

Chapter Twenty-four

Science and Technology

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

OFFICIAL ORGANISATIONS AND ADMINISTRATION

There are many organisations in Australia concerned in some way with the development of science and technology in Australia.

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

A number of other Commonwealth government organisations either support or carry out scientific and technological activities. State Governments are also involved in science and technology via State government departments, science and technology councils and other organisations. Non-government organisations participating in scientific and technological activities include higher education institutions, professional and learned bodies, private organisations and industry groups. See *Year Book Australia 1991*.

The Department of Industry, Technology and Regional Development

The main scientific and technological bodies and activities of the portfolio include the Commonwealth Scientific and Industrial Research Organisation, the Australian Nuclear Science and Technology Organisation, and the 150 per cent tax concession for research and development (R&D), which are described below. Details of others, such as R&D grants and assistance schemes; the Patent, Trade Marks and Design Office; the Snowy Mountains Engineering Corporation; the Commission for the Future; The Australian Space Office; and the National Standards

Commission, are contained in *Year Book Australia 1991*.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO)

CSIRO was established as an independent statutory authority by the *Science and Industry Research Act 1949*. The Act has been amended on a number of occasions since then, including in 1978, following the government-instigated 'Birch Committee of Inquiry' and in November 1986, following the 'Review of Public Investment in Research and Development in Australia', specifically including CSIRO, carried out by the Australian Science and Technology Council (ASTEC).

The 1986 amendments to the Act confirm that CSIRO's primary role is to continue as an applications-oriented research organisation in support of major industry sectors and selected areas of community interest, but with a stronger commitment to the effective transfer of its results to users. The most recent amendments have also included changes to the top management structure and the organisation's advisory mechanisms.

Briefly, CSIRO's primary statutory functions are to:

- carry out scientific research for the benefit of Australian industry, the community, national objectives, national or international responsibilities, or for any other purpose determined by the Minister; and
- encourage or facilitate the application or utilisation of the results of such research.

Other functions include dissemination and publication of scientific information, international liaison in scientific matters, and provision of services and facilities.

The research work of the organisation is carried out in Institutes, each headed by a Director and each specifically established to undertake work in support of industry or community interest sectors of the Australian economy. Institutes are composed of Divisions, which are individually responsible for broad programs of research in support of the objectives of the Institute.

Institute of Information, Science and Engineering: Divisions of Information Technology; Radiophysics; Mathematics and

Statistics; CSIRO Office of Space Science and Applications; Australia Telescope.

Institute of Industrial Technologies: Divisions of Manufacturing Technology; Materials Science and Technology; Applied Physics; Chemicals and Polymers; Biomolecular Engineering.

Institute of Minerals, Energy and Construction: Divisions of Building, Construction and Energy (now incorporates National Building Technology Centre); Exploration Geoscience; Mineral and Process Engineering; Mineral Products; Coal and Energy Technology; Geomechanics.

Institute of Animal Production and Processing: Divisions of Animal Health; Animal Production; Wool Technology; Tropical Animal Production; Food Processing; Human Nutrition.

Institute of Plant Production and Processing: Divisions of Plant Industry; Tropical Crops and Pastures; Horticulture; Entomology; Soils; Forestry and Forest Products.

Institute of Natural Resources and Environment: Divisions of Water Resources; Fisheries; Oceanography; Atmospheric Research; Wildlife and Ecology; Centre for Environmental Mechanics.

CSIRO has a total staff of more than 7,000 in more than 100 locations throughout Australia. About one-third of the staff are professional scientists, with the others providing technical, administrative or other support. CSIRO's budget for 1991-92 was \$620.5 million.

The Australian Nuclear Science and Technology Organisation (ANSTO)

ANSTO was established as a statutory authority under the *Australian Nuclear Science and Technology Organisation Act Number 3 of 1987*, and replaced the Australian Atomic Energy Commission. Its mission is to benefit the Australian community by the development and peaceful application of nuclear science and technology in industry, medicine, agriculture, science and other fields.

Tax Concession for Research and Development

The 150 per cent tax concession for Research and Development (R&D) which commenced

from July 1985 is the major program in the Government's package of measures to encourage R&D in Australia.

The concession allows companies incorporated in Australia, public trading trusts and partnerships of eligible companies to deduct up to 150 per cent of eligible expenditure incurred on R&D activities when lodging their corporate tax return. This effectively reduces the after tax cost of R&D to about 41.5 cents in the dollar at the 39 per cent corporate tax rate.

The concession is broad based, being available to the majority of companies undertaking R&D in Australia. The concession is market driven, being structured in a manner which is neither industry nor product oriented, allowing individual companies to determine both the specific area of innovation and direction of their R&D activities.

Expenditure eligible under the concession at 150 per cent include: salaries, wages and other overhead costs which are directly related to the company's Australian R&D activities; contract expenditure; and capital expenditure on R&D plant and equipment (over three years). Expenditure on acquiring, or acquiring the right to use, technology for the purposes of the company's own R&D activities is 100 per cent deductible.

The concession is only available for R&D projects carried out in Australia or an external Territory and must meet exploitation and adequate Australian content requirements.

To attract the full 150 per cent deduction, annual eligible R&D expenditure must exceed \$50,000, with a sliding scale operating from 100 to 150 per cent where annual eligible R&D expenditures range from \$20,000 to \$50,000. Where R&D is contracted to an approved Registered Research Agency this expenditure threshold is waived and the R&D expenditure can be deducted at 150 per cent.

Cooperative Research Centres (CRC)

Launched in May 1990 the Cooperative Research Centres Program is a major initiative in Commonwealth support of R&D. A CRC committee advises on the operation of the program and selection of up to 50 centres to undertake collaborative research and education in the fields of natural sciences and engineering.

The program has the following objectives:

- to support long-term high quality scientific and technological research which contributes to national objectives, including economic and social development, the maintenance of a strong capability in basic research and the development of internationally competitive industry sectors;
- to capture the benefits of research, and to strengthen the links between research and its commercial and other applications, by the active involvement of the users of research in the work of the centres;
- to build centres of research concentration by promoting cooperative research, and through it a more efficient use of resources in the national research effort; and
- to stimulate education and training, particularly in graduate programs, through the active involvement of researchers from outside the higher education system in educational activities, and graduate students in major research programs.

35 selected centres were in operation by 1 July 1992, and a further 15 have been selected. The Commonwealth Government will

provide funding of up to \$100 million (in 1990-91 dollars) to the centres. This is to be allocated to enable funding of up to 50 per cent of the cost of establishing and operating the centre. The participating organisations in each centre contribute the remainder.

RESEARCH AND DEVELOPMENT — EXPENDITURE AND HUMAN RESOURCES

The statistics which follow are based on the definitions described by the OECD for national research and development (R&D) surveys. The OECD defines R&D as comprising 'creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications'.

Tables 24.1 and 24.2 show the amount of expenditure and human resources devoted to R&D in the business enterprise, general government, higher education, and private non-profit sectors.

**24.1 EXPENDITURE ON RESEARCH AND DEVELOPMENT IN AUSTRALIA
AT CURRENT AND AVERAGE 1984-85 PRICES
(\$ million)**

<i>Sector</i>	<i>1986-87r</i>	<i>1987-88r</i>	<i>1988-89r</i>	<i>1989-90r</i>	<i>1990-91</i>
AT CURRENT PRICES					
Business enterprises					
Private sector	1,156.5	1,340.3	1,635.2	1,787.1	1,813.2
Public sector	123.5	117.6	149.2	187.0	204.2
General government					
Commonwealth	786.5	797.0	868.9	n.a.	1,039.7
State	368.4	394.6	474.4	n.a.	611.4
Higher education					
Universities	844.9	929.8	1,018.4	n.a.	n.y.a.
CAEs	36.7	53.8	54.5	n.a.	n.y.a.
Private non-profit	49.1	53.9	51.9	n.a.	68.3
Total	3,365.6	3,687.0	4,252.5	n.a.	n.y.a.

... continued

24.1 EXPENDITURE ON RESEARCH AND DEVELOPMENT IN AUSTRALIA
AT CURRENT AND AVERAGE 1984-85 PRICES — continued
(\$ million)

<i>Sector</i>	<i>1986-87-</i>	<i>1987-88r</i>	<i>1988-89r</i>	<i>1989-90r</i>	<i>1990-91</i>
AT AVERAGE 1984-85 PRICES					
Business enterprises					
Private sector	992.3	1,072.4	1,244.9	1,254.3	1,216.0
Public sector	106.6	97.6	119.3	139.4	143.4
General government					
Commonwealth	693.8	655.7	679.9	n.a.	717.9
State	322.5	324.2	371.1	n.a.	427.0
Higher education					
Universities	750.8	788.7	816.5	n.a.	n.y.a.
CAEs	32.2	40.3	41.0	n.a.	n.y.a.
Private non-profit	45.5	47.3	43.4	n.a.	49.2
Total	2,943.7	3,026.2	3,316.1	n.a.	n.y.a.

Source: Research and Experimental Development: All Sector Summary, Australia (8112.0).

24.2 HUMAN RESOURCES DEVOTED TO RESEARCH AND DEVELOPMENT
(person years)

<i>Sector</i>	<i>1986-87r</i>	<i>1987-88r</i>	<i>1988-89r</i>	<i>1989-90r</i>	<i>1990-91</i>
Business enterprises					
Private sector	16,198	16,952	18,858	18,572	18,103
Public sector	1,393	1,527	1,597	1,729	1,881
General government					
Commonwealth	11,529	11,491	11,705	n.a.	11,386
State	6,796	7,133	7,992	n.a.	8,295
Higher education					
Universities	21,690	22,435	22,939	n.a.	n.a.
CAEs	1,529	1,888	1,963	n.a.	n.a.
Private non-profit	945	1,016	990	n.a.	1,049
Total	60,080	62,442	66,044	n.a.	n.a.

Source: Research and Experimental Development: All Sector Summary, Australia (8112.0).

Source of funds

In 1990-91, 94 per cent of funding for R&D carried out by businesses came from the business sector and has remained at this level since 1988-89. General government organisations provided four per cent.

60 per cent of general government sector R&D was funded by Commonwealth government organisations and 30 per cent by State government organisations. These

percentages have fallen slightly since 1988-89 and have been offset by increases from both business enterprises and private non-profit organisations.

For the private non-profit sector Commonwealth government organisations funded 31 per cent of the R&D in 1990-91 (down from 37% in 1988-89) while State Governments doubled their contribution to 15 per cent.

**24.3 EXPENDITURE ON RESEARCH AND DEVELOPMENT IN AUSTRALIA
BY SECTOR BY SOURCE OF FUNDS
(\$'000)**

	Source of funds						
Sector	Common- wealth government	State government	Business enterprises	Higher education	Private non-profit and other Australian	Overseas	Total
1988-89							
Business enterprises							
Private sector	59,074	2,709	1,529,077	168	4,060	40,676	1,635,213
Public sector	2,900	1,642	144,126				149,217
General government							
Commonwealth	816,248	3,862	40,617	—	2,651	5,563	868,941
State	43,369	388,377	22,651	299	18,543	1,162	474,401
Higher education							
Universities	940,066	11,856	18,676	—	40,961	6,824	1,018,383
CAEs	11,228	4,779	8,906	28,057	1,180	369	54,519
Private non-profit	19,382	5,660	4,305	632	19,735	2,193	51,906
Total	1,892,267	418,885	1,768,357	29,156	87,130	56,787	4,252,577
1990-91							
Business enterprises							
Private sector	61,296	8,951	1,696,971	4,241	3,542	41,728	1,813,202
Public sector	5,611		195,071				204,209
General government							
Commonwealth	922,933	7,482	48,801	13	51,285	9,161	1,039,676
State	68,891	480,827	35,944	2,099	20,883	2,731	611,376
Higher education	n.y.a.	n.y.a.	n.y.a.	n.y.a.	n.y.a.	n.y.a.	n.y.a.
Private non-profit	21,466	10,304	5,650	890	27,259	2,776	68,344
Total	n.y.a.	n.y.a.	n.y.a.	n.y.a.	n.y.a.	n.y.a.	n.y.a.

Source: Research and Experimental Development: All Sector Summary, Australia (8112.0).

Business sector

Business expenditure on R&D in Australia in 1990-91 is estimated to be \$2,017 million at current prices and has been steadily increasing over the years. However, at average 1984-85 prices, it is estimated to be two per cent lower in 1990-91 than in 1989-90.

Of the total business expenditure in 1990-91, 53 per cent of expenditure (\$1,060 million) and 56 per cent of human resources (11,258 person years) were devoted to R&D in the manufacturing sector (table 24.4). The major industries contributing to this were Appliances and electrical equipment (26% of expenditure, 32% of human resources); Chemical, petroleum

and coal products (17% and 16% respectively) and Transport equipment (17% and 13% respectively).

Outside of manufacturing, the largest industry was Property and business services. In 1990-91 this industry contributed 12 per cent of both expenditure and human resources for all business enterprises in Australia.

Business expenditure on R&D represents 0.53 per cent of Gross Domestic Product (GDP). This ratio increased fairly rapidly in the early 1980s but started to plateau from 1986-87. It has remained steady over the last couple of years, and is relatively low when compared with other OECD countries (table 24.5).

24.4 RESEARCH AND DEVELOPMENT BY BUSINESS ENTERPRISES

Industry of enterprise		Expenditure on R&D (\$m)			Person years of effort on R&D		
ASIC code	Description	1986-87r	1988-89r	1990-91	1986-87r	1988-89r	1990-91
11-15	Mining (excluding services to mining)	55.6	68.7	77.3	524	589	559
	Manufacturing						
21	Food, beverages and tobacco	58.8	87.4	85.3	883	891	925
23-24	Textiles; Clothing and footwear	12.9	9.1	7.5	119	118	74
25	Wood, wood products and furniture	6.4	10.4	7.3	118	122	107
26	Paper, paper products, printing and publishing	10.0	24.1	35.4	158	234	231
27	Chemical, petroleum and coal products	120.1	147.1	178.7	1,857	1,660	1,799
28	Non-metallic mineral products	15.3	22.2	17.5	178	204	159
29	Basic metal products	63.2	91.4	130.5	855	948	969
31	Fabricated metal products	23.0	26.1	32.6	392	382	354
32	Transport equipment	127.9	162.3	155.0	1,562	1,804	1,463
334	Photographic, professional and scientific equipment	25.7	37.5	41.9	433	513	490
335	Appliances and electrical equipment	174.5	236.4	275.1	2,835	3,450	3,605
336	Industrial machinery and equipment	43.3	56.1	60.3	720	799	710
34	Miscellaneous manufacturing	21.6	27.1	32.9	329	400	375
C	Total manufacturing	702.7	937.2	1,060.0	10,438	11,523	11,258
	Other industries						
F	Wholesale and retail trade	99.9	159.4	174.2	1,264	1,689	1,629
61-62	Finance	59.0	106.4	124.0	836	1,165	1,271
63	Property and business services	183.6	228.5	249.0	2,413	2,810	2,490
8461	Research and scientific institutions	45.3	127.4	111.2	640	1,094	986
	Other n.e.c.	134.1	156.8	221.8	1,476	1,584	1,791
16, D-L	Total other industries	521.8	778.5	880.1	6,629	8,342	8,168
	Total all industries	1,280.1	1,784.4	2,017.4	17,591	20,454	19,985
	Private sector contribution	1,156.5	1,635.2	1,813.2	16,198	18,858	18,103
	Public sector contribution	123.5	149.2	204.2	1,393	1,597	1,881

Source: Research and Experimental Development, Business Enterprises, Australia (8104.0).

24.5 BUSINESS EXPENDITURE ON R&D AS A PERCENTAGE OF GDP — OECD COUNTRIES

Country	Per cent
Switzerland	2.14
Japan	2.08
Germany	2.07
United States	1.90
Sweden	1.83
United Kingdom	1.48
Finland	1.17
Denmark	0.84
Italy	0.79
Canada	0.75
Australia	0.53
Spain	0.49
Ireland	0.47

Source: Research and Experimental Development, Business Enterprises, Australia (8104.0).

24.6 GOVERNMENT EXPENDITURE ON R&D AS A PERCENTAGE OF GDP — OECD COUNTRIES

Country	Per cent
France	0.56
Iceland	0.51
Australia	0.44
Germany	0.37
New Zealand	0.37
Finland	0.35
United Kingdom	0.34
United States	0.34
Italy	0.32
Denmark	0.29
Canada	0.27
Japan	0.23
Ireland	0.15
Sweden	0.11

Source: Research and Experimental Development, General Government and Private Non-Profit Organisations, Australia (8109.0).

General government sector

Government expenditure on R&D carried out in Australia in 1990-91 is estimated to be \$1,651 million at current prices and represents an increase of 23 per cent over the two years since 1988-89. At average 1984-85 prices expenditure in 1990-91 is estimated to have increased by nine per cent compared with 1988-89 (table 24.1).

The socio-economic objectives on which most government R&D expenditure was carried out were: agriculture (\$403 million), defence (\$233 million), environment (\$226 million)

and manufacturing (\$178 million). Much the same pattern applies in terms of the human resources devoted to R&D. Labour costs continue to be the main component of R&D expenditure (57%) but, as a proportion of total R&D costs, have been decreasing for a number of years (table 24.7).

Government expenditure on R&D represents 0.44 per cent of GDP. This ratio is at a similar level to the early 1980s. It increased in 1990-91 after the downward trend of the late 1980s, and is relatively high when compared with other OECD countries (table 24.6).

24.7 EXPENDITURE ON RESEARCH AND DEVELOPMENT BY GENERAL GOVERNMENT ORGANISATIONS, 1990-91 (\$'000)

<i>Socio-economic objective</i>	<i>Type of expenditure</i>				<i>Total</i>
	<i>Land and buildings</i>	<i>Other capital expenditure</i>	<i>Labour costs</i>	<i>Other current expenditure</i>	
Defence	11,855	25,082	137,503	58,706	233,145
Economic development					
Agriculture	18,975	23,638	249,968	110,145	402,726
Forestry	2,002	1,823	18,879	9,033	31,738
Fishing	1,635	2,250	25,135	14,321	43,341
Other agriculture, forestry and fishing	380	971	5,752	7,297	14,401
Mineral	1,188	5,989	51,229	42,444	100,849
Energy	1,017	3,915	18,025	9,322	32,279
Manufacturing	7,741	17,685	99,423	53,614	178,463
Construction	622	2,546	19,292	8,456	30,916
Transport	239	1,578	16,039	7,705	25,561
Information and communication services	1,785	4,290	19,634	13,099	38,809
Commercial services	151	302	2,272	1,350	4,074
Economy	1,581	1,545	12,535	4,682	20,342
Environmental aspects	2,961	7,208	70,608	35,882	116,659
<i>Total economic development</i>	<i>40,277</i>	<i>73,741</i>	<i>608,789</i>	<i>317,351</i>	<i>1,040,158</i>
National welfare					
Environment	3,212	7,646	57,451	40,932	109,241
Health	24,518	8,370	66,313	24,337	123,538
Education and training	499	810	7,285	3,756	12,349
Social and community development	1,781	6,098	22,497	15,966	46,343
<i>Total national welfare</i>	<i>30,010</i>	<i>22,924</i>	<i>153,546</i>	<i>84,991</i>	<i>291,472</i>
Advancement of knowledge					
Natural sciences, technologies and engineering	11,453	8,137	32,385	32,467	84,442
Humanities and social sciences	352	55	1,005	423	1,835
<i>Total advancement of knowledge</i>	<i>11,805</i>	<i>8,192</i>	<i>33,390</i>	<i>32,891</i>	<i>86,278</i>
Total	93,947	129,939	933,227	493,939	1,651,052

Source: Research and Experimental Development, General Government and Private Non-profit Organisations, Australia (8109.0).

24.8 HUMAN RESOURCES DEVOTED TO RESEARCH AND DEVELOPMENT BY GENERAL GOVERNMENT ORGANISATIONS, 1990-91
(person years)

<i>Socio-economic objective</i>	<i>Type of employee</i>			<i>Total</i>
	<i>Researchers</i>	<i>Technicians</i>	<i>Other supporting staff</i>	
Defence	1,230	804	949	2,984
Economic development				
Agriculture	1,948	1,913	1,372	5,233
Forestry	191	167	86	444
Fishing	205	230	130	565
Other agriculture, forestry and fishing	40	27	31	97
Mineral	491	264	241	996
Energy	164	87	65	316
Manufacturing	859	476	644	1,979
Construction	200	85	98	383
Transport	179	65	79	324
Information and communication services	243	52	79	374
Commercial services	29	7	9	46
Economy	172	54	44	270
Environmental aspects	694	409	318	1,420
<i>Total economic development</i>	<i>5,415</i>	<i>3,835</i>	<i>3,197</i>	<i>12,447</i>
National welfare				
Environment	520	340	307	1,167
Health	1,099	606	189	1,894
Education and training	109	20	20	149
Social and community development	263	88	89	441
<i>Total national welfare</i>	<i>1,991</i>	<i>1,055</i>	<i>606</i>	<i>3,652</i>
Advancement of knowledge				
Natural sciences, technologies and engineering	311	178	89	578
Humanities and social sciences	17	3	1	21
<i>Total advancement of knowledge</i>	<i>328</i>	<i>180</i>	<i>90</i>	<i>599</i>
Total	8,965	5,874	4,842	19,681

Source: Research and Experimental Development, General Government and Private Non-profit Organisations, Australia (8109.0).

Higher education sector

The estimate of expenditure on R&D carried out in Australia by higher education in 1988

(\$1,073 million) increased by 22 per cent over 1986 (table 24.9). Estimates for more recent (calendar) years are not yet available.

24.9 EXPENDITURE ON RESEARCH AND DEVELOPMENT BY HIGHER EDUCATION ORGANISATIONS
(\$ million)

<i>Socio-economic objective</i>	<i>1986</i>			<i>1988</i>		
	<i>CAEs</i>	<i>Univer-</i> <i>sities</i>	<i>Total</i>	<i>CAEs</i>	<i>Univer-</i> <i>sities</i>	<i>Total</i>
National security (Defence)	0.2	1.7	1.9	0.2	2.2	2.4
Economic development						
Agriculture	2.1	72.0	74.1	4.0	81.5	85.5
Forestry and fisheries	0.4	8.6	9.0	0.8	11.2	12.0
Mining (prospecting)						
Energy sources	0.3	3.7	4.0	0.4	3.3	3.7
Other	0.2	7.0	7.2	0.7	5.5	6.2

... continued

**24.9 EXPENDITURE ON RESEARCH AND DEVELOPMENT BY HIGHER EDUCATION
ORGANISATIONS — continued**
(*\$ million*)

<i>Socio-economic objective</i>	1986			1988		
	<i>CAEs</i>	<i>Univer- sities</i>	<i>Total</i>	<i>CAEs</i>	<i>Univer- sities</i>	<i>Total</i>
Mining (extraction)						
Energy sources	0.1	1.2	1.3	0.3	2.5	2.8
Other	1.2	5.6	6.8	1.5	6.8	8.3
Manufacturing	4.8	24.1	28.9	6.8	39.4	46.2
Construction	0.8	8.2	9.0	1.4	11.2	12.6
Energy	1.9	25.4	27.3	2.5	27.4	29.9
Transport	0.5	4.2	4.7	0.4	4.5	4.9
Communications	1.0	7.2	8.2	1.4	8.9	10.3
Economic services n.e.c.	2.8	33.3	36.1	3.3	46.4	49.7
<i>Total economic development</i>	<i>16.1</i>	<i>200.6</i>	<i>216.7</i>	<i>23.5</i>	<i>248.6</i>	<i>272.0</i>
Community welfare						
Urban and regional planning	0.4	5.6	6.0	0.8	6.2	7.0
Environment	1.4	15.7	17.1	2.6	25.8	28.4
Health	6.8	180.8	187.6	9.9	216.3	226.2
Education	3.8	32.9	36.7	6.8	35.1	41.9
Welfare	0.9	9.1	10.0	0.7	7.9	8.6
Community services n.e.c.	1.7	17.0	18.7	2.1	19.8	21.9
<i>Total community welfare</i>	<i>15.0</i>	<i>261.1</i>	<i>276.1</i>	<i>22.9</i>	<i>311.0</i>	<i>334.0</i>
Advancement of knowledge						
Earth, ocean and atmosphere n.e.c.	0.6	49.9	50.5	1.2	49.5	50.7
General advancement of knowledge	4.9	331.7	336.6	6.7	407.0	413.7
<i>Total advancement of knowledge</i>	<i>5.5</i>	<i>381.6</i>	<i>387.0</i>	<i>7.9</i>	<i>456.5</i>	<i>464.4</i>
Total	36.7	844.9	881.6	54.5	1,018.4	1,072.9

Source: Research and Experimental Development: Higher Education Organisations, Australia (8111.0).

**24.10 HUMAN RESOURCES DEVOTED TO RESEARCH AND DEVELOPMENT BY HIGHER
EDUCATION ORGANISATIONS**
(*person years*)

<i>Socio-economic objective</i>	1986			1988		
	<i>CAEs</i>	<i>Univer- sities</i>	<i>Total</i>	<i>CAEs</i>	<i>Univer- sities</i>	<i>Total</i>
National security (Defence)	13	39	52	6	36	42
Economic development						
Agriculture	63	1,949	2,012	129	2,045	2,174
Forestry and fisheries	19	237	256	35	224	260
Mining (prospecting)						
Energy sources	17	95	112	20	85	105
Other	12	194	206	32	131	163
Mining (extraction)						
Energy sources	2	37	40	12	63	75
Other	38	156	194	51	163	213
Manufacturing	215	682	896	284	949	1,233
Construction	25	201	226	36	233	269
Energy	76	643	719	93	602	695
Transport	28	109	137	19	97	116
Communications	58	200	258	49	196	245
Economic services n.e.c.	105	700	805	136	853	989
<i>Total economic development</i>	<i>659</i>	<i>5,202</i>	<i>5,861</i>	<i>896</i>	<i>5,640</i>	<i>6,536</i>

... continued

**24.10 HUMAN RESOURCES DEVOTED TO RESEARCH AND DEVELOPMENT BY HIGHER
EDUCATION ORGANISATIONS — continued**
(person years)

<i>Socio-economic objective</i>	1986			1988		
	<i>CAEs</i>	<i>Univer- sities</i>	<i>Total</i>	<i>CAEs</i>	<i>Univer- sities</i>	<i>Total</i>
Community welfare						
Urban and regional planning	16	134	150	25	119	144
Environment	66	427	493	92	554	646
Health	283	4,526	4,809	327	4,894	5,221
Education	140	843	984	239	824	1,062
Welfare	41	229	269	29	171	199
Community services n.e.c.	76	379	454	62	401	463
<i>Total community welfare</i>	<i>621</i>	<i>6,538</i>	<i>7,159</i>	<i>773</i>	<i>6,962</i>	<i>7,735</i>
Advancement of knowledge						
Earth, ocean and atmosphere n.e.c.	26	1,181	1,207	40	1,036	1,076
General advancement of knowledge	210	8,730	8,939	249	9,265	9,514
<i>Total advancement of knowledge</i>	<i>236</i>	<i>9,911</i>	<i>10,147</i>	<i>289</i>	<i>10,301</i>	<i>10,590</i>
Total	1,529	21,690	23,218	1,963	22,939	24,902

Source: Research and Experimental Development: Higher Education Organisations, Australia (8111.0).

Private non-profit sector

Private non-profit expenditure on R&D carried out in 1990-91 increased 32 per cent at current prices and 13 per cent at average 1984-85 prices over 1988-89 (table 24.1).

Health is the leading socio-economic objective in terms of R&D expenditure, accounting for 81 per cent or \$55 million of total R&D expenditure in 1990-91 in the private non-profit sector. The same applies in terms of human resource usage. Labour costs continue to be the main component of R&D expenditure (58%) (tables 24.11 and 24.12).

**24.11 EXPENDITURE ON RESEARCH AND DEVELOPMENT BY
NON-PROFIT ORGANISATIONS, 1990-91**
(\$'000)

<i>Socio-economic objective</i>	<i>Type of expenditure</i>				<i>Total</i>
	<i>Land and buildings</i>	<i>Other capital expend- iture</i>	<i>Labour costs</i>	<i>Other current expend- iture</i>	
Defence	—	—	—	—	—
Economic development					
Agriculture	—	4	113	25	142
Forestry	—	—	—	—	—
Fishing	—	—	—	—	—
Other agriculture, forestry and fishing	—	—	11	—	11
Mineral	—	—	—	—	—
Energy	—	9	110	146	265
Manufacturing	—	343	726	239	1,308
Construction	—	2	62	137	201
Transport	—	2	49	131	181
Information and communication services	—	—	—	—	—
Commercial services	12	66	180	70	328
Economy	—	—	597	545	1,142
Environmental aspects	—	8	50	50	108
<i>Total economic development</i>	<i>12</i>	<i>435</i>	<i>1,897</i>	<i>1,343</i>	<i>3,687</i>

... continued

**24.11 EXPENDITURE ON RESEARCH AND DEVELOPMENT BY
NON-PROFIT ORGANISATIONS, 1990-91 — continued**
(S'000)

<i>Socio-economic objective</i>	<i>Type of expenditure</i>				<i>Total</i>
	<i>Land and buildings</i>	<i>Other capital expend- iture</i>	<i>Labour costs</i>	<i>Other current expend- iture</i>	
<i>National welfare</i>					
Environment	—	5	274	159	438
Health	2,563	5,234	32,498	15,056	55,351
Education and training	—	48	2,006	1,403	3,456
Social and community development	6	32	238	23	299
<i>Total national welfare</i>	<i>2,569</i>	<i>5,319</i>	<i>35,015</i>	<i>16,640</i>	<i>59,543</i>
<i>Advancement of knowledge</i>					
Natural sciences, technologies and engineering	113	351	2,893	1,655	5,012
Humanities and social sciences	—	7	92	4	102
<i>Total advancement of knowledge</i>	<i>113</i>	<i>358</i>	<i>2,985</i>	<i>1,659</i>	<i>5,114</i>
Total	2,694	6,112	39,898	19,642	68,344

Source: Research and Experimental Development, General Government and Private Non-profit Organisations, Australia (8109.0).

**24.12 HUMAN RESOURCES DEVOTED TO RESEARCH AND DEVELOPMENT BY
PRIVATE NON-PROFIT ORGANISATIONS, 1990-91**
(person years)

<i>Socio-economic objective</i>	<i>Type of employee</i>			<i>Total</i>
	<i>Researchers</i>	<i>Technicians</i>	<i>Other supporting staff</i>	
<i>Defence</i>	—	—	—	—
<i>Economic development</i>				
Agriculture	2	—	—	2
Forestry	—	—	—	—
Fishing	—	—	—	—
Other agriculture, forestry and fishing	—	—	—	—
Mineral	—	—	—	—
Energy	2	—	—	2
Manufacturing	12	—	1	14
Construction	—	—	2	2
Transport	—	—	1	2
Information and communication services	—	—	—	—
Commercial services	3	1	2	5
Economy	9	3	5	17
Environmental aspects	1	—	—	1
<i>Total economic development</i>	<i>30</i>	<i>4</i>	<i>12</i>	<i>45</i>
<i>National welfare</i>				
Environment	5	1	1	6
Health	429	301	147	877
Education and training	26	4	10	39
Social and community development	5	1	1	6
<i>Total national welfare</i>	<i>464</i>	<i>307</i>	<i>158</i>	<i>929</i>
<i>Advancement of knowledge</i>				
Natural sciences, technologies and engineering	35	31	6	72
Humanities and social sciences	2	—	—	2
<i>Total advancement of knowledge</i>	<i>36</i>	<i>31</i>	<i>7</i>	<i>74</i>
Total	530	342	177	1,049

Source: Research and Experimental Development, General Government and Private Non-profit Organisations, Australia (8109.0).

USE OF ADVANCED TECHNOLOGIES IN THE MANUFACTURING AND MINING INDUSTRIES

The ABS has undertaken Surveys of Advanced Technologies in the manufacturing industry as at 30 June 1988 and 31 December 1991, and in the mining industry as at 30 June 1991. These surveys collected information on the current and planned technological status. In particular, information was collected on the current and future use of selected technologies, on management techniques and on technology related issues such as staff resources. Some of the main findings from the surveys are outlined below.

Of some 14,200 manufacturing establishments with 10 or more employees at 31 December 1991, 41 per cent had acquired at least one of the surveyed advanced manufacturing technologies. Corresponding figures from 1988 were 16,000 establishments of which 33 per cent were using advanced technology. In contrast, of the 486 mining establishments with 10 or more employees at 30 June 1991,

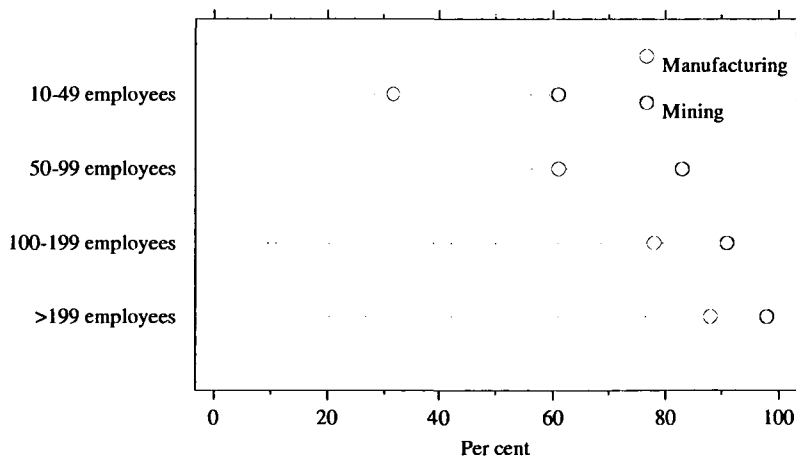
75 per cent had acquired one or more surveyed technologies.

The most common advanced manufacturing technologies were computer aided design and/or engineering followed by stand-alone numerically controlled machines and programmable logic controllers with 18 per cent and 17 per cent of establishments having each technology respectively. The most common mining technologies were non-core drilling followed by rehabilitation design with 52 per cent and 50 per cent of establishments having each technology respectively.

In the manufacturing sector the Other machinery and equipment industry (ASIC subdivision 33) continued to have the highest proportion (64%) of establishments having one or more technologies. In the mining sector the coal industry has the highest proportion (95% of the 88 establishments) having at least one of the advanced mining technologies.

These surveys show a strong relationship between the employment size of an establishment and the acquisition of advanced technologies. Larger establishments were more likely to be using advanced technologies.

24.13 USE OF TECHNOLOGY IN MANUFACTURING AND MINING, BY EMPLOYMENT SIZE, 1991



Source: *Manufacturing Technology Statistics, Australia (8123.0)* and *Mining Technology Statistics, Australia (8413.0)*.

More than half of manufacturing establishments with advanced technologies acquired them primarily from overseas sources. This is in contrast to mining technologies where most were acquired primarily from Australian sources.

Manufacturers continue to have difficulty in obtaining staff skilled in the normal operation or maintenance of advanced technologies (30% reported difficulties in 1991 down slightly

from 35% in 1988). In contrast, 81 per cent of mining establishments with advanced technologies reported no difficulty getting staff skilled in the normal operation, maintenance or programming associated with the surveyed technologies.

Further information on the use of advanced technology in the manufacturing industry is contained in the chapter Manufacturing, Retail and Service Industries.

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Additional information

Additional information on topics presented in this chapter may be found in the annual reports of the organisations mentioned, particularly the Department of Industry, Technology and Commerce, the CSIRO, and in the annual Science and Technology Statements. Statistical information on R&D for the years 1968–69, 1973–74 and 1976–77 may be found in the reports on Project SCORE published by the (then) Department of Science. Statistical information on R&D relating to 1978–79, 1981–82, and 1984–85 to 1990–91 may be obtained from the Australian Bureau of Statistics (ABS). Further statistical information on higher education is obtainable from the Department of Employment, Education and Training.

The Department of Industry, Technology and Commerce's *Australian Science and Innovation Resources Brief 1992*, published in 1992, uses Science and Technology (S&T) indicators to give a good overview and analysis of science and technology information in Australia. It presents information on R&D effort and expenditure; science and technology workforce; S&T information resources; scientific equipment and facilities; patent activity; technology training; financial support for technological development; and transfer of technical knowledge.

FOR MORE INFORMATION

The ABS has a far wider range of information on Australia than that contained in the *Year Book*. Information is available in the form of regular publications, electronic data services, special tables and from investigations of published and unpublished data.

For further information contact ABS Information Services at one of the addresses listed on the page facing the Introduction to the *Year Book*.