CHAPTER 25

SCIENCE AND TECHNOLOGY

Science and technology directly influence the strength and competitiveness of industry by providing a basis for technological change and thereby encouraging economic growth and development. They can be seen as making major contributions to the achievement of many of Australia's social, economic and industrial goals.

The Government's conviction of the importance of science and technology is reflected in the roles and functions of the Department of Science and the Department of Industry, Technology and Commerce. Apart from having general responsibility for science and technology, these departments are concerned with the development and maintenance of Australia's scientific and technological capability.

The Department of Science

Scope and Policy

The portfolio of the Minister for Science covers the Department of Science (with an approved staff level of about 3,000), the Commonwealth Scientific and Industrial Research Organization (CSIRO), the National Standards Commission, the Australian Institute of Marine Science and the Anglo-Australian Telescope Board. The Department maintains close links with all four organisations.

The Department of Science was established in December 1984, with a brief to develop science policy and services. It advises the Minister on a range of policy issues, proposals and submissions from interested parties and also presents submissions to Parliamentary and other inquiries of relevance to the Department's role and responsibilities. It has regular contact with other Commonwealth and State government departments and statutory authorities in order to assist integration of science policies with industry, economic and social policies.

The Department helps to stimulate science in Australia and advises the Government on policies relevant to the needs of research institutions and industry. The current programs can be grouped under the following objectives:

- to stimulate scientific research in industry, government and academic sectors;
- to promote Australia's interests through international co-operation in science;
- to ensure that science issues are considered in the development of government policies;
- to improve community awareness of the advantages and disadvantages of science;
- to develop Australia's role in space activities;
- to carry out Australian Government policy as it relates to Antarctica (see entry on Antarctic Division, p 651);
- to provide the national meteorological service (see entry on Meteorology, p 640);
- to provide the national ionospheric prediction service (see entry on Ionospheric Prediction Service, p 640);
- to provide a Government analytical service (see entry on Australian Government Analytical Laboratories, p 639);
- to provide a national industrial property service to Australia, and development assistance in industrial property services to developing countries under international arrangements.

Financial Support for Research

The Department administers several funding schemes to stimulate research and development. The major ones are the Australian Research Grants Scheme (ARGS) and the Marine Sciences and Technologies Research Grants Scheme.

The ARGS provides suppport for basic research in a range of subjects at universities and other non-government institutions. ARGS grants for 1985 totalled $23.9m. In addition, under the Queen Elizabeth II Fellowships Scheme, up to fifty post-doctoral fellowships are awarded each year to young scientists to carry out full-time research in the physical or biological sciences at institutions in Australia.

The Marine Sciences and Technologies Grants Scheme assists universities and other organisations with projects involving, for example, the Great Barrier Reef, Bass Strait and the North West Shelf; Queen's Fellowships in Marine Science provide post-graduate research opportunities at Australian institutions. Through the portfolio of the Minister for Science, a total of about $31m was provided for marine research in 1984–85, recipients of funds included the CSIRO, the Australian Institute of Marine Science, the Department's Antarctic Division and individual research workers.

In 1983, the Government established the National Research Fellowships Scheme which supports research in priority areas of national interest, industry-based research and fundamental research (estimated expenditure is $2.1m in 1984–85).

Science Information and Education

The Minister for Science announced the formation of the Commission for the Future during 1985. This will assist public discussion and awareness of science and technology issues, particularly where they affect the community. The Commission will report to the Minister for Science but will also be expected to undertake wide-ranging publicity activities with maximum involvement of all sections of the general public.

The Minister for Science announced in 1984 that the Government had agreed to commence negotiations with potential sponsors for the establishment of a National Science Centre as a Bicentennial project. The Centre would have its headquarters in Canberra but would reach out to the whole community through touring exhibitions and provision of the exhibits to other institutions throughout Australia in 1988 and beyond. The Centre, which will be funded by the Australian Bicentennial Authority and other sponsors, will be part of the National Program of projects and events to celebrate the Bicentenary in 1988.

The Department of Industry, Technology and Commerce

The Department of Industry, Technology and Commerce is responsible for advising the Government and implementing its policies in relation to Australian manufacturing and service industries and technology. The Department provides the framework for a stronger national and technological capability and greater efficiency from research and development, production, marketing and distribution.

The Department acquired the technology function in December 1984. Technological innovation is recognised as one of the most important generators of economic growth and structural change in modern economies.

Recently, most Australian R&D has been funded and performed in the public sector. It is a priority of the Government to encourage the establishment of more effective links between public sector R&D institutions and the private sector in order to increase the likelihood of R&D being translated into commercial products and processes. In line with this goal, a tax incentive has been instituted to encourage the private sector to carry out more R&D. Expenditure on R&D by incorporated companies will attract a 150 per cent taxation deduction for amounts over $50,000 per annum. There is a phased scale for deductibility of amounts less than $50,000 but more than $20,000. The taxation concession scheme commenced on 1 July 1985 and will operate initially for six years.

Technology Development and Financial Support for Research

The Department develops and applies various programs to encourage manufacturing industry to become more competitive and export oriented. One such program is the Manufacturing Technology Development Program which fosters the development and promotion of innovative manufacturing technologies. Projects being undertaken within this program include the development of robots, photovoltaic cells and computer-aided manufacturing techniques.

Departmental activities encourage the innovative use of technology; in the field of biotechnology, for instance, the Department seeks to promote close co-operation among researchers, financiers and others interested in the commercial development of genetically engineered organisms.

An important Departmental function is the promotion of an entrepreneurial attitude to the commercialisation of new products and processes. In 1984, the Government established the Management and Investment Companies Licensing Board (the Office of the Board is part of the Department) to encourage the development of a venture capital market in Australia.

Licensed management and investment companies have to invest in young high-growth companies operating mainly in defined industries; the investment involves a taxation incentive. With the Department's assistance, Innovation Centres have been established in New South Wales, Victoria, Western Australia and South Australia. The centres promote interaction between inventors and manufacturers, and give inventors access to the information, expertise, services and facilities needed to carry inventions from the initial stage of technical and economic evaluation to the market place. Similar centres are being planned in Queensland and Tasmania. As well, the Department administers the Assistance to Inventors' Scheme which supports individuals with grants and advice to develop inventions.

The Department is responsible for a number of programs aimed at transferring technology from innovative sources to manufacturers. These programs are concerned with information technology awareness, manufacturing technology transfer and the formation and support of research associations.

Under the *Industrial Research and Development Incentives Act 1976*, three forms of assistance administered by the Department are available to industry: commencement grants, project grants and public interest funding. Commencement grants, each available for up to five years and with an annual limit of $40,000, encourage the growth of industrial R & D capability in mainly small and medium-size companies. Project grants with an annual limit of $750,000 per company, assist companies with an established R & D capability to undertake specific and significant R & D projects. Public interest funding involves the placement of contracts by the Commonwealth for work on industrial research projects with the potential to benefit Australia. Projects in progress cover water treatment, food processing, agricultural technology, biomedical engineering, processing technologies of metals, and the use of computers and micro-electronics in heavy engineering and information applications. Total funds provided for AIRDIS grants and projects in 1985–86 are $65.4m.

Industry Services

Industry Services consists of the provision and oversighting of a range of extension services to industry and covers the activities of:

- the multiplier agencies such as Technology Transfer Council, Australian Productivity Council and the Industrial Design Council of Australia;
- the service agencies comprising the Standards Association of Australia and the National Association of Testing Authorities; and
- the eight industry research associations covering particleboard, timber, welding, bread, brick development, medical engineering, radiata pine and sugar.

Activities of these bodies range widely, covering technology transfer; promoting improved design, quality, product development productivity and management practices in firms; support for industry research and development projects; the development of standards; and testing and accreditation of laboratories. In 1985–86, Commonwealth grants totalling $8.8m will be made available to these bodies, including $2.9m to the multiplier agencies, $3.9m to the service bodies and $2.0m to industry research associations.

Advice and Co-ordination

National Advisory Bodies

Australia has several agencies with policy and funding responsibilities for various aspects of science and technology. In order to achieve integration of advice, relative assessment of priorities and the development of broad strategies for future directions, several national advisory bodies, in addition to government departments such as the Department of Science, the Department of Industry, Technology and Commerce and the Department of Resources and Energy, have been established; the major ones are:

- The Australian Science and Technology Council;
- The National Energy Research, Development and Demonstration Council (See Chapter 18, Energy);
- The Australian Manufacturing Council.

Australian Science and Technology Council (ASTEC): ASTEC was established as a statutory authority in February 1979 under the *Australian Science and Technology Council Act 1978*. The Council reports to the Prime Minister and is the Government's principal source of independent advice on science and technology matters. As part of this role, it maintains an overview of the science and technology activities of Commonwealth Government departments and agencies, universities and private enterprise.

The functions of the Council are to investigate, and to advise the Commonwealth Government on matters relating to science and technology, such as:

- the advancement of scientific knowledge;
- the development and application of science and technology in relation to promotion of the national well-being;
- the adequacy, effectiveness and overall balance of scientific and technological activities in Australia;
- the identification and support of new ideas in science and technology likely to be of national importance;
- the practical development and application of scientific discoveries;
- the fostering of scientific and technological innovation in industry; and
- the means of improving efficiency in the use of resources by the application of science and technology.

Australian Manufacturing Council (AMC): The AMC was established in 1977. New arrangements, enlarging the role of the Council were instituted by the incoming Government in 1983. The Council advises the Minister for Industry, Technology and Commerce on matters of concern to the manufacturing sector and acts as a forum for discussion and consultation on such matters. In conjunction with the AMC there are eleven Industry Councils covering all major areas of the manufacturing industry.

Other official advisory bodies have been established to deal with activities, interests and responsibilities of the Commonwealth Government and its agencies, and to advise on Government support of higher education and of industry. Amongst these bodies are the National Health and Medical Research Council; the CSIRO Advisory Council and its State Committees; the Rural Industry Research Fund Advisory Committees and the Commonwealth Tertiary Education Commission.

Other Organisations

Advice to government on scientific and technology issues comes also from various learned and professional bodies. Advice may be offered on the initiative of the organisation itself or in response to an official request. For example, the Australian Academy of Science maintains a number of national and standing committees which specialise in selected broad fields of science; ad hoc advisory committees are appointed by the Academy to examine and report on specific matters.

Since 1967 the Academy has maintained a Science and Industry Forum which brings together leading scientists and industrialists to discuss topics of national significance; a complementary Science and Society Forum was inaugurated in 1973. Communication between government and the technology area of the science-technology spectrum is facilitated by the Australian Academy of Technological Sciences.

The most broadly based of the learned and professional bodies is the Australian and New Zealand Association for the Advancement of Science (ANZAAS) which is concerned with all fields of the natural and social sciences. It encourages interdisciplinary communication and information dissemination through national conferences, State programs and the bi-monthly magazine, Search.

There are a number of groups within the industry sector—e.g. the Australian Industrial Research Group (AIRG) and the Industry Councils which, from time to time, provide advice to government on specific matters.

Intergovernmental co-ordination is effected through Ministerial councils established for the purpose. While some of these councils are concerned with promoting research and scientific and technical services, they do not directly undertake research or provide services. Typical of these bodies are the Australian Agricultural Council, the Australian Minerals and Energy Council, the Australian Water Resources Council, and the Australian Environment Council. In some instances, councils have control of research funds and provide grants or arrange for projects to be undertaken in particular fields of interest.

In some scientific and technical fields not coming directly within the scope of the Ministerial councils, there are standing arrangements at agency level for consultation and co-operation (the Electricity Supply Association of Australia is an example).

The Building Research and Development Advisory Committee advises the Australian Government and its building research organisations (CSIRO Division of Building Research and the Experimental Building Station of the Department of Housing and Construction) on the research needs and priorities of the housing and construction industry. The Committee also advises the Minster for Housing and Construction on issues of research policy relating to all sectors of the industry.

The Australian Water Resources Council (AWRC) was established in 1963 and is a Commonwealth and State Ministers' forum for dealing with water resources matters. Commonwealth and State collaboration through the AWRC initially concentrated on resources assessment and research, but more recently the Council's functions have been expanded to include management and planning. The AWRC and its committees have provided an important contribution to the development of Commonwealth water policies and programs and, in many cases, provide the means of implementing them.

The Department of Resources and Energy administers a water research program through the Australian Water Resources Advisory Council (AWRAC). AWRAC advises the Minister on water resources priorities and goals and makes recommendations on effective research. The water research program is funded by the Water Research Fund at a cost of about $600,000 a year; it covers basic and applied research into all aspects of water resources.

Resources and Services

Although power to regulate the development and utilisation of Australia's natural resources rests largely with the States, the Commonwealth Government, in part because of its jurisdiction in the control of Australia's overseas trade, also plays an important role. Extensive machinery exists for consultation and collaboration between the Commonwealth and State governments in relation to the development and management of natural resources.

Several important resources and services are dealt with elsewhere in this Year Book and are thus not included in this chapter. These include Health (Chapter 10), Agricultural Industries (Chapter 13), Forestry and Fisheries (Chapter 14), Water Resources (Chapter 15), Mineral Industry (Chapter 16), Transport and Communications (Chapter 20) and Culture, Heritage and Environment, Tourism (Chapter 26).

Soil Resources

A Standing Committee on Soil Conservation was established in 1946. It comprises the heads of soil conservation bodies in the States and representatives of the Department of Primary Industry and the CSIRO. The Committee advises the Australian Agricultural Council on matters relating to soil conservation.

Australian Government Analytical Laboratories (AGAL)

AGAL, part of the Department of Science, provides valuable chemical and microbiological research and services to assist the Commonwealth Government in protecting public health, collecting import duties, enforcing laws against importing illicit drugs and certifying the quality of exports.

With laboratories in Sydney, Melbourne, Perth, Adelaide and Hobart, AGAL conducts more than 160,000 tests a year, mainly for Commonwealth bodies such as the Department of Primary Industry (primary produce), the Australian Customs Service (goods for tariff classification, trade description, spirits, unsafe goods, fertilisers and illicit drugs) and the Department of Health (pharmaceuticals, food, narcotics, sunscreen preparations and cigarettes).

In recent years AGAL has undertaken species testing of meat; detected substitution of barramundi with cheaper fish, and adulteration of honey and spirits; examined salami sausages in connection with a food-poisoning outbreak in Victoria; and analysed imported wound dressings and locally produced powdered infant foods for bacterial contamination.

The laboratories' chemists work closely with the Australian Federal Police in analysing suspected illicit substances and drugs, and providing expert testimony in court cases. AGAL also co-operates with CSIRO, Commonwealth Serum Laboratories, National Biological Standards Laboratory, Standards Association of Australia, National Association of Testing Authorities and a number of international bodies.

The Patent, Trade Marks and Design Office

This Office is part of the Department of Science. It administers systems for the protection of inventions, the registration of trade marks and industrial designs and provides a patent information service. The Office contributes advice and expertise to other areas of the Department and to government agencies involved in encouraging inventions and technological innovation. It also represents Australia's interests in the World Intellectual Property Organization (a United Nations agency) and a number of important international treaties concerned with industrial property, notably the Patent Co-operation Treaty (PCT).

In Canberra, the Office maintains the largest technology library in the Southern Hemisphere, with some 22 million patent documents from about forty countries. Access is provided to interested persons and a selected coverage is available through the State branches.

Each year the Office examines about 8,500 patent applications, 11,000 applications for registration of trade marks and 3,300 applications for registration of industrial designs. it also issues about 250 international search reports a year for international applications under the PCT. With further computerisation of information management systems, these levels are expected to increase.

The office assists industry to extract technological information from the major industrialised nations' patent specifications. Special reports are published on patent trends and developments. Australian Patent Information Service (APIS) officers, based in Canberra, Sydney and Melbourne, further assist industry by conducting technology searches, by providing information on the activities in specialist fields and by providing general overviews of particular technology areas.

Meteorology

The Bureau of Meteorology, part of the Department of Science, operates under the *Meteorology Act 1955*. As Australia's national meteorological authority, its basic mission is to explore Australia's weather and climate and to apply the knowledge gained to the provision of meteorological services to meet Australia's national needs and international obligations.

The Bureau has an operational staff of about 1,700 personnel employed throughout Australia and its Territories (including Antarctica). It has a Head Office in Melbourne, Regional Forecasting Centres in each capital city, Canberra and Darwin, 28 Weather Service Offices at major airports and RAAF bases, and 63 observing offices at other centres.

Users of Bureau services include the general public, defence forces, civil aviation and marine authorities, and specialist groups in primary and secondary industries. Apart from forecasting services, the Bureau satisfies many requests for data from the National Climatological Data Bank.

Programs of research are carried out in support of these services, often in co-operation with other institutions concerned with atmospheric science, including universities and the CSIRO. Major research topics include numerical modelling techniques for predicting atmospheric behaviour; better use of data derived from satellites; tropical cyclones and cold fronts.

Ionospheric Prediction Services (IPS)

The Ionospheric Prediction Service Branch of the Department of Science assists users of radio communications to achieve the most effective and efficient use of radio communication which is influenced by or dependent on the ionosphere. The Branch operates ionospheric and solar observatories in Australia and Papua New Guinea, and produces radio propagation predictions and warnings of ionospheric, solar and magnetic disturbances. The IPS also conducts research into physical phenomena affecting the ionosphere and into radio wave propagation.

National Materials Handling Bureau

The National Materials Handling Bureau of the Department of Industry, Technology and Commerce carries out research, development and promotion relating to the application of improved materials handling, including the equipment, systems, standards, methods, management and control aspects involved in the supply, production, movement, packaging, storage and distribution of goods and materials.

Satellite Remote Sensing

In 1978 the Commonwealth Government decided to establish facilities for receiving and processing information from the US National Aeronautics and Space Administration's series of Landsat satellites. The Department of Resources and Energy operates the facilities. A data-acquisition station is located at Alice Springs, with a data-processing facility in Canberra. Additional information on Landsat stations is provided in Year Book No. 64, pp. 722-724.

Scientific and Technological Information Services

Scientific literature and technical information for scientists and technologists is provided through library and information services provided by the Commonwealth of Australia, State Government instrumentalities, tertiary institutions and industrial organisations. The more

important scientific libraries and information services within the Commonwealth sector are the National Library of Australia, the CSIRO Library network and information services, and the libraries and information services maintained by the Department of Health and the Australian Atomic Energy Commission.

Several Commonwealth agencies, including the Australian Atomic Energy Commission, the Australian Road Research Board and the National Library of Australia, are now offering Australian users access to bibliographic data bases via a commercial computer servicer bureau (AUSINET). The Australian Mineral Foundation provides an earth-resource data base, also through AUSINET. The National Library of Australia and the Department of Health operate a national health information network, the Australian Medline Network. The CSIRO provides access to data bases on CSIRONET. The Overseas Telecommunications Commission (Australia) operates an international packet switched data transfer service known as MIDAS (Multi-mode International Data Acquisition Service) which is a cost-effective means of accessing international computing facilities and host computers in the Asian, American and European regions.

Another overseas trend in which Australian scientists are showing interest is the development of numerical data bases which provide quick access to factual data. The CSIRO is currently operating Thermodata, a metallurgical thermodynamic data base and other similar data bases in crystallography and mass spectra data. Similar numeric and factual data bases are at present being evaluated by other Commonwealth agencies.

A number of Australian scientific and technological indexes and directories now exist or are in the course of production by Commonwealth Government departments and agencies. Examples are:

- a computer-based register of Australian energy research, development and demonstration projects containing an outline of the objectives, methodology and status of each project. The register is maintained by the CSIRO on behalf of the Department of Resources and Energy and contains references to about 1,000 projects. It is used to generate annual updates of the Compendium of Australian Energy Research Development and Demonstration Projects;
- a national directory of current Australian marine research. The Directory of Australian Marine Research in Progress is a joint publication by the Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority, the CSIRO and the Victorian Institute of Marine Sciences. The Directory identifies individuals and organisations undertaking marine research and provides details of their objectives, methodology, publications, current status and funding;
- a computerised bibliographic data base, STREAMLINE, providing references to published and unpublished documents and current research projects on all facets of water and wastewater in Australia, has been established by the Department of Resources and Energy in association with State water agencies. The data base is publicly available on AUSINET, and a regular current awareness bulletin and a directory of research projects are produced.

Units and Standards of Physical Measurement

The maintenance of Australia's standards of measurement is included in the *Science and Industry Research Act*, 1949 as one of the functions of the CSIRO. Furthermore the *Weights and Measures (National Standards) Act*, 1960 requires CSIRO to maintain, or cause to be maintained, standards of all physical quantities for which there are legal units of measurement. This statutory responsibility has devolved upon the Division of Applied Physics which has its headquarters in the National Measurement Laboratory in the Sydney suburb of Lindfield, and branch laboratories in Adelaide and Melbourne. CSIRO has authorised the Australian Atomic Energy Commission and the Australian Radiation Laboratory to maintain the Australian standards for quantities relating to ionising radiations such as radioactivity, exposure and absorbed dose. It has also authorised the Division of National Mapping (Department of Resources and Energy) and Telecom Australia to maintain working standards of time interval and frequency.

The National Standards Commission is responsible for determining the legal units and standards of physical measurement, co-ordinating the national measurement system and approving measuring instruments for use in trade.

In September 1984 the *Weights and Measures (National Standards) Act* was amended and the title changed to the *National Measurement Act*. The amendments clarified the functions of the Commission and transferred to it the responsibility for continuing the

introduction of the metric system of measurement into Australia. This was previously a function of the Metric Conversion Board.

A review of the trade measurement system is being undertaken by a consultant (funded jointly by the Commonwealth and the States) to identify community and industry needs to determine the most effective method of meeting those needs.

National Information Technology Council (NITC)

The NITC was established in 1984 to continue and expand upon the work of the National Information Technology Week Committee which was created in 1979.

Recognising that the major problems relating to the transfer, ownership, adoption and employment effects of technology are not technological but social, political and cultural, the NITC has developed mechanisms to raise the level of industry and community understanding and appreciation of information technology.

The NITC is funded by the Department of Industry, Technology and Commerce and the Australian Computer Society. The work is administered through State committees which receive additional funding from State governments.

Research and Development

Much of the early history of Australian science was based largely on the individual achievements of a few outstanding scientists.

During and after World War I, governments in various parts of the world took initiatives aimed at encouraging scientific research and applying it to economic growth and national development; Australia was no exception. In 1926 the Council for Scientific and Industrial Research (CSIR) was established by the Commonwealth Government. Initially, it concentrated its efforts on the primary industries, typifying the trend of research in Australia at the time, when most major research initiatives were taken by Government and aimed at the primary industries.

With the approach of World War II, however, moves were made to extend scientific support for secondary industry. In the CSIR, Divisions created in the period 1937–40 were to play an important part in the rapid development of Australian industry which occurred under the stimulus of war-time needs.

Expansion of scientific research in general, and industrial research in particular, continued after the war. This expansion extended beyond government into the universities and industry.

Though even today agricultural research absorbs a significant proportion of Australia's research effort, industrial, medical and defence research are now of major importance also. The volume of research in the social sciences and humanities remains small, although in Australia, as elsewhere in recent years, there has been increasing support for the view that adequate weight must be given in governmental policy-making to the social aspects of national proposals.

For details of expenditure and human resources devoted to research, see section below.

Expenditure and Human Resources Devoted to Research and Experimental Development

Project SCORE (Survey and Comparisons of Research Expenditures) which provided details of Australian expenditure on research and experimental development activities was reviewed in 1984. As a result of this exercise the previously separate Project SCORE and Energy Research and Experimental Development Surveys were amalgamated into a single biennial survey known as the *Survey of Research and Experimental Development*. The latest survey was conducted in respect of 1984–85; complete results are not yet available. To satisfy a need for constantly updated statistics, an Inter Year Estimates survey will be conducted on a much smaller scale in each of the intervening years. The first such survey covering only the business enterprise sector was conducted in respect of 1983–84. This survey may be extended to the remaining sectors in 1985–86 and subsequent cycles. While the Survey of Research and Experimental Development provides comprehensive data on research and experimental development activities, it does not cover all resources devoted to scientific and technological activities in Australia. Activities not covered by the survey include scientific or technological services, extension services, education and training, etc.

The first comprehensive survey on research and experimental development (R & D) was carried out for the financial year 1968–69. There have been five subsequent surveys, the latest for which comprehensive results are available being in respect of 1981–82 (1981 calendar year for the Higher Education Sector).

The estimate of gross expenditure on R & D (GERD) carried out in Australia, as derived from the results of the 1981–82 survey, is $1,522m. This represents a 44 per cent increase compared with the 1978–79 Survey. At constant (1979–80) prices, GERD increased by 4 per cent over the same period. The total estimate of human resources devoted to R & D during 1981–82 in Australia is 44,535 man-years; this compares with 43,643 man-years for the previous survey.

Survey Methods and Concepts. The Survey of Research and Experimental Development measures R & D expenditure and human resources in the natural and social sciences in the major sectors of the Australian economy. For the purposes of the survey, four sectors are recognised: Business Enterprises (public and private business enterprises, excluding those mainly engaged in agriculture, forestry, fishing and hunting); General Government (all State and Commonwealth Government organisations but excluding local government organisations); Higher Education (universities and colleges of advanced education), and Private Non-profit (private or semi-public organisations which are not established with the aim of making a profit). The surveys are conducted by means of mailed questionnaires and, in order to provide direct comparisons with other OECD countries, follow guidelines described by the OECD for national R & D surveys. The OECD defines R & D as comprising "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications".

For further details concerning survey methods and concepts see the ABS bulletins mentioned below.

Survey Results. A summary of results for 1968–69 is given in Year Book No. 60. Results for the second survey, 1973–74 (1974 calendar year for the Higher Education Sector); the third survey, 1976–77 (1976 calendar year for the Higher Education Sector); and the fourth survey, 1978–79 (1978 calendar year for the Higher Education Sector) are given in Year Books No. 61, 64 and 67 respectively.

Detailed results for the fifth survey, 1981–82 (1981 calendar year for the Higher Education Sector) are contained in the ABS publications: *Research and Experimental Development, Business Enterprises, Australia, 1981–82* (8104.0); *Research and Experimental Development, General Government Organisations, Australia, 1981–82* (8109.0); *Research and Experimental Development, Higher Education Organisations, Australia, 1981* (8111.0); *Research and Experimental Development, All Sector Summary, Australia 1981–82* (8112.0). Results for the Private Non-profit Sector were included in catalogue 8112.0. Results of the Inter Year Survey, 1983–84 are contained in the ABS publication: *Research and Experimental Development, Business Enterprises (Inter Year Survey), Australia, 1983–84* (8114.0). Some preliminary results for the sixth survey are available and can be found in the ABS publications: *Research and Experimental Development, Business Enterprises, Australia, 1984–85, Preliminary* (8105.0); *Research and Experimental Development, General Government and Private Non-profit Organisations, Australia, 1984–85, Preliminary* (8108.0) and *Research and Experimental Development, Higher Education Organisations, Australia, 1984, Preliminary* (8115.0).

A summary of results from the fifth survey is presented below. Some data are also presented from the 1983–84 Inter Year Survey of the Business Enterprise sector.

Business Enterprise Sector. The estimate of expenditure on R & D carried out in Australia by private and public business enterprises during 1981–82 is $341m at *current* prices. This represents a 39 per cent increase in expenditure compared with 1978–79. At *constant* (average 1979–80) prices, R & D expenditure is estimated to have decreased by 1 per cent over the same period.

The estimate of manpower effort devoted to R & D carried out by business enterprises during 1981–82 is 7,923 man-years. This represents a decrease of 8 per cent compared with 1978–79.

A summary of Business Enterprise R & D data for 1981–82 is shown in the tables below.

The estimate of expenditure on R & D carried out in Australia by private and public business enterprises during 1983–84 is $415m at *current* prices. This represents a 22 per cent increase in expenditure compared with 1981–82. At *constant* prices, R & D expenditure is estimated to have increased by 2 per cent between those years.

The estimate of manpower effort devoted to R & D carried out by business enterprises during 1983–84 is 7,558 man-years. This represents a decrease of 5 per cent compared with 1981–82.

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY BUSINESS ENTERPRISES, EXPENDITURE AT CURRENT AND CONSTANT PRICES
($m)

	1976–77	*1978–79*	*1981–82*	*1983–84(a)*
AT CURRENT PRICES				
Private enterprises	160.4	205.8	285.7	n.a.
Public sector business enterprises	42.4	40.0	54.8	n.a.
Total business enterprises	**202.8**	**245.8**	**340.5**	**(b)414.5**
AT CONSTANT (AVERAGE 1979-80) PRICES				
Private enterprises	n.a.	n.a.	n.a.	n.a.
Public sector business enterprises	n.a.	n.a.	n.a.	n.a.
Total business enterprises	**r269.7**	**r269.1**	**r265.4**	**(c)271.0**

(a) Current and constant prices have been adjusted to compensate for the effect of a coverage difference between the 1983–84 and previous surveys. (b) Sample survey: the standard error associated with this estimate is $22m. (c) Sample survey: the standard error is $14m.

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY BUSINESS ENTERPRISES (*a*), BROAD INDICATORS BY INDUSTRY OF ENTERPRISE (*b*)

Industry of enterprise		*Enterprises that carried out R & D (number)*			*R & D expenditure ($m)*			*Man-years of effort on R & D*		
ASIC code	*Description*	*1976–77*	*1978–79*	*1981–82*	*1976–77*	*1978–79*	*1981–82*	*1976–77*	*1978–79*	*1981–82*
11-15	*Mining (excluding services to mining)*	*22*	*17*	*23*	*7.0*	*9.7*	*22.6*	*446*	*315*	*381*
	Manufacturing—									
21	Food, beverages and tobacco	69	84	69	11.6	16.1	13.1	551	545	367
23-24	Textiles, clothing and footwear	27	22	16	2.1	1.4	0.8	106	42	24
25	Wood, wood products and furniture	22	24	19	0.9	1.6	1.7	50	55	43
26	Paper, paper products, printing and publishing	16	14	12	3.3	4.1	5.3	149	144	125
27	Chemicals, petroleum and coal products	115	118	124	27.1	35.2	53.1	1,335	1,381	1,231
28	Non-metallic mineral products	32	27	22	3.8	4.2	4.8	169	154	109
29	Basic metal products	36	35	27	19.0	20.9	27.4	903	776	673
31	Fabricated metal products	74	81	80	4.0	4.5	6.7	228	198	161
32	Transport equipment	44	47	51	14.6	15.6	31.9	761	604	903
334	Photographic, professional and scientific equipment	20	16	25	4.6	6.7	5.1	232	230	160
335	Appliances and electrical equipment	129	120	156	21.1	33.1	37.2	1,209	1,234	899
336	Industrial machinery and equipment	141	128	153	8.2	8.8	14.7	425	388	413
33	Total other machinery and equipment	290	264	334	33.9	48.6	56.9	1,866	1,851	1,472
34	Miscellaneous manufacturing	57	58	65	3.5	5.9	7.3	185	210	180
C	*Total manufacturing*	*782*	*774*	*819*	*123.9*	*158.1*	*209.1*	*6,306*	*5,960*	*5,287*
	Other industries—									
F	Wholesale and retail trade	90	112	103	9.2	11.4	11.9	381	390	290
63	Property and business services	182	169	203	11.2	14.2	18.5	532	472	465
8461	Research and scientific institutions	30	29	28	11.7	13.3	21.8	504	460	464
(*c*)	Other n.e.c.	62	85	70	39.8	39.1	56.6	1,177	1,030	1,034
16, D-I-K-L	*Total other industries*	*364*	*395*	*404*	*71.9*	*78.0*	*108.8*	*2,594*	*2,352*	*2,255*
	Total all industries	**1,168**	**1,186**	**1,246**	**202.8**	**245.8**	**340.5**	**9,343**	**8,626**	**7,923**

(*a*) Excludes enterprises in ASIC Division A. (*b*) 1978-79 and 1981-82 data are classified by the 1978 edition of ASIC; 1976-77 data are classified by the 1969 edition of ASIC. If the 1978 edition were used to classify the 1976-77 data shown here only minor differences would occur. (*c*) ASIC Codes 16, D, E, G-H, 61-62, J-L excluding ASIC class 8461.

Payments and Receipts for Patent Licence Fees and other Technical Know-How—Australian business enterprises have significantly supplemented their R & D efforts by either purchasing or licensing foreign or Australian technology. This activity is largely associated with transnational firms. The ABS has estimated that Australian enterprises paid $127m in 1981–82 for patent licences and other technical know-how of which $124m was remitted overseas. In 1981–82 Australian business enterprises received $17m from the sale of patent licences and other technical know-how; $12m of this was received from overseas sources.

PAYMENTS AND RECEIPTS FOR TECHNICAL KNOW-HOW BY BUSINESS ENTERPRISES, PAYMENTS AND RECEIPTS BY INDUSTRY OF ENTERPRISE
($m)

Industry of enterprise		*Payments for technical know-how*			*Receipts for technical know-how*		
ASIC code	*Description*	*1976–77*	*1978–79*	*1981–82*	*1976–77*	*1978–79*	*1981–82*
	Manufacturing—						
21	Food, beverages and tobacco	2.9	4.0	14.9	0.3	0.4	-
23-24	Textiles, clothing and footwear	1.4	1.2	1.4	n.p.	n.p.	-
25	Wood, wood products and furniture	0.1	1.2	1.2	n.p.	n.p.	-
26	Paper, paper products, printing and publishing	0.5			n.p.	0.1	n.p.
27	Chemicals, petroleum and coal products	16.1	27.4	36.3	2.4	3.2	3.6
28	Non-metallic mineral products	4.0	4.4	5.6	0.7	0.9	n.p.
29	Basic metal products	3.1	4.0	7.6	1.2	0.6	2.0
31	Fabricated metal products	1.4	1.4	3.3	0.8	1.3	0.7
32	Transport equipment	7.1	10.1	10.8	0.3	0.5	2.0
334, 335	Photographic, professional and scientific equipment, appliances and electrical equipment	12.4	18.6	11.7	0.6	0.9	1.3
336	Industrial machinery and equipment	3.8	3.3	3.2	0.6	0.2	0.2
33	Total other machinery and equipment	16.2	21.9	14.9	1.2	1.1	1.5
34	Miscellaneous manufacturing	3.1	3.9	3.3	0.5	0.5	0.9
C	*Total manufacturing*	*55.8*	*79.5*	*99.2*	*7.5*	*8.8*	*11.5*
	Other industries	*13.7*	*29.1*	*27.4*	*1.7*	*6.6*	*5.9*
	Total all industries	**69.5**	**108.6**	**126.6**	**9.2**	**15.4**	**17.4**

General Government Sector. The estimate of expenditure on R & D carried out in Australia by organisiations in the General Government Sector during 1981–82 is $708m at *current* prices. This represents a 51 per cent increase in expenditure compared with 1978–79. At *constant* (average 1979–80) prices, R & D expenditure is estimated to have increased by 4 per cent over the same period.

The estimate of manpower devoted to R & D carried out by general government organisations during 1981–82 is 17,683 man-years. This represents an increase of 1 per cent compared with 1978–79.

A summary of General Government R & D data for 1981–82 is shown in the tables below.

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY GENERAL GOVERNMENT ORGANISATIONS

R & D EXPENDITURE AT CURRENT AND CONSTANT PRICES
($m)

General government organisations	*1976–77*	*1978–79*	*1981–82(a)*
AT CURRENT PRICES			
Commonwealth	289.5	321.2	514.8
State	126.3	148.7	193.6
Total	415.8	469.9	708.3
AT CONSTANT (AVERAGE 1979-80) PRICES			
Commonwealth	398.9	380.8	403.8
State	164.6	161.7	160.0
Total	563.6	542.5	563.8

(a) Current price estimates for 1981–82 are not strictly comparable with those for earlier years, due to the payment for the first time by some authorities, of their contribution to staff superannuation funds. This discontinuity does not apply to the constant price estimates.

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY GENERAL GOVERNMENT ORGANISATIONS

R & D EXPENDITURE AND R & D MANPOWER BY SOCIO-ECONOMIC OBJECTIVE

	R & D expenditure ($m)			*Man-years of effort on R & D*		
Socio-economic objective	*1976–77*	*1978–79*	*1981–82*	*1976–77*	*1978–79*	*1981–82*
National security (defence)	*87.6*	*89.2*	*113.2*	*4,232*	*3,826*	*3,625*
Economic development—						
Agriculture	123.7	153.3	235.9	5,872	5,820	5,678
Forestry and fisheries	20.5	25.1	40.5	860	1,029	1,119
Mining (prospecting)—						
energy sources	4.3	2.3	12.0	201	70	244
other	10.0	10.1	9.1	397	348	236
Mining (extraction)—						
energy sources	0.1	0.8	5.0	—	24	124
other	5.8	5.7	8.7	245	214	228
Manufacturing	34.8	48.2	65.5	1,431	1,548	1,471
Construction	6.9	6.5	7.0	308	268	205
Energy	13.6	20.0	42.7	468	587	731
Transport	11.3	7.2	6.2	410	202	134
Communications	0.2	0.4	0.6	11	15	26
Economic services, n.e.c.	17.6	12.0	22.6	825	494	558
Total economic development	*248.9*	*291.6*	*455.9*	*11,028*	*10,618*	*10,754*
Community welfare—						
Urban and regional planning	3.0	1.3	2.8	128	53	81
Environment	25.4	35.1	36.7	1,163	1,166	876
Health	11.8	16.2	23.1	523	669	826
Education	2.3	1.8	2.7	162	72	99
Welfare	0.7	1.2	1.7	56	58	64
Community services n.e.c.	2.8	2.0	3.6	140	82	85
Total community welfare	*46.0*	*57.7*	*70.5*	*2,171*	*2,099*	*2,031*
Advancement of knowledge—						
Earth, ocean and atmosphere n.e.c.	18.2	8.0	34.3	511	345	542
General advancement of knowledge	15.3	23.5	34.5	594	535	731
Total advancement of knowledge	*33.4*	*31.4*	*68.7*	*1,105*	*880*	*1,272*
Total	**415.8**	**469.9**	**708.3**	**18,534**	**17,424**	**17,683**

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY GENERAL GOVERNMENT ORGANISATIONS

R & D EXPENDITURE AND R & D MANPOWER BY FIELD OF SCIENCE

	R & D expenditure ($m)			*Man-years of effort on R & D*		
Field of science	*1976–77*	*1978–79*	*1981–82*	*1976—77*	*1978–79*	*1981–82*
Natural sciences—						
Physical sciences	29.0	35.9	39.9	1,248	1,072	915
Chemical sciences	19.3	21.3	25.5	711	683	562
Biological sciences	56.6	43.6	76.1	2,043	1,539	1,657
Earth sciences	35.3	41.4	73.8	1,515	1,332	1,520
Engineering and applied sciences	127.0	142.1	205.2	5,679	5,478	5,587
Agricultural sciences	122.4	163.3	252.3	5,948	6,333	6,271
Medical sciences	7.9	9.4	13.2	393	420	503
Total natural sciences	*397.6*	*457.0*	*686.1*	*17,536*	*16,859*	*17,015*
Social sciences and humanities—						
Economics	9.0	3.0	6.7	466	157	208
Education	2.5	2.1	2.8	172	82	102
Management	0.9	1.7	0.4	42	65	13
Political science	0.1	0.1	0.1	3	3	2
Sociology	1.3	1.4	1.8	76	60	61
Information science	1.1	1.6	5.0	52	68	122
Other social sciences and humanities	3.4	3.1	5.4	185	130	158
Total social sciences and humanities	*18.1*	*12.9*	*22.2*	*996*	*564*	*667*
Total	**415.8**	**469.9**	**708.3**	**18,534**	**17,424**	**17,683**

Higher Education Sector. The estimate of expenditure on R & D carried out in Austalia by higher education organisations during 1981 is $453m at *current* prices. This represents a 39 per cent increase in expenditure compared with 1978. At *constant* (average 1979–80) prices, R & D expenditure is estimated to have increased by 7 per cent over the same period.

The estimate of manpower effort devoted to R & D carried out by higher education organisations during 1981 is 18,241 years. This represents an increase of 7 per cent compared with 1981.

A summary of Higher Education R & D data for 1981 is shown in the tables below.

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY HIGHER EDUCATION ORGANISATIONS
R & D EXPENDITURE AT CURRENT AND CONSTANT PRICES
($m)

Higher education organisations	*1976*	*1978*	*1981*
AT CURRENT PRICES			
Universities	239.9	318.8	443.5
CAE's	4.2	6.7	9.0
Total	**244.1**	**325.5**	**452.5**
AT CONSTANT (AVERAGE 1979–80) PRICES			
Universities	317.9	354.8	379.3
CAE's	5.7	7.1	7.8
Total	**323.5**	**361.9**	**387.2**

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY HIGHER EDUCATION ORGANISATIONS
R & D EXPENDITURE AND R & D MANPOWER BY SOCIO-ECONOMIC OBJECTIVE

	R & D expenditure ($m)							
	Excluding university overheads(a)			*Including university overheads(a)*		*Man-years of effort on R & D*		
Socio-economic objective	*1976*	*1978*	*1981*	*1978*	*1981*	*1976*	*1978*	*1981*
National security (defence)	*0.1*	*0.2*	*0.6*	*0.3*	*0.7*	*9*	*15*	*19*
Economic development—								
Agriculture	11.2	19.2	26.5	25.8	35.5	991	1,500	1,554
Forestry and fisheries	1.2	1.4	3.2	2.0	4.3	134	117	167
Mining (prospecting)—								
energy sources	0.2	0.2	1.4	0.3	1.8	24	17	64
other	0.4	0.7	1.4	1.1	1.8	47	62	67
Mining (extraction)—								
energy sources	0.2	0.2	0.7	0.3	1.0	18	18	44
other	0.5	1.3	1.9	1.8	2.4	44	96	104
Manufacturing	5.5	8.5	9.9	11.2	13.0	488	676	583
Construction	1.2	1.6	2.1	2.0	2.7	109	102	107
Energy	3.8	7.1	17.0	9.0	21.7	290	440	764
Transport	1.3	1.8	2.0	2.3	2.6	104	138	98
Communications	0.9	1.7	2.5	2.2	3.2	90	127	143
Economic services n.e.c.	6.4	9.6	16.8	12.2	21.0	461	644	677
Total economic development	*32.8*	*53.3*	*85.4*	*70.1*	*110.9*	*2,800*	*3,936*	*4,372*
Community welfare—								
Urban and regional planning	1.4	1.8	3.0	2.5	4.0	123	157	161
Environment	3.1	3.6	4.3	4.7	5.7	258	248	256
Health	20.5	47.4	68.2	56.9	87.3	1,412	2,484	3,345
Education	5.4	9.0	13.4	11.4	18.1	494	602	923
Welfare	1.0	2.6	4.4	3.3	5.7	73	167	202
Community services n.e.c.	3.0	6.4	8.7	8.1	11.3	184	398	427
Total community welfare	*34.4*	*70.8*	*102.0*	*86.9*	*132.1*	*2,544*	*4,057*	*5,314*
Advancement of knowledge—								
Earth, ocean and atmosphere n.e.c.	8.2	12.9	20.1	17.6	26.3	700	1,011	1,019
General advancement of knowledge	108.9	116.3	135.9	150.7	182.4	9,233	8,030	7,516
Total advancement of knowledge	*117.1*	*129.3*	*156.0*	*168.2*	*208.7*	*9,933*	*9,040*	*8,535*
Total	**184.3**	**253.6**	**344.0**	**325.5**	**452.5**	**15,290**	**17,047**	**18,241**
Universities' contribution	180.1	246.9	335.1	318.8	443.5	14,929	16,521	17,699
CAEs' contribution	4.2	6.7	9.0	6.7	9.0	361	526	542

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY HIGHER EDUCATION ORGANISATIONS
R & D EXPENDITURE AND R & D MANPOWER BY FIELD OF SCIENCE

	R & D expenditure ($m)							
	Excluding university overheads(a)			*Including university overheads(a)*		*Man-years of effort on R & D*		
Field of science	*1976*	*1978*	*1981*	*1978*	*1981*	*1976*	*1978*	*1981*
Natural sciences—								
Physical sciences	21.4	27.6	38.4	34.4	49.1	1,485	1,638	1,672
Chemical sciences	14.4	18.3	22.1	23.9	29.1	1,136	1,261	1,143
Biological sciences	29.6	43.4	53.9	56.5	73.2	2,518	2,976	3,089
Earth sciences	9.0	10.3	14.4	13.6	18.8	748	750	648
Engineering and applied sciences	19.6	28.0	40.0	36.2	51.4	1,786	2,073	2,145
Agricultural sciences	11.3	18.1	25.2	24.7	33.7	1,096	1,380	1,428
Medical sciences	25.9	38.6	47.3	45.2	59.7	1,692	1,802	2,274
Total natural sciences	*131.2*	*184.3*	*241.3*	*234.5*	*315.1*	*10,461*	*11,879*	*12,399*
Social sciences and humanities—								
Economics	6.4	10.0	12.3	12.1	15.2	463	507	462
Education	6.8	7.9	11.7	11.0	16.2	681	790	891
Management	0.7	0.8	3.1	1.0	3.7	40	61	120
Political science	1.5	3.7	5.6	4.8	7.4	121	259	297
Sociology	2.1	3.5	5.0	4.7	6.7	215	274	257
Other social sciences and humanities	35.6	43.4	65.1	57.4	88.3	3,308	3,280	3,813
Total social sciences and humanities	*53.1*	*69.3*	*102.7*	*91.0*	*137.4*	*4,828*	*5,169*	*5,840*
Total	**184.3**	**253.6**	**344.0**	**325.5**	**452.5**	**15,290**	**17,047**	**18,241**

(a) University overhead R & D expenditure is an estimate of the R & D component of capital and current expenditures associated with academic services and general university services. See catalogue 8111.0 for further details.

Private Non-profit Sector. The estimate of expenditure on R & D carried out in Australia by Private Non-profit organisations during 1981–82 was $21m at *current* prices. This represents a 66 per cent increase in expenditure compared with 1978–79.

A cheap and efficient method of translating English text into Braille, developed by an Australian computer hobbyist, has improved the educational opportunities for blind and visually impaired children.
Australian Information Service

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY PRIVATE NON-PROFIT ORGANISATIONS
R & D EXPENDITURE AND R & D MANPOWER BY SOCIO-ECONOMIC OBJECTIVE

	R & D expenditure ($'000)			*Man-years of effort on R & D*		
Field of science	*1976–77*	*1978–79*	*1981–82*	*1976–77*	*1978–79*	*1981–82*
National security (defence)	—	—	—	—	—	—
Economic development—						
Agriculture	95	30	36	6	1	3
Forestry and fisheries	—	75	—	—	1	—
Mining (prospecting)—						
energy sources	—	—	—	—	—	—
other	—	—	—	—	—	—
Mining (extraction)—						
energy sources	—	—	—	—	—	—
other	—	—	—	—	—	—
Manufacturing	13	—	—	1	—	—
Construction	—	—	—	—	—	—
Energy	16	10	3	3	1	1
Transport	35	68	196	2	3	12
Communications	—	—	—	—	—	—
Economic servicese n.e.c.	70	169	512	4	6	18
Total economic development	*229*	*352*	*747*	*16*	*13*	*34*
Community welfare—						
Urban and regional planning	21	35	—	1	4	—
Environment	2	9	—	2	—	—
Health	8,863	9,979	17,758	476	448	563
Education	990	1,554	1,739	59	65	63
Welfare	44	61	420	4	4	22
Community services n.e.c.	116	2	35	5	1	1
Total community welfare	*10,036*	*11,641*	*19,952*	*547*	*522*	*649*
Advancement of knowledge—						
Earth, ocean and atmosphere n.e.c.	6	150	—	—	3	—
General advancement of knowledge	442	422	210	16	9	6
Total advancement of knowledge	*448*	*572*	*210*	*16*	*12*	*6*
Total	**10,712**	**12,566**	**20,909**	**579**	**546**	**688**
Total Expenditure at constant (1979-80) prices ($m)	13.8	13.7	16.9			

RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY PRIVATE NON-PROFIT ORGANISATIONS,
R & D EXPENDITURE AND R & D MANPOWER BY FIELD OF SCIENCE

	R & D expenditure ($'000)			*Man-years of effort on R & D*		
Field of science	*1976–77*	*1978–79*	*1981–82*	*1976–77*	*1978–79*	*1981–82*
Natural sciences—						
Physical sciences	76	105	183	4	2	6
Chemical sciences	118	112	67	6	2	2
Biological sciences	1,327	2,277	1,668	68	83	48
Earth sciences	11	21	3	1	–	1
Engineering and applied sciences	71	187	220	5	6	14
Agricultural sciences.	2	36	36	–	2	3
Medical sciences	7,465	7,898	15,962	397	370	510
Total natural sciences	*9,070*	*10,636*	*18,139*	*481*	*465*	*583*
Social sciences and humanities—						
Economics.	24	134	413	1	3	15
Education	1,000	1,557	1,743	60	65	58
Management	5	–	5	–	–	–
Political science	–	–	–	–	–	–
Sociology	121	91	73	11	8	4
Information science	–	9	40	–	1	1
Other social sciences and humanities	492	138	497	25	5	28
Total social sciences and humanities.	*1,642*	*1,930*	*2,770*	*97*	*81*	*105*
Total	**10,712**	**12,566**	**20,909**	**579**	**546**	**688**

Major Government Research Agencies

Information on the science and technology activities and expenditures of Commonwealth Government Ministries and their agencies is provided in the *Science and Technology Statement 1984-85*. Total science and technology expenditures projected by the Commonwealth Government in 1984–85 are shown as $1,851m, of which $1,020m was allocated to research and experimental development.

Commonwealth Scientific and Industrial Research Organization (CSIRO)

The CSIRO is the largest scientific research organisation in Australia. On 30 June 1985 it had a total staff of 7,195 people located in more than 100 laboratories and field stations throughout Australia. About one-third of the staff are scientists.

It is a statutory body established by the *Science and Industry Research Act 1949*. Under the Act, CSIRO replaced the former Council for Scientific and Industrial Research, established in 1926. The organisation was restructured by amendments to the Act in 1978.

Briefly, the functions of CSIRO are:

- conduct of scientific research and application of the results;
- research training and funding;
- maintenance of measurement standards;
- publication and dissemination of scientific information.

When the organisation was first set up, its research centred on solving the problems then facing agriculture and industry. Today, its research extends not only to those areas but into others affecting every Australian—the environment, human nutrition, energy, water resources and information technology.

CSIRO is governed by an Executive comprising three full-time members, including the Chairman, and five part-time Members. An Advisory Council and advisory committees in each State and the Northern Territory, have members appointed to represent the range of interests in the Australian community.

CSIRO's research is carried out in some forty-one Divisions and two smaller units, grouped into the following five Institutes.

Institute of Animal and Food Sciences: Divisions of Animal Health, Animal Production, Fisheries Research, Food Research, Human Nutrition, Molecular Biology, Tropical Animal Science, Australian Animal Health Laboratory, Wheat Research Unit.

Institute of Biological Resources: Divisions of Entomology, Forest Research, Horticultural Research, Centre for Irrigation Research, Plant Industry, Soils, Tropical Crops and Pastures, Water and Land Resources, Wildlife and Rangelands Research, Laboratory for Rural Research.

Institute of Energy and Earth Resources: Divisions of Energy Chemistry, Energy Technology, Fossil Fuels, Geomechanics, Groundwater Research, Mineral Chemistry, Mineral Engineering, Mineral Physics and Mineralogy, Minerals and Geochemistry.

Institute of Industrial Technology: Divisions of Applied Organic Chemistry, Building Research, Chemical and Wood Technology, Manufacturing Technology, Protein Chemistry, Textile Industry, Textile Physics.

Institute of Physical Sciences: Divisions of Applied Physics, Atmospheric Research, Chemical Physics, Environmental Mechanics, Information Technology Materials Science, Mathematics and Statistics, Oceanography, Radiophysics.

The main role of the Organisation is to plan and execute a comprehensive program of general scientific research on behalf of the Commonwealth.

Research is carried out mainly in the physical and biological sciences, with the emphasis on strategic research. Strategic research is undertaken to achieve practical results and is characterised by its orientation towards the basic research end of the research and development spectrum.

The transfer of research results into commercial use or other beneficial applications is a principal aim of CSIRO. Early in 1985 the Minister lauched CSIRO's new industrial company SIROTECH. The company sees its main role as the commercialisation of CSIRO research, but also acts as a national technology transfer body. Other activities are undertaken to the extent that they can be carried out conveniently in conjunction with the Organization's main research and technology transfer activities.

Areas of research presently designated as growth areas are:

- Biotechnology;
- Raw materials processing;
- Manufacturing technologies;

- Human nutrition;
- Information technologies;
- Water and soils;
- Plant diseases;
- Space science and technology.

In 1984-85, CSIRO had a budget of approximately $380m. About ninety per cent of CSIRO's funds comes directly from the Australian Government and trust funds concerned with various primary industries.

Australian Government Analytical Laboratories (AGAL)
See entry on page 639.

Antarctic Division, Department of Science

Australia has been active in research and exploration in the Antarctic region since early this century, but the overall effort has expanded appreciably since 1947 when the Government established the Australian National Antarctic Research Expeditions (ANARE) co-ordinated by the Antarctic Division of the Department of Science.

The Antarctic Division formulates and develops Australia's policies on Antarctic matters consistent with Government objectives; administers the Australian Antarctic Territory and the sub-Antarctic islands under Australian jurisdiction; organises and provides logistic support for the ANARE, including establishment and maintenance of the Antarctic stations at Casey, Davis and Mawson and the sub-Antarctic station at Macquarie Island; and plans and conducts scientific programs approved by the Antarctic Science Advisory Committee (ASAS).

The Australian Antarctic scientific program encompasses research in marine and terrestrial biology, oceanography, earth sciences, glaciology, cosmic ray and upper atmosphere physics, meteorology, bathymetry, medical research, surveying and mapping. Each year, the Antarctic Division, universities and private and public research organisations are invited to submit research proposals to ASAS.

Australia is a signatory to the Antarctic Treaty, and many of its scientific activities in Antarctica are undertaken in collaboration with other signatory countries.

Bureau of Meteorology
See entry on page 640.

Australian Institute of Marine Science (AIMS)

The AIMS is located on a 190 hectare site within a national park at Cape Ferguson, 50 kilometres south of Townsville in North Queensland. Comprehensive facilities include laboratories, lecture theatre, library, computer centre, administrative and other support services, a harbour and an ocean-going research vessel.

The Institute's main function is to undertake research; in this regard its activities focus on contributing to an understanding of the tropical marine environment and its associated living communities. Attention is currently concentrated on coral reef and mangrove ecosystems. A multidisciplinary approach is taken to investigate the character of these systems and the manner in which their productivity, diversity, stability and other essential attributes are affected by environment, adaptation and ecological interactions. A significant proportion of the Institute's investigations is undertaken by external collaboration, with an active visiting investigator program being an important means of achieving that objective. The interests of the research staff are necessarily diverse and include physical oceanography, marine chemistry and various aspects of biology, from biochemistry to trophodynamic ecology.

Defence Science and Technology Organisation (DSTO)

The DSTO, part of the Department of Defence, conducts a significant amount of research and development, mainly in engineering and the physical sciences. Current expenditure is about $130m per year. Further details on the work of the organisation, and its ten research and testing establishments are found in Chapter 4, Defence.

Australian Atomic Energy Commission (AAEC)

For information on the AAEC see Chapter 18, Energy.

Engineering Division, Department of Housing and Construction

To support its operations as the major design and construction authority for the Commonwealth, the Department of Housing and Construction carries out applied research and

laboratory testing and provides a comprehensive range of technical services. In many cases, these services directly or indirectly benefit the needs of private industry and the public.

Research and special testing is conducted mainly by the Engineering Division at establishments such as the Experimental Building Station in Sydney, which specialises in building and building components, and the Central Investigation and Research Laboratory in Melbourne, which specialises in engineering materials and products. The Experimental Building Station undertakes sponsored tests for industry for a fee.

Ionospheric Prediction Service

See entry on page 640.

Telecom Australia Research Laboratories

Telecom Australia maintains significant facilities and a staff of approximately 500 for the performance of research and development in telecommunications science and technology.

The primary objective of Telecom's research and development is to evaluate world advances in telecommunications services and systems so that it can select those best suited to the Australian environment. It also applies its research and development facilities to the solution of technical problems arising in the operation of the Australian telecommunications network. Its research and development is co-ordinated with that of industry and academia involved in telecommunications; Telecom supports their efforts with R & D contracts and grants made through the Australian Computer Research Board and the Radio Research Board.

Research in Universities and Colleges of Advanced Education

The Commonwealth Government is the primary source of funding for research activities in universities. Over half of Commonwealth funding is provided under the *States Grants (Tertiary Education Assistance) Act* which is administered by the Commonwealth Tertiary Education Commission. The general recurrent grants received by universities incorporate funding for research purposes. In addition, special research grants are available for members of academic staff to develop their research activities, for the training of research workers and for post-doctoral fellowships.

The Government is continuing to fund nine Special Research Centres at a cost of $16.5 million over the 1985–87 triennium. These centres were established in 1981 in various universities under the then Commonwealth Program for the Promotion of Excellence in Research.

Over the 1985–87 triennium a further $3 million in Commonwealth funds will enable new Key Centres of Teaching and Research to be established in universities and CAEs, to provide high level activity in key fields important to national objectives.

Apart from Key Centres of Teaching and Research, CAEs do not receive special funding for research purposes under the *States Grants (Tertiary Education Assistance) Act*. However, individual members of academic staff are encouraged to seek support for applied research.

Research Organisations Associated with Education Institutions

In recent years there has been an increase in outside support for research in universities and colleges of advanced education. One source has been research contracts for specific projects from government and industry.

A number of the tertiary education institutions have established independent, commercial companies to promote and manage research and consultancy services to industry, commerce, government and the community. Examples are: Unisearch Ltd, associated with the University of New South Wales; ANUTECH Pty Ltd, associated with the Australian National University; Wait-Aid Ltd, associated with the Western Australian Institute of Technology; Technisearch Ltd, associated with the Royal Melbourne Institute of Technology; SAARD, associated with the Swinburne Institute of Technology; Techsearch Inc., associated with the South Australian Institute of Technology; and The University of Newcastle Research Association.

These organisations play an important role in promoting communications between the Higher Education and other sectors. They undertake investigational and research projects and provide consultancy, technical information and testing services in a range of fields including engineering, management, marketing and the social sciences.

Social Science and Humanities Research

Research in the social sciences and humanities is undertaken primarily in universities ($137m out of an Australian total of $162m for 1981–82). Support for this research comes both from general funds, provided to the universities and from specific granting schemes such as the ARGS.

The bulk of the social science and humanities research carried out within Commonwealth Government agencies is performed as part of the general activities of various departments. In addition, several other Commonwealth Government agencies have an active interest in either sponsoring or undertaking such research. These include the Australian Institute of Aboriginal Studies, the Australian Institute of Criminology, the Bureau of Industry Economics, the Bureau of Agricultural Economics, the Bureau of Transport Economics, the Bureau of Labour Market Research, the Institute of Family Studies and the Australian Institute of Multicultural Affairs.

Agencies of the various State governments undertake research relevant to their own activities. A number of research organisations in the transport sphere are funded from both Commonwealth and State sources. The Australian Road Research Board and the Australian Railway Research and Development Organisation are active in social science research.

Exchange of ideas and information on the social sciences is promoted through a number of professional and learned bodies, of which the Australian and New Zealand Association for the Advancement of Science and the Academy of Social Sciences in Australia are the most broadly based. In addition to encouraging the advancement of the social sciences, the Academy sponsors and organises research, subsidises publications and acts as a consultant and advisor in the social sciences field.

Non-government bodies which undertake or promote research in specific fields of the social sciences include the Australian Institute of International Affairs, the Australian Institute of Urban Studies, and the Australian Institute of Political Science.

International Activities

International Organisations

Australia participates in a range of programs and projects of United Nations and other organisations (UNESCO, OECD, United Nations Economic Program, World Meteorological Organisation, World Intellectual Property Organisation and International Atomic Energy Association) and in the activities of both governmental and non-governmental scientific organisations. To facilitate scientific and technological liaison, the Commonwealth Government has scientific representation at Tokyo, Paris (OECD), London, Bonn and Washington. In November 1982, Australia was elected a member of the Intergovernmental Oceanographic Commission Executive Council. Australia also participates in regional collaborative programs organised by the Economic and Social Commission for Asia and the Pacific, the Association of South-East Asian Nations (ASEAN), the Association for Science Co-operation in Asia, the Commonwealth Science Council and the Pacific Science Association. Technical assistance is provided for countries in the region under both multilateral and bilateral arrangements.

Participation in international non-governmental scientific bodies is arranged through learned and professional bodies. For example, the Australian Academy of Science provides representation to the International Council of Scientific Unions (ICSU) and a number of its affiliated bodies.

Antarctic Treaty and Conservation of Antarctic Marine Living Resources

In 1957, as part of the International Geophysical Year (IGY), twelve nations including Australia co-operated in research programs in Antarctica. The outstanding co-operation between nations in the Antarctic during the IGY resulted in discussions which culminated in the establishment of the Antarctic Treaty. It was signed on 1 December 1959 by the nations that had been active in Antarctica during the IGY, including all of those with territorial claims. The original signatories were Argentina, Australia, Chile, France, New Zealand, Norway, UK, Belgium, Japan, South Africa, the USSR and the USA. Since then, six additional nations have been accorded consultative status. They are: Poland, the Federal Republic of Germany, India, Brazil, China and Uruguay. The Treaty, which was ratified by Australia in 1961, among other things reserves the Antarctic area south of 60°S latitude for peaceful purposes, provides for international co-operation in scientific investigations and research, and preserves for the duration of the Treaty the legal positions of signatories to the Treaty with regard to territorial sovereignty, rights and claims.

The Treaty makes provision for other states with non-consultative status to accede to it. Fourteen nations have acceded: German Democratic Republic, Czechoslovakia, Romania, Denmark, the Netherlands, Papua New Guinea, Peru, Italy, Bulgaria and Spain.

Australia hosted the first Antarctic Treaty Consultative Meeting in July 1961 and the twelfth in September 1983. Observers from the contracting parties to the Treaty, which are not also consultative parties, were invited for the first time to the twelfth meeting held in Canberra in September 1983.

The consultative parties have formulated a number of measures to protect the Antarctic environment and ecosystem. The environment of the Australian Antarctic Territory is protected by the *Antarctic Treaty (Environment Protection) Act 1980*, and by recommendations of Treaty meetings that the Australian Government has adopted.

At a diplomatic conference in Canberra in May 1980 the Treaty consultative partners adopted the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). The Convention establishes the basis for a conservation and management regime for the entire ecosystem of the area south of the Antarctic Convergence (about 45° to 56°S). The headquarters of the CCAMLR Commission, established under the Convention, is in Hobart. Twenty nations and the European Community have signed the Convention which is open to accession by any country. Australia was elected to provide the first Chairman of the Commission, and an Australian has been appointed as first Executive Secretary.

Australia is also participating in meetings to negotiate a regime to regulate exploration for and exploitation of Antarctic minerals. The first meeting was held in Wellington, New Zealand, in June 1982. The most recent meeting was in Paris in September 1985.

Studentships and Fellowships

Australia has assisted other countries, principally in the Asian and Pacific regions, by training their nationals. Large numbers of such students, mainly seeking first qualifications at tertiary level, have been accommodated under schemes such as the Colombo Plan. There are also arrangements under which established scientists from overseas are assisted to undertake study and research in Australia.

Bilateral Arrangements

Various bilateral arrangements at both government and non-government levels have contributed to the development and maintenance of co-operation in science and technology between Australian institutions and scientists and those in other countries. Formal bilateral agreements reflect two major aspects: the importance of a regular flow of scientific and technological information into Australia; and the significance of Australian science, technology and industrial property systems in assisting the economic growth of less developed countries. These agreements, solely devoted to scientific and technological co-operation, have been entered into with the USA (1968), India (1975), the USSR (1975), the Federal Republic of Germany (1976), Japan (1980), the Peoples Republic of China (1980) and Mexico (1981). Support is provided for both individual visits and specialist seminars over the whole range of civil science. Where opportunities exist, other co-operative projects which depend on special facilities are supported.

A scientific exchange program between the Australian Academy of Science and the Academia Sinica of Beijing was initiated in 1977. Scientific fields considered most promising are plant physiology, entomology, earth science and radio astronomy.

Visits to Japan and China by Australian scientists can be supported by the Australia/Japan Foundation and the Australia/China Council respectively.

Meteorology

Australia is a member of the World Meteorological Organization (WMO), with the Director of Meteorology being Australia's Permanent Representative on WMO.

Optical Astronomy

The Anglo-Australian Telescope Board was established under the provisions of an international agreement between Australia and the United Kingdom and draws its funds in equal shares from each country. It operates the 3.9 metre Anglo-Australian Telescope at Siding Spring Mountain near Coonabarabran in New South Wales; the Telescope is among the largest in the world and came into full scientific operation during 1975. Its technical excellence and the scientific work which it has made possible have made it widely recognised as one of the world's foremost optical telescopes.

Space

An agreement by the Governments of Australia and the USA to co-operate in the establishment and operation in Australia of space vehicle tracking stations was signed in 1960

and has been renewed since then at ten-year intervals. The agencies for the Australian and US Governments are the Department of Science and the National Aeronautics and Space Administration (NASA) respectively.

As part of the world-wide network supporting NASA's space program, the Australian stations track spacecraft in their orbits around the earth or on their journeys into space, receive telemetred data from the spacecraft, and relay radio commands controlling the spacecraft.

The Department of Science is responsible for managing, staffing and operating the tracking stations on behalf of NASA. The stations are located at Tidbinbilla in the Australian Capital Territory and at Yarragadee in Western Australia. A communications system links them with control centres in the US.

Expenditure by NASA on its tracking station operations in Australia in 1984–85 was about $13m.

An agreement was signed in 1979 between the Commonwealth Government and the European Space Agency (ESA) for the establishment and operation of a space vehicle tracking facility in Australia in support of ESA programs. The facility is located at the site of the Overseas Telecommunications Commission (Aust.) earth station at Carnarvon, W.A.

Seismology

A comprehensive seismic station at Alice Springs (Joint Geological and Geophysical Research Station) is operated jointly under an agreement between the Governments of Australia and the United States of America. The agencies for the Governments are, respectively, the Department of Resources and Energy and the United States Air Force.

The station provides continuous seismic records to assist the United States Government in the identification of underground nuclear explosions and provides seismic records to the Bureau of Mineral Resources. Records are also available, through the Department of Resources and Energy, to Australian scientists for research in earth physics.

Defence

In the field of defence science, Australia collaborates with other countries through a variety of arrangements at intergovernmental level. Futher information including defence science technology arrangements is given in Chapter 4, Defence.

Transport

Through a variety of arrangements at intergovernmental level, Australia is represented at Federal and State levels in a number of international organisations concerned with transport research. Further information is given in Chapter 20, Transport and Communications.

Other

At the non-governmental level, formal arrangements for scientific co-operation with counterpart institutions in other countries have been concluded by a number of Australian bodies. For example, an arrangement covering co-operation in astronomy exists between the University of Sydney and Cornell University (USA), while over a broader area the Australian National University has an arrangement with the University of Moscow which includes exchanges in the scientific fields.

Additional information

Additional information on topics presented in this chapter may be found in the annual reports of the organisations mentioned, particularly the Department of Science, the Department of Industry, Technology and Commerce, the CSIRO and its divisions, the Australian Atomic Energy Commission, the Department of Defence, the Australian Industrial Research and Development Incentives Board and in the annual *Science and Technology Statements*. Statistical information for the years 1968–69, 1973–74 and 1976–77 may be found in the reports published by the (then) Department of Science and Technology on Project SCORE. Statistical information relating to 1978–79, 1981–82 and 1984–85 may be obtained from the Australian Bureau of Statistics (ABS). See paragraphs on expenditure and human resources devoted to Research and Experimental Development (in this chapter) for details of ABS publications.

In 1984 the OECD, at Australia's request, examined ways in which Australian science and technology policies may be developed in the next five years, with particular attention to existing aims, to strengthen Australia's scientific and technological capabilities, develop new

and revitalised industries and achieve greater co-ordination between science and technology policies and economic, industry, education, manpower and social policies. The OECD response was published in 1985 and was the subject of considerable public discussion.

During 1985 Australia launched AUSSAT communications satellites. Further information is given in Chapter 20, Transport and Communication.

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IN RETROSPECT ..... **Year Book No 19 (1926)**

The initial step towards the establishment of a Solar Observatory in Australia was taken on 4th March, 1907, when, as the result of a letter communicated to the press of South Australia, inquiry was made into the possibility of the Adelaide Observatory undertaking this work. Subsequently the movement received the support of the International Solar Union, the Royal Society, the British Association for the Advancement of Science, the Australasian Association for the Advancement of Science, the Smithsonian Institution, and various other scientific bodies throughout the world, and in April, 1908, a memorandum was presented to the Prime Minister setting forth the reasons why a solar station in Australia is desirable. As the result of inquiries among the State Observatories, it was found that none of them had the necessary funds or equipment for undertaking the work.....

As a result of the public support which the movement had received, in December, 1909, the Prime Minister took the first official action towards the establishment of the Observatory by accepting the gift of a 9-inch refracting telescope from Mr. James Oddie, of Ballarat, and by placing on the Estimates a sum of money sufficient for the erection of a temporary building within the Federal Capital area wherein to house the telescope in order that the suitability of this site might be examined. On 19th March, 1910, a conference of surveyors at Canberra, attended also by the Government Astronomer of Victoria, and by the Commonwealth Meteorologist, recommended that Mount Stromlo should be the site of the temporary observatory.

AUSTRALIA AND COMET HALLEY, 1985–1986

(This special article has been contributed by the Mount Stromlo and Siding Spring Observatories, Australian National University)

The return of Comet Halley to the inner solar system during 1985–86 has resulted in the most intensive observational effort ever devoted to a single astronomical object. Australian astronomers, as part of the International Halley Watch network, are playing a major role in this effort.

Comet Halley was named in honour of the noted English astronomer and mathematician, Edmond Halley (1656–1742) who in 1705 published calculations showing that comets observed in 1531, 1607 and 1682 were really the one comet. He predicted its return in 1758 and it was sighted late that year, passing perihelion (nearest point of orbit to the sun) in March 1759.

Later calculations identify it with the large bright comet seen during the Norman Conquest of England in 1066 and with other comet sightings at intervals of about 76 years from 240BC.

Bright comets have always been a source of wonder, excitement and (in past times) fear; even today the physical and chemical composition of comets is not fully understood. The present apparition of Comet Halley provides an unprecedented opportunity to vastly increase our knowledge of these visitors from the outer limits of our solar system.

Comets are thought to enter the solar system from a vast swarm of primordial debris known as the Oort cloud. This cloud contains the remnants of material from the time of formation of the solar system and is thought to extend about 2 light years (19,000,000,000,000 km) beyond the known planets. Occasionally, about once every 100,000,000 years, another star passes close to the Oort cloud. The gravitational effects of this passage 'scramble' the orbits of the comets and some begin to fall in towards the sun. The comet thus becomes an infalling sample of the solar system's remote past, and by studying it astronomers can learn something of what the conditions were that led to the evolution of the solar system and, ultimately, to human life.

When they first leave the Oort cloud, comets are small bundles of ices (mainly water with traces of hydrocarbon nitrocarbon compounds) and dust, up to a few tens of kilometers in diameter. As they approach the sun, solar radiation heats the comet and the ice and gasses boil out of it. Interaction with the solar wind (the stream of charged particles that flow out of the sun) blows the gasses back from the head of the comet and causes them to fluoresce forming an ion tail which always points away from the sun. Dust particles are also lost from the comet and are strewn along the comet's orbit to form a dust tail which may lie in a different direction to the ion tail. When a comet is close to the sun it thus consists of a head (or nucleus), surrounded by a coma (the bright gasses expelled from the nucleus) and having an ion tail of fluorescent gasses and a dust tail. Also surrounding the nucleus is an immense cloud of atomic hydrogen, coming from the breaking up of water molecules in the coma; this hydrogen cloud may grow to the size of the sun.

Most comets fall into elliptical orbits around the sun, with the sun at one focus and a point in the Oort cloud at the other, returning to the inner solar system at long intervals (up to millions of years). Over several passages this orbit may be severely perturbed by the gravitational effects of the planets, particularly Jupiter, and the comet may become 'trapped' inside the solar system, having a shorter orbital period and never returning to the Oort cloud.

The importance of Comet Halley lies in the fact that it is the only fairly young comet for which the period is accurately known, and which has predictable return dates in the near future. It is therefore possible to plan experiments well ahead of the expected return time. During the current passage, Comet Halley will be studied from ground-based observatories, and from a fleet of spacecraft which will rendezvous with the comet in March, 1986. Australian astronomers have a vital role to play in these observations since during the time when the comet is at maximum brightness during March and April, 1986, and at the time of its closest approach to earth on April 11, 1986, Comet Halley will be far south in the sky, inaccessible to the major observatories in the northern hemisphere.

The CSIRO radio telescope at Parkes, N.S.W. is the vital link in communication with the most complex of the spacecraft, the European Space Agency's GIOTTO, due to pass within 500 km of the comet nucleus on March 13, 1986. GIOTTO carries cameras which may provide our first close-ups of a cometary nucleus, as well as experiments designed to sample the chemistry and magnetic fields inside the comet. Since there is a high probability that GIOTTO will be destroyed during its 'close encounter', all data is instantly transmitted to Parkes, thence to Darmstardt, West Germany, for processing. As well as monitoring the GIOTTO encounter, CSIRO scientists will use the Parkes telescope and their smaller millimeter-wave telescope at Epping, N.S.W., to investigate the hydrogen halo and the molecular compounds present in the comet.

From Mount Stromlo, near Canberra, A.C.T., astronomers of the Australian National University's Mount Stromlo and Siding Spring Observatories will be observing Comet Halley at optical wavelengths using the observatory's 1.9 m and 0.8 m telescopes and advanced technology detectors designed and built at the observatories. Experiments planned from Mount Stromlo concentrate on spectroscopic studies, investigating the detailed physical and chemical make-up of the comet, plus infra-red studies, investigating the complex molecules and dusty compounds in the comet.

At the A.N.U.'s Siding Spring Observatory, near Coonabarabran, N.S.W., no less than eight optical telescopes will be involved in the onslaught on Comet Halley. These telescopes include some of the world's most modern telescopes; the brand-new A.N.U. 2.3 m Advanced Technology Telescope (the ATT), the Anglo-Australian Observatory's 3.9 m reflector (the AAT), and the United Kingdom Science and Engineering Research Council's 1.2 m Schmidt camera.

Experiments planned for the AAT, the largest and best-equipped telescope in the southern hemisphere, concentrate on the detailed structure of the comet. The observations include photography of the comet's head, using both conventional cameras and charge-coupled diode arrays (CCDs), and infra-red spectroscopy, which provides information about the molecules and gasses present in the comet.

The most spectacular photographs of Comet Halley are likely to come from the U.K. Schmidt. This telescope is specially designed to have a wide field of view and will be able to photograph both the head and tail of the comet on the one plate for most of the comet's passage. The Schmidt has been photographically monitoring Comet Halley since August, 1985.

A.N.U. astronomers at Siding Spring will be using six telescopes, ranging in size from the 2.3 m ATT to an ultra-high-speed 20 cm Schmidt camera. A full range of optical investigations is planned; photography, mapping the changing structure of the comet; photometry, monitoring the brightness and colour; polarimetry, investigating the interaction of the comet with the solar magnetic field, and the nature of the dust particles; infra-red observations, studying the molecules and dust; and spectroscopy, the most powerful tool of the astronomer, providing detailed measurements of the physics and chemistry of the comet. Prime telescope will be the 2.3 m, which has the unique facility of being able to change the mode of observation in a matter of seconds, making it possible to run, e.g., spectroscopic and photographic observations practically simultaneously. Coupled with the Mount Stromlo Photon Counting Array, the most advanced light-detecting system in the world, the 2.3 m has a major role to play in the study of Comet Halley.

By the time that Comet Halley leaves the inner solar system toward the end of 1986 the efforts of Australian astronomers will have vastly increased our knowledge of comets, our solar system, and the first steps in the evolution of life.