

CHAPTER 28

SCIENCE AND TECHNOLOGY

Further and more detailed information on topics presented in this chapter may be found in the annual reports of the organisations mentioned, particularly the Department of Science, the CSIRO and its divisions, the Australian Atomic Energy Commission, and the Department of Defence. Statistical information may be found in the reports published by the Department of Science on Project SCORE (see page 997) and in the companion report published by the then Office of Secondary Industry of the Department of Trade and Industry *Survey of Industry Research and Development in Australia 1968-69*. More recent data on manufacturing industry is to be found in Department of Manufacturing Industry Bulletin No. 11, November 1974 *R & D in Manufacturing Industry 1971-72*.

In this chapter references will be found to other chapters of the Year Book which deal in greater detail with particular fields of research and development activity.

Overview

Prior to the 1914-18 war, Australian science was based largely on the individual achievements of a few outstanding scientists.

During and after that war, governments in various parts of the world took initiatives aimed at encouraging scientific research and its application to economic growth and national development. Australia was no exception, but the research was concentrated mainly in the government sector and was aimed primarily at agriculture; the universities and industry were little involved.

With the approach of the 1939-45 world war, however, moves were made to extend scientific support for secondary industry. In the CSIR (Council for Scientific and Industrial Research), Divisions created in the period 1937-40 were to play an important part in the rapid development of Australian industry that occurred under the stimulus of war-time needs.

When peace came, expansion of scientific research in general and industrial research in particular continued. This expansion extended beyond government into the universities and industry.

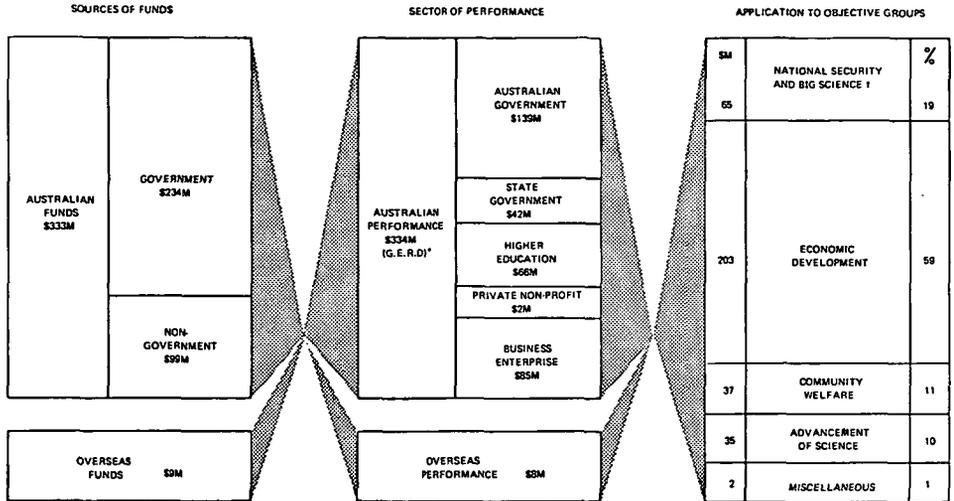
Though agricultural research, even today, absorbs a significant proportion of Australia's research effort, industrial, medical, mining and defence research are now of major importance also. The volume of research in the social sciences remains small, though in Australia as elsewhere in recent years,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

In 1968-69, the most recent year for which comprehensive data are available, total expenditure on research and development (R & D) in both the natural and social sciences was \$342 million, approximately equivalent to 1.3 per cent of the Gross Domestic Product (\$26,972 million) in that year. The sources of these funds, their disbursement among various sectors of R & D performance, and their application to broad objectives are shown in the chart overleaf.

In 1968-69, governments in Australia provided approximately 70 per cent of the funds devoted to R & D and undertook in their own agencies approximately 55 per cent (in terms of expenditure) of the overall national R & D effort.

Whilst these data serve to illustrate the dominant position occupied by governments in the Australian scientific and technological scene, they do not provide a complete picture since comprehensive information is not available on resources devoted to other scientific and technological activities in Australia.

Broad features of Total Expenditure on R & D in 1968-69



Gross expenditure on research and development.

† Space and nuclear objectives

Broad Features of Total Expenditure on R & D in 1968-69

PLATE 61

Co-ordination and advice

Intergovernmental co-ordination of research and scientific and technical services is effected through bodies such as ministerial councils. Among these are the Australian Agricultural Council, the Australian Minerals Council, the Australian Water Resources Council, the Australian Transport Advisory Council, and the Australian Environment Council. The Councils, which are assisted by standing committees of officials, do not undertake research or the provision of services directly but in some instances provide grants or arrange contracts in support of research. The activities of these bodies are aimed principally at economic, social or environmental goals.

In addition to such co-ordinating bodies, several official advisory bodies have been established to deal with sectoral interests. These include: the Australian Research Grants Committee, the Australian Universities Commission, the CSIRO Advisory Council and State Committees, the Defence Science Board and the Defence Research and Development Policy Committee, and the National Health and Medical Research Council.

Some more recently established bodies have been charged not only with promoting short-term activities in their fields of responsibility but also with making recommendations on long-term arrangements. Examples of such bodies are the Interim Commission for Consumer Standards and the Australian Biological Resources Study Interim Council.

Apart from advisory bodies concerned with particular areas and ad hoc bodies which have been set up from time to time to report on specific matters, there were at the time of writing no standing arrangements to provide governments with comprehensive and integrated policy advice on science and technology. However, the Australian Government has announced its intention to establish a Science Council to fulfil this function, and at the State level, the New South Wales Government has announced its intention to establish a New South Wales Science Council.

Advice to government on scientific and technological issues comes also from various learned and professional bodies. Such counsel 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 sectional and standing committees which specialise in selected, broad fields of science, and ad hoc advisory committees are appointed by the Academy from time to time to examine and report on specific matters. The Academy has also maintained since 1967 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.

Other sources of advice to government include the Academy of the Social Sciences in Australia and the Institution of Engineers, Australia (IEA). The IEA is the largest among the technologically oriented professional organisations and has a present membership of about 27,000.

The most broadly based of the professional bodies is the *Australian and New Zealand Association for the Advancement of Science* (ANZAAS). In a recent reorganisation of its structure, the Association established machinery for giving increased attention to policy issues and its new Science Policy Commission has completed its first major study. Other professional organisations have also been giving increasing attention to matters of scientific and technological policy. Some, such as the IEA and the Royal Australian Chemical Institute, have directed their considerations to issues of concern to broad sections of the scientific and technological communities, while others, such as the Federation of Australian University Staff Associations, have concentrated on sectoral issues.

During 1974 Australia was the focus for the last in a series of national reviews conducted by the Organisation for Economic Co-operation and Development (OECD) to assess the scientific and technological situation in member countries. A three member examining panel spent four weeks in Australia in March and April and during that time held discussions with Ministers and officers of the Australian and State Governments, and with representatives of the universities, industry, learned academics and professional bodies. For the assistance of the examiners a Background Report on Australian Science and Technology was prepared by the Department of Science with the co-operation of both government and non-government agencies. The Examiners' Report was discussed at a meeting in Paris in October 1974. The OECD is to publish an account of the formal exchange of views at this meeting together with the Background Report and the report of the examining panel; it is expected to be available in 1975.

Funding

Project SCORE: R & D funds and objectives

As mentioned above, comprehensive data on the resources devoted to scientific and technological activities in Australia are not available. Therefore, though details of Australian expenditure on research and development activities in the financial year 1968-69 are given below, it must be stressed that the data presented do not include many important scientifically or technologically based programs some of which involve large expenditures.

Coverage and methodology. The first comprehensive survey of expenditure on research and development (R & D) was carried out for the 1968-69 financial year. This survey, known as Project SCORE (Survey and Comparisons of Research Expenditure) covered expenditure on R & D in the natural and social sciences in all sectors of the Australian economy. The physical, chemical, biological, earth, engineering, agricultural and medical sciences were included in the natural sciences. Economics, education, management, operations research and sociology were included among the social sciences. The Project was carried out principally by means of questionnaires and, in order to provide direct comparison with other OECD countries, followed (with some exceptions) guidelines laid down by the OECD.

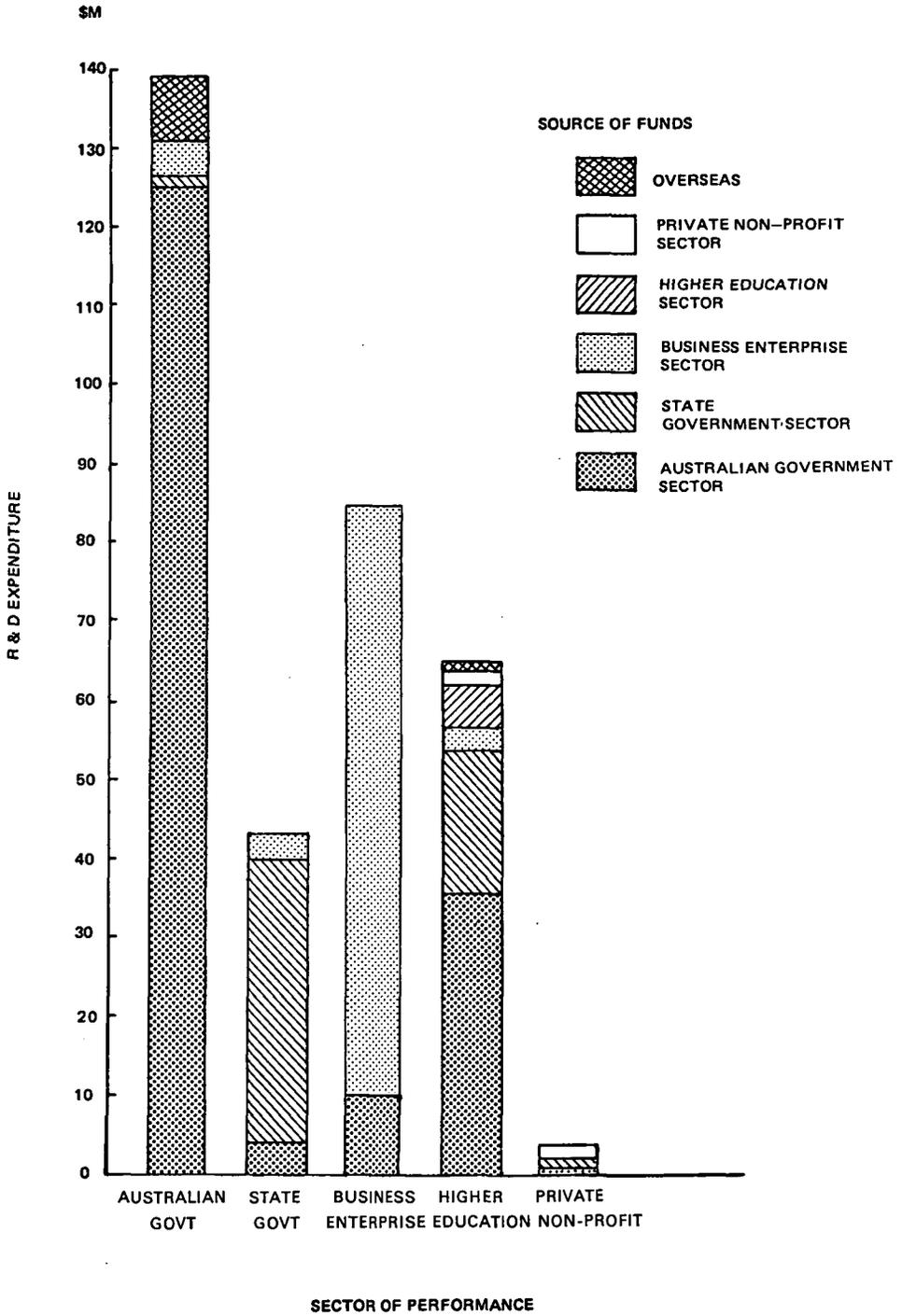
For the purposes of the survey, *research* was defined as systematic critical investigation directed towards increasing the general body of knowledge about, or understanding of, the subject studied. Within this category, *basic research* was taken to be original investigation of which the primary aim was more complete knowledge or understanding of the subject under study, while *applied research* was taken to be original activity of which the primary aim was the solution of a recognised practical problem. Work was defined as *development* where it involved the systematic use or adaptation of research results directed towards the introduction of new or improved products, processes, systems or methods.

Six survey reports were published. In addition to a summary report dealing with the overall national situation, separate reports cover the following sectors: Australian Government, Manufacturing and Mining Industry, State Governments, and the Universities and Private Non-Profit Institutions.

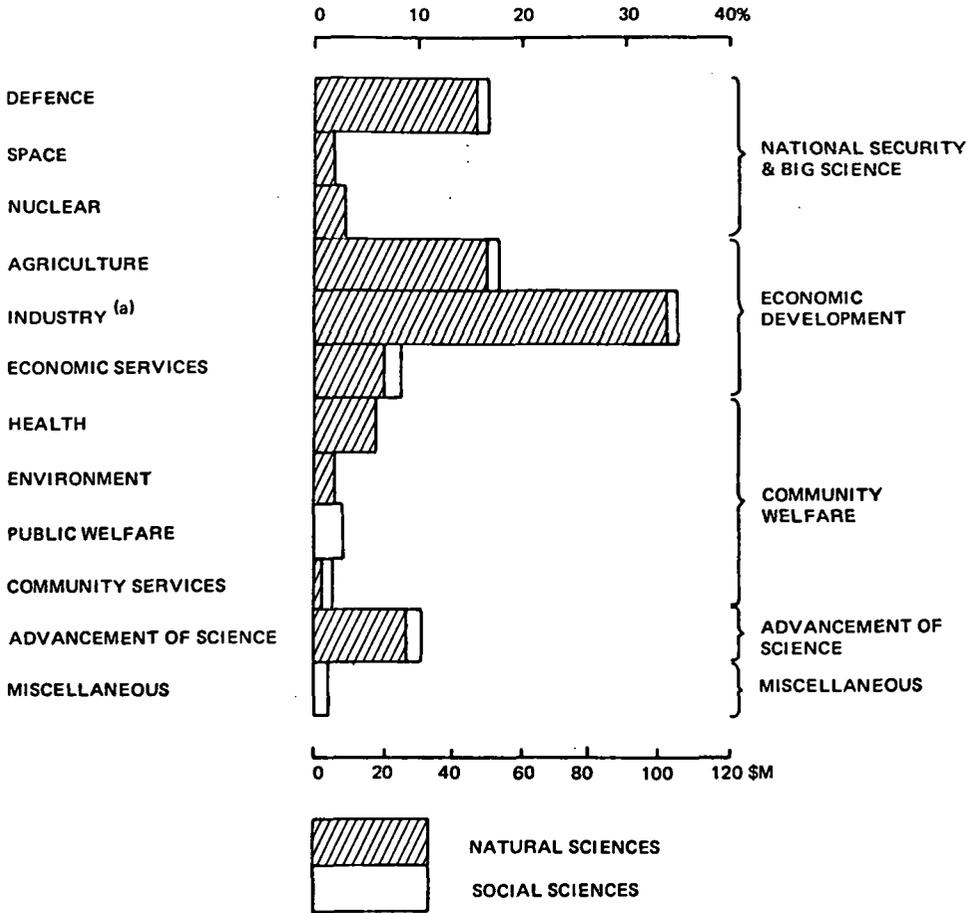
A second survey for the 1973-74 financial year, or 1974 calendar year for higher education bodies, is now in progress.

All Sectors. The broad features of total expenditure on R & D in 1968-69 were shown in the chart on page 996 (plate 61). Plate 62 page 998 shows the distribution of sources of funds provided for R & D by sector of performance.

The distribution of Gross Expenditure on Research and Development (G.E.R.D.) between broad objectives is shown in Plate 63, page 999.



Sources of Funds for R and D by Sector of Performance



(a) The natural and social sciences were not separable for Business enterprise sector data: these were included *in toto* in the natural sciences.

Gross Expenditure on Research and Development by Objectives.

PLATE 63

Details of the distribution of expenditure in 1968-69 between basic research, applied research and development are not available for the business enterprise sector. Hence, reliable data on the distribution of expenditure for these categories cannot be given for the economy as a whole. However, the distribution within the other four sectors was as follows:

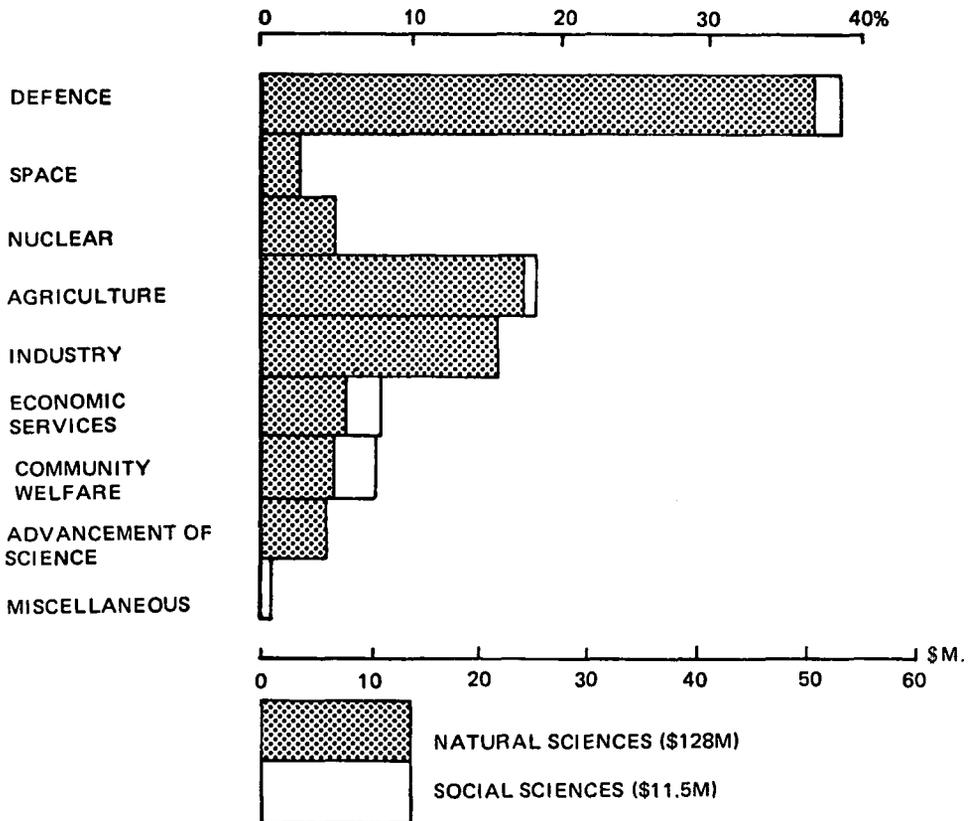
DISTRIBUTION OF R & D EXPENDITURE BY TYPE OF ACTIVITY AND SECTOR OF PERFORMANCE(a)

(Per cent)

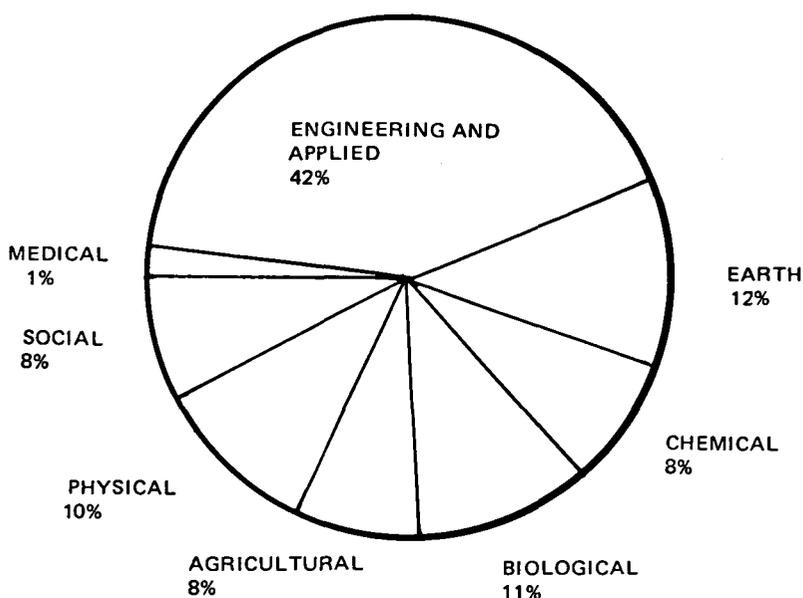
	Australian Government sector	State Government sector	Higher education sector	Private non-profit sector	Total(a)
Basic research	12	5	77	18	28
Applied research	50	62	19	36	44
Development	38	33	4	46	28
Total	100	100	100	100	100

(a) Excludes business enterprise sector.

Australian Government sector. Within the Australian Government sector, total R & D expenditure was \$198 million, 91 per cent of funds coming from within the Australian Government. Of the \$18 million that came from other sources, about \$8 million was from overseas, while about \$7 million came from levies on primary producers. Seventy per cent of the total expenditure on R & D was performed in the Government's own agencies. Distribution of this expenditure by objectives and by field of science is shown in Plates 64 and 65.



Intramural Expenditure in the Australian Government Sector by Objectives



Intramural Expenditure in the Australian Government Sector by Field of Science.

PLATE 65

Combined intramural R & D of the three major Australian Government performers of R & D grew at a rate averaging about 9 per cent per annum over the five-year period, 1963-64 to 1968-69. These major performers were the Commonwealth Scientific and Industrial Research Organization (CSIRO), the former Department of Supply, and the Australian Atomic Energy Commission (AAEC). This average growth rate was approximately the same as that of the Australian Gross Domestic Product (GDP) over the same five-year period.

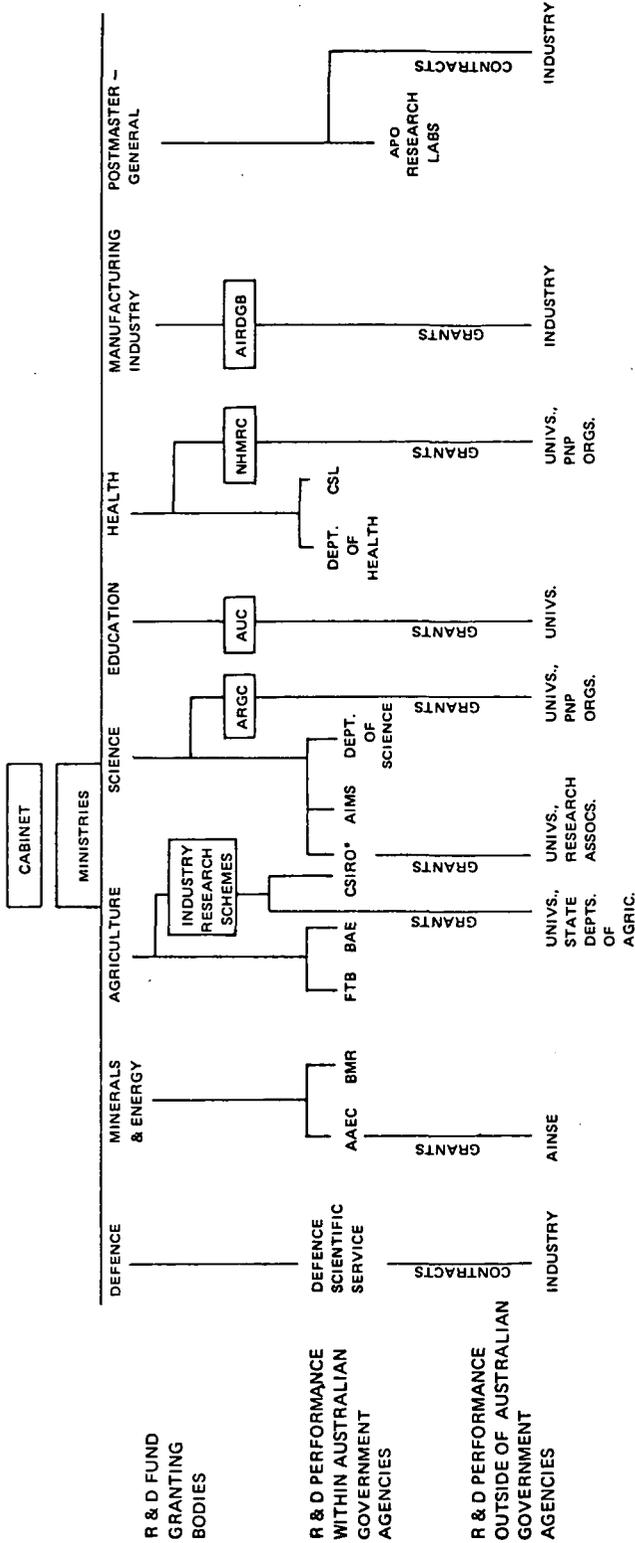
Of the funds (\$59 million) that were channelled to R & D performed outside the Government's agencies:

- almost half (\$27 million) went to the higher education sector;
- about one-third (\$21 million) went to the business enterprise sector;
- approximately 85 per cent was in the form of grants;
- only about 5 per cent was for R & D contracts.

Funds provided through R & D granting schemes supported by the Australian Government increased rapidly during the later 1960s. Annual disbursements through these schemes more than doubled between 1964-65 and 1968-69. A diagrammatic representation of the principal ways in which Australian Government support is channelled into R & D is shown in Plate 66, page 1002.

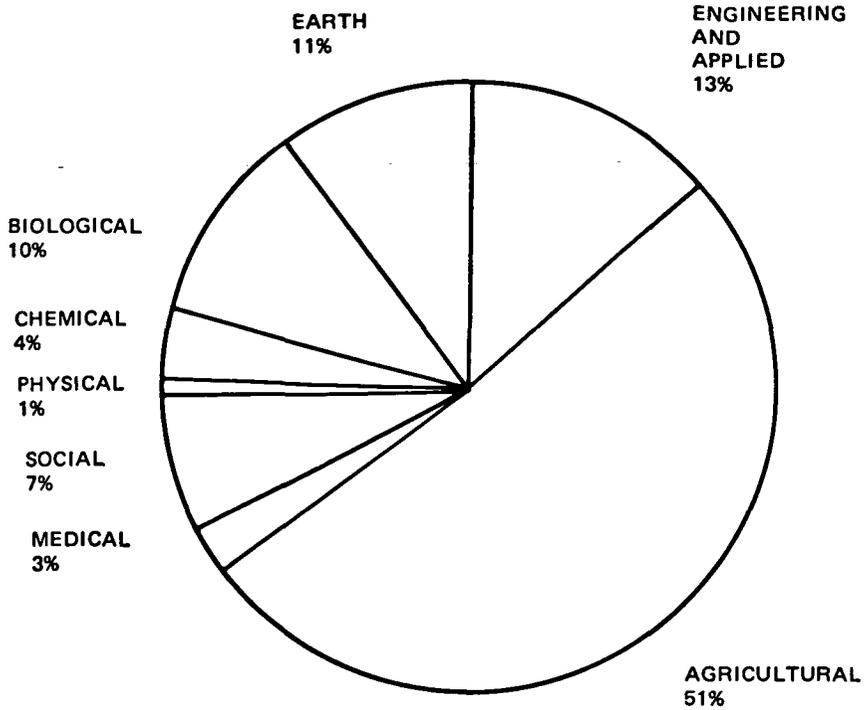
State government sector. Within the State government sector, agricultural research dominated R & D activity in 1968-69. Total R & D expenditure by the State governments was \$62 million, of which \$42 million was for R & D performed in the governments' own agencies. Plate 67, page 1003 shows the distribution of this \$42 million by field of science.

MAJOR CHANNELS OF AUSTRALIAN GOVERNMENT FINANCIAL SUPPLY FOR R & D



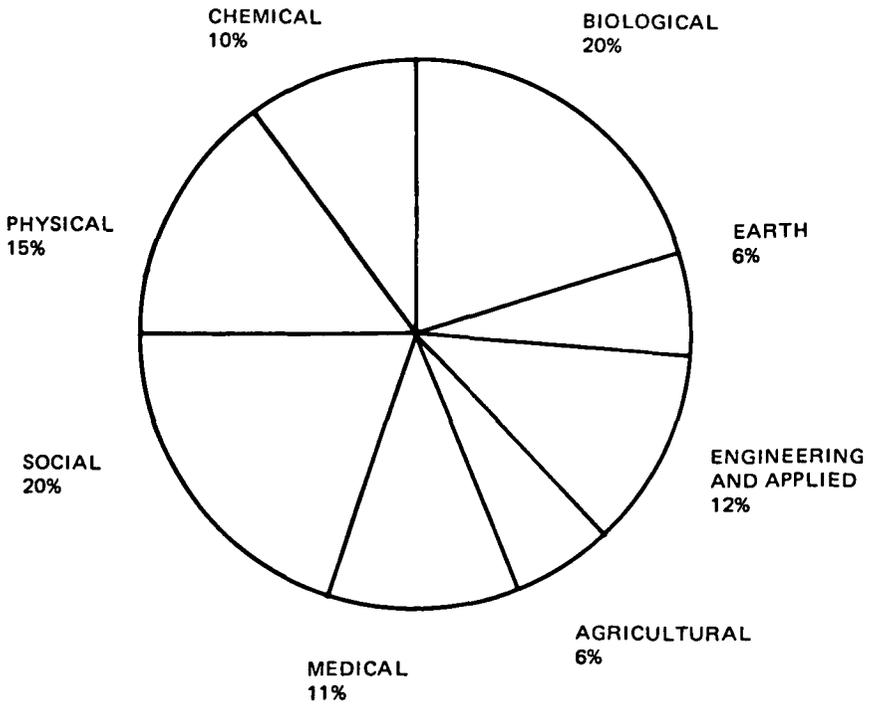
CSIRO is located within Ministry of Science

PLATE 66



Intramural Expenditure in the State Government Sector by Field of Science.

PLATE 67



Intramural Expenditure in the Higher Education Sector by Field of Science.

PLATE 68

Higher Education sector. Within the Higher Education Sector, universities performed almost all of the R & D conducted. The distribution of intramural R & D expenditure by field of science was determined as in Plate 68, page 1003. Approximately 85 per cent of intramural expenditure was incurred by university departments with both teaching and research commitments, the remainder by departments engaged primarily in research activities. Three universities (Australian National, Melbourne, and Sydney) accounted for 46 per cent of total intramural R & D expenditure by Australian universities in 1969.

Sources of funds for R & D performed by the universities were: 56 per cent from the Australian Government sector, 28 per cent from the State Government sector, and 16 per cent from other sources.

Business Enterprise sector. For the business enterprise sector, expenditure by manufacturing and mining industries on industrial research and development (I R & D) performed in Australia was approximately \$85 million. The distribution of expenditure among principal industry groups engaged in R & D was as follows:

	per cent
Industrial machinery and equipment	20
Chemical, petroleum and coal products	19
Transport equipment	19
Basic metal products	13
Fabricated metal products	7
Food, beverages and tobacco	7
Mining	5
Other	10

About 50 per cent of I R & D expenditure was incurred by subsidiaries of overseas-owned firms and a further 10 per cent by enterprises with significant overseas ownership. I R & D expenditure by overseas-owned enterprises was mainly concentrated in the transport equipment and the chemical, petroleum and coal products industries.

Expenditure by manufacturing and mining industries of approximately \$85 million on I R & D, performed within Australia contrasts with payments by these industries of a further \$34 million in 1968-69 to overseas organisations for patents, licences and technical know-how.

Two industries accounted for 61 per cent of this overseas expenditure. These were: industrial machinery and equipment (33 per cent), and chemical, petroleum and coal products (28 per cent). About three-quarters of this expenditure was by industries wholly or mainly owned overseas.

Sales of I R & D totalled \$2.5 million in 1968-69, approximately three-quarters of which was earned by wholly or mainly Australian-owned enterprises.

Balance of payments figures indicate the following receipts and payments made for royalties and copyrights.

	(\$ million)					
	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73p
Receipts	6	7	7	6	4	4
Payments	64	63	68	64	56	75

Private Non-Profit sector. In 1968-69 total expenditure on R & D by the Private Non-Profit sector was about \$3 million, some 55 per cent of the funds coming from within the sector and most of the balance coming from government sources.

Four organisations accounted for about 65 per cent of R & D expenditure within this sector: the Walter and Eliza Hall Institute of Medical Research (Victoria), the National Safety Council of Australia, the Institute of Medical Research, Royal North Shore Hospital (New South Wales), and the Royal Children's Hospital Research Foundation (Victoria).

Health (90 per cent) and Public Welfare (9 per cent) were the principal objectives of research and development activity within the sector.

Manpower

A comprehensive survey of manpower in Australia was made in conjunction with the 1971 national population census. This revealed that 8.1 per cent of the workforce came within the classification 'highly qualified personnel'*. Scientific and technical personnel† constituted only 21 per cent of this category, or 1.7 per cent of the workforce.

In 1971, 3.6 per cent of the total Australian population held tertiary qualifications and 2.5 per cent held technical qualifications. However, the emphasis was in areas other than science and technology since only 0.8 per cent of the total population held tertiary qualifications in the physical sciences and technology. The distribution, over major fields, of scientific and technical personnel‡ holding qualifications above technical level in 1971 was as follows:

<i>Field</i>	<i>Persons</i>
Natural sciences	30,894
Engineering, building technology	57,018
Architecture	6,679
Agriculture and forestry	9,432
Total	104,023

In 1968-69 approximately 43,000 man-years of effort were devoted to the performance of R & D in Australia. This represented some 0.9 per cent of the total effort of the workforce in that year. Approximately 90 per cent of the total R & D effort was expended in work in the natural sciences and the balance in the social sciences. The total manpower effort in R & D within the Australian Government, State government, Higher education and private non-profit sectors (relevant information is not available for the business enterprise sector) was distributed among major objective groups as follows:

<i>Objective</i>	<i>Per cent</i>
Economic development	60
National security and big science(a)	17
Advancement of science	12
Community welfare	11

(a) Includes defence, civil space and civil nuclear R & D.

Some 45 per cent of the R & D effort in these sectors was contributed by professionally qualified scientists and engineers; technicians and draftsmen contributed a further 23 per cent and the balance came from other support staff.

In the business enterprise sector, approximately 13,000 professionally qualified scientists, engineers, technicians, draftsmen and supporting staff were engaged on I R & D in manufacturing and mining industries in 1968-69, representing about 2.0 per cent of the total workforce in those enterprises conducting I R & D.

Approximately 64 per cent of the staff engaged full-time on I R & D were employed by three industry groups:

<i>Industry group</i>	<i>Per cent</i>
Industrial machinery and equipment	24
Chemical, petroleum and coal products	21
Transport equipment	19

* Defined according to the International Standard Classification of Occupation. Includes persons holding technical non-university tertiary, bachelor and higher degrees, and employed as professional, technical, administrative, executive or managerial workers.

† Comprising the occupational classifications of architects, engineers and surveyors, chemists, physicists, geologists and other physical scientists; biologists, veterinarians, agronomists and related scientists, draftsmen and technicians.

‡ Medical, dental, health and paramedical have been excluded because of inability to separate between practitioners and research staff. This group comprised 52,859 persons; 26,605 of these had at least first degrees.

Resources and services

Although power to regulate the development and utilisation of Australia's natural resources rests largely with the States, the Australian 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 Australian 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:

- Transport (chapter 12)
- Communications (chapter 12)
- Health (chapter 14)
- Agriculture (chapter 22)
- Water (chapter 23)
- Forestry (chapter 24)
- Fisheries (chapter 25)
- Minerals and Energy (chapters 26, 27)

Soil resources

Since 1938 all State Governments, except Tasmania, have enacted legislation relating to the mitigation of erosion and the conservation of soil resources. The States of New South Wales and Victoria have set up organisations to deal specifically with the problem of soil erosion whilst, in other States, departments of agriculture discharge that function.

A Standing Committee on Soil Conservation was established in 1946. It comprises the heads of soil conservation bodies in the States and representatives of relevant Australian Government agencies. The Committee co-ordinates activities of interest to its member bodies such as the survey of erosion throughout Australia which was carried out in the late 1960s, and the development of co-operative arrangements for in-service training of technical personnel.

Fauna and flora resources

Responsibility for the conservation and management of fauna and flora resources rests, in the main, with the State Governments. The Australian Government, however, has responsibility for such resources in its own Territories.

During the last century, as each State became established, museums and botanical gardens containing herbaria were set up. Studies of fauna and flora were carried out by these bodies and by the universities. Since the establishment of CSIRO, various divisions of the Organization have also carried out this work but an important part of total Australian research into biological resources continues to be undertaken in the museums and herbaria of the State governments.

The Australian Government recently announced a decision to establish a National Parks and Wildlife Commission and Service whose functions include care and management of national parks and wildlife in Australia and its Territories, conduct of ecological studies to determine additional areas which should be reserved as national parks and nature reserves, and survey and assessment of wildlife populations with particular reference to endangered species. The Government has also made funds available to stimulate taxonomic and ecological studies of Australian fauna and flora resources.

Environmental protection

Responsibility for most aspects of environmental protection rests with the State governments, and all of these have enacted legislation to regulate those operations of governmental and private enterprises that may have a deleterious effect on the physical environment.

The Australian Government has responsibility for environmental protection in its own Territories, in respect to the operations of its own agencies within the States, and in relation to projects or activities carried out by other authorities with the aid of Australian Government funds. It is also concerned with the enforcement of provisions of relevant international conventions to which Australia is a signatory, and with the environmental protection aspects of overseas trade.

The various governments collaborate in environmental and conservation matters through three Ministerial Councils:

- the Australian Environment Council, which provides a framework for consultation on environmental matters;
- the Council of Nature Conservation Ministers, which is concerned with preservation of wildlife and the establishment and management of national parks;
- the Australian Water Resources Council, which is concerned with the assessment, development and use of national water resources.

All of the governments have designated ministers who are concerned with the administration of broad policies for environmental protection. In some cases, governments have implemented policies requiring the provision for public scrutiny of environmental impact statements as a prerequisite to approval of new development projects or activities with significant environmental consequences.

The Australian Government has recently established a Bureau of Environmental Studies within the Department of the Environment and Conservation. This Bureau is charged with reviewing requirements for environmental research, assessing the extent to which such requirements are being satisfied through programs of various agencies, and promoting or directly undertaking research needed to fill gaps in the overall program.

Meteorology

The Bureau of Meteorology, which is a Division of the Department of Science, is the national authority for providing weather forecasting and warning services, and general meteorological information and consultative advice. Users of these services are the general public, defence forces, civil aviation and marine authorities, and specialist groups in primary and secondary industries.

Programs of research are carried out in support of these services, often in co-operation with other institutions concerned with meteorological science, including universities and the Environmental Physics Research Laboratories of the CSIRO. The Australian Numerical Meteorology Research Centre, which specialises in the development of numerical model techniques for predicting atmospheric behaviour, is operated jointly with CSIRO.

At June 1974, the Bureau had a staff establishment of approximately 1960, including about 450 professionals. In addition, a large number of persons assist part-time in maintaining the Bureau's extensive observation network.

Total expenditure in 1973-74 was approximately \$24.5 million. About 65 per cent of funds was provided by the Australian Government through direct appropriation, while all but a small portion of the balance came from charges made to other Australian Government agencies, principally for meteorological services in support of civil and defence aviation activities.

Ionospheric Prediction Service

The Ionospheric Prediction Service Branch of the Department of Science (IPS) exists to assist users of radio communications to achieve the most effective and efficient use of radio transmissions that are influenced by or dependent on the ionosphere. The staff of the Branch make regular measurements of the state of the ionosphere above Australia and its territories and of the sun, and issue both short and long term predictions of the state of the ionosphere as it applies to radio communication.

Research into physical phenomena affecting the condition of the ionosphere forms part of the regular activity of the IPS.

Scientific and technological information services

Information services for scientists and technologists are provided through National and State libraries, and through libraries operated by scientific and technological agencies of the Australian and State Governments, by tertiary education institutions, and by industrial organisations.

In 1971 the Council of the National Library established a Scientific and Technological Information Services Enquiry Committee (STISEC) to investigate, report and make recommendations on the need for scientific and technological information (STI) services in Australia. The Committee's Report was submitted to the Australian Government in May 1973.

The Committee recommended, inter alia, that the Australian Government establish a national STI Authority to advise on the development of a national STI policy, and to promote the orderly development of scientific and technological library and information services in Australia. The Government has recently approved a two-year program of studies and consultations to determine the feasibility of an Australian Library-Based Information System (ALBIS) which will comprehend the major STISEC recommendations. These studies will be undertaken by the National Library of Australia.

Government research agencies

The Commonwealth Scientific and Industrial Research Organization (CSIRO)

CSIRO is the largest scientific research organization in Australia. It is a statutory body established in 1949 to replace the former Council for Scientific and Industrial Research (CSIR).

The main function of CSIRO is to carry out scientific research and investigations in connection with Australia's primary and secondary industries. CSIRO has at present 36 research Divisions and 5 smaller research Units, a number of them being linked together in laboratory groups. The wide range of their activities is illustrated by the following table.

GENERAL DISTRIBUTION OF RESEARCH EFFORT IN CSIRO
(In terms of non-capital expenditure for 1973-74)

<i>Field</i>	<i>Divisions and units</i>	<i>\$ million</i>	<i>Per cent</i>
Crops and pastures	Agro-industrial Research Horticultural Research Irrigation Research Plant Industry Tropical Agronomy	9.9	13.5
Livestock	Animal Genetics Animal Health Animal Physiology Nutritional Biochemistry	9.9	13.5
Land use	Land Resources Management Land Use Research Soils	6.6	9.0
Insects and wildlife	Entomology Wildlife Research	5.6	7.6
Marine science	Fisheries and Oceanography Marine Biochemistry	2.7	3.8
Environmental physics	Atmospheric Physics Cloud Physics Environmental Mechanics	2.4	3.3
Wool processing and textiles	Protein Chemistry Textile Industry Textile Physics	5.0	6.8
Food	Food Research Wheat Research	4.2	5.7
Mineral exploration, processing and properties	Chemical Engineering Minerology Mineral Chemistry Mineral Physics	6.4	8.7
National standards	National Measurement Laboratory	4.4	6.0
Chemical and physical research of industrial interest	Applied Organic Chemistry Chemical Physics Chemical Technology Tribophysics	6.1	8.4
Engineering and construction	Applied Geomechanics Building Research Mechanical Engineering Solar Energy Studies	5.6	7.6
Radiophysics	Radiophysics	2.7	3.7
Computing and statistics	Computing Research Mathematics and Statistics	1.7	2.4

The powers and functions of CSIRO are prescribed in the *Science and Industry Research Act 1949-1973* under which the Organization operates. In brief these are as follows:

- to carry out scientific research and investigations in connection with Australian primary and secondary industries or any other matter referred to it by the Minister for Science,
- to train scientific research workers, and award studentships,
- to make grants in aid of scientific research,
- to recognise and support research associations,
- to maintain national standards of measurement,
- to disseminate scientific and technical information,
- to publish scientific and technical reports, and
- to liaise with other countries in matters of scientific research.

CSIRO has a total staff of some 6,700 persons located in more than 100 laboratories and field stations throughout Australia. About one-third of the staff are professional scientists.

In 1973-74, CSIRO operations cost approximately \$90 million, more than 80 per cent of which was met by the Australian Government through direct appropriation. Of the remainder, about four-fifths was concerned with research for various primary industries and came from statutory trust funds most of which derived from levies on production, and a supplementary contribution by the Australian Government. The balance of operating expenses, comprising less than 4 per cent of the total, came from individual companies, other Australian Government agencies, overseas instrumentalities and private foundations.

The Australian Atomic Energy Commission (AAEC)

The AAEC was established by the Australian Parliament under the *Atomic Energy Act 1953* as a statutory body whose main functions are to facilitate the development of Australia's resources and the utilisation of various forms of nuclear energy within the Australian economy.

Moving in its earliest days towards the planning and construction of a nuclear research establishment at Lucas Heights near Sydney, the Commission arranged for a nucleus of scientists and engineers to obtain training and experience through overseas attachments, mainly in the United Kingdom. By the late 1950s an R & D program had been initiated at its research establishment.

The AAEC's activities are controlled by a Commission which is responsible to the Minister for Minerals and Energy. The Atomic Energy Act provides for the Commission to consist of five Commissioners including a Chairman.

The Commission's current program places emphasis in the following areas:

Nuclear power: the assessment of the potential contribution and the total implications of nuclear power in the co-ordinated development of Australia's energy resources.

Safety and the environment: the establishment of adequate arrangements for safety assessment, licensing and regulation of all nuclear facilities including those for the long-term management and disposal of radioactive wastes, in order to control potential hazards to health and the environment.

Uranium and nuclear fuels: the development of uranium resources, consideration of the desirable extent and timing of uranium processing including enrichment, and the development of a technical base on which Australia could establish its own uranium enrichment technology.

Radioisotopes and radiation: to continue to meet the expanding requirements for radioisotopes, particularly in medicine, and further to explore the benefits to be achieved by the application of radioisotopes and radiation in industry.

International relations: to assist in matters arising from Australia's membership of the International Atomic Energy Agency and the OECD-Nuclear Energy Agency and in matters arising from Australia being a party to the Treaty on the Non-Proliferation of Nuclear Weapons.

At June 1974 the Commission employed 1,241 staff of whom 354 were professional. For the year 1973-74 total expenditure was about \$15.7 million of which \$13.3 million was spent on research.

The AAEC participates in the activities of the Australian Institute of Nuclear Science and Engineering. The Institute, which has a corporate membership comprising the Commission and the Australian universities, is concerned with the awarding of studentships, fellowships and research grants, with the organising of conferences and with arranging the use of AAEC facilities by postgraduate students. In 1973 the Institute's expenditure was about \$330,000.

The Antarctic Division, Department of Science

Australia has been active in research and exploration in the Antarctic region since early in the present century, but the overall effort has expanded appreciably since the 1940s when the Government established the Australian National Antarctic Research Expeditions (ANARE) and the Antarctic Research Division.

Services provided by the Division in relation to research expeditions include:

- the establishment and maintenance of three permanent multi-disciplinary stations on the Antarctic continent and one on sub-Antarctic Macquarie Island;
- the mounting of annual and shorter term research expeditions;
- the co-ordination of activities of agencies involved with ANARE; the Antarctic Division itself, the Bureau of Meteorology and the Ionospheric Prediction Service of the Department of Science; the Bureau of Mineral Resources, Geology and Geophysics, and the Division of National Mapping of the Department of Minerals and Energy; certain sections of the Army; various university departments; and the CSIRO.

In addition to its general support function, the Division directly undertakes research in such fields as cosmic ray and upper atmosphere physics, glaciology, Antarctic biology and medical science matters relevant to Antarctic conditions. Personnel at research stations include meteorologists, physicists, glaciologists, biologists and logistics staff.

At any given time the total staff complement of the Division varies between 160 and 190 persons about half of whom are engaged on a short-term basis to man annual expeditions and provide general support. The permanent staff includes about 15 scientists. Expenditure by the Division in 1973-74 was approximately \$3.8 million.

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

Australian Institute of Marine Science

The Australian Institute of Marine Science is being established on a 190 hectare site within a national park at Cape Ferguson, 50 kilometres south of Townsville. A 5,600 square metre laboratory complex and research vessel harbour are to be constructed by late 1976 at an estimated cost of \$10 million. In the interim, temporary accommodation at Cape Pallarenda, just north of Townsville, is being used by research groups.

The Institute will be mainly concerned with research, emphasising multi-disciplinary projects focused on tropical marine sciences. Initial efforts will be directed towards the Coral Sea, the Great Barrier Reef, and the North Queensland coast. Scientists are being selected for a marine pollution group and plans are being developed for a marine geology group to investigate coral reef structure. By the time a research vessel becomes available, a physical oceanography group will have been formed to research tidal and current phenomena.

By the end of 1976-77, the Institute is expected to have a scientific staff of about 75 composed of about 25 scientists and 50 scientific officers and technicians; there will be 75 additional support staff. At the end of 1974, 30 staff members had been appointed; an additional 11 are expected by mid-1975. No undergraduate teaching will take place but it is expected that co-operative post-graduate programs will be developed with Australian universities.

Approval has been obtained for the design of a 24 metre research vessel and a second vessel of 37 metres is envisaged.

Defence Science

Much of the research and development effort conducted by the Australian Government falls into this category. A fuller discussion may be found in Chapter 4, Defence.

Research in industry

Contrary to the situation in most industrialised countries, a smaller proportion of the overall R & D effort in Australia is undertaken in private industry than in government agencies. However, while precise statistics are not available, industry's percentage contribution to total R & D performance is believed to have increased in the period since 1964-65, partly under the stimulus of the grants scheme introduced by the Australian Government with the aim of encouraging private business enterprises to increase the levels of their expenditure on industrial research and development (I R & D).

The most recent comprehensive data on I R & D expenditure in industry relate to the year 1971-72*, and indicate that the broad industry groups—other industrial machinery and household appliances; chemicals, petroleum and coal products; and transport equipment—accounted jointly for some 53 per cent of total I R & D expenditure.

Other features of the situation in that year were:

 firms with 25 per cent or more foreign equity accounted for about 58 per cent of I R & D expenditure;

 about 59 per cent of total I R & D expenditure was incurred by only about 7 per cent of enterprises that devoted funds to I R & D;

 large rather than small enterprises tended to expend funds on I R & D.

* R & D in *Manufacturing Industry 1971-72*, Department of Manufacturing Industry, Canberra, Bulletin No. 11, November 1974.

The Australian Government has encouraged technological innovation by industry directly through financial incentives and indirectly through patent legislation, taxation and educational measures which provide a favourable economic climate for such innovation. In recent years the principal avenue of direct assistance has been the Industrial Research and Development Grants Scheme.

In 1972-73 some 900 firms applied for grants under the Grants Scheme. This represented an increase of about 70 per cent on the number of applicants in the Scheme's first year of operation. Prior to the introduction of the grants, about 60 per cent of these 900 firms had not incurred any expenditure on I R & D as defined in the Scheme. From the Scheme's inception in 1967 up to June 1973, \$58 million was disbursed. It is estimated that grants for the 1973-74 financial year will amount to about \$16.5 million. Grants received by firms are taxable, hence the net incentive to industrial R & D is rather less than the above figures imply. The broad industry groups that have benefitted principally under the Scheme are basic metal products, industrial machinery and equipment, electric and electronic apparatus, transport equipment and chemicals.

Other fields of activity which to some extent involve the adoption by industry of new technology, and which attract financial support from the Australian Government, include industrial design and product standardisation. The Industrial Design Council of Australia and the Standards Association of Australia received subsidies from the Government of \$340,000 and \$850,000 respectively in 1973-74.

Metric conversion

Related to product standardisation is the conversion to the metric (SI) system of weights and measures which is now in progress in Australia. The conversion program is being developed and implemented under the guidance of a Metric Conversion Board established by the Australian Government. Because implementation of the program depends in large measure on general community co-operation, the Board is assisted by advisory groups representative of all sectors of the community.

Industry organisations

A number of organisations aiming, wholly or in part, to support and encourage I R & D have been established within industry. Some have largely sectional interests, such as the Australian Engineering and Building Industries Research Association, the Australian Mineral Industries Research Association, and the Bread Research Institute.

Organisations with broader interests and roles include the following.

The Australian Industrial Research Group (AIRG). This is an association, founded some ten years ago, of managers of research and development employed in Australian industry. Its members, numbering about 50, control most of the R & D expenditure in Australian industry. Objectives of the Group are to improve the quality of research management in Australia and to stimulate and develop an understanding of research as a force in economic, industrial and social activities. The Group's activities have included conduct of a survey of R & D expenditure by Australian industry, sponsorship of studies into science education and the electronics industry, and provision of advice on desirable amendments to the Industrial Research and Development Grants Act.

The National Association of Testing Authorities (NATA). This Association was established in 1947 at the direction of the Australian Government. NATA is the recognized body for the registration as testing authorities of both government and industrial laboratories within a wide area of science and technology. Laboratories receive registration only after careful assessment to ensure that they meet the required standards. At June 1973 the Association had registered 925 laboratories including 697 in industry, 190 in Australian and State government establishments and 38 in educational institutions.

The Standards Association of Australia (SAA). This Association was founded in 1922 to publish and promote the adoption of Australian standards. Standards are prepared only after a full enquiry has shown that the project is a desirable one and worth the effort involved. Work is based on voluntary agreement and recognition of the community of interest of producer and consumer.

The Industrial Design Council of Australia. This Council is a voluntary association of leading industrialists, academics and other professionals whose aim is to accord design appropriate status in the production process. In particular the Council aims to improve productivity, sales and profits, and to promote a healthy, vigorous manufacturing industry which will in turn contribute to the economic and cultural welfare of the nation. The Council is also concerned to promote a wider understanding of industrial design, and the development of a strong profession in Australia through, among other things, appropriate education for industrial designers.

The Productivity Group Movement. Productivity Groups have been established throughout the country with the object of improving productivity and efficiency by exchanging ideas, reviewing experience and by discussion of the practical problems of group members. The Department of Labor and Immigration promotes and actively participates in the productivity group movement. In 1973 there were some 250 groups comprising over 5,700 member undertakings.

The Industrial Research Institute of South Australia Incorporated. This Institute was established by the Government of South Australia in 1971 with the aim of promoting and co-ordinating industrial research activities within that State. The Institute offers advisory services to individual companies in relation to their research needs, and maintains various information services to South Australian industry generally. Industry, research organisations, and the universities in South Australia, along with the South Australian Institute of Technology, are represented on the governing Council.

The Australian Innovation Corporation Limited (AICL). Some 40 Australian companies are shareholders in this Corporation which was established in 1970. It provides both advice and funds to assist in the promotion and commercialisation of local research, invention and development.

The National Small Business Bureau. This Bureau, established by the Australian Government, is charged with the task of developing a comprehensive and co-ordinated national program of assistance to small business. This includes the bringing together of special expertise in business management, industrial technology, industrial relations and other subjects relevant to promoting and assisting the efficient development of small business.

Research in universities and colleges

Comprehensive data on R & D expenditure and activities in the universities during 1969 were yielded by the Project SCORE survey, to which reference has been made above. That survey provided information on sources of R & D funds, their specific disbursement by way of intramural and extramural work, and their allocation among objective groups. Colleges of Advanced Education were not included in that survey but, in the expectation that their R & D effort will have developed in the meanwhile, they are being surveyed in the current Project SCORE survey.

Forty-six per cent of the funds expended on R & D had been specifically ear-marked for that purpose by the donors. The balance came from general university funds.

Approximately 80 per cent of the R & D expenditure was for basic research whilst almost all of the balance was devoted to applied research. As between the natural and social sciences, work in the former predominated and accounted for about 80 per cent of total expenditure.

While advancement of science was the primary objective of R & D performed by the universities in 1969, about 60 per cent of expenditure was for work having broad secondary objectives such as health, economic services and agriculture.

Research organisations associated with tertiary education institutions

Several of the universities and colleges of advanced education have established independent companies, operating on a commercial basis, to promote and manage research and consultancy services to industry, commerce, government and the general community. Examples are: Unisearch Ltd of the University of New South Wales, which is the largest of these organisations, with annual income at present of about \$500,000; Technisearch Ltd of the Royal Melbourne Institute of Technology; Techsearch Inc. of the South Australian Institute of Technology.

These organisations play an important role in promoting communication between the higher education and other sectors. They undertake investigational and research projects, mainly in the fields of engineering and science. However activities in other fields, such as management, marketing, and the social sciences are increasing. Testing work, performed generally by full-time employees, is undertaken in some instances. Results of work are confidential to the client and are not published unless authorised by that client.

Social science research

Research in the social sciences is undertaken primarily in universities and agencies of the Australian and State governments. Financial support for research in non-government bodies, especially universities, is provided by government. This support comes both from general funds provided to the universities and also from specific granting bodies such as the Australian Research Grants Committee and the Australian Advisory Committee on Research and Development in Education.

In 1968-69, expenditure on social science research amounted to approximately \$28 million, or some 11 per cent of gross national expenditure on R & D. Of this amount, \$13 million was for work performed by the universities, \$11.5 million for work performed by the Australian Government, and \$3 million for work performed by State governments.

The bulk of social science research carried out within Australian Government agencies is performed as part of the general activities of departments such as Aboriginal Affairs, Education, Labor and Immigration, Manufacturing Industry, Social Security and Treasury. However, several agencies have been established specifically to undertake research. These include the Australian Institute of Aboriginal Studies, the Australian Institute of Criminology, the Bureau of Agricultural Economics and the Bureau of Transport Economics. These agencies undertake studies in such fields as:

- economic research;
- educational research;
- statistical and social analysis of health and social security schemes;
- personnel management and industrial psychology, including enquiries into physical working conditions, industrial safety and the effects of technological change on employment;
- research directed at the development of standards for residential accommodation;
- research directed at the development of a system of social indicators to measure community progress in terms other than economic growth, and to determine the processes by which social goals are realised.

Other Australian Government bodies such as the Australian Post Office (APO) undertake research in the social sciences as well as in the natural sciences. For example, the APO conducts research into various aspects of management matters such as industrial psychology as well as into techniques of resource allocation and forecasting.

In 1973 a Social Welfare Commission was established by the Australian Government to enquire into, and make recommendations on, the development of social welfare systems in Australia. A recommendation of this Commission has resulted in a program for the promotion of Social Policy Planning Units. As part of this program, grants are being made to the State governments to establish or develop Social Policy Planning Units within departments responsible for social welfare.

Agencies of the various State governments undertake research relevant to their own activities and programs. Examples of these programs are:

- in the field of health services—studies of social determinants of morbidity, of patterns of utilisation of health services, and of the management of such services;
- in the field of youth and community services—studies of the ecology of urban delinquency, of efficiency of the system of prisoner parole, and of causes of intellectual handicap in children;
- in the field of crime research—the accumulation and interpretation of crime statistics.

A major research program into the causes of family disruption and breakdown in Australia is being supported jointly by the Australian and State governments.

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 (ANZAAS) and the Academy of the 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 on the social sciences.

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, the Australian Institute of Political Science.

International activities

International organisations

Australia participates in the activities of both governmental and non-governmental international scientific organisations. Interaction with the former group of bodies is arranged through Australian Government agencies, but participation in the activities of bodies such as the FAO, IAEA, UNESCO, WHO, WMO is not restricted to governmental scientists. To facilitate scientific liaison and representation some Australian Government agencies have scientific and technological representation at overseas posts (e.g. Japan, United Kingdom, United States of America, IAEA, OECD). Australia also plays an active role in regional bodies such as ECAFE, the Pacific Science Congress, and the Association for Science Co-operation in Asia (ASCA), and has provided technical assistance to countries in the region under both multilateral and bilateral arrangements.

In particular, Australia is co-operating with the endeavours of the Committee for Scientific and Technological Policy of the OECD in its programs on:

- Automated information processing and communication systems,
- Assessment of the social consequence of new and existing technologies,
- International co-operation in scientific research and development,
- Measurement of resources (financial and manpower) devoted by OECD member countries to scientific research and development,
- Research and development in the field of energy resources.

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.

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, but there are more Australians going abroad temporarily than there are foreigners entering temporarily for these purposes.

Registry of Scientific and Technical Services

In response to a request from seven Asian countries and New Zealand, Australia has established a Registry of Scientific and Technical Services in Canberra. The aim of the Registry is to collect and publish information about current research projects conducted by scientific and technical groups within the Asian and Pacific Region. The fields covered are directly related to economic development. A number of directories have been published reporting the work of over 2,600 groups in the Region. These publications provide an information tool to enable co-operative arrangements to be developed between scientific and technical groups with similar interests.

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 those in other countries. For example, an agreement of this kind was reached with the United States in 1968 and more recently the details of an agreement between Australia and the USSR have been finalised.

Under the auspices of the United States/Australia agreement 11 visits, 9 seminars, and 3 joint research projects have been arranged during 1974. These include the Biological Membranes seminar held at the East-West Center of the University of Hawaii, a seminar-workshop on solar energy at the University of Sydney, and a lunar laser ranging project which involves collaboration between NASA in the United States and the Division of National Mapping, of the Australian Department of Minerals and Energy.

Astronomy

In the field of optical astronomy, Australia and Britain are co-operating in the Anglo-Australian telescope project which involves the construction and operation in Australia of a 3.9 metre reflecting telescope at Siding Springs, New South Wales. The telescope, among the largest in the southern hemisphere, was officially opened in October 1974.

A Director has been appointed and appointment of other scientific and technical staff is expected to be completed during 1975. Observing time on the telescope is to be shared equally between Australia and the United Kingdom. When full scale observations begin in 1975, it is expected that much valuable work will be done to complement the significant progress made by radio-astronomers in Australia.

Space

The European Launcher Development Organisation (ELDO) made use of rocket launching facilities at Woomera, South Australia, in the course of its program to develop a satellite launch vehicle. Also in the field of civil space research, 5 tracking stations were built in Australia for the United States National Aeronautics and Space Administration (NASA) and are operated by Australia under an agreement between NASA and the Australian Government's former Department of Supply.*

* The Department of Manufacturing Industry assumed temporary responsibility for administering this agreement, following abolition of the Department of Supply in June 1974; in January 1975, responsibility will pass to the Department of Science.

Defence

In the field of defence science, Australia collaborates with other countries through a variety of arrangements at inter-governmental level. Examples are The Joint United Kingdom–Australia Long Range Weapons Project, and the Technical Co-operation Program involving the United States, and the United Kingdom, Canada, Australia and New Zealand. Further information is given in Chapter 4, Defence.

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 USSR which includes exchanges in the scientific fields.

