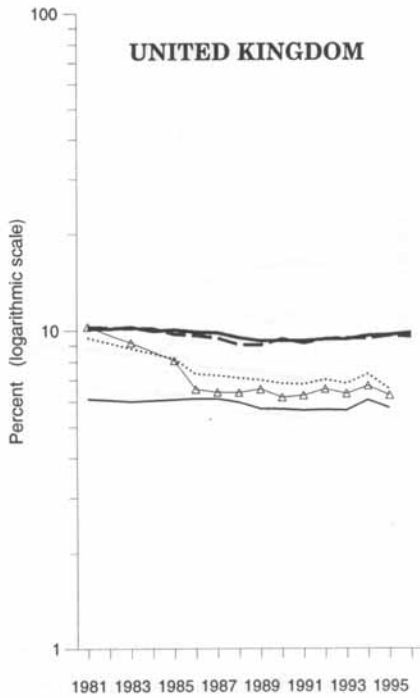
TABLE 9 International comparisons of selected indicators relating to R&D in government laboratories and universities, and basic R&D as %GDP

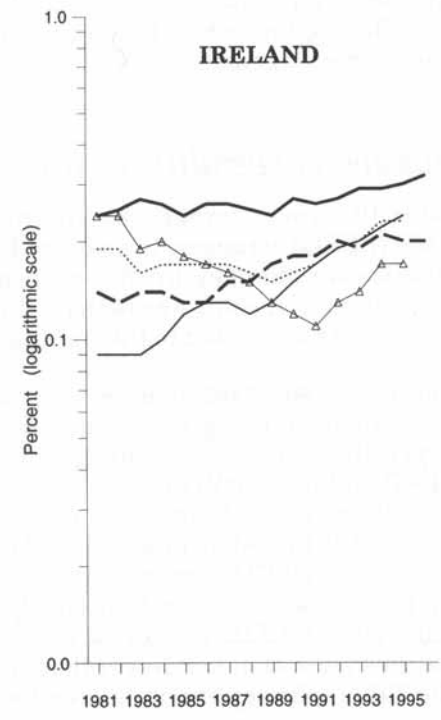
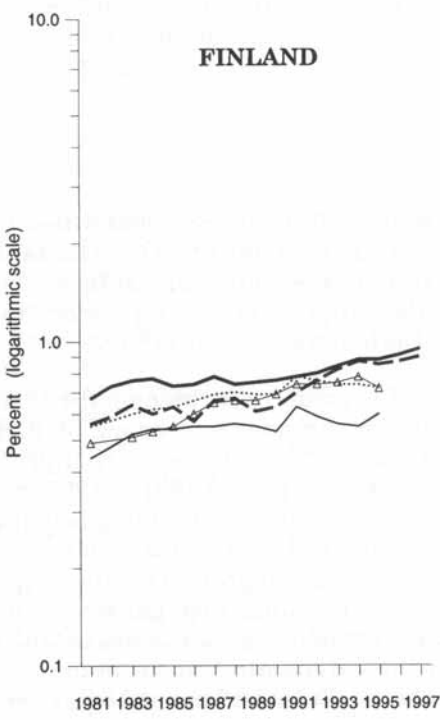
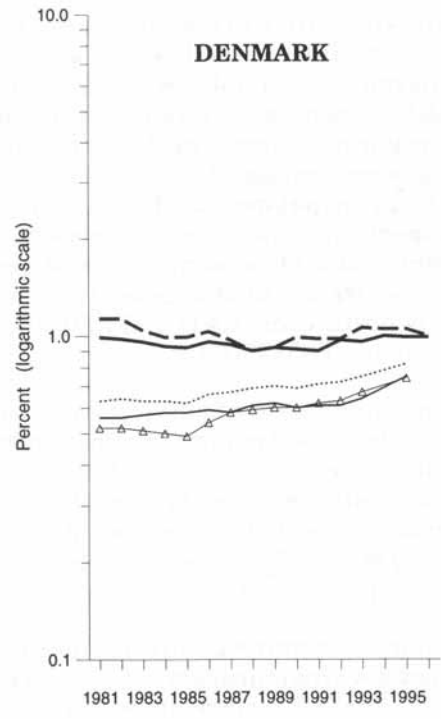
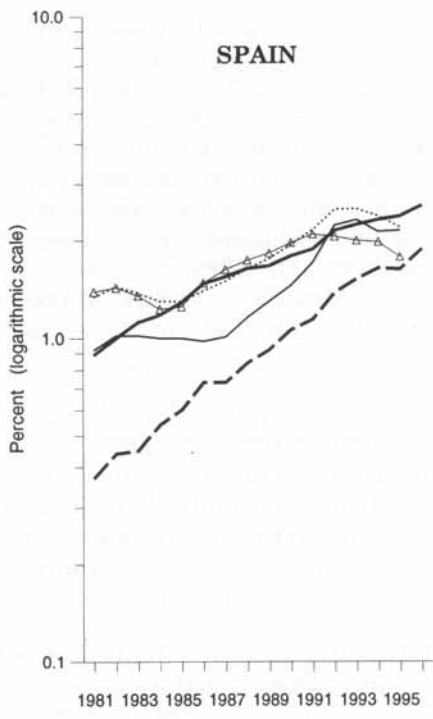
	R&D expend in govt and universities as % GDP	Period 1984 to 1991			Period 1991 to 1997			Basic R&D as (most recent year)
		Change	Average annual % real increase in R&D	Average annual % real increase in Budget	Change	Average annual % real increase in R&D	Average annual % real increase in Budget	
Netherlands (1996)	0.97	0.13	4.9	2.5	-0.01	2.2	2.1	na
Sweden (1995)	0.92	0.01	1.8	1.4	-0.09	1.2	-1.0	0.53
AUSTRALIA (1996)	0.86	0.05	4.6	1.3	0.06	3.5	3.3	0.44
Finland (1997)	0.85	0.26	6.4	7.9	-0.02	1.7	3.6	na
France (1997)	0.85	-0.01	3.0	2.3	-0.06	0.4	-2.9	0.50
Germany (1997)	0.76	0.09	5.7	2.4	-0.03	0.8	-1.6	0.49
Norway (1997)	0.74	0.19	5.6	5.8	-0.01	2.3	0.5	0.28
Denmark (1997)	0.74	0.14	5.6	7.8	0.05	4.1	2.8	na
Switzerland (1996)	0.73	0.26	11.0	15.5	0.05	-0.7	-0.7	na
Korea (1996)	0.71	0.06	10.3	2.9	0.96	21.2	15.0	na
New Zealand (1995)	0.71	-0.12	9.2	1.5	-0.01	3.4	0.4	na
Japan (1996)	0.68	-0.06	3.4	3.2	-0.08	5.2	6.5	na
United Kingdom (1996)	0.66	-0.10	1.1	-2.8	0.00	2.7	-0.1	na
Austria (1997)	0.65	0.11	2.5	4.1	0.11	na	1.7	na
United States (1997)	0.60	0.00	2.8	1.8	-0.08	0.9	-1.5	0.42
Canada (1997)	0.58	-0.01	2.1	0.8	-0.11	-0.6	-7.0	na
India (1992)	0.54	-0.04	4.4	na	na	1.9	na	na
Singapore (1994)	0.53	0.07	12.8	na	0.20	6.6	na	0.29
Belgium (1995)	0.49	0.13	7.4	3.2	-0.03	-0.9	2.5	na
Italy (1997)	0.48	0.10	5.7	5.2	-0.07	-1.5	-6.5	na
Chinese Taipei (1996)	0.44	0.10	16.0	15.7	0.03	6.7	6.9	0.24
Spain (1997)	0.44	0.14	11.6	15.5	0.06	2.8	1.0	0.15
Ireland (1995)	0.39	-0.03	2.1	1.7	0.05	10.7	9.4	0.07
China (1996)	0.26	na	10.3	3.5	-0.15	2.0	2.9	na
Average (24 economies)	0.65	0.06	6.1	4.3	0.03	3.0	1.5	0.34
Average (20 OECD only)	0.69	0.05	4.5	4.1	0.04	1.6	0.5	0.36

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

Figure 8 TRENDS IN NONBERD AND SCIENTIFIC PAPERS







0.35% in 1984-85 to the most recent level (1996-97) of 0.44%. This compares well on the very limited comparisons that are available.

One alternative to making international comparisons as a fraction of GDP is to compare national levels as a proportion of aggregate OECD levels. International trends on this basis are shown in Figure 8 for 'nonBERD' (all R&D expenditure other than in the business sector). An advantage of comparing national performance in this way is that comparisons can also be made on the same basis with national outputs of scientific research papers (the principal measurable output of the non-business sector), and with the impacts of those papers. Figure 8 shows levels and trends on this basis for twelve OECD countries. As well as shares in total nonBERD, Figure 8 also shows trends in shares of its dominant components — higher education expenditure on R&D (HERD) and expenditure on R&D in government agencies (GOVERD).

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

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

Business expenditure on R&D

Table 10 shows comparative international data for business expenditure on R&D (BERD) arranged in order of BERD as a percentage of GDP. The Table also shows changes in this ratio in parallel with those of Table 9. For convenience, the same growth rates in Budget appropriations for science and technology are added to this Table as well as being shown in Table 9.

There were substantial increases in levels of in most countries over the 1980s and much higher growth rates than for the composite category of R&D expenditure in government agencies and universities. However, changes in BERD and in growth rates were much lower for the period 1991 to 1997 than for 1984 to 1991. As in most other economies beginning with relatively low levels of BERD, Australia achieved increases in BERD/GDP and growth rates well above OECD averages - the highest OECD rate of growth for the period up to 1991, and the fourth highest for the period since then (Korea having joined the OECD in the period 1991-97). Nevertheless, growth rates in OECD nations were all much lower than for the three dynamic Asian economies in the Table - Singapore, with a real annual growth rate of about 18 per cent, Chinese Taipei on 16 per cent, and Korea on 13 per cent. But Ireland, with the

leading OECD growth rate (21 per cent), is now ahead of all these, Finland on 11 per cent is ahead of all but Singapore, and Australia has moved ahead of Chinese Taipei.

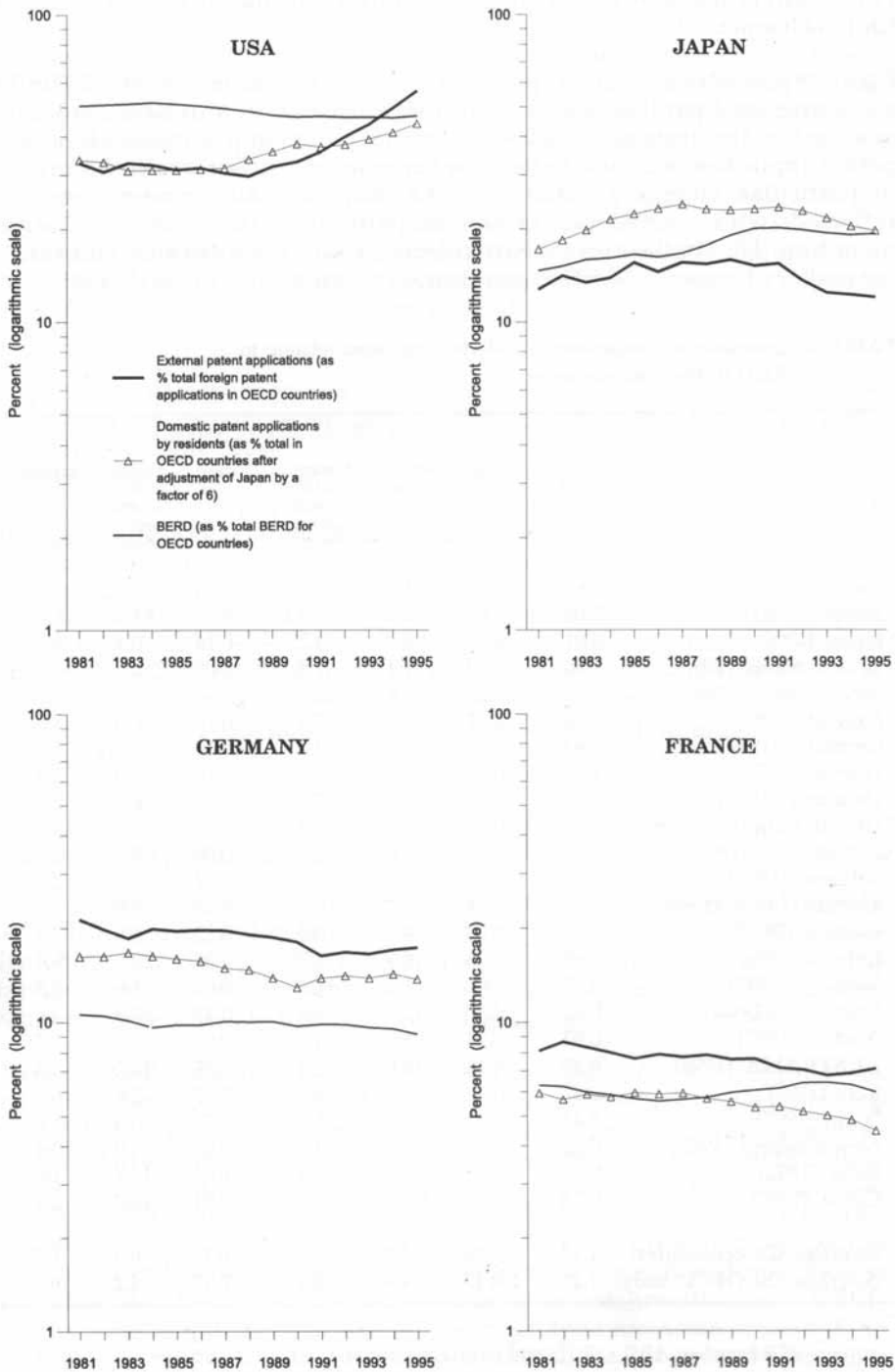
Figure 9 provides OECD comparisons for the business sectors in 12 OECD economies on a parallel basis to Figure 8. However, output here should be assessed on the basis of the share in external patent applications (domestic patent applications in most cases have less relevance). For smaller countries in particular, changing patterns in the share of R&D expenditures are reflected (with a small lag) in similar patterns in the share of external patenting. The similarities are particularly striking for Australia - and verify the reality of increased R&D expenditures reported since the early 1980s.

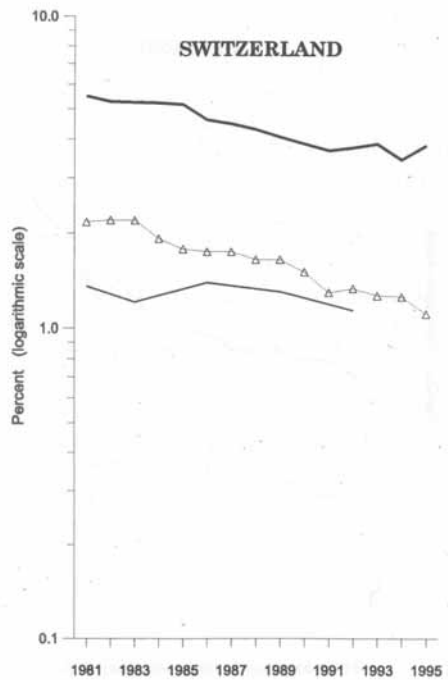
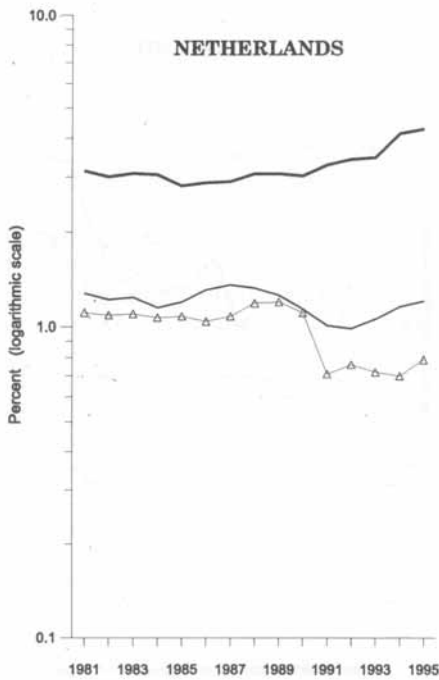
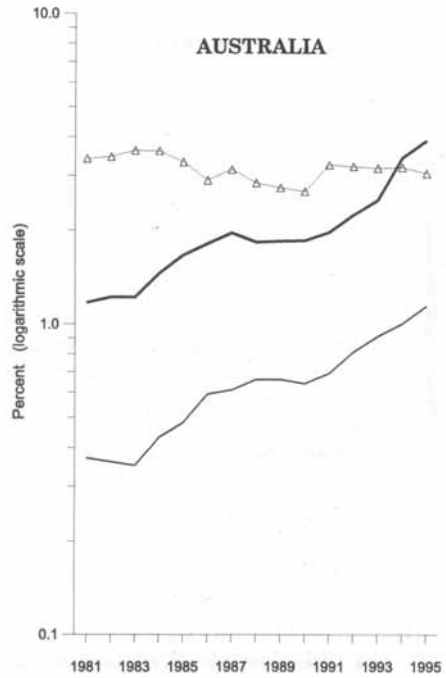
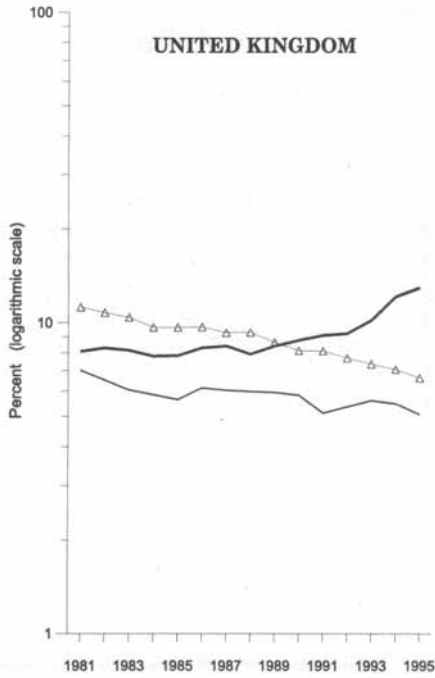
TABLE 10 International comparisons of selected indicators relating to R&D in the business sector

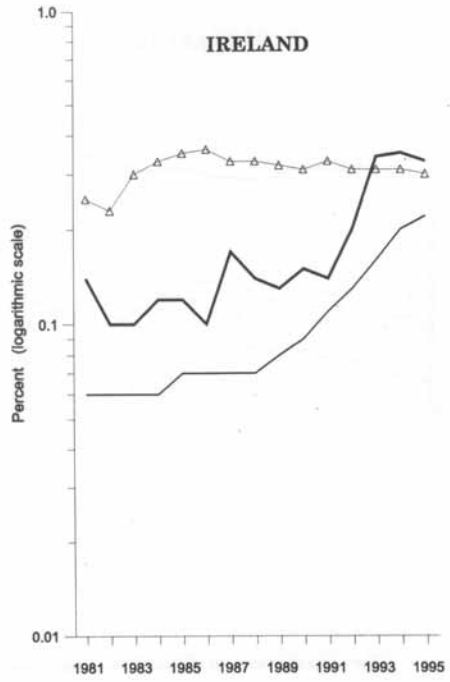
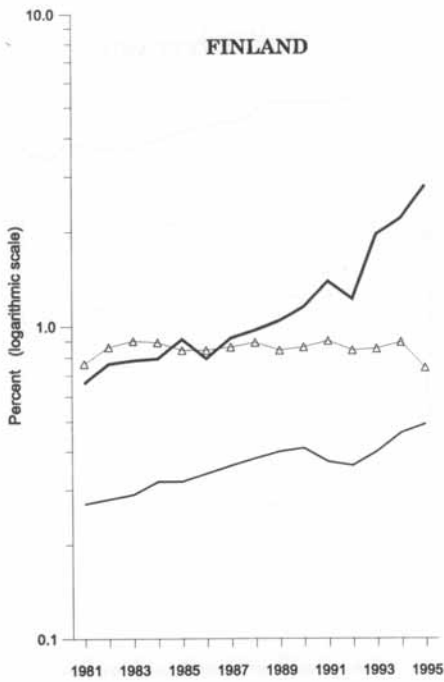
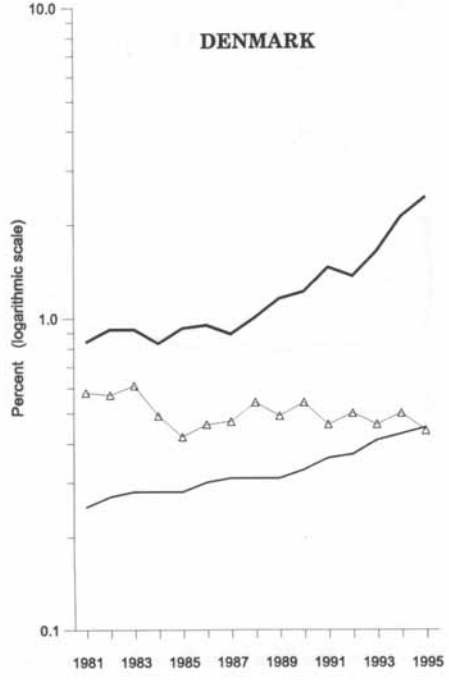
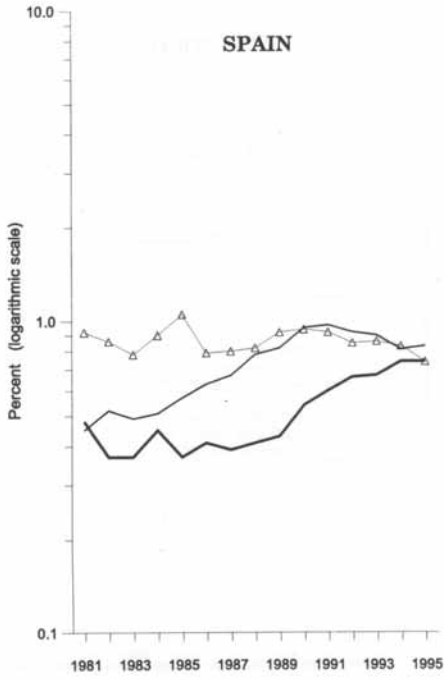
	% BERD/GDP (latest)	Period 1984 to 1991			Period 1991 to 1997		
		Change	Average annual real increase in BERD	Average annual real increase in Budget	Change	Average annual real increase in BERD	Average annual real increase in Budget
Sweden (1995)	2.67	0.33	1.7	1.4	0.74	8.7	-1.0
Korea (1996)	2.04	0.64	19.7	2.9	0.67	13.4	15.0
Japan (1996)	2.01	0.42	8.0	3.2	-0.14	0.1	6.5
United States (1997)	1.96	0.07	2.4	1.8	-0.08	2.3	-1.5
Switzerland (1996)	1.94	0.22	1.4	15.5	-0.18	1.2	-0.7
Finland (1997)	1.88	0.32	7.5	7.9	0.70	11.0	3.6
Germany (1997)	1.63	0.00	4.1	2.4	-0.18	-0.7	1.6
France (1997)	1.38	0.22	5.2	2.3	-0.10	0.0	-2.9
Denmark (1997)	1.27	0.33	7.5	7.8	0.27	6.9	2.8
United Kingdom (1996)	1.26	0.05	2.3	2.8	-0.16	0.0	-0.1
Netherlands (1996)	1.10	-0.02	2.6	2.5	0.09	4.6	2.1
Belgium (1995)	1.07	-0.06	1.7	3.2	-0.02	0.7	2.5
Chinese Taipei (1996)	1.07	0.44	20.7	15.7	0.16	9.8	6.9
Canada (1997)	1.04	0.13	4.1	0.8	0.22	6.6	-7.0
Ireland (1995)	0.99	0.25	10.9	1.7	0.37	20.6	9.4
Norway (1997)	0.97	0.08	1.3	5.8	0.07	4.6	0.5
Singapore (1994)	0.90	0.37	17.0	na	0.27	17.3	na
Austria (1997)	0.83	0.13	6.2	4.1	0.03	na	1.7
AUSTRALIA (1996)	0.80	0.30	10.9	1.3	0.25	10.2	3.3
Italy (1997)	0.57	0.12	6.0	5.2	-0.12	-2.4	-6.5
Spain (1997)	0.44	0.23	14.3	15.5	-0.05	-0.4	1.0
New Zealand (1995)	0.26	0.06	-4.0	1.5	-0.02	4.0	0.4
India (1992)	0.19	0.01	6.9	na	0.01	10.7	na
China (1996)	0.18	0.19	6.2	3.5	-0.01	10.7	2.9
Average (24 economies)	1.19	0.20	6.9	4.3	0.12	6.3	1.5
Average (20 OECD only)	1.27	0.17	4.6	4.1	0.12	4.2	0.5

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

Figure 9 TRENDS IN BERD AND PATENT PERFORMANCE







However, improvements for Spain, Finland, Denmark and Ireland should be noted. These might be regarded as indicating the "dynamic European economies" — to a degree, counterparts to those in Asia.

Government science and technology budgets

As is the case with a range of other science and technology indicators, the OECD regularly publishes data on national budget appropriations for scientific and technological purposes. However, though there are guidelines that broadly define the items that should be included in such data sets, for a variety of reasons it is not possible for countries to collect those data in as rigorous a manner as R&D data collected via central statistical agencies. For this and other reasons, it is unwise to attempt comparative analysis of indicators based on appropriations as a proportion of total budget outlays or GDP. Comparative studies of growth rates, however, may have more validity and have been added to the other indicators set out in Tables 9 and 10.

These growth rate comparisons are relevant to a particular kind of argument sometimes put by interest groups seeking higher public funding for R&D. In essence, this argument relies on comparative analysis of foreign government announcements of more support for science and technology. There can be a risk in such an approach that the repackaging or revamping of old programs — legitimately included in such announcements together with descriptions concerning new funding — will lead analysts and commentators to draw mistaken conclusions. In particular, amounts of 'new money' being provided are easily over-estimated. For this reason, it can be hard to sustain convincing arguments through an approach of this kind.

In the above context, recent months have seen arguments put that announcements of new science and technology funding and programs in Canada, Japan, the UK, and the USA, mean that Australia is being left behind in some sense. In fact, the much harder data in Table 9 shows a very different situation. All those countries have much lower levels of public sector research than Australia. In the case of three of those countries — Canada, the UK and USA — in relatively recent years there were large cuts in Government funding for public sector research which are very apparent in detailed historical data published by the OECD. The picture is summarised in the negative real growth rates shown in science and technology budget appropriations for those three countries over the period 1991 to 1997. It does not appear that recent announcements of funding increases by those countries fully restore funding levels that were previously cut. By contrast, Figure 4 in Section 3 of this *Statement* shows a very consistent pattern of Government funding support for Australian public sector research — this is embedded in the relatively high growth rate in column six of Table 9, while the first column of Table 9 shows that this growth occurred in a context of very high levels of R&D.

For the period 1991 to 1997, the comparisons show that Australia achieved a real growth rate in science and technology appropriations that is well above international averages. More remarkably still, given that the major part of Australia's Government support for science and technology goes towards research in government laboratories and universities, Australia's high budget growth rate corresponds to a comparatively high level of R&D carried out in those sectors (see the first column of Table 9).

A naive interpretation might be that this situation — a high growth rate in appropriations going to public sector science — is untenable when public sector R&D levels are already very high in international terms. However, it might also be noted that those economies arguably most committed to the knowledge-based economy — Finland, Korea, Japan, Chinese Taipei and Ireland — have even higher Budget growth rates than Australia. Moreover, national particularities — in Australia's case a large and unique range of national problems and opportunities arguably requiring research — if analysed carefully and persuasively might possibly present more compelling arguments for increasing public support for public sector science than any international comparisons.

Pending arguments such as might be presented above, the imperative for Australia must be to address the weakness in business sector R&D apparent in the first column of Table 10. And a wide range of information presented in this *Statement* indicates that the Government is seeking to do just that. This issue is addressed not only by a set of programs that are directly aimed at strengthening R&D in the business sector, but also through measures that build linkages between industry and our strengths in public sector science.

A regional perspective

Internationally, while there has been increasing attention paid to national 'systems of innovation', this work has also pointed to the importance of regional systems. This is particularly pertinent to the situation of Australia's States and Territories, where the geographical dispersion of centres of economic activity point to the value of considering indicators relating to individual regions as well as those of the nation as a whole. Taken as a whole, Australia shares some features in common with the five Nordic countries - another set of geographically dispersed centres of activity with a degree of economic integration and having, in total, similar levels of GDP and population. This approach can be carried one step further by considering combined indicators for both signatories to the Closer Economic Relationship (CER) Agreement. Table 11 then presents a range of indicators along these lines - with a range of developed countries included that are comparable to Australia's States and Territories in terms of GDP and population. The various economies listed are ranked by scale of total R&D activity.

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

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

* GERD data relate to 1994, but BERD and other data are for 1995.

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

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

Table 11 provides a different comparative view than that usually seen at a purely national level. For example, Victoria's levels of business R&D activity are seen to be equivalent to those of Denmark, and clearly exceeding those of Ireland, Norway, Austria and Singapore. While the R&D levels for the ACT seem remarkably high, these are essentially for the city of Canberra. Even higher levels would be seen if it were possible to obtain comparable indicators for cities such as Austin, Berkeley, Cambridge, Oxford, etc. where there are also high concentrations of academic and other research within relatively small areas. In fact, there are data (though not available since 1993) for most US States. Several of these are substantially higher on the comparative BERD/GDP indicator than that for the ACT.

SECTION

5

Portfolio
Budgets and Priorities

Introduction

This Section presents summaries of 1999-2000 budget allocations and priority goals relevant to science and innovation. This information is arranged by Ministerial portfolio, with a particular focus on agencies engaged in R&D and on programs funding R&D.

For each portfolio, there is a brief summary of pertinent allocations for the 1999-2000 Budget. Where possible this is compared with the expenditure outcome for 1998-99. Discussion of financial aspects is deliberately brief.

The summary of portfolio funding for major Commonwealth science and innovation programs is followed by an outline of priorities for 1999-2000.

The priorities are drawn from Section 2 of relevant Agency Budget Statements contained in Part C of the *Portfolio Budget Statements*. These statements provide detailed information on agencies' outcomes and outputs, including the purpose and nature of agencies' budget measures. They also show how the science and innovation programs are expected to contribute to the achievement of agencies' planned outcomes and outputs. This information is contained in two tables that show the relationship between agencies' old program and appropriation structures and their new outcome structures and resourcing levels.

Further information is available from the Portfolio Budget Statements of each Department. These can be accessed through the Federal Government entry point on the World Wide Web (www.fed.gov.au).

AGRICULTURE, FISHERIES AND FORESTRY - AUSTRALIA

Science and Innovation in the Portfolio Budget

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

Strong linkages with industry and relevant parts of Government, at both corporate and program levels, are essential to ensure the structural and administrative arrangements to facilitate research and development 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 R&D.

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

- two independent research bureaus; and
- thirteen Research and Development Corporations and one Research and Development Council.

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

Research Bureaus

The structure of Agriculture, Fisheries and Forestry - Australia includes two independent research bureaus:

- the
- (ABARE); and
- the Bureau of Rural Sciences (BRS).

The research bureaus play a vital role in the conduct of public sector research and provide scientific and economic analysis to assist the process of government. The intention is to ensure that research, scientific, technical

support and resource related policy advice to the Government is provided in the most efficient way and takes into account the interests of Australia's agricultural, fisheries and forestry industries and the broader community.

Research undertaken by these bureaus is funded predominantly from consolidated revenue and will total around \$27.4 million in 1999-2000. It is generally directed to areas where the external benefits are high, to the more basic lines of research, to research that may have a wide social impact, and where user pays funding is not generally cost-effective. In addition, the Bureaus undertake research on a contract basis for other agencies and industry.

R&D Corporations and Council

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

R&D Corporations and Council were established to:

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

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

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

- Sugar R&D Corporation;
- Tobacco R&D Corporation; and
- Dried Fruits R&D Council.

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

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

- Land and Water Resources R&D Corporation; and
- 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.

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

The Corporations and the Council report, and are accountable to both their respective industry and the Minister for Agriculture, Fisheries and Forestry. As a result they are aware of, and responsive to, the needs of both industry and the Government.

1999-2000 Science and Innovation Priorities

Australian Bureau of Agricultural and Resource Economics (ABARE)

In 1999-2000, ABARE will:

- maintain commodity outlook analysis as one of the foundations of ABARE's activities; emphasis will be given to the development and public release of short and medium term outlooks for the resource and agricultural sectors. ABARE will continue its program commenced in 1997-98 to further improve the forecasting techniques for the agricultural sector. In addition, ABARE will disseminate the research and commodity output through a wide range of activities including the annual OUTLOOK conference.
- continue the program embarked on in 1998-99 to conduct economic research to enhance Australia's ability to compete in international agricultural markets through analyses of policy developments in key trading partners; particular attention will be given to the World Trade (WTO) negotiations due to commence in 1999 and further development of the modelling capacity to meet Australia's negotiating and assessment requirements for the WTO round.
- further its current water modelling program to design a set of optimisation network modelling tools which incorporate economic decision making with hydrological and biological processes; the models when integrated with a representation of the water trading market in the southern Murray-Darling Basin will allow a comprehensive economic analysis of different aspects of the economic implications of the Council of Australian Governments (COAG) water reform agenda.
- conduct economic research and provide advice and recommendations into a number of Industry Development Strategies and Reforms for the Aquaculture (including Southern Shark), Pig, Wool, Dairy and Forest industries; in addition, the impact on performance of farm businesses of various options for rural and agricultural policy will be analysed.
- increase the effectiveness and efficiency of government policies and programs aimed at enhancing the sustainability of natural resource management in Australia, through evaluating the effect of existing natural resource management policies and programs, and assess the efficiency and effectiveness of alternate policy approaches. ABARE will also provide economic analyses on the impacts of change in the forest use in the final year of the Comprehensive Regional Assessment (CRA process).

Bureau of Rural Sciences (BRS)

Major Scientific advice outputs for 1999-2000 include:

- analysis, research and resource assessments on key issues for agricultural industries including vertebrate pests, agricultural sustainability, gene technologies, carbon accounting of sources and

sinks for greenhouse gases, regional social science parameters and climate and agricultural risk (eg drought exceptional circumstances);

- resource assessments and analyses of scientific issues affecting the sustainable development of the fisheries and forestry industries including commercial and recreational fishing, aquaculture, forestry and allied industries, to support the management of Commonwealth fisheries and the Regional Forest Agreement process;
- assessments and advice on sustainable groundwater resources, sustainable land use, aquifer risk assessment and water resources relating to public health parameters, to support profitable and sustainable resource management and the National Land and Water Audit;
- management and enhancement of national databases on forests, fisheries, land and water resources, e.g. National Forest Inventory, National Plantations Inventory, National Farm Forest Inventory & National Vegetation Information System; this also includes management of metadata on Australian land resources, water resources, fisheries and forestry data.
- development and application of tools and decision support systems for integrated spatial and dynamic modelling and data analysis capacity, to facilitate policy decisions on rural resource management issues; and
- participate in various research and management national committees including those reporting to the Standing Committee on Agriculture and Resource Management (SCARM) and its committees, the Australian and New Zealand Environment and Conservation Committee (ANZECC) and International fisheries/forestry committees.

COMMUNICATIONS, INFORMATION TECHNOLOGY AND THE ARTS

Science and Innovation in the Portfolio Budget

Science and Technology is part of the cultural mainstream of Australian society. Through the Department of Communications, Information Technology and the Arts, the Government has sought to fully develop the synergies between communications and information technology and the creative industries sector. As outlined in Section 2, a major achievement in 1998-99 was the new administrative arrangements following the federal election in October 1998, when the Department of Communications, Information Technology and the Arts was created. The new arrangements were designed to increase opportunities for cooperation between IT-related Government functions previously operating in separate departments. Within the Department now are the Office for Government Online (OGO), the National Office for the Information Economy (NOIE) and the Information and Communications Industry Development Branch.

OGO's mission is to provide better government services – delivered online. OGO directs a number of key initiatives that will ensure the Government's place as an important, leading-edge user of online technology (outlined in Section 2). The newly formed Information and Communications Industry Development Branch will maintain strong linkages with science and technology and investment functions of the Department of Industry, Science and Resources (ISR). NOIE has the responsibility for developing strategies to address the issues arising from the convergence of the information economy, information technology and telecommunications.

Science and technology programs supported through the Department of Communications, Information Technology and the Arts include:

- the Australia-Japan Broadband Link Program, which supports a data communications link between the CRC for Advanced Computational Systems (ACSys) located at the Australian National University in Canberra and the Real World Computing Partnership (RWCP) in Tsukuba, Japan. This three year program, which was commenced in early 1997, granted \$1.2 million to the ACSys CRC to establish the link and facilitate collaborative IT research between Australia and Japan; and
- the High Performance Computing and Communications (HPCC) Technology Diffusion Centres Program, which provides support for

selected centres to aggressively market advanced computing expertise to Australian companies. Funding of \$3 million was provided to establish two centres, at the technology parks in Brisbane and Sydney. This program ends on 31 December 1999 and most of the funding has now been expended.

The portfolio also administers the SEQC and T&CI initiatives described in Section 2.

The Department of Communications, Information Technology and the Arts and the National Museum of Australia will continue to explore and use innovative technologies in the planning and development of the new Museum facility on Acton Peninsula. For example, the plans for the Museum include a theatre featuring cutting edge cinematic techniques, possibly employing virtual reality, as well as a sophisticated media and communications centre providing the Museum with the capability to exchange media programming and data with schools, museums and other institutions in Australia and overseas.

In addition, state of the art multi-media technology will be incorporated in the exhibition spaces to provide more detailed information about specific aspects of the exhibitions and programs and to enhance access to the Museum's collections.

Australia's Cultural Network continues to improve and develop online access to, and participation in Australian cultural endeavour, activities and events, and to improve the productivity of Australian cultural organisations. Scientific sites are among those able to be located through the website finder.

1999-2000 Science and Innovation Priorities

Questacon - The National Science and Technology Centre

The National Science and Technology Centre is an agency within the Communications, Information Technology and the Arts' portfolio. In 1999-2000, the Centre will continue to provide a national focus for popularising science and technology through the touring of interactive exhibitions. A range of educational programs aimed at increasing awareness and creating positive attitudes to science and technology will also be conducted.

The Centre will continue to explore and use innovative technologies to enhance its programs and services. It will address contemporary and emerging science and technology outcomes in a diverse range of exhibitions and programs. A new robotics exhibition is being explored with partner organisations in Japan and the United States. The Innovative Australians Exhibition will continue to tour. Questacon is looking at establishing a presence at the Australian Technology Park in Sydney, with programs focusing on technology and innovation in collaboration with tenants at the Park.

The National Science and Technology Centre will receive \$4.6 million over four years for a major building maintenance program, and refurbishment of exhibition spaces and equipment.

National Film and Sound Archive

In 1999-2000, the Archive will:

- acquire audiovisual items of cultural significance and negotiate agreements with commercial producers to allow the Archive to acquire such material;
- remove from the collection duplicate items and items not considered to be of cultural significance;
- produce new copies of film, sound and video items of high heritage value that are considered to be at high risk of loss;
- improve standards of collection descriptions and the availability of access guidelines and catalogues;
- make the collection database, containing over 400,000 records including approximately 5,000 digitised stills, available on the Internet;
- improve preservation and safe storage of collection material;
- review preservation and storage practices and develop a comprehensive risk management program for the entire national collections;
- contribute to audiovisual archiving nationally and internationally; and
- continue to enhance the collection database to suit the changing demands of managing and distributing cultural collections.

DEFENCE

Science and Innovation in the Portfolio Budget

The Budget allocation for the Defence science and technology function will be \$245.6 million in 1999-2000 (\$247.0 million expected outcome in 1998-99).

Some enduring themes emerge in the work of the Defence Science and Technology Organisation (DSTO). These themes include support for intelligence, surveillance, electronic warfare, communications, information technology, and exploitation of environmental information. They also include signature management, operational research, combat modelling and simulation, overall systems including the human dimension, and knowledge of advanced materials. A recurring theme is the need to understand the strengths and weaknesses of our own key weapons and sensors, and those that might be used against us.

1999-2000 Science and Innovation Priorities

DSTO's strategic direction and priorities reflect many factors. They include not only the direction of technological advance but also such policy guidance as *Australia's Strategic Policy (ASP 97)*, the Government's policy statement, *Building Combat Capability*, and the Defence Executive's publication, *Defence - Our Priorities*.

Priority Areas of ASP 97

ASP 97 nominates four priority areas for the future development of Australia's military force structure: The Knowledge Edge, Defeating Threats in our Maritime Approaches, Strike, and Land Forces.

DSTO will continue to give emphasis to The Knowledge Edge. DSTO's focus on the three Knowledge Edge elements: Intelligence, Command Arrangements and Command Support Systems, and Surveillance of our Maritime Approaches, will remain a high priority. Some issues are:

- gaining greatest military advantage from the information revolution, the so called Revolution in Military Affairs (RMA): at Government direction, the Portfolio is providing additional funds to DSTO in financial year 1999-2000 and beyond to undertake further research in fields relating to the RMA. These funds will be used inter alia for: increased research on RMA technologies related to land operations, smart weapons, electronic warfare, joint systems, and for scientific attachments to the US.

- the need to strengthen DSTO's ability to understand, and give advice on, the consequences of the RMA for joint warfare – particularly on integration of command, control, communications, intelligence, surveillance and reconnaissance systems. To help address this and other related issues, DSTO will establish a Joint Systems Branch; and
- the need to increase DSTO's support to Headquarters Australian Theatre and Australian Defence Headquarters in areas such as campaign planning, analysing preparedness and analysing military strategic options. DSTO will develop a campaign modelling capability to do this.

Support for Defeating Attacks in our Maritime Approaches constitutes a substantial proportion of DSTO's research program. Activities include: continuing to give priority to through-life support of the F/A-18 airframe, sensors and weapons; improving aircraft electronic warfare self protection, including through a joint research program with the US; and continuing to support the Collins Class submarine program through work associated with signature management, operational performance, and reliability. Also, research will continue into improving the survivability of surface combatants from threats posed by advances in anti-ship missiles.

DSTO's work in support of the Strike priority is focused mainly on the F-III aircraft and stand-off weapons. A considerable amount of DSTO's research work is in support of ensuring safe operation of the F-III fleet to its planned withdrawal date of 2020. Other activities include improving the electronic self-protection for the F-III, carrying out a program of stores separation certification for ADF weapons, and contributing to decisions on the acquisition of future stand-off weapons.

In support of priority four - Land Forces - DSTO will provide increased support as Army addresses significant changes to its structure, processes and equipment to focus on more complex and technologically advanced warfighting. In accord with priority areas identified by the Army, DSTO will be supporting it in the following areas: Restructuring the Army trials, battlefield digitisation, surveillance and counter-surveillance, special operations, firepower, and army aviation.

Specific, high priority performance targets for research activities in support of the four priority areas of ASP 97 are set out below, under various Defence Outputs:

Output One: Command of Operations

- Commencing the development of a Theatre Broadcast Technology Demonstrator for transmitting encrypted high-bandwidth video, voice and data signals to deployed troops via small (0.6 m) antennae.
- Developing and demonstrating a prototype campaign planning tool for Headquarters Australian Theatre and concepts for a simulation environment for the exercise of command and control within Headquarters Australian Theatre and its component and subordinate headquarters.

Output Two: Strategic Intelligence

- Developing collaborative research and development programs to assess capability of future imagery systems to support surveillance and intelligence.

Output Three: Capability for Major Surface Combatant Operations

- Conducting research to demonstrate techniques of stochastic resonance for the detection of weak target sound sources such as submarines and maritime mines. This will enhance operational effectiveness in anti-submarine warfare.
- Conducting research in tactical information systems supporting weapon targeting and sensor-to-shooter integration.

Output Five: Capability for Submarine Operations

- Further evaluating acoustic signature reduction methods and quantifying the performance improvement. Also developing additional ways to reduce the radiated noise and increase the operational capability of the submarines.
- Conducting research to improve the reliability of the main diesel engines.
- Investigating several approaches to passive sonar detection that make better use of Knowledge of the ocean environment to improve the probability of detecting very quiet targets such as submerged and surface vessels.

Output Eight: Capability for Mine Countermeasures and Mining

- Conducting research into sonar system strategies to detect, locate and classify maritime mines, and to establish an advanced mine warfare sonar facility for the Royal Australian Navy.

Output Ten: Capability for Special Forces Operations

- Developing new methodologies and evaluation techniques for the application of computer based analytical tools to Special Forces operations.

Output Eleven: Capability for Land Task Forces Operations

- Developing operational analysis procedures to assist in the tender evaluation of armed reconnaissance helicopters. These procedures will then be used to develop tactics for effective use of the new platform.
- Developing, demonstrating and evaluating aerial surveillance concepts for land operations using capability and technology demonstrators.
- Analysing and evaluating, in partnership with the Army, the structure and concepts for operation of a mechanised brigade in defending regional interests.

Output Twelve: Capability for Logistics Support of Land Operations

- Determining optimum logistic structures and processes for land operations by applying modelling and simulation techniques.

Output Thirteen: Capability for Air Strike/Reconnaissance

- Conducting simulated fatigue loading and tear-down inspection on a full-scale F-111 wing and carry-through box. This will aid safe operation of the F-111 fleet to 2020.
- Developing scientific methods to support the management of low cycle fatigue of failure-critical components in military aircraft engines, including possible implementation of retirement-for-cause to reduce wastage of sound components.

Output Fourteen: Capability for Tactical Fighter Operations

- Conducting a program of stores separation certification for the Australian Defence Force weapons using the upgraded transonic wind tunnel.
- Continuing the full-scale fatigue test of the F/A-18 empennage to develop life extension and repair options.
- Conducting research into the F/A-18 radar's detection capabilities, electronic protection, and non-cooperative target recognition performance to improve operational capability.

Output Sixteen: Capability for Strategic Surveillance

- Assisting the Airborne Early Warning and Control Project Office in tender evaluation and risk reduction activities and providing assistance in areas including design reviews, planning for test and evaluation and independent verification and validation during the acquisition phase.
- Developing an integrated surveillance assessment environment for assessing integrated surveillance architectures and their operational employment.
- Developing automated tracking and sensor fusion algorithms for wide area surveillance to estimate the location and identity of air targets by fusing data from multiple surveillance sensors.
- Evaluating the potential capability of high frequency surface wave radar as a surveillance sensor.

Output Seventeen: Capability for Maritime Patrol Aircraft Operations

- Developing and validating models of radar detection and classification performance, and simulation tools for the new AP-3C Orion aircraft radar to optimise the effectiveness of the sensor.

Output Eighteen: Capability for Airlift

- Providing advice on C-130J Hercules aircraft crew workload and related human factor issues to determine the minimum number of crew for the safe and effective operation of the aircraft.

- Undertaking collaborative research with the United States in various aircraft electronic warfare self-protection programs.

Other Priority Areas

In addition to the goals related to combat capability discussed above, DSTO will contribute to Defence goals as follows:

Goal 3: Closer Alliances and International Strategic Relationships

Cooperation with traditional friends and allies in defence science and technology will continue through a range of collaborative activities conducted under existing multilateral and bilateral arrangements for collaboration in defence science and technology. In November 1999, the governing body of The Technical Cooperation Program will hold its annual meeting to review the general health and direction of the cooperative defence research programs among the member countries: the US, the UK, Canada, New Zealand and Australia. Australia and New Zealand will host this year's meeting.

Cooperation in the region with Indonesia, Malaysia, Singapore and Thailand in defence science and technology will continue, focusing on support for aircraft structure management, better maritime surveillance, and more effective radio communication.

Goal 4: Enhanced National Support

In accordance with the Government's Defence and Industry Strategic Policy Statement, DSTO engages with industry to improve the capacity of Australia's industrial and scientific base to develop and support new defence capabilities, and to support and sustain existing defence capabilities whenever and wherever they are deployed. In this regard DSTO's industry interaction objective is:

'To work with industry to enhance Australia's defence capabilities and to contribute to national wealth creation, including through the support of exports.'

To facilitate this engagement, DSTO will release information to industry on its future research programs and priorities. New ways will be devised to make future research directions more clearly visible to a wide range of industry and other interests.

The Capability and Technology Demonstrator Program continues with a number of newly approved demonstrators. These will demonstrate the defence applications of advances in sonar, radar and bio-sensor technologies. They support Australian research initiatives and source considerable work from Australian industry, with strong industry commitment to, and co-investment in, several of the approved proposals.

Other activities will include:

- placing research contracts and licence arrangements with industry, universities and other research organisations;

- developing existing and new industry alliances and other collaborative arrangements in a variety of areas; and
- developing beneficial affiliations with other research institutions.

Goal 5: Growing Skills and Knowledge

DSTO will continue to undertake forward-looking, or enabling, research to position the Organisation to exploit new and developing science and technologies that show promise for application to the defence of Australia. This research, which tends to be beyond the planning parameters of the work sponsored by DSTO's 'Defence customers', makes up some 10 per cent of DSTO's research program.

A pilot Executive Leadership Development Program, designed to enhance the leadership skills of senior scientists in DSTO, was started in the first half of 1999 and will continue until March 2000. The pilot will be evaluated to decide whether to continue with the program.

The DSTO Graduate Certificate in Scientific Leadership program is designed to broaden and improve the management skills of middle-ranking staff in DSTO. The program was reviewed late in 1998 and action is in hand to call tenders from tertiary institutions for the continuation and further development of the program in 2000 and beyond.

Goal 6: Stronger Leadership and Better Management

Subject to due process of negotiation, DSTO is moving towards implementation of a new unified Defence Science Career Structure for its research, professional and technical officers. This is intended to remove artificial barriers to career development and advancement and allow more flexible and effective working arrangements within DSTO.

The Government has approved, subject to Public Works Committee processes, the rationalisation of DSTO's facilities in Melbourne, involving the refurbishment of existing buildings and construction of new buildings at Fishermens Bend, and closure by 2002 of the facilities at Maribyrnong. This will enhance the capacity of the Aeronautical and Maritime Research Laboratory to deliver scientific support to Defence.

EDUCATION, TRAINING AND YOUTH AFFAIRS

Science and Technology in the Portfolio Budget

Through the Education, Training and Youth Affairs portfolio, the Government will provide \$1.6 billion in 1999-2000 to support research and research training in Australian universities.

Support through university operating grants

The major part of the Government's support for university research and research training, approximately \$1,195 million in 1999-2000, is provided through operating grants. This amount comprises the following nominal components: (a) the Research Quantum (RQ), approximately \$220 million; (b) approximately \$151 million of the Australian National University's operating grant for the support of the Institute of Advanced Studies; and an estimate of research and research training expenditure sourced in the operating grant, not included elsewhere.

Targeted research programs

Approximately \$443.6 million will be provided in 1999-2000 directly to universities, researchers and other bodies through a range of targeted research programs: Research Grants (\$132.3 million); Postgraduate Awards (\$79.3 million); Research Fellowships (\$27.4 million); International Researcher Exchange Scheme (\$2.6 million); Research Centres (\$20.5 million); Research Infrastructure (\$100.5 million); the Strategic Partnerships with Industry Scheme (\$57.3 million); International Postgraduate Research Scholarships (\$16.2 million); Learned Academies (\$1.6 million); Anglo-Australian Telescope Board (\$3.7 million); Research Evaluation Program (\$0.7million); and unallocated funds (approximately \$1.4 million).

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

Research Funding Activities

University Operating Grants

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

for research is channelled through universities' operating grants which support both high quality undergraduate teaching and their research and research training capacity. By supporting higher education research, the Government aims to achieve:

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

The estimate of the research and research training component of the operating grant is based on the ABS survey of research expenditure of universities by source of funds (the ABS methodology is outlined in 1994 *Research and Experimental Development — Higher Education Organisations* (8111.0)). One of the sources identified by the ABS is General University Funds (GUF). The operating grant component is the major part of GUF, and can be estimated by using the operating revenue figures from *DETYA Selected Higher Education Finance Statistics*. Using this method, the estimated research and research training component of university operating grants for 1999-2000 is \$1,195 million (see Table 6, Section 3, Science and Innovation in the Budget and accompanying footnotes).

Within this amount three components can be identified:

- *The Research Quantum (RQ)*: RQ is an amount within the operating grant which is reallocated to institutions on the basis of research performance, as measured by the Composite Index. In 1999-2000, the RQ will be approximately \$220 million.
- *An estimate of the component of the operating grant used for research training*: this estimate is derived by using the actual higher degree research student load, weighted in accordance with the relative teaching costs matrix developed in 1990 in the context of the Relative Funding Model (RFM), and using funds allocated to operating grants excluding capital roll in. In 1990, the Research Training Component (RTC) was estimated to be 7.6 per cent of the operating grant. Due to strong growth in postgraduate research student load since 1990, the estimate of research training has increased and is currently estimated to be 11.5 per cent of the operating grant, or \$487 million.
- *Funding for the schools and centres of Institute of Advanced Studies of the Australian National University*: the block grant for the Institute of Advanced Studies (IAS) is estimated to be \$151 million. This amount includes some \$105 million which is allocated by the University to the annual budget of the Research Schools (including the John Curtin School of Medical Research) and Centres of the IAS. In addition, the University estimates that a further \$45 million can be regarded as being attributable to the IAS in respect of University overheads, major equipment and such campus-wide costs as the library, information technology and central administrative activities.

Targeted research funding

Australian Research Council (ARC)

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

The majority of targeted research funding is allocated on the advice of the ARC, which conducts competitive peer reviews through its panels and committees. The primary criterion for allocating funding is the performance record of researchers and the quality of their proposals. Some weight may be given to other criteria such as national priority areas and links to industry. In 1999-2000, the budget for targeted research programs referred to the ARC is approximately \$357 million.

ARC Referred Programs

Research Grants

The 1999-2000 allocation for Research Grants is \$132.3 million. The Research Grants program has two components:

- *Large Grants Scheme:* supports basic and applied research projects in all disciplines except clinical medicine and dentistry. Grants range from a minimum size of \$20,000 for the social sciences, humanities, mathematics and theoretical physics, and from \$30,000 for other disciplines.
- *Small Grants Scheme:* provides block grants to universities to enable them to offer research grants at less than the minimum value of Large Grants. Eligible universities receive a base grant of \$50,000. The remaining funds are distributed according to a formula that takes into account institutional success in obtaining Large Grants and the distribution of Small Grants in the previous year.

A sub-element of the Large Grants Scheme is the Indigenous Researchers Development Scheme which aims to encourage indigenous researchers to improve their research skills to a level where they will be competitive for mainstream research funding. Emphases of the Scheme include the provision of support for research projects, training in research methodology and the preparation of larger research proposals. Up to \$220,000 is available for this Scheme in 1999-2000.

Strategic Partnerships with Industry - Research and Training Scheme

The Strategic Partnerships with Industry - Research and Training (SPIRT) Scheme supports research collaboration between universities and industry. It covers projects in basic, strategic, applied and developmental research and

training in all fields, funded on a dollar for dollar arrangement with industry collaborators.

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

In the calendar year 1999, \$17.4 million has been awarded to 406 new SPIRT Scheme projects. This includes \$9.8 million in funding for 187 Collaborative Research projects; \$1.4 million for 21 Australian Postdoctoral Fellowship Industry Awards and \$6.0 million for 288 Australian Postgraduate Award Industry places. In 1999, funding will total \$53.8 million.

In 1999, 810 ongoing grants and 448 Australian Postgraduate Awards (Industry) are also being supported at a cost of \$33.8 million. These 810 projects involve support from 341 Research Grants, 19 APDI and 559 APAI training awards.

Additional funding in 1999 has been allocated to 50 Australian Postgraduate Award (Industry) places in the fields of information, technology and communication. In late 1998, the Government also provided additional funding of \$58.9 million over the next three years.

Research Fellowships

Fellowships provide support for individuals to undertake research at postdoctoral level and above. In 1999-2000, \$27.4 million will be available for Research Fellowships.

There are five types of Fellowships:

- *Australian Postdoctoral Research Fellowships (APRF)*: These are normally for researchers with less than three years of postdoctoral experience. Fifty five new APRFs have been taken up in 1999.
- *Australian Research Fellowships (ARF)*: These are normally for researchers with more than three years of postdoctoral experience. Fifteen new ARFs have been taken up in 1999.
- *Queen Elizabeth II Fellowships (QEIIIF)*: These are for outstanding researchers who would usually have no more than six years' postdoctoral experience. Fifteen new QEIIIFs have been awarded in 1999.
- *Senior Research Fellowships (SRF)*: These are for researchers with established reputations who would normally have no more than fifteen years of postdoctoral experience. Fifteen new SRFs have been awarded in 1999.
- *International Research Fellowships (IRF) funded under International Researcher Exchange (IREX) Scheme*: These fellowships arise from the implementation of reciprocal research award agreements with the Alexander von Humbolt Foundation of Germany, the Korea Science

and Engineering Foundation, the United Kingdom Office of Science and Technology and the United Kingdom Particle Physics and Astronomy Research Council. Fifteen Fellowships were awarded for 1999.

International Researcher Exchange Program (IREX)

IREX operated for the first time in 1999 and attracted 109 applications. The 43 successful projects support international collaborative links. IREX provides funding to support the movement of researchers to and from Australia enabling collaboration between researchers in research institutions and centres of research excellence. The program specifically supports:

- bi-national agreements for reciprocal exchange of researchers and the Anglo-Australian Observatory (AAO); and
- promotion of links between research centres of excellence in Australia and overseas by funding the exchange of researchers for research collaboration.

Research Centres

A total of \$20.5 million is being provided to Research Centres in 1999-2000. Two types of centres are supported:

- *Special Research Centres* are established on the basis of research excellence and their potential to contribute to the economic, social and cultural development of Australia. The Centres are funded as recognised sources of expertise that promote cooperative links with government, industry and relevant communities. They receive between \$0.5 million and \$1 million per annum. In 1999, funding of \$14.7 million is being provided to 19 Special Research Centres. A review of eight existing Centres and a selection round for further Centres will commence in 2000.
- *Key Centres of Teaching and Research* give equal weight to teaching and research. They are based in existing university departments and aim to boost expertise in areas relevant to national development and to promote cooperation between the higher education sector and industry. Key Centres receive an average grant of \$360,000 a year from the program, but most obtain additional funding from other sources. In 1999, funding of \$5.5 million is being provided to 16 Key Centres of Teaching and Research including eight new Centres arising from a selection round which took place in 1998.

Australian Postgraduate Awards

A total of \$79.3 million is available under the Australian Postgraduate Awards (APAs) Scheme in 1999-2000. In addition, 21,500 Equivalent Full-time Student Units (EFTSU) are provided with exemption from the Higher Education Contribution Scheme. Around 4,500 APAs provide a stipend of up to \$20,503, mainly for students undertaking postgraduate research degrees. They are tenable for up to two years for a Masters student, and three and a half years for a student undertaking a PhD. 1,550 new awards were available in 1999. APAs are allocated to institutions on a formula reflecting research student load, research degree completions and comparative research strength measured by the Composite Index.

International Postgraduate Research Scholarships

The International Postgraduate Research Scholarships Scheme supports high quality overseas postgraduate students in areas of research strength in higher education institutions. The scholarships offer students the opportunity to acquire a postgraduate qualification and experience with leading Australian researchers. In 1999-2000, \$16.2 million will be available to the scheme. In 1999, three hundred new scholarships are available.

Research Infrastructure Equipment and Facilities Program

The Research Infrastructure Equipment and Facilities (RIEF) Scheme is the element of the Research Infrastructure Program (see below) referred to the ARC for advice on the allocation of funds. The Scheme funds relatively large scale initiatives which develop major research infrastructure on a cooperative basis across groups of institutions and with organisations outside the higher education sector. Grants can also be made to individual institutions in cases where cooperative arrangements are impractical or inappropriate. In 1999-2000, this element of the Research Infrastructure Program will provide at least \$20.3 million.

DETYA Non-ARC Referred Programs

Research Infrastructure Program

The Research Infrastructure Program provides the Commonwealth Government's contribution, \$100.5 million in 1999-2000, to research infrastructure in higher education institutions. It supports high quality research by ensuring that areas of recognised research potential have access to the support necessary for their development; by enhancing support for areas of research strength; and by remedying deficiencies in research infrastructure. In order to address a projected decline in funding level, the Government has provided an additional \$93.3 million in funding for research infrastructure over three years, with \$36.8 million available in 1999-2000.

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

The non-referred element is the Research Infrastructure Blocks Grants (RIBG) Program. RIBGs are provided to universities to assist in the development and maintenance of research infrastructure. Consistent with the program priority of providing infrastructure support for Commonwealth competitive grant schemes, the RIBG is allocated to institutions on the basis of the National Competitive Grants Index (NCGI). This element of the Program will provide an estimated \$80.3 million in 1999-2000.

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

The High Performance Computing and Communications (HPCC) Centres of Expertise Program is providing funding to establish an Australian Partnership for Advanced Computing (APAC) to begin during 1998-99. It is

part of the Government's national strategy to facilitate the establishment of an integrated HPCC capability in Australia which promotes international competitiveness through enhanced cooperation between universities, existing HPCC centres and facilities, Government (Commonwealth, State or local) and industry, including infrastructure and applications level sharing and support. It complements the HPCC Technology Diffusion Centres Program administered by the Department of Industry, Science and Resources.

1999-2000 Science and Innovation Priorities

Research in our universities must become increasingly connected with the national innovation system. More needs to be done to bring the providers and users of research together: to involve users more effectively in setting the research agenda, to promote collaborative research, and to commercialise the results of research conducted in the public sector. Given the rapid changes in the nature of knowledge production, linkages will also need to be strengthened between the work of researchers from different but related disciplines and between funding for research and the planning and provision of research infrastructure.

Linkages between the research activities of our universities and the planning and resourcing of the research training system must become better integrated. Furthermore, there is a need to improve the quality and effectiveness of the research training system, including a greater emphasis on broadening research training: for example, by providing a more flexible, adaptable and multi-disciplined approach to graduate training and by ensuring that research training remains at the cutting edge by fostering stronger cooperation between universities and external centres of excellence, and between universities and industry. The success of our national research effort will rely also not only on the quality of the work of individual researchers but also on the institutional environment in which they operate.

ENVIRONMENT AND HERITAGE

Science and Innovation in the Portfolio Budget

The portfolio consists of the Australian Antarctic Division, the Australian Greenhouse Office, the Bureau of Meteorology and Environment Australia. Environment Australia consists of six groups: Australian and World Heritage Group, Biodiversity Group, Environment Protection Group, Portfolio Strategies Group, Science Group and Marine Group including the Great Barrier Reef Marine Park Authority . This structure includes several research organisations and programs, for example, the Environmental Research Institute of the Supervising Scientist, the Australian Biological Resources Study and the National Wetlands Research and Development Program.

Australian Antarctic Division

The Australian Antarctic Division has a total projected accrual budget of \$95.3 million. The Division directly undertakes, and supports, scientific research in the Australian Antarctic Territory, the Southern Ocean and Australia's subantarctic islands. Its priorities as defined in the Government's response to the report, *Australia's Antarctic Program Beyond 2000 - A Framework for the Future*, in addition to the goal of maintaining the Antarctic Treaty System and enhancing Australia's influence within the System are to:

- protect the Antarctic environment;
- understand the role of Antarctica in the global climate system; and
- undertake scientific work of practical, economic and national significance.

Australian Greenhouse Office (AGO)

The Australian Greenhouse Office (AGO) is the lead Commonwealth agency on greenhouse matters, providing a major focus for greenhouse policies and programs, including research. The AGO reports directly to the Minister for the Environment and Heritage, and through him to a Ministerial Committee on Greenhouse. Within the Australian Greenhouse Office, science and innovation priorities are reflected in the following programs:

- National Greenhouse Research Program;
- National Greenhouse Gas Inventory Program; and
- National Carbon Accounting System.

The Bureau of Meteorology

The Bureau of Meteorology, as the national meteorological service for Australia, has primary responsibility for research in support of its own operations and services, including research directed at the broad delineation of the characteristics of Australian weather and climate, and for liaison with the World Meteorological Organization in relation to relevant research in Australia. The Bureau maintains a wide involvement in atmospheric and oceanographic research at both national and international level, encompassing partnership in three Cooperative Research Centres, collaboration in research and development projects with several Australian and overseas universities and government agencies, as well as through bilateral and multilateral agreements with overseas governments and national meteorological services.

To fulfil its research objectives, the Bureau:

- encourages high quality research in-house as a foundation for effective collaboration with the external research community and for implementation of improved systems and techniques for the provision of services;
- fosters meteorology in the tertiary education sector to ensure access to well-trained graduates and maintenance of the national research infrastructure for atmospheric science; and
- ensures effective coordination with the research programs of other relevant institutions both within Australia and overseas.

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

Environment Australia

Within the Biodiversity Group, work will continue on the implementation of the Convention on Biological Diversity. This includes research activities that contribute to the conservation and sustainable use of biological diversity. Biodiversity Group is also responsible for management of parks and reserves owned or leased by the Commonwealth. To assist in this management, research is conducted in a number of parks, including Kakadu and Uluru-Kata Tjuta National Parks.

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

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

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

The objective of the Marine Group is to promote ecologically sustainable management of Australia's coastal and marine resources through the delivery of Commonwealth policy and programs, and to support the Minister's commitments to the Australian public.

The Great Barrier Reef Marine Park Authority is responsible for the management of the Great Barrier Reef Marine Park and is also involved in the management of the Great Barrier Reef World Heritage Area. The Authority works jointly with a number of Commonwealth and Queensland government agencies, such as the Queensland Parks and Wildlife Service, Department of Environmental Protection Agencies, Queensland Fish Management Authority and the Queensland Department of Primary Industry to achieve more effectively the Marine Park's management objectives. The Authority will continue to focus on issues that are critical for appropriate protection and use of the Great Barrier Reef Marine Park and World Heritage Area.

These critical issues, as identified in the Authority's Strategic Business Plan, are:

- conservation, biodiversity and world heritage;
- tourism and recreation;
- fisheries; and
- water quality.

The Authority has recently revised its structure and established work teams dealing with each of the above critical issue areas.

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

1999-2000 Science and Innovation Priorities

Australian Antarctic Division

The Antarctic season 1999-2000 will be the last under the 1995-2000 science strategic plans and associated logistic and operational activities. Program Advisory Committees and Program Leaders are currently developing new plans for the period 2000-2005, a period which coincides with new logistical arrangements.

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

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

Protecting the Antarctic environment

New methods for removing old waste material from the Antarctic and for in-situ remediation of contaminated soils are being developed. These methods are designed to allow removal of waste under Antarctic conditions without dispersing contaminants and causing greater environmental harm.

The proceedings of the first international meeting to consider the threat of introduced diseases to Antarctic wildlife, organised by the Antarctic Division, will be published. They will include recommendations to reduce the risk of disease introduction, advice on response to a disease outbreak and suggested monitoring methods to ensure early detection of disease.

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

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

A management plan for the Larsemann Hills, including a plan for the future directions in science, is being developed following a successful meeting in Hobart between China, Russia and Australia.

Understanding the role of Antarctica in global climate change

Floating ice shelves play a role in the formation of Antarctic Bottom Water, and few more northerly Antarctic shelves have been disintegrating. A new

program will commence in 1999-2000 to investigate melting and refreezing processes beneath the Amery Ice Shelf.

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

Observations of temperature and winds in the upper atmosphere will be conducted using the Division's new Light Ranging and Detection instrument (LIDAR) due to be deployed at Davis during 1999-2000.

Fine detail climate change over the last century will be derived from shallow (to 270 m) firm drilling at various elevations on Law Dome, near Casey. This project involves participation by CSIRO and ANSTO.

Undertaking scientific work of practical, economic and national significance.

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

A network of 14 automatic weather stations is maintained to obtain meteorological and climatological information from inland parts of the Antarctic ice sheets.

Discussions are in hand with the Italian Antarctic Program about a major collaborative marine geoscience study to be undertaken in 1999-2000. Originally it was to be undertaken in 1998-99.

Australian Greenhouse Office

The National Greenhouse Research Program (NGRP) continues to provide national level focus and direction for greenhouse science research. The NGRP's objectives are to:

- provide an overarching framework for Australian greenhouse scientific research;
- enhance the interface between greenhouse science and government to ensure the scientific basis for relevant policies and programs nationally and internationally;
- maintain and enhance scientific and technical proficiency, expertise and standing in greenhouse science;
- identify strategic impacts, risks and opportunities arising from climate and atmospheric change for economic, social and environmental systems;
- identify strategic options for adaptation;

- identify strategic options for mitigation; and
- monitor and influence international developments in the science to meet proactively the international obligations under the Climate Change Convention and the Kyoto Protocol.

The Government will provide an additional \$2 million in 1999-2000. It will provide \$4 million for each of the following three years for the National Greenhouse Research Program.

Inventory

The National Greenhouse Gas Inventory (NGGI) is a database of human induced emissions of greenhouse gases from sources and removals by sinks completed on a sectoral basis. Annual national inventories provide a trend line that may be used to monitor and review response actions and may be used as a base to develop emissions projections.

The NGGI Committee research program is funded from the NGGI Program with a budget of approximately \$850,000. Funds are allocated to improve NGGI emissions estimates, fill deficiencies in knowledge and improve understanding of the scientific processes governing greenhouse gas emissions, especially in those sectors with a relatively high degree of uncertainty associated with greenhouse gas emissions. This program is aimed at producing results in the short to medium term which are directly applicable to the NGGI. Continuing improvement in the NGGI enhances its role as a key diagnostic instrument for mitigation strategies both at a technical and policy level.

Carbon accounting

In 1998, \$12.5 million was allocated over 5 years for the development of a national carbon accounting system, to provide the comprehensive framework and scientific services necessary to account for Australia's emission reduction and sink enhancement programs. Data on Australia's carbon stocks will be verified by satellite monitoring and audited by on-ground sampling procedures and the development of models to extrapolate data to a regional and continental scale.

The Government has announced the establishment of the Cooperative Research Centre for Terrestrial Carbon Accounting, which will receive a total of \$55.96 million over seven years, with \$17.68 million contributed by the Commonwealth. The Centre will ensure that Australia is in a strong position to argue internationally for a comprehensive system of accounting for carbon emissions and sinks, through improvements of the fundamental science that underpins the National Carbon Accounting System.

Bureau of Meteorology

Science and innovation priorities for 1999-2000 are set out below under various Bureau of Meteorology Outputs:

The broad rationale of the Monitoring and Prediction Output is to provide, operate and maintain the basic observation, communications and data processing systems necessary to maintain a round-the-clock, nation wide weather watch and to meet present and future national and international needs for raw and processed meteorological data. Within this context for 1999-2000, the Bureau of Meteorology will:

- continue the re-equipment and modernisation program with emphasis on replacement of obsolescent equipment and enhanced operational effectiveness;
- maintain the Bureau's basic observational networks to the standards possible through the additional funds under the 'Providing World-class Weather Forecasting' budget measure;
- implement further improvements in the efficiency and effectiveness of the systems for external access to the Bureau's data and products; and
- further enhance the efficiency and effectiveness of forecasting operations through the operational implementation of the Australian Integrated Forecast System (AIFS).

The overall objectives for the Research Output reflect a continuing strategic emphasis on research directed towards improving the quality of the Bureau's services and developing an improved understanding of some of the meteorological and oceanographic processes which are central to major issues, such as global warming and environmental change. Against this background for 1999-2000, the Bureau of Meteorology will:

- improve further the scope, accuracy and reliability of the Bureau's numerical prediction systems;
- work towards improving climate prediction systems especially for seasonal timescales;
- maintain a program of climate research directed towards improved understanding of the natural variability of Australia's climate and reducing uncertainties in simulated changes to climate through the incorporation of improved representations of clouds;
- work on developing very short range forecasting capability and with a view to carrying out a demonstration project during the Sydney Olympic Games;
- trial the existing El Nino - Southern Oscillation ocean forecasting model and work towards improving the model's predictive capability; and
- actively participate in the meteorology and hydrology related Cooperative Research Centres to strengthen the overall foundations of Australian meteorology and especially basic meteorological research in the tertiary sector.

The overall objective of the Services Output is to meet the needs of the general public and specialised users for meteorological and related services. In 1999-2000, the Bureau of Meteorology will:

- continue to provide basic public weather, climate and hydrological services to meet the needs of all Australians;
- continue to monitor the extent and nature of community needs for services and the effectiveness of services provided;
- promote the application of services within the community and redesign and develop services in response to community needs as appropriate;
- continue to monitor and evaluate the Bureau's service operations to enable services to be provided efficiently and to a high and gradually improving standard;
- develop further the comprehensive, integrated and robust system for access to and delivery of services;
- complete the preparation of a basic set of new reference maps of climate parameters, as the basis of a major review of Australia's climate, as well as a number of specialised and regional climate surveys;
- monitor the status of the Reference Climate Station Network and participate in international programs analysing global trends in climate;
- improve the geographic coverage of generalised Probable Maximum Precipitation (PMP) design rainfall methods by developing a methodology for Western Tasmania that is consistent with the Generalised Southeast Australia Method (GSAM); and
- improve the accuracy of generalised Probable Maximum Precipitation (PMP) design rainfall methods by revising the Generalised Tropical Storm Method (GTSM) in association with Australian water industry partners.

In 1999-2000, the International Meteorological Activities Output will focus on a number of initiatives that will contribute to meeting Australia's international obligations, advancing Australia's interests and supporting the operations and services of the Bureau. The Bureau of Meteorology will:

- contribute to high level decision-making and scientific and technical planning in international meteorology through the programs and activities of the WMO (World Meteorological Organization) and related international organisations;
- contribute to enhanced cooperation through joint bilateral activities with relevant National Meteorological Services, multinational bodies and through the WMO Voluntary Cooperation Program; and
- collaborate with AusAID as a major funding source for supporting activities in the region, to undertake activities, including participating in the WMO-ESCAP project on smoke haze for the ASEAN countries and, contributing to a feasibility study on meteorological support to the South Pacific.

Environment Australia

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

Environment Australia will maintain a keen interest in research into the role native vegetation plays within the landscape and will further develop best practice principles for its establishment, protection and sustainable management. One of the priorities is to ensure that the information from research funded by the Biodiversity Group is disseminated to the managers of native vegetation - especially to private landholders and community groups working within native vegetation management.

The Environmental Research Institute of the Supervising Scientist (ERISS) will continue to carry out research in the principal programs on the impact of mining on people and ecosystems in the Alligator Rivers region and on the protection and management of wetlands. Priorities include:

- assessing the impact of the possible development of Jabiluka. ERISS will continue collecting radiological, sediment transport and hydrology data from the area around the Jabiluka mine site, in particular Swift Creek, the catchment of which contains the mine site;
- completing detailed study of a radiological state of the rehabilitated Nabarlek mine site;
- providing support for and further developing the National Centre for Tropical Wetlands Research and the Asia/Pacific Wetland Training Program;
- developing techniques for and undertaking inventory and assessment of tropical wetlands, including assessing changes to wetlands as a consequence of climate change and sea level rise; and
- undertaking risk assessment of major pest species in northern Australian wetlands.

Great Barrier Reef Marine Park Authority

The main priorities for the Great Barrier Reef (GBR) Marine Park Authority during 1999-2000 will be:

- development of a comprehensive system of protected representative areas on the GBR;
- inclusion of 27 new areas into the Marine Park;
- implementation of management plans for specific regions of the Marine Park;
- zoning of the Gumoo Woojabuddee Section of the Marine Park near Shoalwater Bay;

- protection of threatened species such as dugongs, turtles, whales and dolphins;
- sustainable fishing and management of land-based run off and pollution; and
- tourism use management.

HEALTH AND AGED CARE

Science and Innovation in the Portfolio Budget

Research activities are undertaken within the Health and Aged Care Portfolio and external research is funded through major portfolio research funding programs. Research is undertaken by the Australian Institute of Health and Welfare. Funding for research is provided through the National Health Medical Research Council (NHMRC) research grants programs, the Commonwealth Aids Research Grants Scheme and a number of smaller grants schemes which fund applied health and medical research relevant to the activities of the Department of Health and Aged Care.

In 1999-2000, funding for health and medical research through the NHMRC will be approximately \$173 million and research into HIV/AIDS will be approximately \$12 million.

The Australian Institute of Health and Welfare will receive \$8.1 million for support of its activities.

A further \$20 million over two years will be provided for capital works to establish or augment physical facilities in health and medical research institutes for the conduct of high quality health and medical research. The funding will be provided through a competitive grants round.

The Government will establish a National Institute of Clinical Studies, providing \$20 million over four years, with \$2.3 million available in 1999-2000.

1999-2000 Science and Innovation Priorities

The recommendations of the Wills' *Strategic Review of Health and Medical Research* are expected to be available about the time of the publication of this Budget Statement. These recommendations will be a major determinant for the portfolio's science and innovation priorities in 1999-2000.

Priorities will include:

- identifying and implementing strategic priorities in health and medical research;
- support for building up health and medical research infrastructure essential for advancing Australia's research capability;
- a greater focus on outputs and outcomes;

- strengthening basic research in all fields and facilitating its transfer into policy and practice;
- participating in the biotechnology revolution through an emphasis on support for medical genomic research;
- strengthening links between health and medical research and industry;
- building more effective research partnerships, networks and alliances with industry and other government and non-government research funders; and
- strengthening the capacity of the research sector through initiatives aimed at providing better career and employment opportunities for researchers in both the public and private sectors.

The Department of Health and Aged Care will continue to work, in partnership with other Government agencies, to provide an appropriate research, regulatory and commercialisation environment which will ensure that Australia is able to benefit from the potential offered by developments in all areas of application of biotechnology.

In particular, the Department will have responsibility for working with those agencies responsible for education, environment, agriculture and industry, in consultation and negotiation with the States and Territories on the development of a national regulatory system for gene technology. The current regulatory systems operated through the Therapeutic Goods Administration for pharmaceutical, medical device and diagnostic products and the Australian and New Zealand Food Authority for food products, supported by scientific and ethical guidelines developed by the NHMRC, already provide a reassurance for the community that products on the market are safe for their intended use. It is proposed that these systems will continue to apply to the new products of gene technology, while a new system will be developed to ensure adequate regulatory coverage of all genetically manipulated organisms not subject to existing legislative controls.

The Portfolio's major research funding programs are administered by the National Health and Medical Research Council which will continue to work on a number of proposals to facilitate meeting the above priorities by:

- developing and implementing simplified research-funding arrangements;
- working with other governments, agencies and funding bodies to coordinate the funding of health and medical research and research infrastructure;
- developing strategies aimed at strengthening the capacity of the research sector through a number of initiatives including greater training and support of researchers, and enhanced collaborative links and opportunities with international researchers;
- evaluating issues identified as possible strategic research priorities through a national consultation process;

- working with IP Australia to raise the awareness and understanding of medical researchers about management of intellectual property arising from their work;
- convening a working group on medical biotechnology to advise on the development and implementation of a health sector strategy for biotechnology as part of the Government's broader Biotechnology Action Agenda;
- continuing to work with County Investment Management Ltd to progress an initiative announced in 1998, whereby County will establish a Medical Research Investment Fund as a longterm investment fund which will provide additional support to NHMRC funded research, in return for a share in the intellectual property arising from that research; and
- promoting and fostering injury research in Australia through a specialist injury Research Committee. Advancing the issue of injury prevention and treatment requires collaborative action across a wide range of disciplines; and the Injury Research Committee will invite interested parties to enter into cooperative research funding and working arrangements.

INDUSTRY, SCIENCE AND RESOURCES

Science and Innovation in the Portfolio Budget

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

The major objectives and planned achievements for the Department of Industry, Science and Resources (ISR) in 1999-2000 include the:

- provision of strategic leadership in industry and science;
- development and implementation of industry, science and innovation policy;
- effective design and management of industry and science programs;
- promotion and facilitation of investment in Australia; and
- delivery of effective scientific business services.

Policy advice and analysis across a broad front relating to science, technology, innovation, research and development are provided by the Science and Technology Policy Branch, Innovation Branch and International Science and Technology Branch of the Department's Innovation and Science Division to meet Government, community and international needs.

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

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

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

improve the efficiency and international competitiveness of Australian industry.

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

Program or agency	Estimated cash expenditure 1998-99 \$m	Estimated accruals* 1999-2000 \$m
CSIRO	475.4	488.5
ANSTO	74.5	77.0
AIMS	18.5	21.2
AUSLIG	34.6	29.1
AGAL	27.2	27.1
Ionospheric Prediction Service	3.5	3.6
AGSO	74.9	58.9
R&D Start	127.9	160.5
Innovation Investment Fund	25.0	34.5
REEF	4.4	6.9
Technology Diffusion Program	12.5	27.0
Factor (f) Pharmaceuticals Pharmaceutical Industry Investment	159.3 - -	- 62.6
CRC Program	145.2	139.7
National Research Facilities	10.2	5.1
National Space Program	1.5	0.0
TOTAL	1190.2	1219.4

*Adjusted to remove capital user charge. See Box3.1

Innovation, science and technology policy

An important development was the establishment of the Innovation and Science Division during the year. This brought together areas in the Department dealing with policy issues spanning the quality of the science base to business innovation. This means that the Department has a strong and integrated policy unit on science and innovation matters. At the same time, the implementation of science programs was moved to AusIndustry.

Cross-portfolio advice and coordination

- *PMSEIC provides information and advice* to the highest levels of government. The Council is chaired by the Prime Minister and has a membership consisting of senior ministers and leading figures in business, science and technology. The non-ministerial members of the Council constitute the Standing Committee, which is chaired by the Chief Scientist, who is also the Council's Executive Officer. The Standing Committee examines issues in science, engineering and innovation and prepares reports and recommendations for consideration by the full Council. It has taken over the responsibilities of the Australian Science, Technology and Engineering Council (ASTEC) which was wound up in 1998. (PMSEIC's website is at <http://www.isr.gov.au/science/pmseic/pmseic.html>)
- *The Chief Scientist* also provides advice directly to the Prime Minister and the Minister and maintains close and effective working relationships between the Government and organisations with responsibilities for science, technology and engineering.
- The CCST enables departments and agencies with responsibilities in science and technology to share information about their programs, policies, problems and future work plans. The Committee takes a close interest in issues being considered by PMSEIC. (CCST's website is at <http://www.isr.gov.au/science/ccst/ccst.html>)

Scientific research organisations

Scientific research organisations within the portfolio make a substantial contribution to national research and development activities.

- *The Commonwealth Scientific and Industrial Research Organisation's (CSIRO's)* primary functions are to carry out scientific research for the purpose of assisting Australian industry, furthering the interests of the Australian community, contributing to the achievement of national objectives or the performance of national and international responsibilities; encourage or facilitate the application or utilisation of the results of scientific research; and carry out services, and make available facilities, in relation to science. Its secondary functions include liaison with other countries in matters connected with scientific research; training of research workers; establishment and maintenance of standards of measurement; collection, interpretation and dissemination of information on scientific and technical matters; and publication of scientific and technical reports, periodicals and papers.

- *The Australian Nuclear Science and Technology Organisation (ANSTO)* is Australia's only nuclear research organisation and the centre of Australian nuclear expertise. ANSTO maintains and manages through its baseline funding, its nuclear research infrastructure and operates core nuclear facilities in Australia and overseas for the benefit of the Australian research and development community and industry. These include the National Medical Cyclotron, the Australian National Tandem Accelerator and the High Flux Australian Reactor (HIFAR). ANSTO provides expert scientific and technical advice across the nuclear fuel cycle to government and supports Australia's national and strategic nuclear policy objectives. ANSTO undertakes research on specific topics to advance the understanding of nuclear science and the nuclear fuel cycle.
- *The Australian Institute of Marine Science (AIMS)* is one of Australia's key research agencies and the only one committed primarily to marine research, with an emphasis on tropical marine science. The Institute's objectives are to promote the conservation and sustainable development of Australia's marine resources and to support internationally competitive, Australian industries.

Scientific service providers

Scientific service providers within the Department provide strategic support to the Government and industry.

- *The Australian Surveying and Land Information Group (AUSLIG)* is Australia's national mapping agency and the Commonwealth Government's primary source of advice on land information matters. AUSLIG's role is to ensure that fundamental geographic information is available for the benefit of the Australian community through partnerships with industry and government. This is achieved through AUSLIG's mapping, remote sensing, geodesy, maritime boundaries, spatial data infrastructure and information access programs.
- *The Australian Government Analytical Laboratories (AGAL)* play an important strategic role in protecting Australian public health and safety, the environment and international trade, through its quality services in analytical chemistry, microbiology, fire safety and physical testing. AGAL's operations are aimed at providing support for government and industry and, in particular, they provide a crisis response capability.
- *The Ionospheric Prediction Service - Radio and Space Services (IPS)* offers a comprehensive range of services to Australian and overseas agencies operating in the fields of radiocommunications, land, sea and air transport, broadcasting, defence applications, spacecraft operation and geophysical exploration. IPS warns of changes in the ionosphere and the near-earth space environment that may affect the performance of the customers' systems. A network of observatories in Australia, Papua New Guinea and Antarctica, which monitors solar, geomagnetic and ionospheric behaviour, backs up the services that IPS provides. IPS also exchanges information with a worldwide net of similar observatories. IPS provides consulting services to optimise the planning and operation of radio networks and presents

training courses, customised to meet customers' needs, throughout Australia.

- *The Australian Geological Services Organisation (AGSO)* is Australia's national geological research and survey organisation. AGSO's role is to improve the quality, extent and accessibility of publicly available geoscience knowledge with the aim of enhancing the development of more productive, competitive and diversified Australian mineral and petroleum exploration industries, the management of Australia's ocean resources consistent with sustainable development principles, and the development of strategies to mitigate the effects of natural geological hazards.

Programs supporting research and innovation by business

Research and Development Tax Concession

The Tax Concession for Research and Development was implemented in 1985 and remains the Government's major business R&D program. It aims to encourage increased investment in R&D by Australian companies in order to make them more innovative and increase the international competitiveness of Australian industry. The program is effectively market driven, being structured in a manner which is neither industry nor product specific, allowing companies to determine both the area of innovation and the direction of their R&D activities. Since the Program's inception in 1985, about 33,000 companies, both large and small, have been claiming R&D expenditure under the concession.

A deduction of 125 per cent is allowable for qualifying expenditure incurred on R&D carried on in Australia. A company's total research and development expenditure for the year must be greater than \$20,000 to qualify for the concession, unless the R&D is carried out by a Registered Research Agency in which case the expenditure threshold is waived.

The concessional deduction is available to Australian incorporated companies, eligible companies in partnership and to public trading trusts. To be able to claim the concession, the company must be registered with the IR&D Board. Applications for registration must be made annually, within 6 months of the end of the company income year. Certain research and development activities carried on outside Australia are eligible for the tax concession. The value of overseas research and development that qualifies for the concession is limited to 10 per cent of the value of the research and development associated with the project. Expenditure on plant, including pilot plant, used exclusively for research and development is deductible at the concessional rate over three years.

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

The R&D Start program has been in existence since November 1996 and is designed to encourage and support industry R&D by providing a range of financial assistance schemes to encourage businesses to invest in R&D and innovative activity.

In 1996-97, the IR&D Board approved 142 grants to the value of around \$152 million for small and medium sized companies. R&D *Start* encourages projects of high merit, where there is a demonstrated need for funding and benefits to the nation. The targeted funding it provides complements the generally available tax concession, and supports innovative projects with high commercial potential.

Grants under the program are available to non tax exempt Australian companies for research conducted in Australia. The projects supported are those in which the expected outcome is a commercially viable product, service or process. All Australian companies can now apply for grants irrespective of the size of their annual turnover.

The program has the following three elements:

- *Core Start* provides assistance of up to 50 per cent of project costs for smaller Australian companies through grants for R&D projects and, through loans, for the early commercialisation of technological innovation.
- *Start Plus* provides grants up to 20 per cent of project costs for larger Australian companies, with group turnover of \$50 million or more, to undertake R&D projects.
- Further assistance is available for high merit projects. *Start Premium* offers an additional repayable amount which 'tops up' either *Core Start* grants or *Start Plus* to a maximum of 56.25 per cent of project costs.

The Industry Research and Development Board has the flexibility to vary the level of support to companies depending on levels of spillovers, closeness to market, nature of technology and capacity to attract private finance. Applications for grants can be received at any time and are considered every six to eight weeks. Eligibility for R&D *Start* funding and eligibility for the R&D Tax Concession are not mutually exclusive under the expanded program. If funding is received under R&D *Start* and the tax concession is also claimed, then the "clawback" provisions of the concession will apply.

Innovation Investment Fund (IIP) program

Stimulus to the commercialisation of research and development is provided through the Innovation Investment Fund (IIP), an initiative announced in 1997 by the Prime Minister in the Small Business Statement, More Time for Business, and expanded in the Industry Statement. The IIP aims to provide access to equity capital to encourage new technology companies to improve the commercialisation outcomes of Australia's strong research and

development capabilities and to create a self-sustaining, early-stage technology-based venture capital market. Through the use of private sector funds managers, the IIP is also creating new equity management skills in the Australian business community.

Together with private sector funding, the \$230 million provided by the Government over the ten years of the program will create an overall investment pool of about \$345 million for early stage venture capital investments. The first five funds were licensed in 1998: A&B Investment Management (\$41.25 million); AMWIN Management (\$41.25 million); Momentum Funds Management (\$30 million); Rothschild Bioscience Managers (\$42.5 million); and Coates Myer (\$41.25 million).

Technology Diffusion Program

With the majority of new discoveries being generated overseas, Australia's competitiveness depends on its ability to attract, import and diffuse these advances as well as improving the rate of diffusion of new technologies to Australian industry. The Technology Diffusion Program, a major initiative by the Australian Government, aims to increase industry's ability to absorb new technology and strengthen alliances nationally and internationally between Australian science and technology agencies and industry.

The Technology Diffusion Program comprises two components:

Technology Alliances, which seeks to improve Australia's access to global science and technology, comprises five elements:

- *Industrial Research Alliances Program* that provides support for Australian researchers to work with international partners on projects which bring the S&T community and industry together;
- *Targeted Research Alliances* that provides support for international research collaboration with those countries and in those sectors where there is considered to be the greatest potential for accessing leading edge technologies and promoting the Government's industry development objectives;
- *International Conference Support Scheme* supports efforts to attract internationally prestigious conferences to Australia;
- *Major Research Facilities* supports access by Australian scientists to global research facilities not available in Australia; and
- *International Science and Technology Networks* supports scientific collaboration between Australian scientists and their international counterparts.

The *Technology Transfer* component aims to improve the productivity and competitiveness of Australian Industry by promoting the uptake of leading edge technologies, particularly by small and medium sized enterprises. It is complementary to *Technology Alliances* and provides support for the establishment and maintenance of networks, demonstration and awareness initiatives and feasibility studies.

Renewable Energy Equity Fund (REEF)

REEF provides venture capital to small, innovative companies for the development of renewable energy technologies.

National Business Information Service (BIS)

BIS is provided by AusIndustry, and is a major initiative within the Government's Business Entry Point. BIS provides information on: government and industry association programs and services and general information to assist business; and all licences and permits (Commonwealth, State, Territory and local government) that are required in order to operate a business. The full Business Entry Point information and transactions service is available through the Internet at www.business.gov.au; the Business Call Centre (free call 132846) provides access to BIS for people who may not have access to the Internet.

Pharmaceutical Industry Development Program

The Pharmaceutical Industry Development Program, contributes to the development of an internationally competitive pharmaceutical industry in Australia. A major element of the program, the Factor (f) Scheme will conclude on 30 June 1999. It will be succeeded by the Pharmaceutical Industry Investment Program (PUP). The PUP will compensate companies for the effects of the Pharmaceutical Benefits Scheme (PBS) by paying notional or actual price increases for products affected by the PBS in return for the increased activity in Australia. Funding of \$300 million has been allocated for the five years to June 2004. PUP is expected to generate \$1.1 billion in R&D expenditure and \$6 billion in value added production by participating companies over the life of the program.

IP Australia

IP Australia provides industrial property rights services for inventions, trade marks and designs. Legal protection given with the rights encourages industry to develop and exploit new technologies as well as facilitating the transfer of overseas technology to Australia. The organisation operates on full cost recovery.

Science, technology and industry linkages

- The Cooperative Research Centres (CRC) Program seeks to maximise the capture of the benefits of research through the development of enhanced cooperative linkages between researchers and research users in the public and private sector. It provides support for long-term collaborative ventures linking researchers from universities and government research organisations with business enterprises and public sector research users. It promotes high quality cooperative research and education programs through centres of research concentration, strengthening the links between research and its commercial and other applications.

- The *Major National Research Facilities (MNRF) Program* is directed at keeping Australia at the leading edge of scientific and technological developments. Under the Program, funding is provided for facilities in a range of key scientific fields where the establishment costs are beyond the capacity of any individual Australian institution. These facilities will create centres of capability for pursuing research with state-of-the-art equipment.
- The *Space Industry Development Centres (SIDC) Scheme* was established to accelerate industry investment in the research and development of space related products and services. Under this scheme, private companies and universities collaborate to develop innovative space technologies with commercial potential. Three SIDCs have been established since 1990, of which two have run the course of their five year grant agreements with the Commonwealth. The Space Centre for Satellite Navigation at the Queensland University of Technology, which specialises in satellite navigation and positioning technology, will complete its final work program in October 1999.

New Initiatives for 1999-2000

Priorities for 1999-2000 are outlined below:

- *Shipbuilding Innovation Scheme*: The Government will provide assistance to registered shipbuilders at a rate of 50 per cent of innovation expenditure for up to a total of 2 per cent eligible production costs; with the introduction of the Scheme, regional areas including Western Australia, north Queensland and Tasmania will continue to be beneficiaries of a financially viable, innovative and internationally competitive shipbuilding industry. A total of \$40.5 million will be allocated over four years from 1999-2003, with \$9.1 million available in 1999-2000.
- *Identification of new offshore oil zones*: \$33 million will be allocated over the four year period from 1999-2000 to boost AGSO's effort in identifying new offshore oil zones.
- *Biotechnology Strategy*: The Government will allocate \$6.0 million in 1999-2000 and \$4.0 million in 2000-01 to fund Biotechnology Australia.
- *Boosting Australia's Innovation and Science Culture*: \$2.4 million will be allocated to the Science and Technology Awareness Program in 1999-2000. Funding for the Australia Prize (\$0.762 million) will be continued until 2000-01.
- *Institute of Molecular Bioscience (IMB)* (Section 2 refers)
- *Marine Science Centre* (Section 2 refers)
- *Venture Awareness* (Section 2 refers)
- *Investment Ready* (Section 2 refers)

1999-2000 Science and Innovation Priorities

Under accrual accounting, portfolios' activities are now reported as 'outcomes'. In this new terminology, total appropriation for 'Outcome 2: *Enhanced economic and social benefits through a strengthened national system of science and innovation*' is \$192 million.

To achieve Outcome 2, the Department will:

- provide strategic leadership in science and innovation;
- develop and implement science and innovation policy;
- undertake effective design and management of science and innovation programs; and
- deliver effective scientific business services.

The Department will provide policy advice and analysis in relation to science, innovation, research and technology.

Science and Technology Policy

Key priorities during 1999-2000 will be:

- policy advice to Government on nuclear science and technology, including the operation of the existing research reactor and construction of its replacement, the management of spent reactor fuel and completion of work associated with the Probabalistic Safety Assessment of the existing reactor;
- a marine science and technology plan, as an integral part of the Government's oceans policy;
- advice on performance indicators for the portfolio science authorities for the 2000-2001 to 2002-2003 triennium; and
- the *Science and Technology Budget Statement 2000-01*, which will provide an account of Commonwealth science and innovation expenditure, priorities and recent outcomes.

Innovation policy

Key priorities during 1999-2000 will be to:

- conduct an inaugural National Innovation Summit in partnership with the Business Council of Australia to develop consensus on strategies to be pursued by Government, industry and the research community to strengthen innovation and improve the level of commercialisation of Australian R&D;
- raise the level of research and development that is commercialised;
- establish a strong track record in commercialisation and diffusion;
- identify perceived barriers and impediments to innovation and commercialisation including the industry perspective;

- determine ways to increase investment in Australian high tech firms through existing and new programs plus the implementation of taxation measures to stimulate Venture Capital; and
- map the structure and interconnections in Australia's innovation system

Advisory arrangements

The Department will seek to obtain the maximum benefit from government-wide advisory arrangements by:

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

A new Chief Scientist is expected to be appointed in May 1999, following the conclusion of the term of appointment of the previous Chief Scientist, Professor John Stocker.

International Science and Technology

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

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

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

1999-2000 is the third year of the funding triennium for CSIRO. CSIRO's budget for the triennium was agreed at the time of the 1996-97 Budget. There are no significant budget measures for 1999-2000.

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

Priority areas and planned outcomes for each of 22 Sectors identified by CSIRO for planning purposes are specified in the CSIRO Strategic Research Plan 1997-98 to 1999-2000. Annual operational plans set out how the Sector plans are put into effect through the work of CSIRO's 23 research Divisions. The operational plans also describe the major activities and outcomes for CSIRO's corporate support areas.

Some key activities planned for CSIRO in 1999-2000 are outlined below:

- CSIRO, in collaboration with the University of Queensland, will build a complex to accommodate its Division of Tropical Agriculture and the Institute of Molecular Bioscience in Brisbane, which will be a world class centre for biotechnology research, employing 750 staff;
- in Newcastle, CSIRO will create a Centre for Sustainable Energy Research and Demonstration, which will research coal and other forms of energy and their storage; and
- in response to an urgent request from the Government of Malaysia, CSIRO, through the Australian Animal Health Laboratory in Geelong, is researching the nipah virus, which has killed scores of people and numerous pigs in Malaysia. In doing this research CSIRO will gain a greater understanding of the implications for the Australian livestock industry.

CSIRO's Planned Investment Profile 1999-2000

CSIRO Alliance and Sector	1998-99 Estimated accrual \$ million	1999-2000 Estimated accrual \$ million
Manufacturing, Information and Services	149.45	185.24
Minerals and Energy	86.77	107.56
Environment and Natural Resources	86.77	107.56
Agribusiness	159.09	197.19
Total Appropriation	482.08	597.54

Australian Nuclear Science and Technology Organisation (ANSTO)

In 1999-2000, ANSTO will:

- manage the design and construction of a replacement reactor providing enhanced neutron facilities for Australia into the 21st Century; a detailed project management schedule has been developed which embraces both external factors such as the required environmental assessment of the replacement reactor and the necessary Public Works Committee progress. Additionally a detailed project plan has been developed which will lead to the letting of a supply contract in the latter part of 1999-2000.
- implement a strategy for the disposition of its inventory of the High Flux Australian Reactor (HIFAR) spent fuel arising over the lifetime of HIFAR; and
- provide Government and industry with expert scientific and technical advice, conduct scientific and technological R&D, provide products and services, and contribute to the development of critical technologies.

Australian Institute of Marine Science (AIMS)

The outcome and broad output proposed by AIMS represents an ongoing contribution to understanding the marine environment. Details of the output for 1999-2000 is identified in the Australian Institute of Marine Science Research Plan: 1997-2000 (available at <http://www.aims.gov.au/pages/research/trp/pages/trp2-00.html>).

Outputs for the next triennium will be developed through the Institute's planning process which includes consultation with a broad range of users of marine R&D and a review of current research in the context of emerging needs and national priorities. The research plan for the 2000-2003 triennium will be finalised early in 2000.

AIMS has identified 'enhanced scientific knowledge supporting the protection and sustainable development of Australia's marine resources', as its outcome and 'research products and services for users of marine resources' as outputs relating to this outcome. Its priorities include continuation with a 6-year refurbishment program (1998-2004) of existing facilities and bringing ageing research facilities up to occupational health and safety standards.

Australian Government Analytical Laboratories (AGAL)

The importance of chemical and microbiological measurements has been highlighted by World Trading Organisation (WTO) agreements and AGAL priorities include work to ensure Australia's membership of the Consultative Committee for Amount Substance (CCQM) - the leading international forum in chemical metrology. AGAL continues to give high priority to the delivery of the drug testing program for the Sydney 2000 Games.

Australian Surveying and Land Information Group (AUSLIG)

AUSLIG contributes to the departmental output "Science Business Services" which supports the outcome "Enhanced economic and social benefits through a strengthened system of science and innovation". AUSLIG's priorities include:

- delivery of national mapping, remote sensing, geodesy and maritime boundaries programs;
- revision of priority 1:100,000 scale maps; and
- provision of customer access to spatial data through online services and distributor network.

Ionospheric Prediction Service - Radio and Space Services (IPS)

The strategic goals of IPS are:

- to be recognised as a centre of expertise for space weather; and
- to provide timely radio propagation, geophysical and space weather services that customers will rely on to perform their operations, that are appropriate to the needs of the Australasian community, and that use best technical and business practices.

Providing outputs in scientific business services, IPS has two key activities:

- monitoring and analysis of space weather phenomena through a network of national and regional solar and ionospheric observatories; and
- the provision of on-line and consultancy services in radio propagation and space weather.

The IPS priorities include:

- becoming a Hub for Space Weather Data in Australasia;
- upgrading Space Weather monitoring network;
- focusing marketing on expansion of services;
- increasing service delivery;
- developing human resources; and
- increasing leadership/management capability.

AusIndustry

The key priorities for the AusIndustry in 1999-2000 are discussed below:

125% R&D Tax Concession Program

Increased monitoring activity for both R&D syndicates and for company applications under the general concession is now under way with further

improvements planned next year.

An upgraded information and education program was initiated in 1998-99 to help reduce uncertainty and to facilitate improved compliance with the provisions of the concession. This program will be continued, principally through updating, revising and expanding the range of Industry Research and Development Board guidelines and through industry information services designed to inform companies of relevant information through seminars, printed material and other publicity.

Measures to streamline and enhance the integrity and efficacy of the concession will come into effect through the 1998-99 amendments to the *Industry Research & Development Act 1986*.

The Industry Research and Development Board, through AusIndustry, will continue to monitor active R&D syndicates which are remaining after syndicate access to the program ended in 1996. The stated policy of the Board is to ensure that, where possible, commercialisation of successful R&D outcomes is genuinely pursued.

Approximately 70 per cent of active syndicates (about 200 in total) have received a preliminary review. The remaining 30 per cent will receive preliminary review and all active syndicates will be the subject of a detailed review over the next two years.

The general tax concession continued to be monitored through assessment of claimed R&D, with cases selected on a risk management approach operated on a consultative basis with the ATO. Resources devoted to case reviews will be supplemented, with increased emphasis on the monitoring of whether the results of R&D activities are being exploited to the benefit of the Australian economy.

Effective detection and correction of non-compliant claims will continue from coordination of data-base and information matching activities with the ATO.

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

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

Key indicators of effectiveness will be if the projects supported by the R&D Start Program:

- increase innovation and commercialisation of supported competitive product, processes and services;
- foster collaborative research projects between research institutions and industry; and
- provide national benefits.

Performance will be measured by:

- effectiveness of the projects as outlined above;
- timeliness of the approval process; and
- efficient management of grant funds.

It is anticipated that grant offers of between \$170-200 million will be made in 1999-2000.

Innovation Investment Fund (IIF)

The priority for 1999-2000 is to conduct a second selection round for fund managers. A call for applications for three to four fund managers is expected in 1999. This will involve further Commonwealth funding of around \$100 million to be matched at a maximum of 2:1 with private sector capital.

Renewable Energy Equity Fund (REEF)

The Renewable Energy Equity Fund (REEF), announced in the Government's statement, *Safeguarding the Future: Australia's Response to Climate Change*, is based on the existing IIP model and will provide venture capital to small, innovative companies for the development of renewable energy technologies. By assisting in funding further growth of the renewable energy industry, it will help reduce Australia's greenhouse gas emissions.

As with the IIP, the Government will provide two-thirds (\$20 million) of the agreed level of capital for the REEF fund, with at least another third to be sourced from private capital raised by the fund manager. The call for applications will occur during 1999 with the fund becoming operational shortly after.

The priority for REEF is to implement the program during 1999-2000. This will involve selecting and licensing one fund manager.

National Business Information Services

Enhancements to the BIS planned for 1999-2000 are outlined below:

Best practice standards for data quality, information management and discovery are being integrated into the site and its associated support services, and will form the basis for national, whole-of-government approaches. The full BIS functionality will be developed over the next 2 to 3 years.

As part of the national BIS initiative, the present Business Licence Information System (BLIS) is being significantly upgraded and will form the compliance stream of the BIS. At the moment, Commonwealth and State and Territory licensing requirements are covered on the BLIS and delivered by each State and Territory. Local Government information is only presently available in Tasmania and South Australia. By end of 1999, local government

information from all other States and Territories (except NSW) will be available on BLIS.

BIS will also cover mandatory codes of practice requirements for the first time. The Commonwealth will fund the collection of the data and development of the delivery mechanism during 1999. Business will then be able to access an integrated code of practice database and search it by business type. Commonwealth data, NSW and other State data will be available progressively during 1999.

Priority is being given to enlarging the range of information accessible through the BIS mechanism. A national stocktake of business information was carried out in 1998. In 1999, work has commenced with all States and Territories to bring the stocktake results into the BIS and jointly develop electronic/interactive content that is much easier for business to access and use.

The BIS is being developed in an Internet environment and its supporting software and tools allow seamless linking of information drawn from distributed information (see <http://about.business.gov.au>). This has required the development of unique software tools by Australian firms, which include:

- CORE - Content On-line Registration Environment, which is a suite of integrated software programs that will allow for distributed authoring and remote registration. CORE can be seen at <https://admin.business.gov.au/core.html>.
- VAMP - Very Automated Metadata Process, which is a custom software development aimed at trawling through the document information and creating appropriate metadata based on the content. The current phase of development should be completed mid-1999, and it is already operational through CORE. It will be upgraded on an ongoing basis, in the light of its performance.

There is already strong overseas interest in the leading-edge work being undertaken through the BIS project.

Cooperative Research Centres (CRC) Program

Following the 6th Selection Round, the CRC Program will focus on the negotiation of the contracts which will establish the 26 CRCs successful in the 1998 selection round. The revised program guidelines place a greater emphasis on improving commercialisation and outcomes of CRCs and seek to encourage centres in achieving a greater level of self sufficiency. The new centres' contracts with the Government will implement these changes.

In addition, during 1999-2000 the CRC Program will focus on:

- sixth month visits to the newly established centres;
- second year reviews for Fifth Round Centres;
- planning and preparation for the next selection round in the year 2000;

- development of suitable agreements for those CRCs that still wish to continue operation in the format of a CRC after their funding ceases; and
- with the establishment of a new CRC database, pursuit of long term tracking of outputs and outcomes from the Program.

The terms of appointment of members of the CRC Committee expired on 31 March 1999. The structure and composition of the Committee is being reviewed in light of the recommendations of the 1998 Mercer/Stocker Report, as they relate to the overall governance of the Program.

Science Awareness

The key priority in 1999-2000 will be a review of the Science and Technology Awareness Program. The Review will provide input to consideration of a strategy to improving awareness about the important contribution that science and innovation make to competitiveness of our economic and social well being.

TRANSPORT AND REGIONAL SERVICES

Science and Innovation in the Portfolio Budget

Areas in the portfolio dealing with science and technology relate to road safety and motor vehicle emissions research conducted by the Federal Office of Road Safety (FORS), and transport sector research conducted by the Bureau of Transport and Economics (BTE). Expected aggregate expenditure outcomes for major projects are \$1.675 million for 1998-99 and \$2.1 million for 1999-2000.

1999-2000 Science and Innovation Priorities

Priorities in 1999-2000 include:

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

SECTION

6

Research
Achievements

Introduction

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

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

AGRICULTURE, FISHERIES AND FORESTRY

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

Southern bluefin tuna

In 1997-98, ABARE developed a bioeconomic model of the southern bluefin tuna fishery. The model provides an analytical tool for assessing the costs and benefits of alternative management scenarios for the fishery. The model will be used to inform the Australian government in the negotiations over international management arrangements for southern bluefin tuna.

GTEM - global trade and environment model

ABARE further developed the next generation of its global trade and environment general equilibrium model. In addition to the features of its predecessor (GIGABARE), GTEM incorporates other features that enable it to better evaluate each of the key features of the Kyoto Protocol. Two additional greenhouse gases have been incorporated and three others will be added. Other enhancements will include forest sinks and disaggregation of key economies, such as Russia. GTEM is providing analysis that can inform the Australian government in its post-Kyoto climate change policy negotiations.

Plantation competitiveness

ABARE has conducted research into the regional competitiveness of plantations in Australia. This has involved the development of a spatial economic framework that assesses the returns from plantations against estimates of agricultural land values for key plantation growing regions of Australia. Work is continuing to apply the framework to other plantation-based issues, including the implications of a carbon trading market on plantation development.

Bureau of Rural Sciences (BRS)

Role *provide professional, independent scientific advice to support the profitability, competitiveness and sustainability of Australian agricultural, forestry, fishing, aquaculture and food industries. At the interface between science and policy, BRS has a unique role in analysing, assessing and packaging science for decision-making and evidence-based policy development.*

Recent Achievements

Forests

BRS published the *State of the Forests Report 1998*, the first comprehensive scientific assessment of the state of Australia's forests. It provides reliable objective information on forest management in Australia. BRS also manages the National Forest Inventory databases, which have produced interim tables for 1999 of the National Plantation Inventory, underpinning such initiatives as the Plantations 2020 Vision for Australia. Further information can be found on the website www.brs.gov.au.

Greenhouse

BRS has used satellite data to quantify extent of land cover change – a critical activity in understanding Australia's sources and sinks of greenhouse gas emissions and meeting Kyoto commitments. BRS has also published a report on scientific and technical opportunities to reduce Australian greenhouse gas emissions.

Land use and water resources

BRS has assembled the national groundwater database that is critical to the implementation to Great Artesian Basin rehabilitation program and in 1998, published a report on bore rehabilitation. BRS plays a national role in mapping dryland salinity and providing scientific advice on its management.

Australian Wool Research and Promotion Organisation (AWRAP)

Role To:

- *investigate and evaluate the requirements for R&D in relation to the wool industry;*
- *provide funds for R&D activities which implement the corporate plan; and*
- *facilitate the dissemination, adoption and commercialisation of the results of R&D.*

Recent Achievements

Apparel product enhancement

Wool fibre modification, known as Optim, has been commercialised. A plant was commissioned, markets are being developed and Optim fibre is being sold in Japan and Italy. In a second project, an improved and simplified dyeing and bleaching process for total easy-care wool/cotton blends has been developed in partnership with a commercial company. The new technology will enable the partner to meet the total easy-care requirements of the knitwear sector. The outcomes of the project will provide increased opportunities for wool to penetrate the growing casual/leisurewear markets in all seasons.

Redlegged earth mite control

Redlegged earth mite (RLEM) is an invertebrate pest which costs southern Australian woolgrowers about \$100 million in lost production each year. The key finding is that RLEM can be controlled more effectively by spraying during spring. In a commercial trial in Western Australia, there was a 99 per cent reduction in RLEM, a 78 per cent increase in sub-clover seed, followed by a 207 fold increase in seedling production in the treated plot compared to the untreated plot.

Pesticide residue reduction

A report commissioned by AWRAP and undertaken by the National Registration Authority focuses on the environmental impact of the residue left by pesticides for lice and fly control in wool scour effluent and their impact on the international wool trade. The study has identified the withholding periods needed for pesticide residues in greasy wool to meet the environmental requirements of wool scour plants. Australian wool producers will be able to use pesticides for lice and fly control and still meet tough new residue requirements proposed for wool going to Europe, but they will still need to select and use those pesticides wisely.

Dairy Research and Development Corporation (DRDC)

Role *The Dairy Research and Development Corporation's mission is "to minimise the economic, environmental and social benefits for our stakeholders through targeted, innovative and energetic R&D."*

To realise this mission, the DRDC objectives are to:

- increase industry competitiveness and profitability;
- improve social and environmental sustainability of dairying; and
- improve the human resource capability of the dairy industry.

Recent Achievements

Disease countdown begins

After years of extensive consultation and research, Australia is now implementing *Countdown Downunder* - a national program to significantly reduce mastitis in dairy cows. The program has published agreed national guidelines for controlling the disease at the varying stages of lactation, to help farmers reduce the incidence of mastitis to internationally acceptable levels. The Farm Guidelines produced under the program are now being reprinted as the first 5,000 were bought within weeks of publication.

Focus on business

Dairy Business Focus, a pilot business program emphasises the need for farming partnerships (e.g. spouses; children and parents; siblings) to identify the most important areas that require attention, ranging from herd expansion to resource management to ownership transfer to succession planning. Farmers complete the one-day introductory seminar and three-day course, then seek out Dairy Business Focus advisers who will help them convert their plans into actions. The project, which has attracted nearly a quarter of Victoria's dairy farmers to its first stage, is now being established in all other dairying states.

Getting a reaction

Reactive Phosphate Rocks have been available for some years but until now farmers had little knowledge about their effectiveness and suitability as a source of phosphate for fertilising pastures. In a major cooperative effort, the Research and Development Corporations for the Dairy, Meat and Wool industries, together with support from major fertiliser companies, the Reactive Phosphate Rocks were assessed. The work identified the soils, rainfall patterns and numbers of years over which the rocks would release suitable amounts of phosphate. With this knowledge, farmers can now

determine the economic benefit of choosing this form of fertiliser for their paddocks in comparison to other products.

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 fisheries R&D, and facilitating the dissemination, adoption and commercialisation of the results of R&D.*

The national network of Fisheries Research Advisory Bodies and individual FRDC Subprograms identify priorities for R&D funding, and using a combination of public calls and communication with industry organisations, invites applications for R&D funding. This process ensures the relevance of fisheries R&D, minimises duplication and ensures maximum returns on investment.

In 1997-98 the FRDC spent \$15.6 million on R&D and managed 540 R&D projects worth over \$39.7 million.

Recent Achievements

Review and synthesis of Australian fisheries habitat research

The FRDC commissioned the Australian Institute of Marine Science (AIMS) to undertake a complete review of existing fisheries habitat information and to provide advice on R&D priorities. The review, which has taken over three years to complete has provided a list of strategic R&D areas as well as a comprehensive list of specific R&D actions to underpin these. This strategic framework will assist the FRDC and other research funding bodies and providers towards investing in the most effective R&D possible.

The six strategic R&D areas for future research include defining:

- major habitats in the EEZ and coastal zones;
- the roles of habitats in maintaining fisheries production, ecosystem integrity and biodiversity;
- the underlying natural dynamics and environmental variability in major fisheries; and
- the impacts of human activities such as coastal development, fishing and aquaculture on fisheries ecosystems.

And to develop:

- ecosystem health indicators; and

- mitigation, rehabilitation and management strategies.

Grains Research and Development Corporation (GRDC)

Role *The GRDC's mission is to invest in research and development for the greatest benefit to its stakeholders – graingrowers and the Commonwealth. The Corporation links innovative research with industry needs. The GRDC's vision is for a profitable, internationally competitive and ecologically sustainable grains industry.*

The GRDC's research portfolio covers 25 leviable cropping industries spanning temperate and tropical cereals, oilseed and pulses, worth over \$7 billion a year in farm production alone. The GRDC is a statutory corporation, operating as a research investment body in partnership with growers and Government. Its operations, planned to involve a total 1999-2000 budget of \$103.8 million, are jointly funded by a levy on grain production and matching Commonwealth contributions.

To improve the profitability of grain producers, the GRDC has set out, in its Five Year Plan "Partners for Profit", four investment objectives for the period 1997 to 2002:

- meeting quality requirements;
- increasing productivity;
- protecting and enhancing the environment; and
- delivering outcomes.

Recent Achievements

Wheat

Ten new wheat cultivars were released across Australia in 1997-98, promising greater yields and increased disease resistance, with the quality characteristics to meet the demands of domestic and international markets. The continued success of Australia's multi-billion dollar wheat industry is dependent on the development and breeding of cultivars suited to the requirements of end users, from flour millers to pasta processors. Research investments by the GRDC have resulted in the release of cultivars for biscuit, bread and noodle processing suited to growing in Australia's three grain regions.

Pulses

Pulse crops play an important role in farming systems, being used in rotation with cereal and oilseed crops to replace nutrients and improve soil quality. The outbreak of Anthracnose in lupins in Western Australia and South Australia in late 1996 presented a significant threat to the developing pulse industry throughout Australia. AGWEST, supported by the GRDC, initiated a worldwide research response that led to the identification of lines resistant to the disease. Two narrow leaf (*Lupinus angustifolius*) cultivars were found to have resistance, along with the breeding line 497, which was released to growers in the 1997-98 year. A quarantine facility was also set up to enable overseas lines to be screened for resistance.

Horticultural Research and Development Corporation (HRDC)

Role *To fund and manage R&D to advance Australian horticultural industries, including fresh and processed fruits, vegetables, turf, nuts, nursery products and cut flowers and foliage.*

Recent Achievements

Production guidelines for pome fruit

To meet their obligations to provide safe food to customers, major supermarkets from around the world now require their suppliers to be accountable and provide evidence that their produce is 'clean' and that its production was environmentally 'friendly'. To meet these requirements, Integrated Food Production (IFF) guidelines were developed for the Australian horticultural industries by a working party comprising agribusiness, industry and state departments of agriculture. In early 1999, the first draft of the guidelines was presented to industry, followed by training sessions and audits in each growing region using Pink Lady apple producers exporting to the United Kingdom to test the rigor of the system. It is envisaged that the guidelines will eventually be published as part of a National Orchard Handbook.

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Chestnuts

The Australian chestnut industry has recently completed the development of the *Chestnut Industry Resource Manual*. It addresses issues of best practice in production and post harvest handling. The manual has been collated and documented in an easy to read format suitable for existing and new producers. This information is critical to the chestnut industry, which is actively investigating export markets for its fresh product and opportunities

for pre-peeled/processed chestnuts. This manual is a 'living document' to be updated as appropriate.

*{Contact: Mr Richard Bennett, Australian Horticultural Corporation;
tel: +61 (0) 3 5831 3919; e-mail: bennettr@mcmmedia.com.au}*

Biological control success in strawberries

Biological control of spider mites in strawberries has been used in Australia for a number of years. In Queensland this technology has been fine tuned and further developed through a technique referred to as 'pest-in-first'. Research has evaluated various timing and release rate options and has been shown to be an effective way to establish a predatory mite population in commercial strawberries. Adoption of this integrated pest management approach has been promising with approximately 30 per cent of Queensland plantings using the technology in 1998. Research results from the Queensland program are being trialed in Western Australia to determine their suitability to temperate conditions. Results to date indicate that this technology offers real commercial potential as an alternative to chemical control.

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tel: +61 (0) 7 5441 2211; e-mail: greern@dpi.qld.gov.au}*

Increased pyrethrum productivity

A number of methods have been used to harvest pyrethrum in Tasmania during the last decade. The current method used is slow and costly. A number of unexplained losses in the active ingredient, pyrethrin, inside the pyrethrum flowers also occurs. The outcomes of a project which assessed potential improvements have resulted in reductions in harvest time, reductions in raw material loss and increases in the efficiency of crop drying. The effects of environmental factors such as rain following windrowing and pathogens on the harvested material on pyrethrin loss have also been studied both in the laboratory and the field. This information will be incorporated into commercial harvest strategies and will be tested during the next two seasons.

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The tomato processing industry

A strategy of greater awareness and adoption of technology by the tomato processing industry has been developed. The program, led by the Industry Development Manager, concentrates on the adoption of improved crop management practices and new technologies, but it also assists the industry efforts in the areas of logistics and crop planning, and helping to improve the business management skills of growers. Continuous improvement in crop productivity levels, now at parity with competitors, is directly linked to changes in grower practices and the success of the technology transfer program.

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National quality assurance for the stone fruit industry

In response to the identified and increasing need for stone fruit growers to provide quality assured produce for both the domestic and export markets, the Australian Fresh Stone Fruit Growers Association have adopted SQF 2000. This system has been customised based on specific quality assurance (QA) criteria for the Australian stone fruit industry. Upon accreditation and signing of an industry code of practice, the facilitators work with groups of growers to develop individual QA manuals and systems for each enterprise. To date over 60 growers have gained, or are in various stages of gaining, SQF 2000 accreditation.

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tel: +61 (0) 3 5831 3919; e-mail: bennetr@mcmmedia.com.au}*

Disease control in the passionfruit industry

Passionfruit crops are very susceptible to diseases. In the past, effective control of disease has been dependant on regular pesticide application targeting both the disease and the disease transmitters. In recent years new hybrids have been developed and are currently being evaluated under commercial conditions by the Australian Passionfruit Growers Association. As well as pest and disease resistance, the selection criteria includes assessment of productivity, appearance, taste and suitability to local environment. Passionfruit selections produced from this program have already been adopted, with Supersweet currently being used by 65 per cent of New South Wales plantings.

*{Contact: Mr Chris Gallagher, Australian Passionfruit Industry Association;
tel: +61 (0) 2 6672 6986}*

Nursery industry needs

A potting media safe handling course has successfully brought recent research findings to industry. A key source of information for the course came from research which examined the transmission of Legionella bacteria. The research quantified the potential risk associated with Legionella and pot media. The course has been conducted in all Australian states over the past 12 months and has involved more than 300 participants with the majority implementing changes immediately. The course, developed by the National Nursery Training Officer and Occupational Health and Safety experts allows horticultural businesses to protect the safety of their workforce and meet legislative requirements through incorporating leading edge technology as quickly as possible.

*{Contact: Mr Greg McPhee, Nursery Industry Association of Australia;
tel: +61 (0)2 6622 7722; e-mail: gregmc@nor.com.au}*

High quality sweet cherries

The Australian cherry industry has responded to the demand from domestic and overseas markets for improved, high quality, large sweet cherries by way of a successful Australia wide breeding program. To meet market demand, a national cherry industry breeding program has produced two new Australian varieties, Sir Don and Sir Tom (after Sir Donald Bradman and Sir Thomas Playford respectively). These new varieties have been registered for Plant Breeders Rights and are being multiplied for commercial distribution.

The ongoing Australian sweet cherry breeding program aims to breed other new high yielding varieties in line with consumer demand for superior sweet cherries and the Australian growing environment.

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Rural Industries Research and Development Corporation (RIRDC)

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

RIRDC has three core businesses:

- fostering the development of new industries, both prospective and emerging (such as new animals and plants, agroforestry, Asian foods, deer, rare natural animal fibres);
- managing research and development investments for established industries (chicken meat, eggs, honeybee, horses, rice, fodder crops and pasture seeds); and
- addressing strategic cross-sectoral issues facing the rural sector (global competitiveness, resilient agricultural systems and human capital).

The Corporation also provides services for the semi-independent Dried Fruits Research and Development Council. The Corporation's budget in 1998-99 was \$23.6 million.

Recent Achievements

Release of a new rice variety focusing on the Japanese market

The first locally bred short grain rice variety, Opus, was released during the year and will be produced for export next rice season. This variety has been developed to specifically target Japanese consumers who especially demand soft-cooking qualities. It should enable Australian rice growers to capture a larger share of the slowly de-regulating Japanese market.

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

Biological canegrub control launched

Biological control of greyback canegrubs, the sugar industry's most serious pest, has become a commercial reality. A Licence Agreement was signed in March 1999 to enable the commercial production of BioCane™, based on the fungus *Metarhizium anisopliae*. This fungus infects young canegrubs in the soil and kills them before they can inflict major damage on sugarcane roots. The Parties to the agreement are CSIRO (Division of Entomology), SRDC, Bureau of Sugar Experiment Stations, and the licensee, Bio-Care Technology Pty Ltd. An application for registration of BioCane with the National Registration Authority has also been made.

(Contact: Dr Peter Twine, Bureau of Sugar Experiment Stations, Brisbane; tel: +61 (0) 7 3331 3318; e-mail: ptwine@bses.org.au)

COMMUNICATIONS, INFORMATION TECHNOLOGY AND THE ARTS

National Film and Sound Archive

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

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

Recent Achievements

Decomposition of film images

Motion picture film is an ephemeral medium; over time it breaks down, causing damage to, and eventual permanent loss of the images. Researchers are undertaking a long-term investigation into the effects of the by-products of this breakdown on the silver gelatin image. Early results provide an improved understanding of the mechanisms of film breakdown, and the impact of any by-products on the images. The information can then be used to reduce the detrimental effects, thus increasing the life of affected film.

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DEFENCE

Defence Science and Technology Organisation (DSTO)

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

Recent Achievements

Starlight computer security technology

Starlight technology is the culmination of ten years of effort by DSTO to develop a 'family' of affordable and highly trusted computer security devices which readily 'clip on' to commercial, off-the-shelf workstations and personal computers. The first product is the Interactive Link which provides the capability to access two networks of differing security levels. It enables users on 'secure' computer networks to access lower classification (or even insecure) computer networks from a single workstation without compromising the information on the higher-classified network. In addition, information can be transferred from the low-side network to the high-side network. The Australian-based company Vision Abell leads a consortium with a sole licence to develop and market information security products based on the *Starlight* technology.

(Contact: Mr Peter Drewer, Defence Science and Technology Organisation; tel: +61 (0) 8 8259 6924; e-mail: peter.drewer@dsto.defence.gov.au}

New rainwear fabric and raincoat

The current raincoat used by the Army is considered unsuitable for operations in northern Australia because of its lack of 'breathability'. DSTO has developed a lightweight, breathable rainwear fabric capable of offering reduced physiological burden and improved comfort in tropical conditions. The multi-layer material, made in Australia, employs the latest in membrane technology and lamination techniques.

(Contact: Mr Bernie Gray, Defence Science and Technology Organisation; tel: +61 (0) 3 9626 8428; fax: +61 (0) 3 9626 8410; e-mail: bernie.gray@dsto.defence.gov.au]

Satellite broadcasting to the troops

DSTO has adapted the technology of satellite broadcasting of multiple television channels and Internet services to small antennae to demonstrate delivery of high data rate encrypted military information (video, voice and

data) to forces deployed in remote areas. This new concept has been termed *theatre broadcast system* (TBS).

Research achievements have included the development of: a TBS architecture which enables military grade encryption; a real-time scheduler involving an algorithm that has been shown to outperform traditional scheduling schemes; file-delivery protocols which are optimised for the military environment; proxies which provide the TBS user with a transparent web interface into the system; and tools which aid in the management of the TBS.

(Contact: Dr Michael Flaherty, Defence Science and Technology Organisation; tel: +61 8 8259 6592; email: michael.flaherty@dsto.defence.gov.au)

Global positioning for aircraft wreckage

DSTO has developed a portable aircraft wreckage plotting system by connecting a laptop computer to a Global Positioning System (GPS) receiver and a digital camera. The system has been successfully trialed in two recent investigations. An investigator can walk around the site carrying the system in a backpack, logging the position of each piece of wreckage and other information, such as ground markings or burnt areas. At the same time, the investigator can take digital photographs. At the end of the survey, the computer produces a map of the site with the location of each part clearly identified by type, linked to the investigator's description of the part, or the digital photograph. The software system allows aerial photographs of the site to be superimposed on the map to better define the accident site.

(Contact: Dr Graham Clark, Defence Science and Technology Organisation; tel: +61 (0) 3 9626 7497; e-mail: graham.clark@dsto.defence.gov.au!)

Testing for metal fatigue

A real-time control system for aircraft structural fatigue testing developed by DSTO has been made available for commercial development. The Digital Loop Controller (DLC) system was developed to meet the demanding requirements of an F/A-18 fatigue test program. Particular strengths of the system are its ease of use, low test set-up and configuration costs, adaptability to configuration changes during testing, and extensive system diagnosis features. Although designed for aircraft fatigue testing, the system is suitable for control of any kind of structural test, from small specimen to full-scale structures.

(Contact: Mr Alan Patterson, Defence Science and Technology Organisation; tel: +61 (0) 3 9626 7655; e-mail: alan.patterson@dsto.defence.gov.au)

Missile simulator to be marketed

South Australian firms Vision Abell and Elettronica have been licensed to market world-wide DSTO's long range, ultra-violet (UV) missile approach warner simulation system technology.

UV missile approach warners detect missile threats by sensing the UV range in the plume of the rocket motor. The DSTO technology is designed to simulate the signature of an anti-aircraft missile to test whether warners aboard military aircraft are performing correctly. The technology can also be

used for pilot and air crew training and for test and evaluation of new warners. New jamming and evasion techniques and manoeuvres can also be evaluated.

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e-mail: paul.robinson@dsto.defence.gov.au}

Artificial intelligence in simulated combat

DSTO has taken a leading role internationally in improving the way in which human decision making is represented in combat simulation models. The approach uses a convincing representation of human decision making in complex situations. These 'intelligent agents' can make use of a repertoire of standard operating procedures and prioritised responses according to the situation as it develops. The agents are normally based on the beliefs-desires-intentions paradigm, implemented in a multi-agent reasoning language developed by the Australian Artificial Intelligence Institute (AAII).

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e-mail: graeme.murray@dsto.defence.gov.au}

Directional warheads

DSTO has developed a technique using state-of-the-art finite element technology to design a directional warhead with explosive initiation tailored to achieve maximum blast and fragmentation output in the direction of the target. The advantage of such directional warhead design is the achievement of maximum damage to the target and minimum collateral damage to the surrounding environment.

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EDUCATION, TRAINING & YOUTH AFFAIRS

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

Recent Achievements

Agricultural Sciences

Predicting the groundwater pollution potential of pesticides

A study at the University of Western Australia has examined the various factors that control the mobility of pesticides in the soil profile and, in particular, the importance of soil organic matter in the sorption and degradation processes. A major outcome of this work has been the development of a user friendly software package (PESTSCRN 3) for use by both management and regulatory agencies. PESTSCRN 3 enables a rapid assessment of the travel times and fraction of applied pesticide remaining at any given depth in the soil profile for different pesticide/soil combinations under different environmental conditions. PESTSCRN3 has also proven effective in predicting the transport levels of pesticides in sandy soils of the Swan Coastal Plain. Its applicability to a wider range of soil profile textures, structural conditions and recharge scenarios is being examined.

[Contact: Professor LAG Aylmore, Faculty of Agriculture, University of Western Australia;

tel: +61(0) 8 9380 2484; e-mail: aylmore@cyllene.uwa.edu.au]

Piglets are real babes for pork industry and research

A litter of five piglets born at the University of Queensland's Veterinary Science Farm at Pinjarra Hills has important ramifications for both the viability of the Australian pork industry and international research into genetic engineering and cloning. The piglets were the first born in Australia using a new technique involving special culture of the embryos before freezing by an ultra-rapid method called vitrification. The litter is the result

of five to six day old embryos transferred to a sow after having been frozen for four weeks. A second litter of five piglets, where the embryos were collected and frozen using the same method at between three and four days old, was born in January - a world first using this simple technique.

{Contact: Associate Professor Randal Cameron, School of Veterinary Science and Animal Production, University of Queensland;

tel: +61 (0) 7 3365 5721; e-mail: r.cameron@mailbox.uq.edu.au}

Green Machine sets the mark in soil moisture measurement

Mobile instrumentation developed at the University of Melbourne's Centre for Environmental Applied Hydrology provides the world's first detailed maps of soil moisture variation across catchments. Dubbed the Green Machine, it measures moisture in the top 30 centimetres of soil and links the data to specific locations using a satellite global positioning system. The information on soil moisture is important to crop growth and agriculture and it can also be used in flood predictions and weather forecasting. The researchers have found that while conventional models provide an adequate explanation for soil moisture patterns at wetter times of the year, they are not good at predicting what will happen during the dry season. International interest and support for the work of the Green Machine has come from New Zealand (where it is already being used in a long term project), the United States, Austria and the European Community.

{Contact: Dr Rodger Grayson, Centre for Environmental Applied Hydrology, University of Melbourne;

tel: +61 (0) 3 9344 6623; e-mail: r.grayson@civag.unimelb.edu.au}

Banksia cultivars for floriculture

The first three cultivars of Banksia ever to be developed for cut flower production are now available to Australian growers. All were produced from the improvement program at the University of Adelaide's Department of Horticulture, Viticulture and Oenology, and all are named for Peter Waite, who endowed the University to create the Waite Campus for teaching and research in agriculture. "Waite Orange" is an orange and buff banksia with large blooms, which extends the production period of orange banksias for most of the year. "Waite Crimson" is a dark red banksia which blooms in September, and "Waite Flame" is an orange/red banksia which blooms in July. All produce terminal blooms on long straight stems, and are ideal for the increasing export market for native cut flowers.

{Contact: Professor M Sedgley, Horticulture, Viticulture and Oenology, University of Adelaide;

tel: +61 (0) 8 8303 7249; e-mail: msedgley@waite.adelaide.edu.au}

Improving livestock nutrition

Researchers at La Trobe University's Department of Biochemistry have identified phenolic acids that form chemical bridges between polysaccharides and lignin in the cells walls of grasses and cereals and showed that digestibility was lower in those walls in which levels of the bridge were higher. The levels of bridge increased as the plants matured. Digestibility can now be estimated chemically in the laboratory, rather than involving long and expensive trials with animals. The research has given the

University an international lead in laboratory techniques to determine why grasses and cereal straws, as they mature, become increasingly indigestible by ruminants.

*(Contact: Professor Bruce Stone, School of Biochemistry, Genetics and Human Variation, La Trobe University;
tel: +61 (0) 3 9479 2174; e-mail: b.stone@latrobe.edu.au)*

The acid test for legumes

Acidic soils are an obstacle to bacteria which are needed to put nitrogen-fixing root nodules on agricultural legumes. By mutating acid-tolerant strains to acid-sensitive ones, and then typing the mutated genes, researchers at Murdoch University's Centre for Rhizobium Studies have identified some of the genes needed for acid tolerance. They have also found that part of the problem of acid sensitivity is due to the toxicity of heavy metals increasing under acid conditions. Their research aims to map the control genes which respond to the acid environment and the networks of other genes they regulate.

*(Contact: Professor Michael Dilworth, Centre for Rhizobium Studies, Murdoch University;
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New process turns wood into chemicals

A new process, known as fast pyrolysis, developed by a research group at the University of Melbourne's School of Forestry, can break wood down into useful organic chemical feedstocks. Production can be achieved at low cost, from sawdust and forestry wastes, with no added energy input, and at little risk to the environment. The chemical products are worth more than US\$1,500 a tonne. The University has taken out a provisional international patent on the process. The secret of fast pyrolysis is to use carefully controlled temperatures and conditions to ensure that the wood is taken apart without destroying its chemical structure. The process takes place at temperatures hundreds of degrees lower than traditional pyrolysis and in the presence of a catalyst. Products include furfuryl alcohol, cellulose and phenols. The alcohol can be used to make polymers which are heat and corrosion resistant. Almost all furfuryl alcohol used in Australia at present is imported from the United States or China. The phenols can be used in adhesives, explosives, plastics, medicines and food additives and are part of a US\$20 billion market worldwide.

*(Contact: Dr Branko Hermesec, School of Forestry, University of Melbourne;
tel: +61 (0) 3 53214109; e-mail: b.hermesec@landfood.unimelb.edu.au)*

Gene regulation in nematode feeding cells

Plant parasitic nematodes (root-knot and cyst-nematodes) are major pests of plant crops which attack roots. They induce the formation of feeding cells in host roots, from which they feed for several weeks. Researchers at the WA State Agricultural Biological Centre at Murdoch University have combined confocal scanning laser microscopy and transgenic plants containing the green fluorescent protein from a jellyfish, to study gene expression in the root cells from which the parasitic nematodes feed. Using these technologies they identified genes whose expression is switched on or switched off as a result of

nematode feeding. This information will help the development of new strategies to make crop plants resistant to these nematode pathogens.

{Contact: Professor Mike Jones, Director, State Agricultural Biotechnology Centre, Murdoch University;

tel: +61 (0) 8 9360 2424; e-mail: mgkjones@central.murdoch.edu.au}

Applied Sciences and Technology

Tunable laser technology

Recent work in the Centre for Lasers and Applications at Macquarie University has dramatically improved pulsed tunable laser technology with highest-possible resolution. The research concentrates on optical parametric oscillator (OPO) devices that are versatile spectroscopic sources, able to generate tunable coherent radiation over wide wavelength ranges from infrared to ultraviolet. This approach is modular, taking advantage of recent advances in solid-state optical materials, single-mode tunable diode lasers, and a new form of electronic control of OPO optical cavities. Ongoing research aims to produce portable OPO systems for field-based sensing and to extend the range of available wavelengths.

{Contact: Professor Brian Orr, Department of Chemistry, Macquarie University;

tel: +61 (0) 2 9850 8289; e-mail: borr@alchemist@chem.mq.edu.au}

Lasers used to "weld" severed nerves and blood vessels

Lasers already play an important role in medical treatments. They are used, for example, to destroy tumours, restore sight and remove disfiguring birth marks. New work at the Centre for Lasers and Applications at Macquarie University is proving effective in pre-clinical trials to rejoin severed nerves and blood vessels. Laser physicists, in collaboration with the Microsearch Foundation of Australia, have developed a biodegradable material which becomes a glue when activated by a semiconductor laser. The material is used to join severed vessels rather like the connectors in a hose. The laser beams seal the join. Microsurgeons from the Microsearch Foundation have used the technology to rejoin vessels which could be further damaged by traditional suturing.

{Contact: Professor Jim Piper, Centre for Lasers and Applications, Macquarie University;

tel: +61 (0) 2 9850 8911; e-mail: jim.piper@mq.edu.au}

Active fabrics

A range of fabric materials can be coated with inherently conducting polymers. During 1998 the Intelligent Polymer Research Institute (IPRI) at the University of Wollongong demonstrated that such materials can act as strain gauges that can be read directly via a change in resistance. The concept of monitoring forces generated during exercise has been demonstrated through collaboration with a researcher from the Department of Biomedical Science at the University of Wollongong. It is also possible that these sensing fabrics can be monitored remotely via telemetry—imagine them on a pipeline, integrated into the sails of a ship or incorporated into sports clothing! During

1998, IPRI secured funding to develop photovoltaic fabrics (tents, blankets etc) on behalf of the US Army Research Office.

{Contact: Professor Gordon Wallace, Intelligent Polymer Research Institute, University of Wollongong;

tel: +61 (0) 2 4221 3319; e-mail: gordon_wallace@uow.edu.au}

Advanced fibre composites help replace non-renewable materials

The range of applications of plantation grown timbers in engineered structures can be greatly enhanced by the use of advanced fibre composites. Research at the Centre of Built Infrastructure Research, University of Technology, Sydney, has shown that laminated veneer lumber beams reinforced by advanced fibre composites can be used for heavily loaded flooring systems or bridge decks in lieu of components made of more traditional non-renewable materials. This new technology can also be used to retrofit existing timber structures to strengthen and/or stiffen them. It provides designers and those responsible for the maintenance and management of built infrastructure with a cost-effective way to rehabilitate and to extend the operational life of bridges and other structures.

{Contact: Professor Steve Bakoss, Faculty of Engineering, University of Technology, Sydney;

lei: +61 (0) 2 9514 2629; e-mail: steve.bakoss@uts.edu.au}

Bioactive ceramic coatings for biomedical applications

Researchers at the University of Technology, Sydney have developed very thin, nanocrystalline coatings of pure hydroxyapatite, which will increase the adhesion of implants to the surrounding bone. The new coatings produced by sol-gel techniques offer a number of potential benefits over other coating techniques. These nano-coatings can be easily applied to complex shapes at relatively low temperatures. The thin coatings avoid problems associated with thermal expansion mismatch with metallic or ceramic implant substrates. Such technology is important in clinical applications where an initial bone attachment determines the success rate of an implant.

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tel: +61 (0) 2 9514 1784; e-mail: besim.ben-nissan@uts.edu.au}

Improving Australian competitiveness in plastics manufacture

Research undertaken at the Rheology and Materials Processing Centre as a partner in the Cooperative Research Centre for Polymers has allowed its commercial partners to make significant improvements to their manufacturing of plastic films. The in-depth understanding gained from studies into the areas of melt-strength and extensional rheology have enabled outcomes such as the use of previously unworkable and cheaper raw materials, the recycling of waste materials into film production processes, better quality products, and cost-time reductions in the development of new plastics.

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Visualising the injection moulding process

Direct visualisation of polymer melt behaviour inside a mould is a very effective method that has significantly improved understanding of the injection moulding process for more than two decades. Researchers at the Polymer Technology Centre, Royal Melbourne Institute of Technology, have built a cost-efficient multi-functional glass-inserted mould, which can be used for studying three-dimensional melt flow behaviour during the filling phase. The researchers have used it to explain many phenomena encountered in injection moulding. The mould design features an interchangeable 'transducer bloc' that allows direct and indirect measure of melt temperature and cavity pressure, and inserting of ultrasound, magnetising and local heating devices, etc. for specialised research.

(Contact: Mr Greg Shah, Polymer Technology Centre, Royal Melbourne Institute of Technology;

tel: +61 (0) 3 9925 4830; e-mail: g.shah@rmit.edu.au)

Solutions for environmental monitoring

Collaboration between researchers from the Centre of Electrochemical Research and Analytical Technology (CERAT) at the University of Western Sydney and AD Instruments has developed highly sensitive and selective methods for the determination of ultra-trace concentrations of nickel, cobalt, cadmium, lead, zinc and tin in natural waters and sediment samples in the environment. The immediate commercial outcome of the project has been the new Fast Scan Maclab System introduced by AD Instruments in 1998. The company's strong export focus (70 per cent of production) will guarantee worldwide access to the technology innovation arising from the collaboration with CERAT. In the long term, this new product will find application in industrial process control and environmental monitoring.

[Contact: Associate Professor Samuel Adeloju, School of Civil Engineering and Environment, University of Western Sydney;

tel: +61 (0) 2 4736 0811; e-mail: s.adeloju@uws.edu.au)

Extracting the most from wine

The Australian Wine Research Institute is interested in a new silicate compound developed by researchers in the Department of Chemical Engineering at the University of Melbourne, because of its potential to remove the cloudiness in wine caused by grape proteins. The traditional way of doing this, using a type of clay called bentonite, is increasingly viewed as a health risk because it can release small amounts of aluminium into the wine under acidic conditions. The new silicate is one of a family of compounds which can be tailored to take out exactly what the user wants to remove from solution. Potential applications include separating and purifying Pharmaceuticals in bulk.

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tel: +61 (0) 3 9344 6621; e-mail: g.stevens@chemeng.unimelb.edu.au)

Biological Sciences

Nanobes - the smallest life forms?

University of Queensland researchers have discovered novel miniature organisms which call into question the minimum size for life as we know it on Earth. At 20 to 150 nanometres (billionths of a metre) in length, these organisms, called nanobes, are much smaller than the smallest certified terrestrial bacteria ever found on the planet. Researchers discovered the living colonies of organisms in ancient sandstones retrieved from an oil drilling site 3-5 kilometres below the Australian seabed. The researchers behind the investigation are from the University's Centre for Microscopy and Microanalysis, and the Microbiology and Parasitology Department. They believe they may be the only research group in the world with actively growing nano-organisms. Testing has shown that the nanobes fulfil many criteria to qualify as biological life. Such research may make a major contribution to the debate concerning extra-terrestrial life and the origin of life on Earth and other planets.

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Test tubekoala babies

University of Queensland and Lone Pine Koala Sanctuary recently announced that a further five koala babies had been born by means of artificial insemination - the world's first marsupial offspring born following artificial insemination of their mothers. The new koala babies were conceived as part of the pioneering studies which investigated the mechanism of ovulation in the koala, and represents a major achievement for University of Queensland researchers, who have spent more than five years developing the successful protocol. Artificial breeding of koalas has a number of advantages for both their wild and captive conservation and management, enabling better understanding of how to encourage, or prevent the breeding process. This issue is particularly important for island populations of koalas in southern Australia where over-population by the koala has caused severe defoliation.

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Intertidal wetlands of the 2000 Olympics site

Over the last six years, researchers at the University of Technology, Sydney have been working with the Olympic Co-ordination Authority on a program aimed at rehabilitating and managing the intertidal wetlands of the Olympic site, which is the largest remaining wetlands area in the Sydney estuary. Three species of saltmarsh plants otherwise rare or non-existent in the Sydney area were found in the wetlands. The program has involved several projects, including ecological monitoring of saltmarsh and mangrove stands, saltmarsh transplantation experiments and investigations of specific growth requirements for the rare saltmarsh species. The transplantation project

showed that all six species trialed could be propagated from cuttings, and survive in their appropriate zones up the tidal gradient.

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New organisms found

A joint venture project between the Flinders University of South Australia and the Danish pharmaceutical company Novo Nordisk AS was designed to identify new lead compounds from micro-organisms useful in pharmaceutical products. The researchers have identified some 2,000 new micro-organisms including bacteria and microscopic fungi in the arid regions of South Australia. Most importantly, in some regions up to 25 per cent of these strains were found to be unique.

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Bugs clean up the environment

Researchers at Victoria University of Technology (VUT) have made a breakthrough in the fight against pollution. Micro-organisms have been isolated from soil that totally degrade high molecular weight polycyclic aromatic hydrocarbons to carbon dioxide and water. These hydrocarbons are carcinogenic and toxic pollutants that enter the environment via the processing, disposal and combustion of fossil fuels, the accidental spilling of hydrocarbons and oils, and coal liquefaction and gasification processes. These pollutants are abundant near urban and industrial centres with significant concentrations being reported in the sediments and soils of many industrialised areas throughout the world. Research into remediating these polluted sites has focused on the isolation of single microorganisms that totally degrade the hydrocarbons; however such organisms have remained elusive. The VUT approach was to combine isolated fungi and bacteria in the one culture, otherwise known as a co-culture, which permits these different organisms to cooperatively breakdown the hydrocarbons to harmless products. The defined co-culture can be used in bioremediation programs to quickly and safely decontaminate soil and liquid environments that are polluted with these particular hydrocarbons.

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Sex in bushcrickets

Research conducted by an ARC Senior Research Fellow at the University of Western Australia on native bushcrickets has shown that the time needed to recover from a bout of reproduction determines the relative availability of each sex and thus which sex will compete for mates. Sexual selection also acts on males after mating via the competition between sperm from different males with multiple matings. Sperm competition has traditionally been viewed as an extension of male competition, but the work with bushcrickets shows that females can play a major role. It has been shown that the structure

of songs produced by male insects to attract females represents a compromise between the benefits of mate attraction and the costs of attracting predators. The research described above has fostered extensive international collaboration and exchange of personnel with Sweden, Finland, Austria, the United Kingdom and the United States.

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Evolution within microscopic organisms

The protists are mostly microscopic organisms which include the ancestors of animals, plants and fungi. They dominate the diversity of organisms with nuclei and have recently been shown to be principal consumers in many natural ecosystems. This project documented the diversity of these organisms in Australia and developed what may be the first rational framework in which to classify all eukaryotes. In doing so, the project has helped the exploration of the evolution of cells and cell-biological phenomena. This work has helped to develop an understanding of how life evolved on Earth, and has been instrumental in attracting NASA funding to projects exploring the possibility of life on other planets.

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Using herbicides to control malaria

Promising new drugs against malaria are emerging from an unlikely source - the School of Botany at the University of Melbourne. A collaboration between the botanists and researchers at the Walter and Eliza Hall Institute of Medical Research has demonstrated that malaria parasites can be killed in the laboratory using a drug that disrupts the manufacture of fatty acids in plant cells. At present, malaria is resurgent in the tropics and is responsible for the deaths of up to three million people a year. *Plasmodium* - the protozoan group to which the four parasites which cause human malaria belong - has evolved elaborate genetic mechanisms that allow it to evade the defences of its hosts. But the plasmodia also possess a relic of their plant origins, an equivalent of a chloroplast, the site of photosynthesis in plant cells. Chloroplasts have their own genetic material, and the relic inside the plasmodia still contains 68 plant genes, which code for enzymes controlling essential biochemical reactions like fatty acid synthesis. These reactions make ideal targets for drugs. Because they are effectively plant reactions, any drugs which attack plasmodia are not likely to be toxic to humans.

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Evolutionary ecology of snakes

This research involved an integrated program that uses reptiles as "model systems" to investigate general questions in evolutionary biology and ecology. By continuing a long-term monitoring project on tropical predator-prey systems (pythons and rats, filesnakes and fishes) in the Northern Territory, the project has led to a unique view of the ways in which year-to-year variation in rainfall patterns effects the ecosystems on tropical floodplains. Such information is crucial if we are to understand how human

activities influence these kinds of systems. Detailed experimental studies on other snakes and lizards have clarified the ways in which females may be able to control paternity of their offspring (by actively selecting among the sperm from different males) or modify the attributes of their offspring in response to environmental cues that the mother experiences during pregnancy.

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Chemical Sciences

Analysis of volatile molecules

Commercial decisions in industries dealing with chemical materials such as petroleum processing and exploration, environmental analysis and monitoring, food and beverage purity and contaminant detection, and pesticide manufacturing and monitoring, can be heavily reliant on accurate analytical information. New chromatography technology developed at the Royal Melbourne Institute of Technology considerably improves the speed and reliability of these analyses. The technique to separate volatile organic compounds uses chromatography principles. This new method involves joining two columns of different separation characteristics together with the new modulated cryogenic device to yield a molecular separation where compounds are spread out over a two-dimensional field. The technique is being applied to such difficult samples as those in fingerprinting oil spills and automated atmospheric sampling.

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Infrared spectroscopy

Researchers at the University of Wollongong, in collaboration with CSIRO's Atmospheric Research Division, have utilised infrared spectroscopy to enable the precise analysis of the ratio of the two isotopic forms of carbon dioxide in air, carbon-12-CO₂ and carbon-13-CO₂. As well as being useful for atmospheric chemistry studies, the new method of isotope ratio analysis has proven of commercial value in the field of gastroenterology, leading to the development of an instrument for diagnosing stomach ulcers by a simple breath test. Currently the instruments used for this are based on the complex isotope ratio mass spectrometry method, and are quite expensive. The Wollongong researchers are in the process of developing a compact inexpensive commercial instrument based on infrared spectroscopy for this diagnosis. The University was granted a US patent on their method in 1998 and other international patents are pending. The University is in collaboration with an Australian manufacturer of medical instruments for the development, manufacturing and worldwide marketing of the instrument.

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Earth Sciences

Birth of earth's atmosphere

Breakthrough research at the University of Queensland based on understanding the reason for changes in the ratio of the element niobium (Nb) to uranium (U) in the Earth's mantle over geological time has pinpointed the beginning of the Earth's present oxygen-rich atmosphere. The change from a hostile atmosphere devoid of free oxygen to an oxygen-rich atmosphere sustaining an explosion of new life forms happened about two billion years ago. The study's findings, published in a recent edition of the prestigious journal *Science*, dispel theories placing the time of the evolution of the present atmosphere at either 570 million years ago (the first appearance of multi-cellular animals in the fossil record) or approximately 3.7 billion years ago (the age of the Earth's oldest traces of life).

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Deep diamonds

A unique geological structure in the upper part of the Earth's mantle has been revealed in fragments carried to the surface from as deep as 220 kilometres by the diamond-bearing magmas in northwestern Canada. This region is one of the oldest parts of the Earth and the very simple layered mantle structure recognised by researchers in a national key centre at Macquarie University may show the way that continents first formed over four billion years ago. Research has shown that many of the diamonds have very unusual mineral inclusions trapped inside them, indicating they were originally formed at depth of over 600 kilometres ("super deep" diamonds). This information on the structure of the mantle, and the nature of the diamonds and their location in the mantle has contributed to industry exploration strategies in this Canadian region which is now the site of the world's newest diamond mines.

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Engineering

Remote control underground mining

Underground mining by remote control is fast becoming a reality with the successful demonstration of a prototype below-ground communications network developed by Curtin University of Technology in conjunction with Transcom International Limited. The micro-cellular wireless communications system, known as UCELNET, was successfully tested in December 1998 deep in the Yanchep caves, about 55 kilometres north of Perth, Western Australia. UCELNET uses digital cellular radio technology to create an integrated wireless communications network for mine-wide coverage. It provides all of the user features associated with modern mobile phones as

well as meeting requirements unique to the underground mining industry, such as accurate positioning of underground operations personnel carrying the phone. There is considerable interest in this unique system which has been designed to offer many new facilities for underground mine operators to enhance both efficiency and safety. The system's technology also has the potential to be modified and applied to surface application in shopping centres, factories, offices and homes.

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Dangers of carbon monoxide exhaust

In Australia, suicide by carbon monoxide car exhaust gassing accounts for approximately 500 deaths per year. Research on carbon monoxide car exhaust gassing suicide in Australia, conducted by Monash University Accident Research Centre (MUARC), culminated in the publication of a landmark research report and publication in the international literature during 1998. Translation of the MUARC research findings, together with those of other researchers, to motor vehicle design solutions has gained strong industry interest through a national coalition convened by the Australian Medical Association. The proposed design changes would also protect against potentially hazardous levels of cabin vehicle gasses in the driving situation.

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Barriers for heavy vehicles

Car crashes into the rear of trucks present a particularly high and severe injury risk to car occupants, negating the usual occupant protection features of modern cars. The solution is to have well designed rear underrun barriers on the back of heavy vehicles. A prototype system has been developed at Monash University and has now been successfully tested. The system consists of four energy absorbing struts together with the associated cross beams. Following on from this development work, the Federal Office of Road Safety (FORS) requested that a trial system be fitted to actual heavy vehicles in the field, for evaluation.

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Icetrek equipment

Royal Melbourne Institute of Technology (RMIT) research has resulted in a major advance in the development of equipment for Antarctic and Arctic expedition and research. RMIT, in partnership with Nylex Rotomould has developed a new type of moulding process for Antarctic expedition equipment. The significant findings of the research are the identification and characterisation of suitable structural polymers for products continually exposed to extreme cold (minus 70°C). The research has led to a significant advance in design techniques for polar equipment such as sleds, containers

and support equipment. For example, the process and material were used to manufacture sleds for the 1998-99 Icetrek expedition to the South Pole, successfully completing field trials in the 1,800 kilometre expedition. The success of this trial has resulted in Nylex Rotomould receiving export orders for sleds and related equipment.

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Waste management pilot plant

A University of Queensland project, harnessing methane from solid waste, stands to revolutionise Australia's future waste management. The technology cuts waste decomposition time to two months - a process normally requiring at least 40 years in conventional landfills. A pilot plant at the University's Veterinary Science Farm at Pinjarra Hills accepts waste from 100 Brisbane households. One-third of the weight of waste evaporates in the form of methane and carbon dioxide. These gases are emitted by the micro-organisms breaking down the waste. The plant, consisting of two rubber-lined steel tanks, heaters and pumps, harnesses methane and carbon dioxide for use in either gas-powered electrical generators or as the liquid fuel methanol to power state-of-the-art cars. Processing waste in the tanks, rather than the present system of burying rubbish at sanitary landfills, enables the energy from the methane to be harnessed, therefore removing a harmful greenhouse gas from the environment. In addition, the tank system also eliminates smells and mess associated with current landfill methods.

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Information, Computer and Communication Technologies

Decoding satellite signals

The University of South Australia's Institute for Telecommunications Research has designed the ERSDEM2 demodulator. Unlike other remote sensing demodulators, ERSDEM2 is designed to decode signals from different satellites. ERSDEM2 can successfully demodulate signals from American, Canadian, French, Japanese and Indian remote sensing satellites. NASA recently took delivery of a ERSDEM2 unit to be used at the Goddard Space Flight Centre.

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POSSUM

An animation program developed at the University of Queensland can quickly and economically check the accuracy of the mathematical design of computer software for critical systems such as air traffic control and blood

bank stock monitoring. Known as POSSUM, the program was developed in the University's Software Verification Research Centre. Through use of a graphic interface, POSSUM provides a shortcut to the standard formal verification process required for the approval of critical systems software. While not a replacement for formal verification methods, the pace of technological development will make the use of POSSUM for design assurance increasingly viable. POSSUM has already been used in a British Aerospace Australia missile decoy system known as NULKA, where formal design assurance was demanded by the Australian Defence Department's Safety Critical Systems Standard. Other critical systems which could benefit from POSSUM include heart pacemakers, nuclear power stations, traffic monitoring and control, oil pipelines and production and police, fire and ambulance emergency response.

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Virtual clinic for Traditional Chinese Medicine (TCM)

The University of Technology, Sydney, Faculty of Science and the Institute of Interactive Multimedia have just completed the development of a Virtual Clinic for students of Traditional Chinese Medicine (TCM). The CD-ROM will be released to Australian universities within the next few weeks to assist in teaching TCM clinical diagnosis. The program allows relatively inexperienced students to carry out a full examination on a patient - something that cannot be done in a real-life clinic at such an early stage in the student's education.

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FISh programming

Researchers at the University of Technology, Sydney have developed a new computer language (FISh) which improves the tools available to engineers and scientists in undertaking highly complex calculations and analysis. The FISh programming language supports a highly expressive programming style that allows programs to be re-used in a wide variety of circumstances. For example, a single program could be used to forecast temperatures either on the ocean surface or in the volume of air above it. Normally, greater expressiveness slows down execution but FISh code is optimised by analysing the shapes of its data. Tests show that it runs at speeds equivalent to those of the fastest commercial languages.

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Stagestruck

Stagestruck is an innovative multi-award winning CD-ROM program created by designers and programmers from the University of Wollongong's Interactive Multimedia Learning Laboratory within the Faculty of Education, and its partner, the National Institute of Dramatic Art (NIDA).

Other partners in the consortium included the Sydney Opera House, Opera Australia and the Australian Ballet. Stagestruck takes the user through all facets of performances and allows them to create a score, design sets, make costumes, produce the soundtrack and experience just what goes into a performance. Players can write their own scripts, choreograph performances, watch auditions and rehearsals, and even meet famous actors. Guided tours and histories of theatres and venues all over Australia are available, including a detailed look at the design and construction of the Sydney Opera House.

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Accessible corporate databases

Researchers from the Queensland University of Technology (QUT) have developed the first prototype in the world that allows off-the-shelf databases to be connected to the Web and Internet with very little overhead. So far, the Web and Internet have mostly been used for displaying (read only) information. However, the potential of the Web has not been used as a systematic tool to enhance business productivity. Because modern corporations use proprietary databases that use different formats, accessing databases through the Web has been an on-going problem. QUT research has led to the development of techniques that enable corporations to hook up their business databases to the Web and enable both employees and customers to interact with all corporate databases as if a single database is being accessed. Using this technology, business database transactions can be conducted in a very efficient and cost-effective manner.

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Mathematical Sciences

Assessing telecommunications network performance

A University of Queensland research team has helped develop a model to evaluate quickly and accurately the performance of telecommunications networks. The project involved collaboration with researchers from Massey University and the University of Auckland. A critical feature of this research was the ability to model dependency between neighbouring sub-systems. Past models in this area assumed system components behaved independently when in reality, many lines and circuits are shared; this assumption is particularly poor during peak times when alternative routes must be found. The new model can be installed into switching software controlling telephone, mobile telephone, satellite or computer networks to ensure more efficient service and reduced congestion at peak times.

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Medical and Health Sciences

Mind Switch

Researchers at the University of Technology, Sydney have developed a system, called the Mind Switch, that allows a person to remotely control (turn on, change channels, turn up volume) electrical devices such as a television using their brain signals. Presently, a trial is being conducted in the homes of severely disabled persons, in which the disabled are being evaluated for their ability to control their television entirely through brain signals. So far, it has been tremendously successful, with control (e.g. turning on or off, changing channels, turning up the sound etc.) occurring reliably and quickly.

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New hope for the obese

The Endocrine Research Group in the Department of Biochemistry and Molecular Biology, Faculty of Medicine, Monash University, has discovered an anti-obesity compound (AOD 9604) in their investigations of the role of human growth hormone in the development of obesity and diabetes. A company, Metabolic Pharmaceuticals Limited, has been established to develop therapies for metabolic diseases such as obesity and diabetes and is now listed on the Australian Stock Exchange. It will conduct clinical trials on AOD 9604 and research into a new treatment for type II diabetes mellitus.

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Manic depression

University of Queensland researchers from the Vision, Touch and Hearing Research Centre have revealed a neural mechanism associated with manic depression. Research published in the prestigious *Proceedings of the Royal Society* journal recently, present evidence that people with manic depression had a slower switching mechanism between the left and right hemispheres of their brains. The research suggests that the slower switching mechanism makes the brain more vulnerable to being "stuck" in mood-related regions of one or other hemisphere. The left hemisphere is linked to positive emotions and the right hemisphere to negative emotions. Excessive time "stuck" on one side or the other can trigger the outward symptoms of the disorder such as depression (right side) or mania (left side). This study has produced a neurophysiological model of manic depression that can be tested in both laboratory and clinic. The neural model advances understanding of many aspects of the disorder. The model also provides a new method for testing drug therapies in the laboratory.

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Low birth weight in Aboriginal babies

University of Queensland researchers have ruled out prematurity as the cause of the high incidence of low birth weight in Aboriginal babies. The researchers, from the University's North Queensland Clinical School, found that Aboriginal women are approximately twice as likely to have low birth weight babies (less than 2,500 grams) than Euro-Caucasian women. Lower birth weight was a significant factor in the higher infant mortality rate among North Queensland Aboriginal populations. Around 78 per cent of indigenous perinatal deaths occurred to babies weighing less than 2,500 grams compared with 66 per cent of non-indigenous baby deaths. The study represented the first time the incidence of low birth weights in Aboriginal pregnancies had been examined prospectively (from early pregnancy) and longitudinally. In the few previous studies, research was based on retrospective data and memory. Further research is now needed to determine the influence of tobacco, nutrition or familial characteristics on the lower birth weights of Aboriginal babies.

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Modelling vision

Conventional measurements of visual performance (e.g. letter charts) cannot provide complete information about what a person actually sees in complex scenes. Researchers at the Centre for Eye Research at the Queensland University of Technology have developed a software model of the human eye which allows the reconstruction of the image formed on the retina, based upon the measured aberrations of the eye and cornea. This approach brings together signal processing theory and vision science in a unique way. The technique has improved fundamental understanding of the process of vision and will lead to better methods for treating vision disorders.

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Growth factor speeds up bone healing

A protein that helps nerve fibres grow also significantly speeds up the healing process of bone fractures. La Trobe University researchers, have shown that application of nerve growth factor (NGF) increases the strength of bone at the repair site. The researchers have found that NGF-treated bone healed more rapidly than controls. The fractures of the growth factor group were biomechanically stronger after six weeks. The finding could lead to new clinical therapies for fractures and a better understanding of osteoporosis.

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Physical Sciences

Galactic mystery of Circinus

Researchers at the University of Queensland in collaboration with the Australian Telescope National Facility and German scientists at the Max Planck Institut für Radioastronomie (MPIfR) have discovered the presence of a jet of material expelled great distances from the centre of the nearby Circinus galaxy. Circinus is a spiral galaxy like our own Milky Way galaxy, located near the direction of the pointers to the Southern Cross constellation but 12 million light years away. The material - charged particles moving in magnetic fields - has been identified by comparing optical and radio telescope images captured at observatories in two continents. The activity (or violent energy) at the centre of the galaxy was so great that the material was observed as being thrown thousands of light years away from the galaxy. The long-term implications of the research are important since better knowledge about the activity in galaxy centres should help astronomers to understand how galaxies are formed and why they are made up the way they are.

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Social Sciences and Humanities

Expanding Auslan

The University of Newcastle, through its affiliation with Renwick College of the Royal Institute for Deaf and Blind Children, has completed a comprehensive project to expand the existing dictionary of Auslan, the sign language of the Australian deaf community. The dictionary is unique among international sign language dictionaries in that it offers Auslan users extensive insights into the nature of their own language. The first-ever complete dictionary of Auslan has been produced as a CD-ROM, "Signs of Australia". Other countries are now seeking Renwick College's expertise to help document their own deaf sign languages on CD-ROM.

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Astronomical dating of Southeast Asian inscriptions

A team of researchers from the Faculty of Asian Studies, Australian National University, has succeeded in developing and applying a computerised algorithm to date over a thousand inscriptions from Thailand, Laos and Burma. This corpus of inscriptions is critical for understanding Southeast Asian history before European contact. Astronomical data appearing on the inscriptions, often in diagrams indicating approximate positions of the Moon and planets, is assessed by the algorithm to determine astronomically possible dates for specific configurations. Undated sources can thus be assigned a range of probabilistic dates and dated sources can have dates

confirmed. This work represents a significant advance in assessing the reliability and internal sequencing of indigenous Southeast Asian historical materials.

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User friendly English

In a collaborative project between the Education Department of Western Australia and Edith Cowan University, Aboriginal and Islander Education Workers from eight schools across Western Australia have been working together with linguists, educators and Aboriginal and non-Aboriginal research assistants to explore the differences between Aboriginal English and Standard English at the grammatical, semantic and pragmatic levels. The research has led to the development of dialect-sensitive pedagogical approaches and teacher resource materials, outlined in two reports currently in press. The intention is to make standard English more accessible (or "user friendly") to Aboriginal students by building on their existing English competence rather than rejecting it.

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Road crash risk

A study by the Road Accident Research Unit at the University of Adelaide has shown that travelling at 65km/h in a 60km/h speed limit zone, doubles a driver's risk of being involved in a casualty crash, and the risk continues to double with each further increase of 5km/h in travelling speed. These findings are based on a comparison of the speeds of crash-involved and non-crash-involved cars. A comparison with the results of a similar study on drink driving, also conducted by the Road Accident Research Unit, shows that the increase in the risk of crash involvement is the same when travelling at 65km/h as it is when travelling at the speed limit with a blood alcohol concentration of 0.05.

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Smoking while pregnant increases risk of child behaviour problems

Up to 25 per cent of child behaviour problems may be attributed to mothers smoking in early pregnancy, according to a University of Queensland study. The research team was drawn from the University's Australian Centre for International and Tropical Health and Nutrition, the Mater Children's Hospital, and the University's Department of Anthropology and Sociology. Recently published in the prestigious journal *Paediatrics*, this is the first known longitudinal study to examine the association between child behaviour problems - such as aggression and delinquency - and smoking before, during and after pregnancy.

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Making up lost time in literacy

Current estimates of school students in Australia experiencing serious literacy difficulties are around 25 to 30 per cent. An evaluation of a systematic literacy intervention program targeting primary school students with reading disabilities has found dramatic and consistent improvements. The three-year project conducted by Macquarie University's Special Education Centre has monitored over 200 children aged 8 to 13 years who were at least two and up to five years behind in reading. Following daily instruction for two terms (about five months), using the Making Up Lost Time In Literacy (MULTILIT) program, these low-progress readers typically made gains in reading and related skills of around 15 to 18 months. The MULTILIT program includes instruction in word attack skills, sight word recognition and supported reading of natural language texts.

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Managing emotions at work

The area of emotions at work has often been neglected by both organisations and management science because of an outmoded emphasis on the need for workers to refrain from any display of emotion, often seen as a sign of weakness. However, emotions are vital factors in both job satisfaction and staff turnover with job satisfaction a major influence on performance and productivity. University of Queensland researchers, in collaboration with researchers from Bond University and Arizona State University, have developed the first known model of emotional intelligence -how well people deal with their emotions - in workgroups. The researchers developed the model, the Workgroup Emotional Intelligence Profile (WEIP) in questionnaire form. Emotional intelligence was defined as the ability not only to read and understand one's own emotions and those of others, but to use such information in problem-solving.

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Archaeological survey and excavation of the Bounty

Researchers from James Cook University have recently carried out the first archaeological survey and excavation of the famous vessel *HMAV Bounty* and the mutineers' settlement on Pitcairn Island, located in the remote southern Pacific Ocean. The *Bounty* is located in the pounding waters of Bounty Bay in depths of approximately 3 to 6 metres. Excavations by the team have recovered original timbers, rigging and armament. They have also brought back the only intact cannon for restoration and display in Townsville. On land they have excavated the historically significant sites of the residences of Fletcher Christian, John Adams, Thursday October II and George Nobbs.

{Contact: Associate Professor P Veth, School Anthropology and Archaeology, James Cook University;

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Sequential processes in intelligence and cognitive aging

Research undertaken at the University of Sydney has improved our understanding of the reasons for cognitive difficulties experienced by the older segments of the population. These difficulties affect the ability to cope with life demands and may be directly responsible for the high incidence of deaths due to accidents experienced by the elderly. The results of this work show that the main reason for cognitive decline resides in the diminished ability to sustain, divide and switch attention. The benefit from this work is the availability of new and reliable diagnostic tests. These tests are already in use with brain injured patients.

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Institute of Advanced Studies, Australian National University

Role To be one of the world's great research institutions, distinguished also by outstanding teaching, guiding students to the frontiers of knowledge and the best standards of scholarship.

The Institute of Advanced Studies aims to maintain and enhance the University's world class standing and excellence by:

- engaging in research and scholarship at the highest international standards;
- strengthening Australia's capacity to undertake fundamental research both generally and in relation to subjects of national importance;
- providing outstanding postdoctoral and graduate training in all areas of the Institute's research activity;
- encouraging collaborations which allow other Australian universities to benefit from the concentration of research resources available at the Institute;
- fostering international exchanges and collaborations which enable Australia to contribute to and benefit from the latest advances in front-line research;
- encouraging links which make the scholarship and research resources of the Institute accessible to the Australian community, industry and government;
- being well-placed to respond rapidly to a changing environment and new opportunities; and
- optimising use of its resources by promoting internal links, including those with The Faculties, based on shared or complementary technologies and interests.

The Institute of Advanced Studies (IAS) of the Australian National University consists of nine research schools and one research centre. In addition, staff of the Institute participate in several cross-campus research groupings and centres. The Institute's fields of academic inquiry include biological sciences, chemistry, bio-medical sciences, physical sciences including mathematics, astronomy and the earth sciences, information technology and cognate areas of engineering and broad interests in the social sciences and environmental sciences.

The Institute has a distinctive place in the Australian higher education system. Uniquely, it is block funded to undertake full-time research at the highest international standards and to provide postgraduate and postdoctoral research training. Thus the Institute has a major role in carrying out basic research as a world leader in the research fields in which it is engaged. Further, it has a special responsibility to be a resource for the Australian higher education system and for Australian research as a whole.

Recent Achievements

Cloning of enzyme heparanase

Recently the Cell-Cell interaction Group at the John Curtin School of Medical Research has cloned the enzyme heparanase, a key enzyme involved in the degradation of the extracellular matrix caused by invading tumour cells and by leukocytes entering inflammatory sites. Cloning and characterisation of this enzyme has eluded researchers for almost 20 years. This research has important implications for controlling metastasis.

*(Contact: Professor Chris Parish, Immunology and Cell Biology Division, John Curtin School of Medical Research;
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The economic costs of high indigenous arrest rates

Collaborative work of researchers at the Centre for Aboriginal Economic and Policy Research and the Research School of Social Sciences concludes that contrary to conventional wisdom, contact with the criminal justice system adversely affects employment prospects of indigenous Australians. In this study the effect of arrest on the employment status of indigenous Australians was examined using data from the 1994 National Aboriginal and Torres Strait Islander Survey. Differences in arrest rates between indigenous and non-indigenous Australians may explain about 15 per cent of the difference in employment/population rates between those groups. Ensuring that indigenous citizens stay out of jails should be a priority policy issue for governments who are concerned about indigenous employment outcomes and this research has been very influential in highlighting this issue.

*(Contact: Professor Jon Altman, Director, Centre for Aboriginal Economic and Policy Research;
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Adaptive policies and institutions for natural resource management

In recent years, the sustainable management of natural resources has emerged as a major challenge for public policy. While the broad principles of sustainable development are established and stated in law and policy, creating the processes and structures to implement these is proving difficult. Ongoing research at the Centre for Resource and Environmental Studies (CRES) has provided a basis for analysis and prescription of 'adaptive policy, institutions and management' (APIM). The framework formed the basis of advice provided to the Land and Water Resources R&D Corporation on the establishment of an R&D program in the social and institutional area, via commissioned research involving researchers from CRES, Wollongong and Charles Sturt Universities.

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paper 01/99}.*

HI Parkes All-Sky Survey

Researchers from the Research School of Astronomy and Astrophysics in collaboration with the Anglo-Australian Observatory and the Multibeam Working Group, have examined the first results from the HI Parkes All-Sky Survey in the region of the South Celestial Pole. They have found that it provides a new and spectacular view of the neutral hydrogen distribution in the vicinity of the Magellanic Clouds and the southern Milky Way. The results suggest that our Galaxy is tearing apart its companion galaxies with gravitational tides.

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Seismology reveals movement and thickness of Australian Plate

In recent years, the Research School of Earth Sciences has deployed new generation seismic recorders in a series of arrays across Australia. The experiments have produced records which provide a three dimensional map of the Earth beneath Australia. New results in 1998 define both the thinnest (beneath the Pilbara region) and thickest (beneath central Australia) regions of the continent. In addition, there are unusual patterns within the Earth's mantle, beneath the crust. At 100 kilometres depth, a strong alignment of minerals defines a complex pattern attributed to the ancient assembly of the Australian continent, now frozen into the mantle. By contrast, at 200 kilometres, the mineral alignment is uniform across the continent and defines the movement of the Australian plate in a northerly direction. The new data appear to define the base of the Australia lithosphere at around 150 kilometres. The detail of subcrustal and lithosphere interpretations are important for models of diamond prospectivity and of major boundaries focusing deformation and multiple ore-forming processes.

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Australian soils - how old and how sustainable?

There is an increasing awareness of the fragility of soils in many regions of the world and of the effects of land-use pressures in terms of high soil erosion

rates. There is, therefore, a need to be able to date weathering and soil profiles. The Research School of Earth Sciences has developed several techniques for dating soil and weathering profiles. An additional important dimension is monitoring changes in the carbon content of soils and subsoils which follow changes in land use, particularly land clearing and re-forestation. New research in 1998 on basaltic soils in semi-arid north Queensland gave soil production rates of 30 cm/million years - a rate which is several orders of magnitude lower than soil formation in alluvium or dune sand. The data urge caution in land-use changes which may perturb erosion rates. Further research on weathering profiles in western and central New South Wales has established the extraordinary stability of some regions with weathering profiles of more than 250 million years age being preserved.

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The Anglo-Australian Telescope Board

Role *The Anglo-Australian Telescope board (AATB), through its operational arm, the Anglo-Australian Observatory, facilitates the best possible science through provision of world-class optical and infrared observing facilities for British and Australian astronomers. It also takes a leading role in the formulation of long-term plans and strategies for astronomy in both countries and, through its research and development of new instrumentation, to the advancement of astronomy internationally.*

The Anglo-Australian Telescope Board operates under an agreement between the Governments of the United Kingdom and Australia and is equally funded by them. The Australian Government will contribute approximately \$3.5 million in 1999-2000. The facilities include the Anglo-Australian Telescope (AAT) and the UK Schmidt Telescope (UKST) at Siding Spring Observatory outside Coonabarabran, and a laboratory in Sydney.

The AAT was state-of-the-art when officially opened in 1974. Twenty-five years later, it remains at the leading edge in astronomical research against considerable international competition. Throughout those years, many significant astronomical discoveries have been made using the Observatory's telescopes, and as a consequence Australian and British astronomers have a very high standing in the international scientific community. One of the reasons for this continued excellence is the vision and expertise of the Observatory's scientific and engineering staff, who have constantly upgraded the telescopes by incorporating the latest technological developments into instrument design. In fact, staff at the Observatory are considered world leaders in many areas of astronomical instrumentation.

Recent Achievements

Galaxy Redshift Survey now the largest ever

Astronomers using the AAT have now made the biggest-ever map of the Universe. The scientists are only part way through their research, aiming to make the map ten times as big.

The ambitious 2dF Galaxy Redshift Survey, which aims to produce an extremely detailed three-dimensional map of a significant part of the Southern heavens, has now pinpointed the distances to 30,000 galaxies. The companion survey of distant quasars has now passed 3,000 quasars, and is twice as large as the previous largest quasar survey.

The surveys aim to find the redshifts of 250,000 galaxies and 25,000 quasars. Redshifts give astronomers an idea of how far away a galaxy or quasar is. This enables them to build up a real three-dimensional picture of the Universe, rather than the two-dimensional view we see on the sky.

The surveys make use of the 2dF, a complex instrument built at the AAO. The 2dF employs optical fibres to enable 400 objects to be observed simultaneously.

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The origin of the X-ray background

Observations using the Low Dispersion Survey Spectrograph (LOSS) instrument at the AAT have identified an obscured quasar in a sample of objects detected with the ASCA X-ray satellite. Quasars hidden at visible wavelengths have previously been proposed as a major component on the enigmatic X-ray background. The X-ray background was first discovered in 1962 and its nature is one of the longest-standing cosmological puzzles. This discovery provides direct observational evidence that obscured galactic nuclei are present in deep X-ray samples and may be responsible for the bulk of the X-ray background.

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ENVIRONMENT AND HERITAGE

Australian Antarctic Division

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

Recent Achievements

Understanding penguin mortality

Adelie penguins near the Mawson base are being investigated as part of a long-term monitoring program to investigate prey/predator interactions in the krill-based ecosystem. In the 1994-95 summer, none of the chicks survived, all dying of starvation. In the 1998-99 summer, about 50 per cent of the chicks died of starvation. Most of those that survived are lighter than they should be and are not likely to survive their first year. Only further monitoring will establish whether this apparent cyclic crash in Adelie penguin recruitment is a natural phenomenon associated with the "Antarctic circumpolar wave".

Krill susceptible to ultraviolet light changes

Experimental research has revealed that Antarctic krill, the central animal in the Antarctic marine ecosystem, may be highly susceptible to damage by increased ultraviolet light resulting from the springtime stratospheric ozone depletion over Antarctica. Investigations show that krill DNA is likely to be damaged by UV-B, and that krill mortality is greatly increased when they are exposed to even low levels of UV-B in laboratory conditions simulating Antarctic conditions.

Bureau of Meteorology

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

To fulfil its research objectives, the Bureau:

- encourages high quality research in-house as a foundation for effective collaboration with the external research community and for the implementation of improved systems and techniques for the provision of services;
- fosters meteorology in the tertiary sector to ensure access to well-trained graduates and maintenance of the national research infrastructure for atmospheric science; and
- ensures effective coordination with the research programs of other relevant institutions both within Australia and overseas.

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

Recent Achievements

Fine-scale weather prediction

During the year, the Bureau introduced substantial improvements to its suite of operational numerical weather prediction models, achieving increases in resolution of both the global and regional-scale models, which are leading in turn to predictions of greater accuracy and precision. The improvements were achieved through fully utilising the capabilities of the joint Bureau of Meteorology-CSIRO High Performance Computing and Communications Centre (HPCCC)'s NEC SX-4 supercomputer. In a related development, a fine-scale model, with a horizontal resolution of 5 km, is being implemented as a core component of a new Air Quality Forecast System. The new system is being developed in collaboration with CSIRO, EPA Victoria and EPA NSW to provide trial air quality forecasts for Sydney and Melbourne under the Department of the Environment and Heritage Clean Cities Program.

Satellite rainfall in the tropics

The BMRC, through its monitoring site in Darwin, used sophisticated radars, rain-gauges and other instrumentation to provide important ground validation and calibration information for the joint NASA-NASDA Tropical Rainfall Measuring Mission (TRMM) satellite. The satellite was launched in November 1997 with the specific aim of measuring the distribution of rainfall in the tropics, especially over the vast tropical oceans, and has achieved great success internationally. Data collected in Darwin for more than a decade have been vital in first developing the satellite instrumentation and now in ensuring the quality of the satellite measurements. In addition, during May-June 1998, the Darwin facilities were deployed to Dong Sha Island in the South China Sea, as part of the South China Sea Monsoon Experiment, for validation of the TRMM satellite rainfall information in a true oceanic environment.

Biodiversity Group of Environment Australia

Role *To assist the Minister and Environment Australia in the conservation and appreciation of Australia's biological diversity and associated cultural heritage, through leadership and cooperation.*

Recent Achievements

Botanical research

Through its partnership with CSIRO Division of Plant Industry in the Centre for Plant Biodiversity Research, a collaborative venture in scientific research and documentation, the Australian National Botanic Gardens is involved with taxonomic and systematic research on Australian native plants. Computer-based identification tools for major plant groups were expanded, including the publication of an interactive key to the families of flowering plants, enhancement to the interactive key to the eucalypts of South East Australia and an improved edition of the interactive key to the rainforest trees and shrubs of North Queensland. The Centre is a member of an international consortium including the Harvard University Herbaria and the Royal Botanic Gardens Kew to construct a freely available authoritative online index to the world's scientific plant names.

Science Group of Environment Australia

Role *To ensure through research, assessment and the provision of technical advice, that the environment of the Alligator Rivers Region is protected from the effects of uranium mining to the very high standard required by the Commonwealth Government and the Australian people. The Chief Science Adviser also provides technical and policy advice to the Minister for the Environment and Heritage on a wide range of science-policy matters and mining-related environmental issues of national importance and on radiological matters, and conducts more broadly based environmental research on issues of national significance.*

Recent Achievements

Wetlands assessment

A framework developed by the Environmental Research Institute of the Supervising Scientist (ERISS) for assessing the likely impact of climate change and sea level rise on wetlands in Kakadu National Park has been used

as the basis for assessing two major wetlands in Asia. These sites were the heavily populated Yellow River Delta in China and the lightly populated Olongo Island in the Philippines. Predicted impacts and possible managerial responses were outlined in each study. The results and possible responses were discussed with local managers and officials at workshops at each site.

In a separate project, ERISS participated in a review of existing wetland inventory information on behalf of the Ramsar Convention on Wetlands. This demonstrated that for much of the world including Australia, wetland inventory information was either not available or not comprehensive. Recommendations included the adoption of standardised techniques for data collection, storage and reporting.

Great Barrier Reef Marine Park Authority (GBRMPA)

Role *The GBRMPA is the principal advisor to the Commonwealth Government on the care and development of the Great Barrier Reef. The authority conducts and supports research to ensure best scientific and technical information is available for decisions and policies relevant to the effective management of the Great Barrier Reef Marine Park.*

Recent Achievements

The Great Barrier Reef- a positive report card

The State of the Reef World Heritage Area Report was completed in November 1998. This report is the first ever attempt to synthesise information on the state of the whole Great Barrier Reef World Heritage Area as well as the human pressures on the environment and the management responses to those pressures. The major findings of this report are that there are no major adverse trends in most environmental attributes, but that continued vigilance and management is needed, especially for those attributes where there is a lack of good trend data. However, for dugongs south of Cooktown, three species of marine turtle and lagoonal benthos, the trends are not encouraging and management action is required.

Environmental effects of prawn trawling

A five-year study was concluded into the effects of trawling on seabed communities in the inter-shoal and inter-reef areas in the Far Northern Section of the Great Barrier Reef Marine Park. This study provides a major new focus for managing the trawl fishery on the Great Barrier Reef, requiring a whole-of-ecosystem approach to management, rather than the traditional fisheries stock management approach. This study also has major

implications for the Authority's aims to develop a comprehensive system for the protection of "Representative Areas" on the Great Barrier Reef.

Crown-of-thorns starfish outbreaks

Intensive monitoring of crown-of-thorns starfish numbers in the Cairns and Central Sections of the Great Barrier Reef since 1994 has provided an early warning of crown-of-thorns starfish outbreaks to the Authority and the tourist industry. Survey results show very high juvenile starfish recruiting on reefs in the Cairns area, indicating that a new outbreak may take place in 2-3 years time. This expected outbreak is in addition to the outbreak that peaked between 1994 and 1998 in the Cairns area, reducing coral cover by up to 90 per cent on some reefs. The Authority is working with tourist operators to help them undertake local control programs and thus minimise the effects on tourism operations.

Dugong Protection Areas

A comprehensive system of Dugong Protection Areas was implemented to assist the recovery of dugong populations between Cardwell and Maryborough. Long-term monitoring of dugongs in and adjacent to the Great Barrier Reef Marine Park showed that populations south of Cooktown had suffered on average a 50 per cent decline between 1986 and 1994. A total of 16 sanctuaries were declared primarily to control the effects of net fishing operations. A coordinated research strategy is being developed to assist in the conservation of dugongs and to determine performance indicators for measuring the effectiveness of the sanctuaries.

HEALTH AND AGED CARE

National Health and Medical Research Council (NHMRC)

Role *The objective of the National Health and Medical Research Council is to advise the 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.*

Recent Achievements

Reducing kidney disease in the Tiwi Islands

Tiwi people have the highest rate of kidney disease in Australia at 60 per cent. Researchers at the Menzies School of Research are attempting to find out why the Tiwi and Melville people of the Northern Territory have such an elevated rate of kidney disease. A major finding of the study has been that the Tiwi people have markedly enlarged filtering units in their kidneys as do some other indigenous people in North America. The Menzies group has now instituted a program of kidney health promoting behaviours such as improving diet and exercise and screening and follow-up behaviours.

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What causes heart attacks?

Heart attacks are either caused by massive cardiac arrhythmia or by loss of muscle tissue in the heart. Researchers at the Baker Medical Institute in Melbourne are studying the trigger for heart attack occurrence. Modelling studies have been carried out which indicate that a small molecule called IP3 initiates the development of arrhythmias. The research team is working in cooperation with others both within and outside of the institute to discover how the molecule is created and can be arrested.

*{Contact: Dr Elizabeth Woodcock, Baker Medical Institute;
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Memory pill

A research agreement has been signed between Biota Holdings and the Howard Florey Institute of Experimental Physiology and Medicine. Under the agreement with the Florey Institute, Biota will work with Professor Fred Mendelsohn and his team who have discovered a neuropeptide which dramatically stimulates memory performance in animals. The compound

was isolated after the mapping of a receptor distribution in animal brains. Work is in progress to evaluate if the compound can be developed as the basis for a treatment of memory disorders in humans.

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Physiology and Medicine;

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Genetically engineered antibodies for therapy

A collaborative team of scientists and clinicians from the Child Health Research Institute and Flinders University have set up a project group which aims to develop genetically engineered antibodies for therapeutic applications in leukaemia and in a number of eye diseases. The group have lodged a provisional patent on the potential applications of small antibody fragments in a variety of eye diseases. Development of diagnostic applications of one of the engineered antibodies against leukaemia is the subject of a new project within the CRC for Diagnostic Technologies, in collaboration with AMRAD Biotech Pty Ltd. Additional industry contracts are currently being negotiated.

/Contact: Dr Ian Nicholson, Child Health Research Institute, Flinders University of South Australia;

tel: +61 (0) 8 8204 7443; fax: +61 (0) 8 8239 0267}

Less trauma for kidney donors

The Division of Surgery at The Queen Elizabeth Hospital, Adelaide, South Australia has, after a period of basic research, begun to perform laparoscopic assisted donor nephrectomies. This is an operation in which a kidney is taken from a living related donor using laparoscopic dissection techniques. The advantage of this operation is that it enables the person giving the kidney to have a shorter post-operative stay with less pain, and an earlier return to normal work and leisure activities. Thirty donors have now undergone this procedure with excellent outcomes both in their recovery from the operation and in the function of the transplanted kidney in the recipients.

/Contact: Mr Mohan Rao; e-mail: mrao@tqehsmtp.tqeh.sa.gov.au; OR

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Clag: a laboratory-based malaria discovery

Red blood cells infected with the malaria parasite *Plasmodium falciparum* stick to the lining of blood vessels of various tissues including the brain. This stickiness (cytoadherence) is the major cause of cerebral malaria and is being studied because of the possibility of designing drugs to reduce sickness and death. During culture of the parasites in the laboratory they often lose the ability to cytoadhere. Some time ago, it was shown that this was because they lose a fragment of one chromosome.

Recently, after years of searching, the Molecular Parasitology Unit of the Menzies School of Health Research, has discovered a prime candidate for a cytoadherence gene, which is part of the chromosome region that gets lost. It has been called clag (for cytoadherence-linked asexual gene). Its structure suggests that it is most probably located at the red cell surface. The researchers have used new genetic engineering procedures to insert a

debilitated *clag* gene back into *Plasmodium falciparum*. This resulted in malaria parasites that could no longer cause binding. This is compelling evidence that *clag* plays a critical role in cytoadherence. The researchers will now study the function of *clag* in detail. If the role of *clag* in binding can be understood, they may eventually be able to find a way to reverse it and prevent severe malaria.

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Hepatitis E virus

Development of basic discoveries about the immune response to hepatitis E virus has culminated in the launching of a new test for the diagnosis of hepatitis E virus infection, co-launched by the Macfarlane Burnet Centre and AMRAD Corporation, an Australian pharmaceutical and biotechnology company. The research and development necessary for the successful commercialisation of this discovery was supported by a research syndicate.

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Proteins which cause tumours

For the past ten years, researchers at the University of Western Australia have been investigating the protein called *Cbl* which has the ability to cause tumours when it is altered by genetic mutation. The research has determined that *Cbl* can regulate signals that are transmitted from the external environment of the cell into the interior of the cell. Depending on the nature of the signal this can lead to changes in cell growth, cell function, cell mobility and cell shape. The way that *Cbl* carries out this function is by down regulating a class of cellular signal transducers called protein tyrosine kinases, which are key components in establishing protein networks that relay messages across the cell membrane and finally into the nucleus. An enhancement in the activity of protein tyrosine kinases is a common feature of many human tumours. The researchers have found that *Cbl* proteins are involved in at least two aspects of down regulating tyrosine kinases. Firstly *Cbl* can reduce the levels of tyrosine kinases that are in a cell and secondly *Cbl* has the ability to down regulate the biochemical activity of tyrosine kinases to modify other proteins. This work has resulted in the identification of a key negative regulator of protein tyrosine kinases.

{Contact: Associate Professor Wallace Y Langdon, Department of Pathology, University of Western Australia;

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Anti-HIV virosomes - a strategy to minimise total body HIV burden during early infection

Human AIDS is caused by the persistent infection of the human immunodeficiency virus (HIV) which resides primarily in CD4+ T-lymphocytes, epidermal Langerhans cells and other related dendritic cells, monocytes and macrophages. The mechanism of viral entry into cells initially involves binding to the CD4 cell surface receptor. The University of Western Australia has used chemical and biological approaches to develop specific delivery systems that can direct large DNA molecules to those cells

that harbour the virus. This delivery system relies on docking the foreign gene to the surface of the infected cell and then initialising internalisation by pharmacological methods. Experiments are now underway to produce a practical gene therapy for future clinical trials. This approach has significant clinical potential either alone or in combination with more conventional chemotherapy, especially for the treatment of HIV very early in infection and in children.

*{Contact: Dr Rod Minchin, Department of Pharmacology, University of Western Australia;
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Gastroenteritis in children

Gastroenteritis is one of the most common infectious diseases affecting Australian children. A four year national study, funded by NHMRC, showed that 20,000 children are admitted to hospital each year for treatment of this disorder, and that 50 per cent of episodes are caused by rotavirus infection.

Rotavirus was discovered in Australia in 1973 by Professor Ruth Bishop and her colleagues at the Royal Children's Hospital Research Institute, Melbourne. In a pivotal study, these researchers showed that neonatal rotavirus infection immunised infants against severe rotavirus disease, paving the way for development of oral vaccines. One first generation vaccine has recently been licensed in the United States, and is likely to be introduced soon into Australia. An Australian human neonatal strain vaccine candidate completed a phase II trial in 1998, which was supported by AusIndustry and AMRAD Corporation. A multinational company is considering its further development.

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INDUSTRY, SCIENCE AND RESOURCES

MAJOR RESEARCH ACTIVITIES

Australian Geological Survey Organisation (AGSO)

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

AGSO's research outputs underpin informed Government, industry and public decision making by satisfying client needs for high quality geoscience information and innovative research so as to enhance:

- the development of a more productive, competitive and diversified Australian minerals and petroleum exploration industry;
- the management of Australia's marine resources consistent with the principles of sustainable development; and
- the development of effective strategies to mitigate the effects of natural geological hazards.

Recent Achievements

Enhancing airborne geophysical gamma-ray data

AGSO has recently developed a new methodology to significantly enhance the usefulness of airborne gamma-ray data for geological and environmental applications. The new methodology greatly enhances the ability of scientists to estimate concentrations of the radioelements at the earth's surface by limiting the "noise" to less than half of previous typical values. This will greatly increase the amount of geological information an experienced interpreter can extract from data. The major outcome of this research is enhanced and expanded geological applications for these data at effectively no extra cost. AGSO is already applying the new methodology to the benefit of its clients, which include mineral exploration companies, State agencies,

educational and research institutions. It is expected that all Australian airborne geophysical contractors will adopt the new methodology for the benefit of their clients. AGSO is currently undertaking a series of major studies drawing on the funding initiative to demonstrate petroleum exploration opportunities.

Satellite detection of natural hydrocarbon seepage

AGSO has recently developed a methodology based on remote sensing techniques to identify natural hydrocarbon seepage in remote or frontier regions of Australia's marine jurisdiction. The method uses Synthetic Aperture Radar (SAR) data collected by satellites to locate oil slicks on the sea surface, and enables natural seepages to be distinguished from pollution. The detection of seeps allows large areas to be focused upon for follow-up work using airborne and shipborne techniques. The airborne technique, called airborne laser fluorescence, detects fluorescence spectra from oil slicks using a laser mounted in an aircraft. Each spectra is unique and allows the oil to be identified. This can give a strong indication of which petroleum system is functioning in the basin. This information allows sampling strategies to be devised and ultimately helps remove a major risk element for explorers in frontier petroleum regions.

Gas hydrates discovery

A Law of the Sea marine survey undertaken by AGSO in collaboration with its French counterpart led to the discovery of a zone of gas hydrates in the Tasman Sea. The hydrates, which occur widely in deep ocean sediments and sedimentary rocks, contain a highly concentrated form of methane that may be an important future energy resource. The find could provide clues to the petroleum potential of the Lord Howe Rise. Indications from the survey are that the hydrates cover at least 25,000 square kilometres (about half the size of Tasmania) in an area straddling Australian and French jurisdictions. Further research will be needed to map the extent, characteristics and origins of the deposits. To encourage mineral exploration and facilitate the discovery of significant economic mineral deposits, AGSO produces a range of geoscience information products in cooperation with the States and the Northern Territory as part of the National Geoscience Mapping Accord (NGMA). The NGMA is a cooperative Commonwealth, State and Northern Territory initiative to produce a new generation of geological maps and information for onshore Australia drawing on new data collection, processing and analysis techniques.

Multi-hazard risk assessment of Cairns

AGSO issued the first comprehensive report under its Cities Project entitled *Community risk in Cairns: a provisional multi-hazard risk assessment*. The report uses state-of-the-art computerised methods to assess and prioritise the risks to the Cairns community from tropical cyclone, earthquake, flooding and landslides. The vulnerability of the Cairns community was assessed under five themes - Setting, Shelter, Sustenance, Security and Society. The report found that the highest risks facing Cairns come from severe wind and storm tide from tropical cyclones. The next highest risk is from strong earthquakes, followed by flooding of the Barren River delta and finally, flash flooding and

landslides caused by extreme rainfall. Results and datasets from the study are being incorporated into the emergency management plans of the Queensland Department of Emergency Services and Cairns City Council. Some of the data developed under this project were used by Cairns emergency managers in carrying out the evacuation of 2,000 people threatened by flooding during Cyclone Rona in early February 1999. Equally important from a national viewpoint are the decision support tools developed in the project. These tools can be applied across Australia to help reduce the growing risk posed by geohazards to Australian communities.

Australian Government Analytical Laboratories (AGAL)

Role *To develop analytical methods of suitable precision, accuracy and efficiency to meet demands for emergency testing services related to the protection of public health and safety, threats to Australia's export markets for agricultural produce, and protection of the environment. Investigatory and advisory capability resides with the Scientific Services Laboratory in the areas of fire safety, construction and related activities.*

The Australian Government Analytical Laboratories (AGAL) play an important strategic role in protecting Australian public health and safety, the environment and international trade, through its quality services in analytical chemistry, microbiology, fire safety and physical testing. AGAL's operations are aimed at providing support for government and industry and in particular they provide a crisis response capability.

Recent Achievements

Test for folate levels in food

A highly sensitive bioassay has been developed in support of the Australian and New Zealand Food Authority's pilot folate/neural tube defects health claim program. There is strong scientific evidence that a diet high in folate prior to, and in the early months of pregnancy, can prevent up to two-thirds of neural tube defects. The development of this assay has been used to determine the level of folate in a number of foods and food products so as to enable these foods to be labelled appropriately, thus providing information on healthy food choices for women of child-bearing age.

Sophisticated discovery of food adulteration

AGAL scientists developed powerful new analytical tools utilising molecular biology techniques, which can be used for food adulteration studies. These include specific DNA typing methods which can be used to identify individual animal species used in the preparation of meat products. In addition, a different DNA typing method is now available for the differentiation of fish species. In the light of many commercial, regulatory and consumer issues relating to genetically modified foods, work is now underway to develop and trial methods for the analytical testing of GMO derived foods.

Australian Institute of Marine Science (AIMS)

Role *To generate the knowledge to support the sustainable use and protection of the marine environment through innovative, world-class scientific and technological research.*

In pursuit of this objective, AIMS is working closely with some industries (e.g. offshore oil and gas, tourism and pharmaceuticals), works indirectly with others (e.g. fisheries) and has close links with management agencies (e.g. the Great Barrier Reef Marine Park Authority).

Recent Achievements

Reporting status of the Great Barrier Reef

Long-Term Monitoring of the Great Barrier Reef - Status Report Number 3, released at the International Tropical Marine Ecosystems Management Symposium in Townsville, gives data for 1992-1998 on the status and trends in coral, reef fish and crown-of-thorns starfish over much of the Great Barrier Reef. Of major interest is the finding that reefs on the outer shelf off Cooktown and Gladstone had very low coral cover when the program began six years ago. The amount of coral has now increased dramatically and the numbers of many fish species have also increased.

"Real time" summaries of data have been made available online to provide an up-to-date information tool for managers and others interested in the Great Barrier Reef. The interactive data summaries and copies of the report are available on the AIMS web site (www.aims.gov.au/monmap/monmap.htm)

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1998 summer an extreme event on the Great Barrier Reef

The extensive coral bleaching event on the Great Barrier Reef (GBR) in early 1998 highlighted the possible causative role of elevated sea surface temperatures and links with El Nino-Southern Oscillation (ENSO) events. Analysis of sea surface temperature data from three sources off northeast Australia suggests that the summer of 1998 was the most extreme year in the past 95 years (the period of instrumental records) on the GBR. The anomalies of 1997-98 were typical of ENSO events over the recorded period (1903 to 1998). Sea surface temperatures have significantly increased over this period matching warming of terrestrial temperatures (Queensland average and Queensland minimum air temperatures) over the same period.

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Australian Institute of Sport (AIS)

Role *The Australian Institute of Sport is the elite sport arm of the Australian Sports Commission. the objectives of the AIS are:*

- *to enhance the sporting performance of Australia's elite and potential elite athletes and teams;*
- *to enhance the personal, educational and vocational development opportunities for elite athletes; and*
- *to improve the efficiency and effectiveness of national sporting organisations.*

The Australian Sports Commission (ASC), incorporating the AIS, has two principal objectives:

- to increase participation in sport and sporting activities by Australians; and
- to achieve excellence in sport performed by Australians.

Recent Achievements

Development of a new automated gas analysis system

Several years ago, the AIS designed and built an automated respiratory gas analysis system that incorporated volumetric determination of pulmonary ventilation, collection and analysis of all expiratory gas (rather than just gas samples) and reduced resistance to breathing. However, the use of two large (600 litre) gasometers to measure respiratory gas volumes restricted the portability of the system. Recently, a new system has been completed which employs a single 25 litre piston to measure gas volume. This system includes an automatic calibration function which minimises any possibility of operator error. It also allows more precise reading of outputs from the oxygen and carbon dioxide analysers, and provides for direct assessment of gas temperature and pressure at the point of volume measurement. Several hospitals have expressed interest in replicating the device for use in respiratory wards.

Development of a calibration unit for respiratory gas analysis systems

The AIS has designed and constructed a mechanical unit that can simulate the high rates of pulmonary ventilation produced by athletes and also generate "expiratory" gas with precisely known oxygen and carbon dioxide concentrations. This unit (known as Max Calibrator II) can be attached to standard respiratory gas analysis systems to check on the accuracy of oxygen uptake measurements. It permits ready identification of the sources of any

measurement errors. The unit is already being used to ensure comparability of oxygen uptake measurements in sports physiology laboratories throughout Australia, but is being further refined to simulate exhalation of saturated gases as occurs in humans.

Effects of simulated altitude exposure

Using the "Altitude House" built during 1997 and 1998, four controlled studies were conducted into the effects of sleeping under hypoxic conditions on the subsequent performance of highly-trained athletes. Overall, the results show that the power output achievable over a 4-minute period is increased by about 1.7 per cent — enough to make a difference of about 25 metres in a 4-km cycling race. While exposure to simulated altitude for 8-11 hours per night does produce a transient increase of -50-80 per cent in the blood concentration of erythropoietin (a hormone that regulates the production of red blood cells), this does not appear to be the mechanism of its effect on performance. Instead, the performance benefit is probably due to an increase in muscle buffering capacity. One of the groups showed that 3 weeks of sleeping in the Altitude House increased muscle buffering capacity by an average of 17 per cent. The findings indicate that, contrary to popular belief, daily exposure to hypoxic conditions develops anaerobic rather than aerobic capabilities. This has considerable practical implications with regard to the types of athlete likely to benefit, the stages of training during which altitude exposure should be incorporated, and the optimal delay between cessation of altitude exposure and participation in competition.

Measurement of power outputs of competitive road cyclists

Special power cranks (SRM, Germany) were fitted to the bicycles of cyclists taking part in major stage races. This allowed power output to be monitored during competition. Data were collected every second and then down-loaded to a laptop computer. Software developed by the AIS was used to profile the patterns of effort during races. The results for cyclists competing in the 1999 Tour Down Under showed that road racing is composed of many short duration (<15 sec), high intensity (>800 watts) efforts, separated by periods of 15 sec to 2 minutes during which power output is quite low. In the majority of races approximately 20-25 per cent of the time is spent at power outputs below 50 watts. These findings have led directly to modification of the nature of training sessions leading up to important competitions. Additionally, a new laboratory testing protocol has been developed based on the competition analysis data. The test has already been successfully used by leading male and female Australian road cyclists.

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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, 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

Radiation standards

As part of the responsibility for maintaining the standards for radiation activity, ANSTO has led the way in the development of the next generation of equipment for the accurate determination of radiation activity. A joint research project has been formed with the National Physical Laboratories (NPL) in the United Kingdom for the establishment of two state-of-the-art digital coincidence counting systems, one to be housed at ANSTO, and the other at NPL. A preliminary system has already been successfully trialed and work continues towards the development of the final systems. These systems will supersede the present analogue instruments, and will provide greater flexibility in choosing the precise means of analysis required for a given radioisotope.

Southern Hemisphere glaciation study

Samples of glacial ice from sites in New Zealand, Tasmania and Antarctica have been subjected to nuclear analysis for beryllium-10 and chlorine-36. This analysis has shown that the ages of the samples from Antarctica are younger than anticipated, lending support to the model of a dynamic and recently active East Antarctic Ice Sheet.

CSIRO

Role *CSIRO's primary functions are to carry out scientific research to:*

- *assist Australian industry;*
- *further the interests of the Australian community;*
- *contribute to the achievement of Australian national objectives or the performance of the national and international responsibilities of the Commonwealth;*
- *encourage or facilitate the application or utilisation of the results of this or any other scientific research; and*
- *carry out services, and make available facilities, in relation to science.*

Recent Achievements

Agribusiness

Biological sheep shearing

The Bioclip process for shearing sheep has been commercialised by an Australian company. Bioclip was developed by a team of scientists at CSIRO after they showed a naturally-occurring protein would defleece a sheep. The protein causes a natural break to occur in the wool fibres. Sheep using Bioclip are fitted with a retaining net and given a single vaccination of the protein. Stained wool that might devalue the fleece is removed as part of the process. A week later the fleece is shed as a whole inside the net, and is easily removed by hand. The research and development phase of the project was funded by CSIRO and The Woolmark Company. The technology has aroused strong international interest.

Healthy butter spreads better

A CSIRO team has achieved a double breakthrough by developing a healthier type of butter that will spread straight from the fridge. They achieved this by developing special diets for dairy cows that mix mono-unsaturated fats and poly-unsaturated fats in an ideal combination, and then found ways to ensure these desirable fats pass into the milk and butter. The result is a doubling in butter's spreadability, when taken out of the fridge at 5°C, making it nearly as spreadable as margarine, without losing its special eating qualities. It has also decreased the level of undesirable fatty acids in butter and replaced them with the healthier mono- and poly-unsaturates.

Matching sheep on the Web

CSIRO scientists have created a website that allows graziers to match the genetic abilities of individual rams to the precise requirements of their ewes and farm enterprise, online. For more than five years, CSIRO and NSW Agriculture scientists have collected and analysed data from a number of central test programs throughout Australia. These programs involve the elite sires from many of the most influential studs. The resulting database provides woolgrowers and other ram breeders with a clear indication of the "performance", or genetic merit, of individual rams. The project was supported by The Woolmark Company and the Cooperative Research Centre for Premium Quality Wool.

Edible coatings for fruit

CSIRO scientists have developed a range of edible coatings for cut fruit. The first commercial product is ready-to-eat slices of apple, sealed in a hygienic vegetable-based coating and presented in special packaging. This enables the fruit to retain its freshness in the refrigerator for weeks, rather than days. The edible coatings can also carry new flavours to make fruit even more interesting than before. Apart from school lunches, the fruit snacks have a wide range of uses, including travel, picnics and fruit platters that won't go stale.

Environment

Evidence of massive landscape change unearthed

A team from CSIRO and the CRC for Catchment Hydrology has found signs that European settlement in Australia unleashed an episode of erosion, sediment deposition and change in river systems orders of magnitude greater than we have assumed to date. Metres of mud and sand deposited on river floodplains, which the scientists at first thought to be the result of hundreds or even thousands of years of erosion, are proving to have happened in as few as 30 or 40 years. Subsequent tests will reveal whether it was clearing for agriculture at the top of the catchment or forestry operations in the lower catchment which was mainly responsible for the sediment — and the relative contribution of the two. This understanding will be vital in devising the best strategies for farmers, foresters and land managers to combat future large scale erosion and deposition events and improve water quality and sustainability.

Urine as a resource

Urine is high in nitrogen and low in phosphorus, and has been applied as liquid fertiliser since farming began. CSIRO and Swedish researchers from the Swedish Institute of Infectious Disease Control have developed a healthy and environmentally sound water-saving system that retrieves urine as a valuable resource. The new urine-separating waste system saves water, recycles nutrients, and minimises the risk of faecal contamination. The urine is piped off to holding tanks, from which farmers later pump it into tankers for use on the farm. Faecal matter is collected and stored separately and

composted in special bins. Composting proceeds far more rapidly without the urine and the resulting organic matter is used as a soil improver.

Fighting acid soils

CSIRO scientists have found a fresh way to tackle one of the gravest threats to Australia's, and the world's, environment and food supply — acid soils. Australia has more than 7 million hectares of acid soils that cost the nation a billion dollars in lost income every three years as the growth of sensitive crops and pastures is gradually stunted. Experiments have shown that trees, used effectively, can help arrest or even reverse the process in which farmed soils slowly turn acidic. Some species of trees are better than others at reversing the process: deciduous trees are more effective than eucalypts, acacias and pines. The study was supported by Australia's Rural Industries Research and Development Corporation (RIRDC) and the Vincent Fairfax Family Foundation.

Poison-eating bugs strike gold

Scientists from CSIRO and BacTech Pty Ltd, a Perth-based mining biotechnology firm, have discovered indigenous microbes capable of devouring toxic effluent from gold extraction. This discovery has led to the development of a process for cleansing the waste streams from inland gold mines, where clean water is often a scarce and costly commodity. Based on a process used by the Homestake mine in the United States, this system uses uniquely Australian organisms adapted to the local conditions. The discovery could also pave the way for a major advance in "clean green" processing of other minerals such as copper, nickel and zinc from sulphide ores. The project is funded by the Western Australian Government through its WA Innovation Support Scheme (WAISS), which fosters small innovative enterprises in the State.

Information Technology & Services

Study uncovers public fraud

A study exploring the use of high performance data mining tools and techniques to uncover public fraud in Medicare, identified patterns and trends that will enable the Medicare system to monitor payments as they are made, stopping fraud as it happens. Patterns of public fraud were searched for, and cases with fraud convictions recorded against them have been identified. The study was conducted by the Professional Review Division of the Health Insurance Commission in collaboration with CSIRO and the Advanced Computational Systems Cooperative Research Centre (ACSys).

Software to make aircraft safer

New ways to make software for aircraft mission computers safer have been developed by the Defence Science and Technology Organisation and CSIRO. The new methods can test mathematically if a particular software design is correct. This can help designers be more confident that when they upgrade an aircraft system, they aren't introducing a change in the software that makes it

less reliable. Therefore the level of design assurance for airworthiness certification can be raised. They could also make a difference in assuring the safety of software used to control other systems such as process control systems, and medical equipment.

Manufacturing

'Flu drug approved for humans

The world's first influenza drug, Relenza™ (zanamivir), will be available to treat 'flu victims in Australia in winter 1999, following regulatory recommendation for approval granted in February 1999 by the Australian Drug Evaluation Committee. Relenza™ is based on fundamental research conducted at the Australian National University and CSIRO since the late 1970s. Its development was funded by the Australian firm Biota Holdings, based in Melbourne. The worldwide pharmaceutical company Glaxo Wellcome is commercialising the drug and has conducted clinical trials around the world.

Advanced packaging materials

CSIRO and the Australian company Southcorp are developing CSIRO's oxygen scavenging discoveries into a series of commercial packaging materials under the ZERO2 label. The presence of oxygen limits the storage life of many foods and also some non-food products. Removal of oxygen prevents the formation of taints caused by oxidation reactions and also inhibits the growth of many micro-organisms. The CSIRO technology chemically scavenges oxygen inside packages, and it will now be incorporated in various types of packaging such as plastic film, PET bottles, cans, and caps used to seal glass bottles.

Australian scientists in world-first cell discovery

A team of Australian scientists from CSIRO and the Biomolecular Research Institute has achieved a world-first advance by describing the structure of a vital receptor found on the surface of the body cells of all animals including humans. Receptors are vital links in the body's command chain. Messenger chemicals like hormones and growth factors attach and switch on their special receptor, which in turns commands the cell to perform particular tasks, such as to grow or to process sugar. The discovery has major implications for our understanding of the mechanisms behind growth and development, and diseases such as diabetes and many forms of cancer. The diabetes aspect of the work was funded in part by Biota Diabetes Pty Ltd, a wholly owned subsidiary of Biota Holdings Limited, and the Federal Government's AusIndustry program.

Polymer breakthrough

A world breakthrough in polymer technology by CSIRO scientists has solved one of the most intractable problems of modern plastics and paints — how to stick them together in a nearly unbreakable bond. The new SICOR technology will also help the plastics and paints industries to attain higher

environmental standards by eliminating the need for damaging solvents and ozone-depleting chemicals, while at the same time reducing costs. SICOR is already being introduced in the Australian automotive industry, to bond paint to the surface of moulded polymer vehicle parts, and plastics mouldings to metal panels. A \$16 million licencing agreement has been signed with a US building products company. In another major application, SICOR will for the first time enable waste polyethylene, which normally clogs up city landfills, to be efficiently recycled for new uses — lowering both the energy use and greenhouse emissions involved in plastics production.

Minerals & Energy

New 3D mineral exploration technique

A world-leading 3D potential field interpretation technique has been developed by CSIRO and the Australian Geodynamics Cooperative Research Centre. From commonplace magnetic and gravitational survey datasets, the process extrapolates 2D images to 3D images, with greater accuracy and much greater objectivity, than a geologist could ever hope to achieve by the traditional process of hand tracing. The 3D modelling allows the geologist to see not just the gravitational and magnetic signals from sub-surface rock mass, but also gives natural and plausible predictions of the magnetic and gravitational status of the terrain below ground. This technique has broad applications in both minerals and petroleum exploration. The technique is being commercialised by Fractal Graphics, a 3D geological modelling specialist.

The TEMPEST mineral exploration system

A new airborne mineral exploration system, known as TEMPEST, has been developed by the Cooperative Research Centre for Australian Mineral Exploration Technologies and represents the culmination of more than six years collaborative research and development by private and public sector scientists and engineers. The system is being commercialised by one of the Centre's participants, Perth-based World Geoscience Corporation Ltd, which developed TEMPEST in collaboration with CSIRO. The Australian designed and developed system will be released commercially later this year. It can be used to explore for minerals such as gold, diamonds, nickel, copper, lead and zinc buried at depths up to 300 metres. Its ability to detect underground water and groundwater salinity also makes it a valuable environmental management tool.

New sensors reduce gold processing costs

New CSIRO-developed online sensors can produce significant savings of the more than \$100 million worth of cyanide used each year to process Australia's gold ores. In the widely used carbon-in-pulp gold leaching process, gold in the ore is dissolved with cyanide and oxygen in a slurry made alkaline with lime. Reducing consumption of these reagents, especially cyanide, is one way of cutting costs. Current commercial cyanide sensors are not widely used by industry because they are not perceived to be sufficiently

robust, reliable or maintenance-free and interpretation of the data they provide is difficult. Two major gold operators have so far saved \$1.5 million by using the improved sensors.

The Cooperative Research Centres (CRC) Program

The objectives of the Program are:

- *to enhance the capture of the benefits of research by strengthening the links between research and its commercial and other applications through the active involvement of the users of research in the work and management of the CRCs.*

The benefits arise in various ways, including the commercialisation of specific outputs of individual CRCs, the delivery of improved technology to an industry sector as a whole, and improved knowledge applied to the management of the environment and natural resources. These different models are illustrated in the description of some achievements identified below.

A strong feature of the program is the stimulation of a broader education and training experience, particularly in graduate programs, through initiatives such as the active involvement of researchers from outside the higher education system, and to enhance the employment prospects of students through initiatives such as involvement in major cooperative, user oriented research programs.

The program requires that the participants in an individual CRC contribute resources to at least the value of the program funding provided to the CRC. In practice, the participants contribute an average of 2.3 times the program funding. Industry is a major contributor in those CRCs which have an industry focus, averaging 25 per cent of resources overall.

The Cooperative Research Centres Committee, which is appointed by the Minister, provides advice on the CRC Program. Under the CRC Program, Government funding of \$140 million will be provide in 1999-2000 to support the existing 67 and 4 new Centres.

CRCs are established under formal contracts with the Commonwealth, normally for seven years, to undertake long-term strategic research focusing primarily on the natural sciences, engineering and their application.

CRCs are subject to a formal independent performance review after the completion of the second and fifth years of operation. A strong focus of the fifth year review particularly is the progress against milestones in the achievement of the outputs for the CRC identified in the business plan.

As the program has matured, significant outcomes are becoming increasingly evident.

Recent Achievements

Coordinating sugar production

Pilot studies by researchers at the CRC for Sustainable Sugar Production have indicated that there is substantial opportunity of maximising mill region profitability by optimising cane supply scheduling arrangements. The CRC has developed models applying operations analysis methods to optimise when different mill sub-districts, farms or even individual cane blocks within a farm should be harvested. The studies indicate that additional annual profit worth up to \$13.2 million in the Mackay Sugar region (4 mills) and up to \$1.6 million in the Mossman mill coastal region can be generated by optimising cane supply scheduling. CRC workshop attendees indicate considerable industry interest in the methodology with senior sugar milling and canegrower representatives from most major mill regions wanting to work further with the CRC to explore the options available to them.

Breakthrough vaccine developments

The CRC for Vaccine Technology, in collaboration with international biotechnology companies, is currently developing new and improved vaccines for five significant human diseases: rheumatic fever, glandular fever; malaria; melanoma; and HIV/AIDS. The incidence of rheumatic fever is particularly high in Aboriginal communities. The CRC and its partners have conducted three successful human Phase 1 vaccine trials for glandular fever, malaria and melanoma. Personalised dendritic cell tumour therapy for melanoma is a significant breakthrough with the potential to revolutionise cancer treatment. These new vaccine developments will improve vaccine delivery and enhance immune responsiveness.

Australian sugar goes international

Poorly dried sugar tends to cake in transport and improperly cooled sugar discolours. There is a serious price penalty on the international market for each of these defects. CSR Sugar Mills Group and the CRC for Robust and Adaptive Systems Ltd (CRASys) have jointly developed dynamic computer models for the drying phase of raw sugar production. The strategy is capable of guaranteeing cooling and drying to within prescribed limits and has the capacity to increase export revenues by up to \$100,000 per annum per mill - a factor critical to the continued competitiveness of Australia's export sugar industry. The models developed by CSR and CRASys combine physical understanding of the evaporation process with mathematical modelling techniques for the analysis of data from experiments. This has now provided a systematic method for developing applicable computer models of sugar driers from readily available measurements.

MF/Flow 3D

The CRC for Intelligent Manufacturing Systems and Technology's partner Moldflow, has released a new product "MF/Flow 3D". The package is an enabling technology for plastics manufacturers, bringing new products to market faster with minimum tooling and try out costs. It is true 3D simulation incorporating unique world leading software. The package simulates the flow of plastics in thick-walled, injection moulded plastics parts – something that was impossible for traditional plastics flow solvers. It establishes exactly where weld lines will form, air traps will occur and where the flow will lead or lag. All velocities, pressures, temperatures, flow front positions and heat transfer effects are fully computed in three dimensions. The product is already successful with sales expected to exceed \$1 million in its first year.

Catchment management and river rehabilitation

The CRC for Catchment Hydrology places particular emphasis on technology transfer, with 25 per cent of its resources directed to this activity. Included in the last 12 months:

- The CRC-Forge method addresses the high uncertainties in estimating extreme floods, an issue crucial for the owners of large dams (and others). To maximise the impact of the CRC research, collaborative development projects have been developed for all eastern states and Tasmania. An independent economic assessment of this research indicates a benefit-cost ratio of 4.9 for dam spillway upgrades alone.
- A 2-volume *Australian Manual of Stream Rehabilitation*, a joint publication of the CRC and the Land and Water Resources Research and Development Corporation is the first of its kind and will provide a decision support and priority setting framework for effective river rehabilitation.
- The CRC has had great success with its Industry Seminar/Report series to communicate research outcomes to the land and water management industry. Seven seminars this year have attracted over 850 practitioners in Melbourne, Canberra, Sydney and Brisbane; to date, over 2,000 industry reports have been sold.

Control of bitou bush

Bitou bush, the scourge of biodiversity and land use on more than 70,000 hectares of the NSW coastal bushland, has been ranked as one of the 10 most important weeds of Australia. South African in origin, it is just one of 20 major weeds targeted by the biological control efforts of the CRC for Weed Management Systems. In 1996, the CRC released a small South African fly named *Mesoclanis* which attacks only the developing seeds of bitou bush. In two years, the fly has increased more than a billion fold and spread north to Fraser Island, Queensland and south to Tathra, NSW, a distance of over 1,200 kilometres. The flies can now be found across virtually the entire range of bitou bush. Although the fly populations are still increasing, they are already reducing seed production by 40-100 per cent in some areas. It is estimated that the fly will save at least \$200 per hectare in control costs alone or \$14 million, not including benefits to biodiversity and improved aesthetic values.

Solid-liquid separation: A problem for the mining industry as well as the tea drinker

Unless you want a mouthful of tea leaves in your morning cuppa, you need some method of separating the tea leaves from the tea. Of course, this problem is now solved by the widespread use of a filter called a teabag. But if you didn't have a tea bag you would just have to let the leaves settle and pour off the tea carefully. Tea bags are not an option in hydrometallurgical processing, which is used to extract commodities such as alumina, gold, nickel, etc., generating at least \$10 billion worth of export earnings. The settling tanks used for solid-liquid separation in a hydrometallurgical plant are huge; they can be as large as four cricket pitches in diameter! To assist settling, a chemical called a flocculating agent is usually added. Researchers at the A J Parker Cooperative Research Centre for Hydrometallurgy have made great strides in understanding how the flocculating agents work and what is the best design for the settling tanks. As a result of this work, chemical savings of several million dollars per annum have been identified and fewer settling tanks will be built in future, saving millions of dollars in capital costs.

Subtitle breakthrough

From 1 January 2001, all news and current affairs television programs must be captioned. The CRC for Advanced Computational Systems (ACSys), under its Digital Media Libraries Program, is investigating the application of audio and video processing to the problem of automating some components of captioning for television viewing. The automation of this low skilled task will see productivity increase by enabling staff to focus on more complex areas of their employment. This development in captioning technology significantly enhances the life of the hearing impaired.

Breeding better beef

The CRC for Cattle and Beef (Beef Quality) has identified gene markers and candidate genes responsible for carcass and beef quality traits. This research can guarantee the eating quality of Australian beef and also help secure our position as the world's leading beef trader. The identified gene markers for growth, carcass retail yield, fatness, marbling, tenderness of triplon and eye-round muscles, meat and fat colour will be evaluated in the CRC's progeny-test dataset.

Innovative export table grape packaging

The CRC for International Food Manufacturing and Packaging Science has developed a packaging innovation which is likely to save the export grape industry about \$1 million to \$2 million each year. It is a new fungicide-impregnated export pack for grapes that reduces grape spoilage by 30 per cent during transport and storage. Grape bleaching is the primary cause of lowered grape quality and market value. In addition to the common moulds that all citrus and berry fruits invite, grapes also attract a grape-specific fungus, *Botrytis cinera*, which is present as spores in all vineyard soils. *Botrytis cinera* causes the grapes to shrivel and die. Unfortunately, it resists cold conditions and can grow in the refrigerated temperatures normally used for grape storage. The controlled-release, food grade approved, fungicide in the new export pack reduces the opportunity

for *Botrytis cinera* to damage the grapes during transport and storage. The controlled-release technology applies just enough fungicide to produce the appropriate fungistatic action, while minimising the undesirable bleaching and residue effects normally found in conventional cardboard boxes containing a sulphur dioxide release sheet.

Industry Research and Development Board

Role *To increase the level and commercial success of industry research and development undertaken in Australia.*

The Industry Research and Development Board was established on 1 July 1986 under the *Industry Research and Development Act 1986*. Under this Act the Board has responsibility for administering several innovation programs including the Tax Concession for Research and Development, the *R&D Start* program, and the Innovation Investment Fund. AusIndustry, a Division of the Department of Industry, Science and Resources, assists the Board to administer the innovation programs and the Innovation and Science Division is responsible for policy development for the programs.

Innovation Programs

R&D Tax Concession

The figure below shows levels of business expenditure on R&D between years 1968-69 and 1996-97.

The tables below show, as at March 1999, the number of companies registered and the expenditure on R&D, by State and by the year expenditure was incurred, from 1985-86 to 1996-97.

Figure 10 BUSINESS EXPENDITURE ON R&D

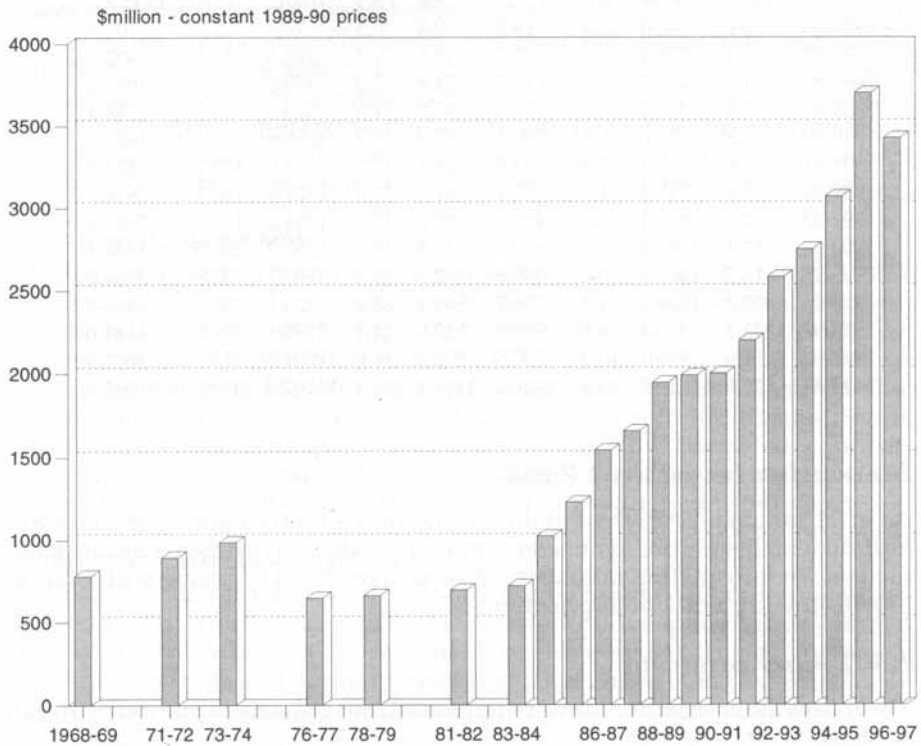


Table 11: Number of registrations by year when expenditure was incurred and State as at March 1999

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	TOTAL
1985-86	15	790	1	202	143	31	543	143	1868
1986-87	14	646	3	175	90	24	386	109	1447
1987-88	15	867	5	236	123	27	571	144	1988
1988-89	17	881	6	266	136	35	596	151	2088
1989-90	19	978	7	308	147	35	622	182	2298
1990-91	21	1050	7	320	158	32	698	195	2481
1991-92	30	1162	7	374	175	36	814	227	2825
1992-93	28	1206	10	392	170	46	851	242	2945
1993-94	34	1380	9	487	205	41	988	274	3418
1994-95	39	1399	6	543	216	42	1053	294	3592
1995-96	37	1414	8	552	229	45	1109	324	3718
1996-97	34	1224	12	475	201	36	986	286	3254
1997-98	25	958	7	371	163	26	745	237	2532
TOTAL	328	13955	88	4701	2156	456	9963	2809	34456

Table 12: R&D expenditure by year when expenditure was incurred and State as at March 1999 (\$ million)

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	TOTAL
1985-86	0.1	62.0	0.0	19.2	0.8	0.3	22.3	2.9	107.6
1986-87	1.4	276.9	0.0	73.2	19.5	4.7	274.3	41.1	691.1
1987-88	3.0	437.7	0.3	142.7	34.8	7.8	379.3	49.6	1055.2
1988-89	5.3	494.1	0.9	150.3	47.0	11.6	523.4	66.7	1299.3
1989-90	4.8	557.0	1.8	208.1	57.0	13.2	659.6	106.4	1607.9
1990-91	5.6	693.1	1.8	323.5	69.5	11.9	954.0	125.1	2184.5
1991-92	10.6	749.6	1.8	352.1	81.2	33.6	1321.4	144.4	2694.7
1992-93	12.1	832.1	2.2	488.6	82.0	18.0	1331.3	199.3	2965.6
1993-94	12.1	1018.4	36.9	528.2	119.8	28.2	1397.2	247.5	3388.3
1994-95	14.7	1366.6	0.9	559.6	142.3	28.7	1503.2	333.5	3949.5
1995-96	22.2	1346.3	1.3	758.1	143.1	33.8	1822.1	329.7	4456.6
1996-97	23.2	1253.8	4.8	535.1	162.9	34.1	1738.4	388.7	4141.0
1997-98	11.9	929.1	10.9	287.5	176.2	31.0	1231.2	323.7	3001.5
TOTAL	127.0	10016.7	63.6	4426.2	1136.1	256.9	13157.8	2358.6	31542.9

Innovation Investment Fund

As at 31 January 1999, the Fund had invested a total of approximately \$11 million which was spread over ten companies. Most investments to date have focused on information industries. A second round of licensing will occur in 1999 following a call for applications.

R&D Start program

The following research achievements come from projects supported through the R&D Start Program:

Ship fire protection system

Colbeck & Gunton has grown alongside the success of Tasmanian shipbuilder Robert Clifford whose Incat high speed catamarans are skimming the waters world wide. It is Colbeck & Gunton's task to provide innovative fire protection systems for the big aluminium "cats". They want to stay number one in the world and the only way to do that is to keep on looking for better ways of doing what they are doing. They have overseas customers and have worked in conjunction with a shipyard in China. Exports include fire doors and fire dampers to Spain, Italy and the United Kingdom.

Prostate cancer treatment

South Australian-based international pharmaceutical and healthcare company, FH Faulding is set to enter the next stage of developing an innovative approach to the treatment of prostate cancer, thanks in part to receiving a \$900,000 *Start Plus* grant. The grant will support the \$4.5 million pre-clinical stage of a project involving tissue-specific destruction of cancer cells using a special virus patented by the CSIRO. The virus is injected into the prostate gland and a gene within the virus produces an enzyme which triggers a toxic attack on the cancer cells while sparing the body's other cells. It is hoped that the first human trials will occur within the next two years.

Pump control systems

Multitrode, based on the outskirts of Brisbane, received a \$289,550 *R&D Start* grant to develop an integrated pump-station management system, primarily for use in municipal water supply and sewerage systems. Multitrode pump control systems are now distributed by ITT Flygt as its preferred system for municipal water supply and sewerage pumping and industrial applications in the United States, Canada and Mexico. Apart from the United States, Multitrode exports to most of the technologically advanced countries including Germany, France, the United Kingdom and Japan. By the end of this year the company expects 80 per cent of its production to be exported.

Copper bromide laser system

With a \$236,250 three-year *R&D Start* grant, South Australian company Norseld successfully marketed the laser system the company had developed. The laser, which is used to treat many of the vascular lesions commonly encountered in clinical dermatological practice, is now being exported to the United States, Canada, Japan, Thailand, the United Kingdom, Germany and Sweden.

Smartcards

Keycorp, Australia's leading publicly-listed electronic commerce and smartcard technology company, will use a \$12.6 million grant for its \$22 million smartcard (Stored Value) project, Privacy Host®. \$4.5 million of the assistance is being offered as a *Start Plus* grant to be provided over a two year period, while the remaining \$8.1 million is the first allocation of the new *Start Premium* component. The Privacy Host project is an extensive software and hardware development, including server and database systems and an enhanced terminal platform that enables Keycorp to expand the range of services offered at point of sale. The key to Privacy Host is its ability to dynamically manage and link applications and contents on smartcards, terminals and the internet.

IPS Radio and Space Services (IPS)

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

Recent Achievements

NASA panel on sunspot number prediction

An IPS staff member has joined a select international panel of scientists to provide predictions of the amplitude and timing of the new cycle of solar activity. These predictions underlie much of the work that IPS does. The panel was formed by the US Space Environment Center and is sponsored by NASA, which has a particular interest in solar cycle predictions. The IPS prediction method was judged by the panel to be the most accurate. The next meeting of the panel will be held in July 1999 to fine-tune the predictions as we approach the maximum phase of the cycle.

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Extension of coverage of real-time ionospheric maps

IPS has been providing near real-time maps of the ionosphere over the past few years. These maps form the basis of a host of IPS services, provided mostly over the World Wide Web, supporting the use of high frequency (HF) radio communications. The initial maps were based on data obtained from IPS stations within Australia but, with the success of services based on the maps, IPS has expanded its coverage by using data supplied from other international agencies. The Australian ionospheric map has been expanded to include New Zealand and the ocean areas south of Australia. A map covering North America and Europe has been established and has proved to be very popular on the Web. More recently, a real-time ionospheric map of the Japanese region has been established.

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TRANSPORT AND REGIONAL SERVICES

Bureau of Transport Economics (BTE)

Role *To provide expert advice to the Government and information to the community by conducting and disseminating the results of relevant, high quality applied economic research related to transport and regional services.*

Recent Achievements

Trading greenhouse emissions

A report on *Trading Greenhouse Emissions: Some Australian Perspectives*, contains contributions by authors from government, academic and private sector agencies on various aspects of trading greenhouse emissions. One chapter, written jointly by authors from the Bureau of Transport Economics and CSIRO, presents a scientifically-based method of accounting for carbon sequestration in temporary sinks such as tree plantations.

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Valuation of road safety

A report titled *The Willingness to Pay Method for Valuing Road Accidents*, prepared for Austroads, critically assesses the human capital and willingness to pay approaches for valuing changes in the risk of death or injury due to road accidents. Australia uses the human capital approach for road safety evaluation. The report discusses the conceptual, methodological and policy issues involved in each approach, surveys current practice in several countries and considers policy options for Australia.

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Federal Office of Road Safety (FORS)

Role *To enhance the safety of Australian roads by providing leadership and coordination in the areas of road safety policies that will help minimise deaths, injuries and crashes. To progress vehicle standards to meet the government's safety, environment and trade objectives. To promote an effective nationally uniform regulatory framework to promote efficiency and safety for the road transport and vehicle industries.*

The Federal Office of Road Safety (FORS), in its role as the Government's adviser on national road safety policies, relies heavily on strategically applied research. This is to ensure that resources are directed towards achieving the most appropriate, cost-effective measures to minimise the national road toll.

Recent Achievements

Offset frontal crash protection

Research that was part of an international cooperative effort has resulted in a new offset frontal protection regulation, Australian Design Rule (ADR) 73/00. This ADR will be implemented from January 2000 and augments ADR 69/00, introduced in 1995, for full frontal crashes. Australia is the first country in the world to introduce crash test requirements to cover the range of real-world frontal crashes, whether involving the full width of the vehicle or only part of the front structure.

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Abbreviations

AAT	Anglo-Australian Telescope
AATB	Anglo-Australian Telescope Board
ABARE	Australian Bureau of Agricultural and Resource Economics
ABC	Australian Broadcasting Corporation
ABRS	Australian Biological Resources Study
ADR	Australian Design Rule
AGSO	Australian Geological Survey Organisation
AGAL	Australian Government Analytical Laboratories
AGLS	Australian Government Locator Service
AIMS	Australian Institute of Marine Science
AIS	Australian Institute of Sport
ANSIR	Australian National Seismic Imaging Resource
ANSTO	Australian Nuclear Science and Technology Organisation
APAC	Australian Partnership for Advanced Computing
ARC	Australian Research Council
ASC	Australian Sports Commission
ASDI	Australian Spatial Data Infrastructure
ASDTL	Australian Sports Drug Testing Laboratory
ASTEC	Australian Science and Technology Council
ATO	Australian Tax Office
AUSLIG	Australian Surveying and Land Information Group
AWRAP	Australian Wool Research and Promotion Organisation
BMRC	Bureau of Meteorology Research Centre
BRS	Bureau of Rural Sciences
BTE	Bureau of Transport Economic
CCAMLR	Commission for Conservation of Antarctic Marine Living Resources
CCST	Coordination Committee on Science and Technology
CRC	Cooperatative Research Centre
CSTP	Committee for Scientific and Technological Policy
CTD	capability and technology demonstrator program
DCITA	Department of Communications, Information Technology and the Arts
DETYA	Department of Employment, Training and Youth Affairs
DFAT	Department of Foreign Affairs and Trade
DFRDC	Dried Fruits Research and Development Council
DHAC	Department of Health and Aged Care
DLC	Digital Loop Controller
DRDC	Dairy Research and Development Corporation
DSTO	Defence Science and Technology Organisation
ERISS	Environmental Research Institute of the Supervising Scientist
FORS	Federal Office of Road Safety
FRDC	Fisheries Research and Development Corporation
GBRMPA	Great Barrier Reef Marine Park Authority
GMAC	Genetic Manipulation Advisory Committee

GPS	Global Positioning System
GTO	Gene Technology Office
GTSM	Generalised Tropical Storm Method
HIFAR	High Flux Australian Reactor
HPCC	High Performance Computing and Communications
HRDC	Horticultural Research and Development Corporation
IIP	Innovation Investment Fund
IPS	IPS Radio and Space Services
ISR	Department of Industry, Science and Resources
JAFOOS	Joint Australian Facility for Ocean Observing Systems
LIDAR	Light Ranging and Detection instrument
LWRRDC	Land and Water Resources Research and Development Corporation
NARL	National Analytical Reference Laboratory
NHMRC	National Health and Medical Research Council
NOIE	National Office for the Information Economy
OGO	Office for Government Online
OPO	optical parametric oscillator
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
RAWG	Aboriginal and Torres Strait Islander Health Research Working Group
REEF	Renewable Energy Equity Fund
RIRDC	Rural Industries Research and Development Corporation
RMIT	Royal Melbourne Institute of Technology
SEQC	Software Engineering Quality Centres
SRDC	Strategic Research Development Committee
T&CI	Testing and Conformance Infrastructure
TBS	theatre broadcast system
TIP	Working Group on Technology and Innovation Policy
UKST	UK Schmidt Telescope
WEIP	Workgroup Emotional Intelligence Profile
WHO	World Health Organisation
WIPO	World Intellectual Property Organisation
WMO	World Meteorological Organization

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This Statement was prepared by the Science and Technology Analysis Section, Department of Industry Science and Resources, based on contributions from many Commonwealth agencies.

The Section also produces a number of other publications designed to promote informed public discussion on science, technology and innovation issues. If you require more information on these publications, please contact the Section by telephone (02) 6213 6417 or email mavila@isr.gov.au.

Australia is one of the most inventive countries in the modern world. Our achievements reflect the vision, talent and diversity of the Australian research community and profoundly affect the quality of all Australians' lives. This is illustrated by the prolific list of publicly funded scientific and technological achievements presented each year in the Science and Technology Budget Statement:

- The discovery of 'nanobes' in sandstone 3-5km below the Australian seabed promises to be a major scientific advance that may give clues to the origins of life on earth. These tiny organisms, as little as 20 nanometres long, appear to be not only the smallest living organisms ever found on earth, but to represent a whole new life form.
- The CSIRO has solved the intractable problem of bonding plastic and paint in a process that eliminates the need for damaging solvents and ozone-depleting chemicals, and enables recycling of waste polyethylene. The new SICOR technology, also being used by Australian industry, is the subject of a \$16 million licensing agreement with a US company.
- A prototype that connects 'off the shelf' databases to the Internet promises to expand e-commerce opportunities by allowing interactive use of business databases by staff and customers.
- And road accident research shows that travelling 65kmph in a 60 zone doubles the risk of being involved in a casualty crash — the risk equivalent of driving at 60kmph with a blood alcohol limit of 0.05.
- This year's achievements also include: a new low cost process that can turn sawdust and forestry wastes into chemicals worth over US\$1500 per tonne, with no added energy input and little risk to the environment; a laser technique that can 'weld' severed nerves and blood vessels; a 'mind switch' that allows severely disabled people to control electrical devices using brain signals; a pill that improves memory; and a new appreciation of the role of 'emotional intelligence' at work.

It is important to raise Australians' awareness of the important contribution science and technology make to economic and social well being. Descriptions of Australia's research accomplishments, and the Government funding arrangements which underpin them, will continue to attract the interest of journalists, policy-makers, peak organisations, business interests and many others in the community.

Cover photograph:

The Helicon Activated Reactive Evaporation (HARE) technology, developed at the Australian National University's Plasma Research Laboratory, is a fast, clean, environmentally-safe process for making high quality films for many industry applications, including microelectronic and optical devices. HARE has been successfully commercialised by ANUTECH Pty Ltd through R&D and licensing arrangements with a Japanese microelectronics manufacturer, and is currently on offer to international microelectronics companies for integration into industrial wafer processing systems.

Photograph by Marcus Fillinger, photographer,
courtesy of ANUTECH Pty Ltd, Australian National University

