

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 for the years 1968–69 and 1973–74 may be found in the reports published by the Department of Science on Project SCORE (see page 989). Also relevant are reports 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*) and by the then 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 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 1973–74, the most recent year for which data are available, total expenditure on research and development (R & D) in both the natural and social sciences was estimated at \$651 million, approximately equivalent to 1.3 per cent of the Gross Domestic Product (\$50,557 million) in that year. The data are summarised in the table on page 989.

In 1973–74, governments in Australia provided approximately 60 per cent of the funds devoted to R & D and undertook in their own agencies approximately 42 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 Australian scientific and technological research and development activities, they do not provide a complete picture since comprehensive information is not available on resources devoted to other scientific and technological activities in Australia.

Advice and co-ordination

In recent years Governments have shown increased concern with the adequacy of channels for advice on science and technology. Advisory bodies have been established, charged with making recommendations concerning a broad range of scientific and technological activities. At the national level, the Commonwealth Government appointed an Advisory Committee on Science and Technology (ACST) in 1972. This Committee was disbanded in 1973 and an Interim Australian Science and Technology Council (ASTECC) established in May 1975. At the State level, the New South Wales Government appointed a New South Wales Science and Technology Council in February 1976.

Prior to the establishment of advisory bodies with a wider role, a number of official advisory bodies had been established to deal with sectoral interests. Such bodies include: the Australian Research Grants Committee (ARGC), the Universities Commission, the CSIRO Advisory Council

and State Committees, the Defence Science Board, the Defence Research, Development, Trials and Evaluation Review Committee, and the National Health and Medical Research Council (NH & MRC).

ASTECS establishment followed an intensive period of discussion and review concerning arrangements for the provision to the Government of adequate advice on policies for science and technology in Australia. Following the dissolution of the ACST in January 1973, a Green Paper *Towards an Australian Science Council* was issued by the then Minister for Science in March 1974, which invited public discussion and comment on issues related to the establishment of a science council. Further stimulus was provided by the review of Australian science and technology undertaken by the OECD during 1974, which resulted in the issue in September of the *OECD Examiners' Report on Science and Technology in Australia*. This report delineated some of the structural and policy problems facing the organisation, management and further development of science and technology in Australia, as perceived by the examining team, and described approaches which had been taken in other countries in an attempt to meet similar problems. The Examiners' Report was widely discussed within Australia and was the subject of a meeting at the OECD in October 1974.

These various deliberations culminated in the issue by the Government in January 1975 of a White Paper *Science and Technology in the Service of Society—The Framework for Australian Government Planning*. Features of this framework included a Ministerial Committee on Science and Technology, the Australian Science and Technology Council (ASTECS), a Parliamentary Science and Technology Forum, and the Department of Science.

The role of ASTEC was envisaged in the White Paper as including broad functions of reporting and making recommendations to the Government. Following the election of a new Government in December 1975 the interim ASTEC was re-constituted and requested to prepare by the end of 1976 a report which would assist the Government in its decisions on the establishment of a permanent science and technology council. The policy of the Government envisages that the Council will be the major independent advisor to government on such matters as:

- the development and application of science and technology to national needs and objectives; new areas of science and technology which are of importance to Australia, including fields of industrially and commercially oriented research and development;
- the balance, adequacy and effectiveness of national efforts in various fields of science and technology, including defence science, and means for improving efficiency in the use of resources;
- the relative importance of efforts in those fields of science and technology which may contribute to national economic and social development and welfare and to the advancement of scientific knowledge; and,
- the effective development and utilisation of scientific and technological manpower.

Successive Governments have seen the Department of Science as having a complementary role in relation to an advisory council on science and technology. As a government department it has ready access to information available to government concerning civil science and technology, and is able to provide a scientific and technological perspective at the interdepartmental level. The Department's role includes the fostering of closer working relationships and consultation among government agencies, tertiary institutions, scientific associations, the private sector and the community. The Department's administrative functions in relation to certain scientific services and research activities (such as the Bureau of Meteorology, the Commonwealth Government Analytical Laboratories, and the Antarctic Division) help to ensure that its policy advice is tempered with an awareness of practical problems in science and technology.

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; ad hoc advisory committees are appointed by the Academy from time to time to examine and report on specific matters. In addition, the Academy has 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.

The most broadly based of the learned and professional bodies is the Australian and New Zealand Association for the Advancement of Science (ANZAAS). The Association has established a Science Policy Commission to give increased attention to policy issues. Other sources of advice to government within their various spheres of interest include the Academy of the Social Sciences in Australia, the Australian Academy of Technological Sciences, the Institution of Engineers, Australia (IEA), the Royal Australian Chemical Institute (RACI), and the Federation of Australian University Staff Associations (FAUSA). In recent years, matters of scientific and technological policy have received much discussion among such learned and professional organisations as well as in academic circles.

Intergovernmental co-ordination of research and technical services between the Commonwealth and the States is effected through bodies such as Ministerial councils. Among these are the Australian Agricultural Council, the Australian Minerals and Energy Council, the Australian Waters 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 the achievement of economic, social or environmental goals.

Expenditure and manpower

Project SCORE

As mentioned above, comprehensive data on the resources devoted to scientific and technological activities in Australia are not available. Therefore, though some details of Australian expenditure on research and development activities are given below, it should be noted that these data do not include many important scientifically or technologically based programs. Programs not covered by Project SCORE (Survey and Comparisons of Research Expenditure), some of which involve large expenditures, are those which have no research and development component; such programs include those aimed at providing scientific or technological services.

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, covered R & D expenditure and manpower in the natural and social sciences in all sectors of the Australian economy. 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. In addition to a summary report dealing with the overall national situation, separate Project SCORE reports cover the following sectors: Commonwealth Government, Business enterprise, State Government, Higher education, and Private non-profit. A summary of the results for 1968-69 is given in Year Book No. 60, pp. 995-1005.

The results of a second survey, for the 1973-74 financial year (1974 calendar year for higher education bodies), were in press at the time of writing. The results are being published in two volumes: Volume 1 contains the reports for the Commonwealth Government, State Government, and Private non-profit Sectors, while Volume 2 presents an all-sector summary together with the reports for the Business enterprise and Higher education sectors.

For the purposes of the survey, *research* was defined as original 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 investigation of which the primary aim was the solution of a recognised practical problem. Work was defined as *experimental development* where it involved the systematic use or adaptation of research results directed towards the production of new or improved products, processes, systems or methods. The physical, chemical, biological, earth, engineering and applied, agricultural and medical sciences were included in the natural sciences, which together with the social sciences, were covered in the 1968-69 and the 1973-74 surveys. The 1973-74 survey also covered R & D in the humanities, which were excluded in 1968-69.

Because of changes in definition and interpretation between the two surveys, the results of the 1973-74 survey will not be directly comparable with those previously published for 1968-69. However, the latter results are to be re-processed and revised figures published for purposes of comparison. The third survey is planned for the 1976-77 financial year.

All Sectors. Gross expenditure on R & D performed in Australia (GERD) in 1973-74 was \$651 million, of which \$594 million (91 per cent) was spent in the natural sciences, engineering and technology; and \$56 million (9 per cent) was spent on research in the social sciences and humanities. Expenditure and manpower according to sector of performance were as follows.

Sector of performance	Expenditure		Manpower	
	\$ million	per cent	f.t.e.(a)	per cent
Business enterprise	228	35	14,710	28
Commonwealth Government	202	31	14,516	27
Higher education	142	22	17,111	32
State Government	73	11	6,382	12
Private non-profit	6	1	578	1
	651	100	53,296	100

(a) Full-time equivalent.

The following tables contain figures for expenditure on R & D in 1973-74 according to source and sector of performance and for both expenditure and manpower according to major objectives

INTRAMURAL EXPENDITURE ON R&D IN AUSTRALIA IN 1973-74 BY SECTOR OF PERFORMANCE AND SECTOR OF SOURCE OF FUNDS
(S'000)

Sector of performance	Sector of source						Total
	Commonwealth Government	State Government	Private non-profit	Business enterprise	Higher education	Overseas	
Commonwealth Government	179,485	242	231	12,370	4	9,228	201,560
State Government	8,819	63,013	167	1,335	6	154	73,494
Private non-profit	1,866	440	2,685	371	24	547	5,933
Business enterprise	(a)20,609	(b)	..	206,459	..	968	228,036
Higher education	133,926	1,310	4,189	1,632	..	607	141,664
Total	344,705	65,006	7,272	222,166	34	11,504	650,687

(a) Includes a small State Government contribution. (b) See footnote (a).

INTRAMURAL EXPENDITURE AND MANPOWER DEVOTED TO R&D IN AUSTRALIA IN 1973-74, BY OBJECTIVE SUB-GROUP

Objective sub-group	Natural Sciences				Social Sciences and Humanities			
	Expenditure		Manpower		Expenditure		Manpower	
	\$'000	per cent	fte(b)	per cent	\$'000	per cent	fte(b)	per cent
Business Enterprise(a)	228,036	38.4	14,710	31.6	..	..	..	..
Other Sectors—								
Defence	55,962	9.4	5,093	11.0	525	0.9	43	0.6
Primary industry	83,609	14.1	6,737	14.5	2,858	5.1	233	3.4
Secondary industry	31,273	5.3	2,279	4.9	221	0.4	18	0.3
Economic services	34,423	5.8	2,065	4.4	963	1.7	65	1.0
Other economic development					3,246	5.8	220	3.2
Health	11,501	1.9	1,063	2.3	125	0.2	13	0.2
Environment	13,145	2.2	920	2.0	..	..	..	..
Public welfare	334	0.1	26	0.1	2,966	5.3	279	4.1
Community services	6,970	1.2	450	1.0	1,699	3.0	141	2.1
Other community welfare	..	..	..	..	1,698	3.0	100	1.5
Advancement of knowledge(c)	129,157	21.7	13,158	28.3	41,976	74.6	5,684	83.6
Total	594,410	100.0	46,500	100.0	56,277	100.0	6,796	100.0

(a) Business enterprise respondents were not asked to differentiate between natural and social sciences—in this table all Business enterprise R & D has been assigned to the natural sciences. Business enterprises R & D cannot be assigned unambiguously to objective sub-groups because the survey classification was by industry rather than by objective (b) Full-time equivalents. (c) All R & D in the Higher education sector was assigned to Advancement of knowledge.

When the published figures are adjusted to allow for the differences between the 1968-69 and 1973-74 surveys it can be seen that there was an increase in R & D expenditure in all sectors over the five year period. Overall, the ratio of R & D expenditure to the GDP was maintained. [(GERD/GDP for 1973-74)/(GERD/GDP for 1968-69) = 1.05].

A comprehensive survey of manpower in Australia was made in conjunction with the 1971 national census. This revealed that scientific and technical personnel, 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, accounted for 1.7 per cent of the workforce. Furthermore, 0.8 per cent of the Australian population held tertiary qualifications in the physical sciences and technology and 2.5 per cent held technical qualifications. The distribution of educational attainment of the population in 1971, over major fields of scientific and technical personnel was as follows. Medical, dental, health and paramedical personnel 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.

Field	Persons holding degrees or equivalent	Persons with tertiary qualifications (excluding degrees)	Persons at technical level
Natural sciences	25,593	5,302	4,465
Engineering, building technology	23,152	33,866	93,092
Architecture	2,992	3,687	..
Agriculture and forestry	7,281	2,151	20,369
Total	59,018	45,006	117,926

Details of the distribution of expenditure in 1973-74 between basic research, applied research and experimental development are as follows.

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

	Business enterprise sector	Commonwealth government sector	State government sector	Higher education sector	Private non-profit sector	Total
Basic research	10	24	8	73	57	28
Applied research	22	52	68	23	37	37
Experimental development	69	24	25	4	6	35
Total	100	100	100	100	100	100

Commonwealth Government Sector. Within the Commonwealth Government sector, total intramural expenditure on R & D was \$202 million, representing 0.40 per cent of Australia's 1973-74 Gross Domestic Product (\$50,557 million) and 1.6 per cent of Commonwealth Government outlays for 1973-74 (\$12,499 million). Manpower involved in this R & D effort was equivalent to 14,516 man-years, representing 0.25 per cent of the effort of the Australian workforce (5,867,700). Of this effort about 5,000 man-years were attributed to workers who held professional qualifications. Distribution of this expenditure and manpower effort by objectives and field of science is shown in Plates 63 and 64, pages 992 and 993. Other major features were:

- (a) Socio-economic objective groups accounted for the intramural R & D expenditure of the Commonwealth Government as follows:

	<i>per cent</i>
Economic development	47
National security	28
Advancement of knowledge	14
Community welfare	11

- (b) Expenditure in the Economic development group was distributed between the following sub-groups:

	<i>per cent</i>
Primary industry	19
Secondary industry	13
Economic services	13
Other	2

- (c) Two respondents, CSIRO and the then Department of Supply, accounted for 68 per cent of the total intramural expenditure.

- (d) Intramural expenditure on R & D in the natural sciences and in the social sciences and humanities was distributed as follows:

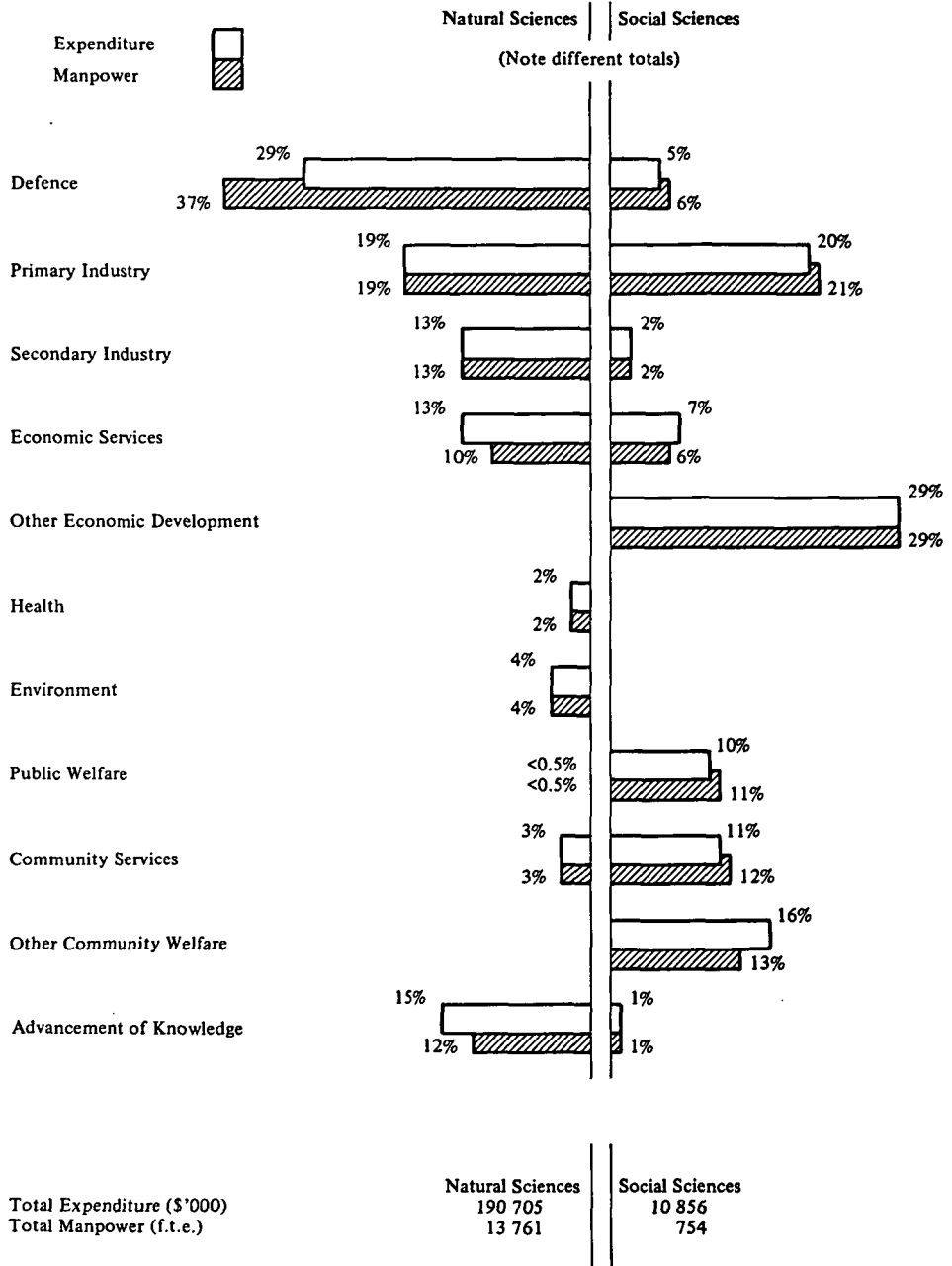
	<i>per cent</i>
Natural sciences	95
Social sciences	5

(No expenditure was reported for R & D in the humanities.)



42 per cent of the total effort was in Engineering and Applied Sciences, the dominant major field of science in the natural sciences.

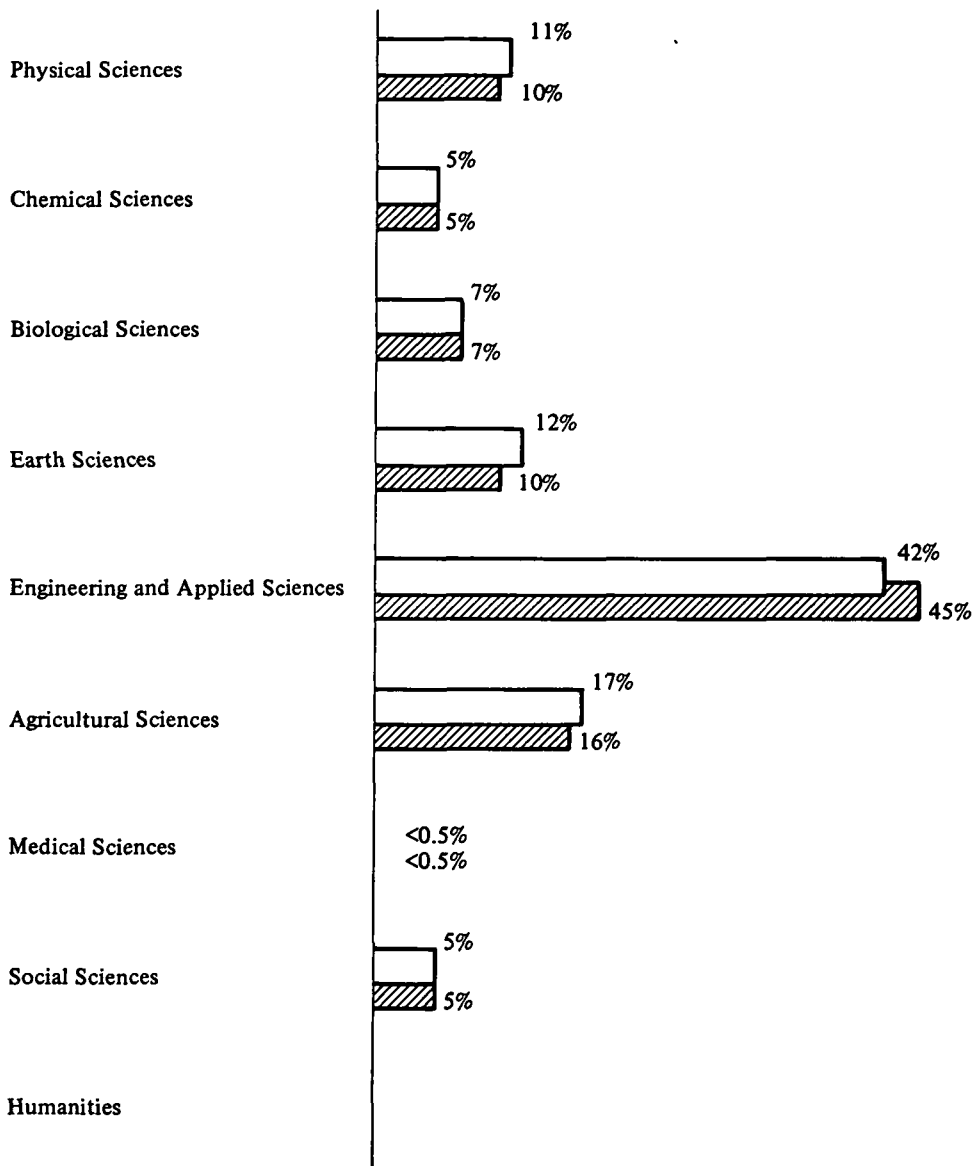
A diagrammatic representation of the principal ways in which Commonwealth Government support is channelled into R & D is shown in Plate 65, page 994.

**DISTRIBUTIONS OF EXPENDITURE AND MANPOWER
IN THE COMMONWEALTH GOVERNMENT SECTOR BY OBJECTIVE
SUB-GROUP**



**DISTRIBUTIONS OF EXPENDITURE AND MANPOWER
IN THE COMMONWEALTH GOVERNMENT SECTOR BY MAJOR FIELD
OF SCIENCE**

Expenditure 
Manpower 



Total Expenditure (\$'000) 201 561

Total Manpower (f.t.e.) 14 516

PLATE 64

IMPORTANT CHANNELS OF COMMONWEALTH GOVERNMENT FINANCIAL SUPPORT FOR R & D

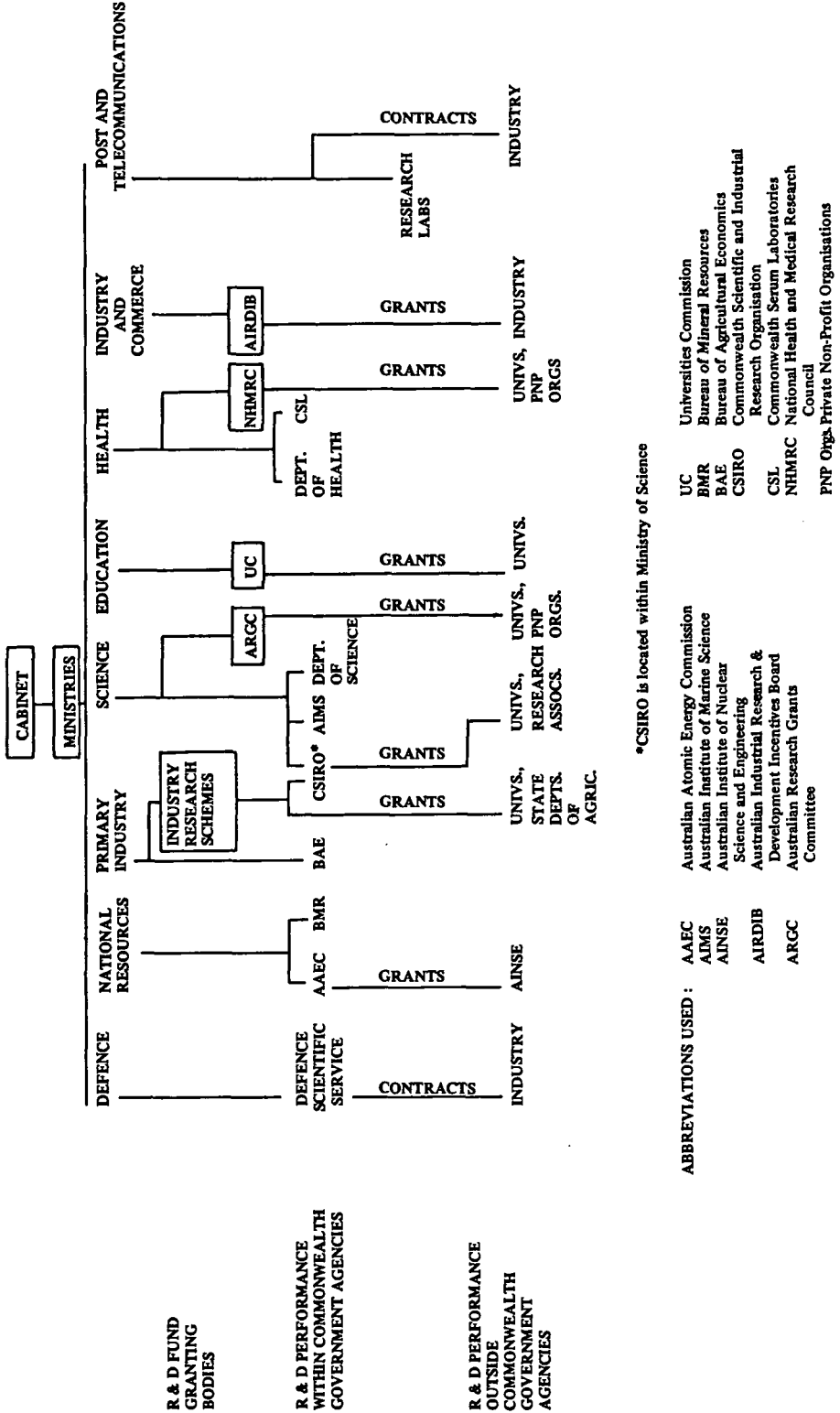


PLATE 65

State Government Sector. Within the State Government sector the overall intramural expenditure on R & D was \$73 million, representing 0.15 per cent of Australia's 1973-74 Gross Domestic Product and 1.0 per cent of State Government outlays (\$7,308 million). Manpower involved in this R & D effort was 6,382 man-years, representing 0.11 per cent of the effort of the Australian workforce. Of this effort, about 2,700 man-years were attributed to workers holding professional qualifications. Distribution of this expenditure and manpower effort by objectives and field of science is shown in Plates 64 and 65, pages 996 and 997. Other major features were:

Within socio-economic objectives, Economic development accounted for 84 per cent of intramural R & D expenditure. The remaining expenditure was distributed between Community welfare (14 per cent) and Advancement of knowledge (2 per cent). Expenditure in the Economic Development Group was distributed between sub-groups as follows:

	<i>per cent</i>
Primary industry	64
Economic services	12
Secondary industry	8

Expenditure in the Primary Industry Sub-Group was distributed between the objectives:

	<i>per cent</i>
Agriculture	56
Forestry	5
Fisheries	3

In every State, the Department of Agriculture was by far the largest performer of R & D. Intramural expenditure on R & D in the natural sciences and in the social sciences and humanities was distributed as follows:

	<i>per cent</i>
Natural sciences	96
Social sciences and humanities	4

60 per cent of the total effort was in Agricultural sciences, the major field of science in the natural sciences.

**DISTRIBUTIONS OF EXPENDITURE AND MANPOWER
IN THE STATE GOVERNMENT SECTOR BY OBJECTIVE SUB-GROUP**

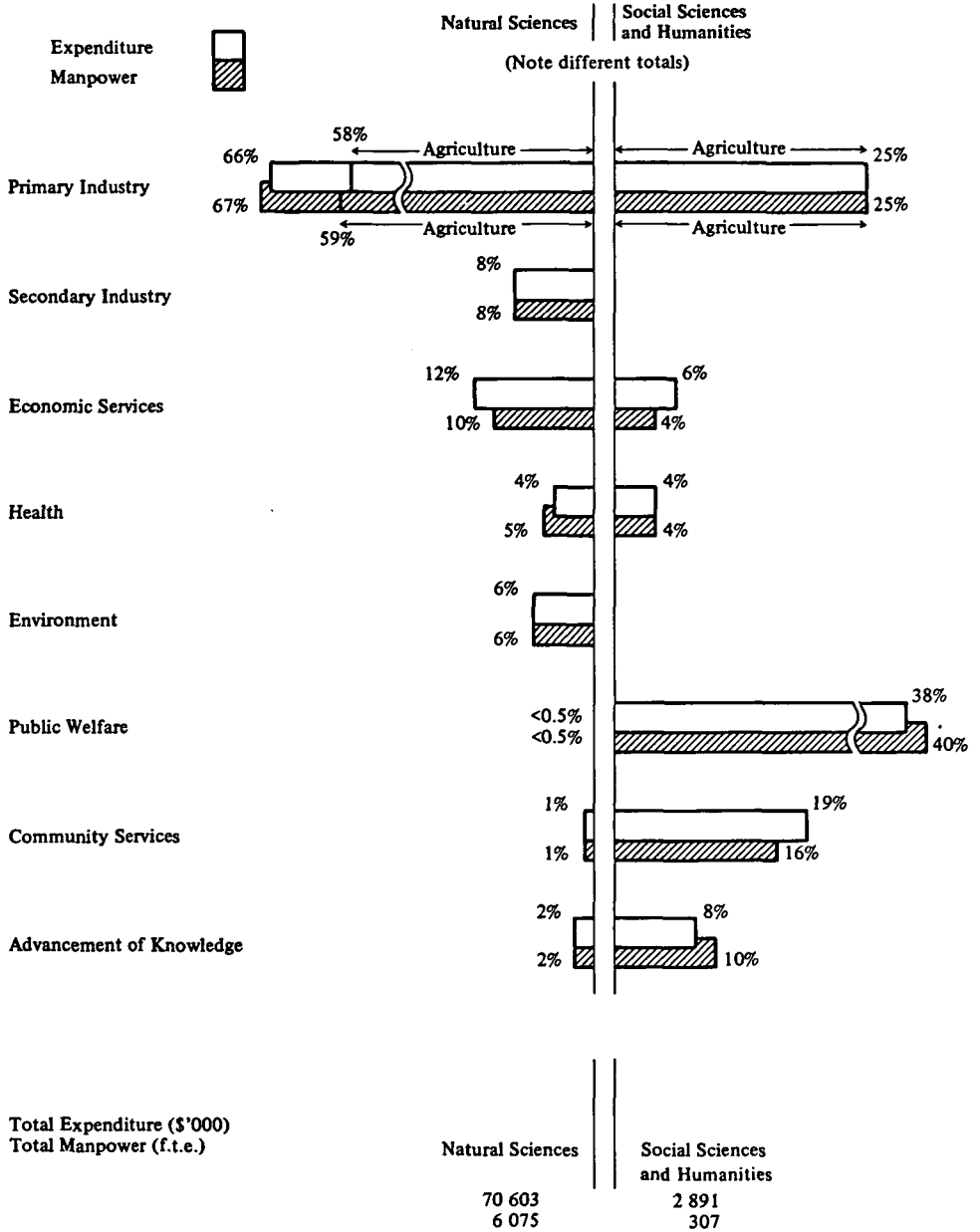


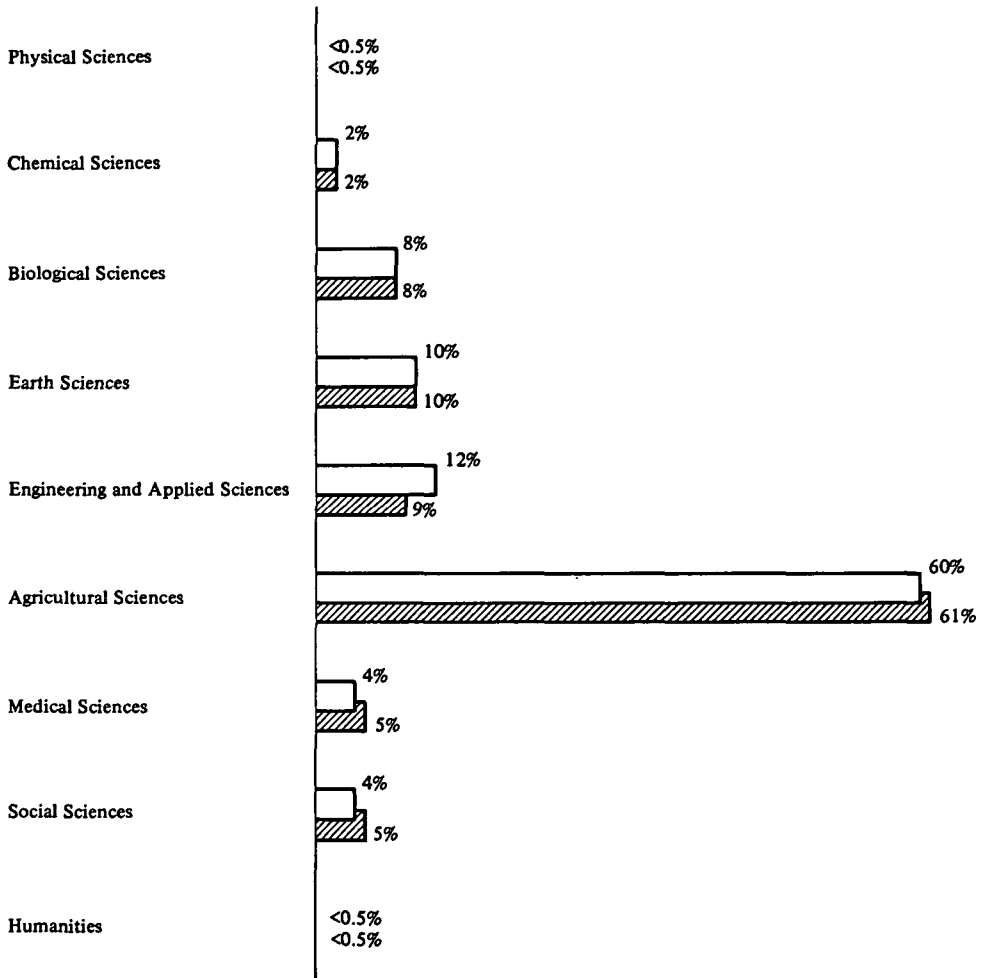


PLATE 66

**DISTRIBUTIONS OF EXPENDITURE AND MANPOWER
IN THE STATE GOVERNMENT SECTOR BY MAJOR FIELD OF
SCIENCE**

Expenditure 
Manpower 



Total Expenditure (\$'000) 73 494

Total Manpower (f.t.e.) 6 382

Private non-profit sector. In this sector the intramural expenditure on R & D of \$5.9 million represented only 0.01 per cent of Australia's 1973-74 Gross Domestic Product. The manpower involved in this effort was 578 man-years of which about 310 man-years were attributed to workers who held professional qualifications. Within socio-economic objectives, the Community welfare group accounted for 98 per cent of R & D expenditure. Within this sector almost 75 per cent of R & D was performed by ten medical research institutes.

Higher education sector. The gross intramural expenditure on R & D in this sector was \$142 million, consisting of \$61 million directly spent on research in the universities, together with an estimated value of \$80 million for R & D performed in combined teaching and research activities. Colleges of Advanced Education accounted for the remaining \$1 million. The gross intramural expenditure of \$142 million represented 0.28 per cent of Australia's 1973-74 GDP. The manpower involved in this effort was 17,111 man-years representing 0.29 per cent of the total effort of the Australian workforce.

An analysis of expenditure and manpower effort according to field of science is shown in the following table.

HIGHER EDUCATION SECTOR

	<i>Expenditure</i>		<i>Manpower</i>	
	\$'000	per cent	f.t.e.(a)	per cent
Physical sciences	19,597	14	2,010	12
Chemical sciences	11,187	8	1,391	8
Biological sciences	23,397	17	2,639	15
Earth sciences	6,099	4	694	4
Engineering	14,836	10	1,918	11
Medical sciences	14,887	11	1,497	9
Agricultural	10,023	7	1,313	8
Social science and humanities	41,638	29	5,648	33
Total	141,664	100	17,111	100

(a) Full-time equivalent.

Business enterprise sector. The gross intramural expenditure on R & D in the business enterprise sector was \$228 million, representing 0.45 per cent of Australia's 1973-74 GDP. The manpower involved in this effort was 14,710 man-years, representing 0.25 per cent of the total effort of the Australian workforce. Figures for expenditure and manpower effort according to industry are shown in the following table.

INTRAMURAL EXPENDITURE AND MANPOWER DEVOTED TO R & D IN AUSTRALIA IN 1973-74 BUSINESS ENTERPRISE SECTOR

<i>Industry</i>	<i>Expenditure</i>		<i>Manpower</i>	
	\$'000	per cent	f.t.e.	per cent
Manufacturing—				
Food, beverages and tobacco	9,901	4.3	800	5.4
Textiles, clothing, footwear	3,877	1.7	270	1.8
Paper and printing	2,420	1.1	170	1.2
Chemicals	19,525	8.6	1,740	11.8
Pharmaceuticals	8,138	3.6	240	1.6
Basic metal products	14,621	6.4	990	6.7
Transport equipment	53,044	23.3	2,530	17.2
Fabricated metal products	55,605	24.4	4,800	32.6
Other manufacturing	15,610	6.8	960	6.5
Total manufacturing	182,741	80.1	12,500	85.0
Other industries	45,295	19.9	2,210	15.0
Total all industries	228,036	100.0	14,710	100.0

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 Transport (Chapter 12), Communications (Chapter 12), Health (Chapter 14), Agriculture (Chapter 22), Water (Chapter 23), Forestry (Chapter 24), Fisheries (Chapter 25) and 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 conservation 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 Commonwealth 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 Commonwealth, 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 work on fauna and flora but an important part of total Australian research into biological resources continues to be undertaken in the museums and herbaria of the State Governments.

In 1975, the Commonwealth Government established 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 Commonwealth has also made funds available, through the Australian Biological Resources Study Interim Council, to stimulate taxonomic and ecological studies of Australian fauna and flora resources. Funds were also provided towards the establishment of biological resources data centres which are to enable the storage and retrieval of biological data on a national basis. Planning of longer term national botanical and zoological studies has been commenced.

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 Commonwealth 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 Commonwealth funds. It is also concerned with the enforcement of provisions of relevant international conventions to which Australia is a signatory.

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.

Each government has 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.

A Bureau of Environmental Studies within the Department of Environment, Housing and Community Development 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 include 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 by the Bureau of Meteorology and the CSIRO.

At June 1975, the Bureau had a staff establishment of approximately 2,000, including about 450 professionals. In addition, a large number of persons assist part-time in maintaining the Bureau's extensive observational network.

Total expenditure in 1974-75 was approximately \$31.2 million. About 62.5 per cent of funds was provided by the Commonwealth Government through direct appropriation, while all but a small portion of the balance came from charges made to other Commonwealth 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 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 Commonwealth and State Governments, by tertiary education institutions, and by industrial organisations. In 1973, a Committee of inquiry recommended, inter alia, that the Commonwealth Government establish a national scientific and technological information (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. Three national subject libraries are now being established by the National Library of Australia: the Australian National Scientific and Technological Library (ANSTEL) which was officially opened in 1975; the Australian National Social Sciences Library (ANSOL); and the Australian National Humanities and Arts Library (ANHUL). Other major sources of STI within Australia are CSIRO's Central Information Library and Editorial Section (CILES) and the Australian Manufacturing Technology Information System (AMTIS) which is being established within the Commonwealth Government Department of Industry and Commerce.

Major government research agencies

The Commonwealth Scientific and Industrial Research Organisation (CSIRO)

The CSIRO is the largest scientific research organisation 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 the CSIRO is to carry out scientific research and investigations in connection with Australia's primary and secondary industries. The CSIRO has at present 37 research Divisions and 6 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 1974-75)

<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	12.5	13.9
Livestock	Animal Genetics Animal Health Animal Physiology Nutritional Biochemistry	12.4	13.8
Land use	Land Resources Management Land Use Research Soils	8.2	9.1
Insects and wildlife	Entomology Wildlife Research	7.0	7.7
Marine science	Fisheries and Oceanography Marine Biochemistry	3.9	4.3
Environmental physics	Atmospheric Physics Cloud Physics Environmental Mechanics	2.9	3.2
Wool processing and textiles	Protein Chemistry Textile Industry Textile Physics	6.2	6.9
Food	Food Research Wheat Research	5.1	5.6
Mineral exploration, processing and properties	Chemical Engineering Minerology Mineral Chemistry Mineral Physics	7.7	8.5
National standards	National Measurement Laboratory	5.2	5.8
Chemical and physical research industrial interest	Applied Organic Chemistry Chemical Physics Chemical Technology Tribophysics	7.3	8.0
Engineering and construction	Applied Geomechanics Building Research Mechanical Engineering Solar Energy Studies	6.9	7.6
Radiophysics	Radiophysics	3.0	3.3
Computing and statistics	Computing Research Mathematics and Statistics	2.1	2.3

The powers and functions of the CSIRO are prescribed in the *Science and Industry Research Act 1949* under which the Organisation 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.

The CSIRO has a total staff of about 7,000 persons located in more than 100 laboratories and field stations throughout Australia. About one-third of the staff are professional scientists.

In 1974-75, the CSIRO operations cost approximately \$105 million, more than 80 per cent of which was met by the Commonwealth Government through direct appropriation. Of the remainder, about four-fifths was spent on research concerned with various primary industries and came from statutory trust funds most of which derived from levies on production, and a supplementary contribution by the Commonwealth Government. The balance of operating expenses, comprising less than 4 per cent of the total, came from individual companies, other Commonwealth agencies, overseas instrumentalities and private foundations.

The Australian Atomic Energy Commission (AAEC)

The AAEC was established by the Commonwealth 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 National Resources. 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 1975 the Commission employed 1,304 staff of whom 370 were professional. For the year 1974-75 total expenditure was about \$18.0 million of which \$16.6 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 post-graduate students.

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 National Resources; 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 logistic 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 1974-75 was approximately \$4.5 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 (AIMS)

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. In the interim, temporary accommodation at Cape Pallarenda, just north of Townsville, is being used by research groups.

The Institute is mainly concerned with research and will emphasise multi-disciplinary projects focused on tropical marine sciences. Research projects at AIMS fall into four main areas: marine food webs; reef-building organisms and coral reefs; tropical oceanography; and marine pollution. These areas were selected both for their current importance to marine science and for their relevance to many applied problems. Specific programs being undertaken by the Institute concern: inshore productivity; plankton behaviour; ultraplankton; coral taxonomy; coral calcification; reef diagenesis; oceanographic mixing processes as related to cycling and budgets of plant nutrients; and pollution studies of trace metals.

Defence science

Much of the research and development effort conducted by the Commonwealth Government falls into this category. A fuller coverage 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 Commonwealth 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 Commonwealth 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 1974-75, some 1,400 firms applied for grants under the Grants Scheme. From the Scheme's inception in 1967 up to June 1975, \$91 million was disbursed. 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. Following a review by the Government, the Scheme was revised in 1976 so as to operate in a more cost effective manner. The new Scheme, now known as the Industrial Research and Development Incentives Scheme, commenced operation in the 1976-77 financial year.

Other fields of activity which to some extent involve the adoption by industry of new technology, and which attract financial support from the Commonwealth, 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 well advanced in Australia. The conversion program has been developed and implemented under the guidance of a Metric Conversion Board established by the Common-

wealth Government. The Board estimates that the program is now about 70 per cent complete and envisages that it will be substantially completed by 1980. Because implementation of the program depends in large measure on general community co-operation, the Board has been 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 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 Commonwealth Government. NATA is the recognised 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 Commonwealth 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 inquiry 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 Employment and Industrial Relations 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 Commonwealth Government, has primarily a research and co-ordination role in relation to national and State 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 the efficient development of small business.

Research in universities and colleges

University research is financed from four main sources:

- general recurrent funds recommended by the Universities Commission;
- special grants for research recommended by the Commission;
- grants from other Government sources, particularly the Australian Research Grants Committee (ARGC) and the National Health and Medical Research Council (NH & MRC); and
- grants, contracts and donations from private sources.

In 1973, research expenditure in Australian universities totalled some \$49.5 million (excluding salaries and wages). Of this sum, \$2.3 million was provided through the NH & MRC and \$5.4 million through the ARGC. The latter Committee assesses proposals in the social sciences and humanities, in physics, chemistry, biology, earth sciences, engineering and applied sciences. The prime criterion for support is the excellence of the proposal made. In three areas, those of upper-atmosphere research, marine science and multidisciplinary research, the Committee has sought to give special encouragement. Over the 1973-75 triennium, particular sums were "earmarked" for grants in these fields. In all other areas grants have been made without regard to the distribution of funds between the different areas.

Colleges of Advanced Education do not maintain expensive research facilities or programs akin to those of the universities. Staff are nevertheless encouraged to undertake research to the extent that this is possible. Research of an applied nature, and associated consultancy services to industry and commerce, are expected to become increasingly prominent within the colleges.

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 Commonwealth 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.

The bulk of social science research carried out within Commonwealth Government agencies is performed as part of the general activities of various departments. However, several agencies have been established specifically to undertake research.

Studies are undertaken in such fields as:

- economic research;
- education research;
- statistical and social analysis of health and social security schemes;
- personnel management and industrial psychology, including inquiries 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.

Agencies which have been established to undertake research in particular areas include the Australian Institute of Aboriginal Studies, the Australian Institute of Criminology, the Bureau of Agricultural Economics and the Bureau of Transport Economics.

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 Commonwealth 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, and 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 Commonwealth 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 Government agencies have scientific and technological representation at overseas posts (e.g. Japan, United Kingdom, United States of America, USSR, IAEA, OECD). Australia also plays an active role in regional bodies such as ESCAP (formerly 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 consequences of new and existing technologies.
- Effects of technology transfer by multinational enterprises.
- Measurement of resources (financial and manpower) devoted by OECD member countries to scientific research and development.

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 Australian scientists going abroad temporarily than there are foreigners entering temporarily for these purposes.

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 solely devoted to scientific and technological co-operation have been entered into with the USA (1968), India (1975) and the Federal Republic of Germany (1976) and are administered by the Department of Science. A fourth such agreement with the USSR (1975) is administered by the Department of Foreign Affairs.

Activity under the United States/Australia agreement has reached a steady level. Support is provided for about eight specialist seminars, and between ten and twenty individual visits, each year. Where opportunities exist, other co-operative projects which depend on special facilities are supported.

None of the more recent agreements have yet reached a constant level of activity, in all cases, however, opportunities for co-operation are being actively pursued. Under the USSR/Australia agreement exchange visits by expert groups have taken place in a number of specialist fields, including earth sciences, plant industry, radio astronomy, entomology, and textile technology.

Astronomy

In the field of optical astronomy, Australia and Britain are co-operating in the Anglo-Australian telescope project which involves the 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.

Observing time on the telescope is shared equally between Australia and the United Kingdom. It is expected that work with the telescope will complement the significant progress made by radio-astronomers in Australia.

Space

Agreements have been signed by the Governments of Australia and the United States of America to co-operate in the establishment and operation in Australia of space vehicle tracking stations. The agencies for the Australian and the American 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 stations track spacecraft in their orbits around the earth or on their journeys into space, receive telemetered data from the spacecraft, and issue radio commands controlling the spacecraft's manoeuvres. The Department of Science is responsible for managing, staffing and operating the stations on behalf of NASA. The stations which are now in operation are at Orroral Valley, Honeysuckle Creek and Tidbinbilla in the Australian Capital Territory. For 1974-75, NASA expenditure on operations in Australia was \$11.5 million.

An extensive communications system links the tracking stations with the control centres in the United States of America. At all stations the responsibility for the system is vested in a station director who is a senior officer of the Department of Science.

High altitude

The Balloon Launching Station at Mildura, Victoria, is operated by the Department of Science under a joint-sponsorship arrangement with the U.S. National Science Foundation. The station provides a service for scientific research requiring the use of high altitude balloons. These services are available to research workers from the U.S.A., Australia and other countries.

Defence

In the field of defence science, Australia collaborates with other countries through a variety of arrangements at inter-governmental level. 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 University of Moscow which includes exchanges in the scientific fields.

