

Chapter Twenty-two

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, Science and Technology. 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.

The Department of Industry, Science and Technology

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, the Australian Institute of Marine Science 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 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*, which has been amended on a number of occasions since then. Its primary role is as an applications-oriented research organisation in support of major industry sectors and selected areas of community interest, with a strong commitment to the effective transfer of its results to users.

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.

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 and Mining; Mineral and Process Engineering; Mineral Products; Coal and Energy Technology; Petroleum Resources.

Institute of Animal Production and Processing: Divisions of Animal Health; Animal Production; Wool Technology; Tropical Animal Production; Food Science and Technology; 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; Office of Space Science and Applications; Australia Telescope.

CSIRO has a staff of approximately 7,000 in more than 70 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 1993-94 was \$682.1 million.

The Australian Nuclear Science and Technology Organisation (ANSTO)

ANSTO is established as a statutory authority under the *Australian Nuclear Science and Technology Organisation Act Number 3 of 1987* as amended, 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.

The Australian Institute of Marine Science

The Australian Institute of Marine Science (AIMS) is the premier institute in Australia involved in marine research, with emphasis on tropical marine science. The Institute was established in 1972 and has its headquarters at Cape Ferguson, 50 kilometres south of Townsville. It is a federally funded statutory authority governed by a Council appointed by the Australian Government.

The general objective of AIMS is to gain a coherent understanding of static patterns and dynamic processes involved in complex tropical marine systems, and to develop a predictive capability for these systems. AIMS research effort is organised within four research groups — coastal processes and

resources, coral reef ecosystems, environmental studies and biotechnology and tropical oceanography.

The Institute's activities in marine science and technology are associated principally with an understanding of marine communities of tropical Australia, South East Asia, and in the Pacific and Indian Oceans. Its long-term research into complex marine ecosystems and the impacts of human activities on the marine environment is used by industry and natural resources management agencies to ensure the conservation and sustainable use of marine resources in these regions.

Most of the attention of AIMS is focused currently on the environment and living communities of the tropical coast, Great Barrier Reef, North-West Shelf and surrounding pelagic systems of the tropical seas. This geographical emphasis reflects AIMS' financial, technical and operational capabilities and its relationship with other national and State agencies and academic institutions which work in oceans surrounding Australia.

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 their after tax cost of R&D to 50.5 cents in the dollar at the 33 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 R&D projects must satisfy the adequate Australian content requirement. In addition the results of the R&D must be exploited on normal commercial terms and to the benefit of Australia.

To attract the 150 per cent deduction, annual eligible R&D expenditure must exceed \$20,000. Where R&D is contracted to an approved Registered Research Agency this expenditure threshold is waived.

RESEARCH AND DEVELOPMENT — EXPENDITURE AND HUMAN RESOURCES

The statistics which follow are based on the OECD definitions 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'.

Statistics on the amount of expenditure and human resources devoted to R&D in the business enterprise sector are collected, in varying degrees of detail, annually. Comparable statistics on the general government, higher education, and private non-profit sectors are only collected biennially. Tables 22.1 and 22.2 provide a summary of the latest statistics available for these four sectors.

**22.1 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>	<i>1991-92</i>
AT CURRENT PRICES						
Business enterprises						
Private sector	1,165.1	1,338.2	1,646.1	1,802.6	1,835.4	1,973.3
Public sector	123.5	117.6	149.2	187.0	203.6	214.5
General government						
Commonwealth	786.5	797.0	868.9	n.a.	1,039.7	n.a.
State	368.4	394.6	474.4	n.a.	611.4	n.a.
Higher education						
Universities	844.9	929.8	1,018.4	n.a.	1,332.8	n.a.
CAEs	36.7	53.8	54.5	n.a.		n.a.
Private non-profit	49.1	53.9	51.9	n.a.	68.3	n.a.
Total	3,374.2	3,684.9	4,263.5	n.a.	5,091.2	n.a.

... continued

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

<i>Sector</i>	<i>1986-87r</i>	<i>1987-88r</i>	<i>1988-89r</i>	<i>1989-90r</i>	<i>1990-91</i>	<i>1991-92</i>
AT AVERAGE 1984-85 PRICES						
Business enterprises						
Private sector	999.7	1,070.7	1,253.2	1,265.1	1,230.9	n.a.
Public sector	106.6	97.6	119.3	139.4	143.0	n.a.
General government						
Commonwealth	693.8	655.7	679.9	n.a.	717.9	n.a.
State	322.5	324.2	371.1	n.a.	427.0	n.a.
Higher education						
Universities	750.8	788.7	819.8	n.a.	} 972.7	n.a.
CAEs	32.2	40.3	41.0	n.a.		n.a.
Private non-profit	45.5	47.3	43.4	n.a.	49.2	n.a.
Total	2,951.1	3,024.5	3,327.7	n.a.	3,540.7	n.a.

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

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

<i>Sector</i>	<i>1986-87</i>	<i>1987-88</i>	<i>1988-89</i>	<i>1989-90</i>	<i>1990-91</i>	<i>1991-92</i>
Business enterprises						
Private sector	16,198	16,952	19,177	18,572	18,636	18,315
Public sector	1,393	1,527	1,597	1,729	1,867	2,054
General government						
Commonwealth	11,529	11,491	11,705	n.a.	11,386	n.a.
State	6,796	7,133	7,992	n.a.	8,295	n.a.
Higher education						
Universities	21,690	22,435	22,939	n.a.	} 27,081	n.a.
CAEs	1,529	1,888	1,963	n.a.		n.a.
Private non-profit	945	1,016	990	n.a.	1,049	n.a.
Total	60,080	62,442	66,363	n.a.	68,314	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 three per cent (table 22.3).

Sixty 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.

Eighty-nine per cent of higher education funding came from the Commonwealth Government with a further six per cent from the private non-profit sector. A further two per cent each from State governments and business enterprises made up most of the remainder.

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.

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

Sector	Source of funds						
	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	1,539,980	} 168	4,060	40,676	1,646,116
Public sector	2,900	1,642	144,126			—	149,217
General government							
Commonwealth	816,248	3,862	40,617	—	2,651	5,563	868,940
State	43,369	388,377	22,651	299	18,543	1,162	474,400
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	1,892,265	418,885	1,779,260	29,156	87,130	56,786	4,263,480
1990-91							
Business enterprises							
Private sector	48,501	} 8,889	1,734,565	} 2,441	3,542	41,003	1,835,414
Public sector	5,611		194,491			—	203,629
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	1,190,555	29,556	29,917	n.a.	73,438	9,334	1,332,799
Private non-profit	21,466	10,304	5,650	890	27,259	2,776	68,344
Total	2,257,957	537,058	2,049,368	5,443	176,407	65,005	5,091,238

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

Business sector

Business expenditure on R&D in Australia in 1991-92 (table 22.4) was estimated to be \$2,188 million at current prices, an increase of seven per cent over 1990-91.

Of the total business expenditure in 1991-92, 56 per cent of expenditure (\$1,225 million) and 56 per cent of human resources (11,421 person years) were devoted to R&D in the manufacturing sector. The major industries contributing to this were Appliances and electrical equipment (25% of expenditure, 31% of human resources); Chemical, petroleum and coal products (16% and 16%, respectively) and

Transport equipment (13% and 12%, respectively).

After manufacturing, the next largest R&D activity was in Property and business services. In 1991-92 this industry contributed 13 per cent of expenditure and 14 per cent human resources for all business enterprises in Australia.

Business expenditure on R&D represents 0.57 per cent of Gross Domestic Product (GDP). This ratio increased fairly rapidly in the early 1980s but plateaued from 1986-87. It is relatively low when compared with other OECD countries (table 22.5).

22.4 RESEARCH AND DEVELOPMENT BY BUSINESS ENTERPRISES

Industry of enterprise		Expenditure on R&D (\$m)			Person years of effort on R&D		
ASIC code	Description	1988-89r	1990-91	1991-92	1988-89r	1990-91	1991-92
11-15	Mining (excluding services to mining)	96.1	90.5	136.9	745	693	760
	Manufacturing						
21	Food, beverages & tobacco	87.4	86.3	109.5	891	954	981
23-24	Textiles; Clothing & footwear	18.8	14.2	16.8	154	112	138
25	Wood, wood products & furniture	10.4	7.3	16.9	122	107	104
26	Paper, paper products, printing & publishing	24.1	35.9	48.6	234	239	225
27	Chemical, petroleum & coal products	159.2	195.7	194.4	1,816	1,943	1,820
28	Non-metallic mineral products	22.2	17.5	20.8	204	159	192
29	Basic metal products	91.4	141.7	152.4	948	1,034	1,014
31	Fabricated metal products	26.1	27.9	30.0	383	349	352
32	Transport equipment	162.3	158.0	163.5	1,804	1,475	1,426
334	Photographic, professional & scientific equipment	37.5	41.9	50.9	513	490	516
335	Appliances & electrical equipment	236.9	278.5	314.5	3,450	3,678	3,590
336	Industrial machinery & equipment	56.1	60.0	60.1	799	695	682
34	Miscellaneous manufacturing	27.1	35.4	46.7	399	388	383
C	Total manufacturing	959.6	1,100.3	1,224.9	11,715	11,622	11,421
	Other industries						
F	Wholesale & retail trade	159.4	175.6	191.6	1,690	1,642	1,469
61-62	Finance	115.7	136.6	94.7	1,461	1,597	1,423
63	Property & business services	229.3	250.9	282.7	2,831	2,520	2,898
8461	Research & scientific institutions	78.2	63.6	63.1	747	645	681
	Other n.e.c.	156.8	221.5	193.8	1,584	1,784	1,718
16, D-L	Total other industries	739.6	848.3	826.0	8,313	8,188	8,189
Total all industries		1,795.3	2,039.0	2,187.8	20,774	20,503	20,369
Private sector contribution		1,646.1	1,835.4	1,973.3	19,177	18,636	18,315
Public sector contribution		149.2	203.6	214.5	1,597	1,867	2,054

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

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

<i>Country</i>	<i>Per cent</i>
Japan	2.15
Switzerland	2.14
Germany	2.02
United States	1.90
Sweden	1.61
United Kingdom	1.36
Finland	1.17
Denmark	0.85
Italy	0.80
Canada	0.77
Ireland	0.65
Australia	0.57
Spain	0.49

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

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

<i>Country</i>	<i>Per cent</i>
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 was estimated to be \$1,651 million at current prices, an increase of 23 per cent over the two years since 1988-89. At average 1984-85 prices expenditure in 1990-91 increased by nine per cent compared with 1988-89 (table 22.1).

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 22.7).

Government expenditure on R&D represents 0.44 per cent of GDP. This ratio is at a similar level to the early 1980s after a downward trend in the late 1980s, and is relatively high when compared with other OECD countries (table 22.6).

22.7 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).

22.8 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 the higher education sector in 1990 (\$1,333 million) increased by 24 per cent over the two years from 1988. At average 1984-85 prices expenditure increased by 13 per cent over the same period (table 22.1).

Table 22.9 shows that the socio-economic objectives on which most higher education expenditure was carried out in 1990 were

natural sciences, technologies and engineering (\$343 million), health (\$251 million) and humanities and social sciences (\$225 million). Slightly more human resources were devoted to humanities than health. These three objectives accounted for 61 per cent of expenditure.

All categories of expenditure increased as a percentage of total expenditure since 1988 except labour costs which declined from 71 per cent in 1986, 69 per cent in 1988 to 62 per cent in 1990.

**22.9 EXPENDITURE ON RESEARCH AND DEVELOPMENT BY HIGHER EDUCATION
ORGANISATIONS, 1990**
(\$ million)

<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	—	0.2	1.3	0.4	1.9
Economic development					
Agriculture	2.4	6.0	40.9	17.1	66.5
Forestry	0.2	0.4	2.9	1.0	4.6
Fishing	1.1	0.5	3.4	1.8	6.8
Other agriculture, forestry and fishing	—	0.4	2.6	0.9	4.0
Mineral	1.2	2.7	16.4	7.2	27.5
Energy	0.5	2.1	8.9	3.7	15.2
Manufacturing	2.8	10.6	43.5	16.7	73.4
Construction	0.5	1.9	11.3	3.6	17.3
Transport	0.1	0.4	1.9	0.7	3.2
Information and communication services	1.5	3.7	16.6	4.7	26.4
Commercial services	0.9	0.9	6.0	2.2	10.0
Economy	5.0	3.9	36.5	12.8	58.3
Environmental aspects	1.6	1.9	13.6	4.9	22.1
<i>Total economic development</i>	<i>18.2</i>	<i>35.2</i>	<i>204.7</i>	<i>77.3</i>	<i>335.6</i>
National welfare					
Environment	3.7	6.7	35.0	15.2	60.6
Health	11.2	22.0	162.6	55.3	251.2
Education and training	6.9	5.1	47.9	14.8	74.9
Social and community development	3.4	3.0	25.3	8.3	40.0
<i>Total national welfare</i>	<i>25.3</i>	<i>36.8</i>	<i>270.8</i>	<i>93.6</i>	<i>426.7</i>
Advancement of knowledge					
Natural sciences, technologies and engineering	14.6	45.1	207.1	76.4	343.2
Humanities and social sciences	9.6	17.6	150.7	47.4	225.4
<i>Total advancement of knowledge</i>	<i>24.3</i>	<i>62.7</i>	<i>357.7</i>	<i>123.8</i>	<i>568.5</i>
Total	67.9	135.0	834.6	295.1	1,332.8

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

**22.10 HUMAN RESOURCES DEVOTED TO RESEARCH AND DEVELOPMENT BY HIGHER
EDUCATION ORGANISATIONS, 1990**
(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	31	6	10	47
Economic development				
Agriculture	1,038	330	109	1,477
Forestry	64	15	6	85
Fishing	82	30	29	140
Other agriculture, forestry and fishing	53	25	5	83
Mineral	441	113	41	595
Energy	247	70	36	354
Manufacturing	1,268	242	81	1,590
Construction	262	42	21	325
Transport	46	10	4	60
Information and communication services	488	75	35	597
Commercial services	142	42	25	210
Economy	712	59	101	871
Environmental aspects	373	69	33	474
<i>Total economic development</i>	<i>5,215</i>	<i>1,120</i>	<i>525</i>	<i>6,861</i>
National welfare				
Environment	983	220	118	1,321
Health	3,244	1,272	435	4,951
Education and training	1,310	69	125	1,504
Social and community development	658	61	71	790
<i>Total national welfare</i>	<i>6,194</i>	<i>1,622</i>	<i>749</i>	<i>8,566</i>
Advancement of knowledge				
National sciences, technologies and engineering	4,842	1,191	525	6,557
Humanities and social sciences	4,384	226	440	5,051
<i>Total advancement of knowledge</i>	<i>9,226</i>	<i>1,417</i>	<i>965</i>	<i>11,608</i>
Total	20,666	4,166	2,249	27,081

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 (\$68 million) increased 32 per cent at current prices and 13 per cent at average 1984-85 prices over 1988-89 (table 22.1).

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 22.11 and 22.12).

**22.11 EXPENDITURE ON RESEARCH AND DEVELOPMENT BY
PRIVATE 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>	12	435	1,897	1,343	3,687
National welfare					
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>	2,569	5,319	35,015	16,640	59,543
Advancement of knowledge					
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>	113	358	2,985	1,659	5,114
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).

**22.12 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>	
Defence	—	—	—	—
Economic development				
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>
National welfare				
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>
Advancement of knowledge				
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

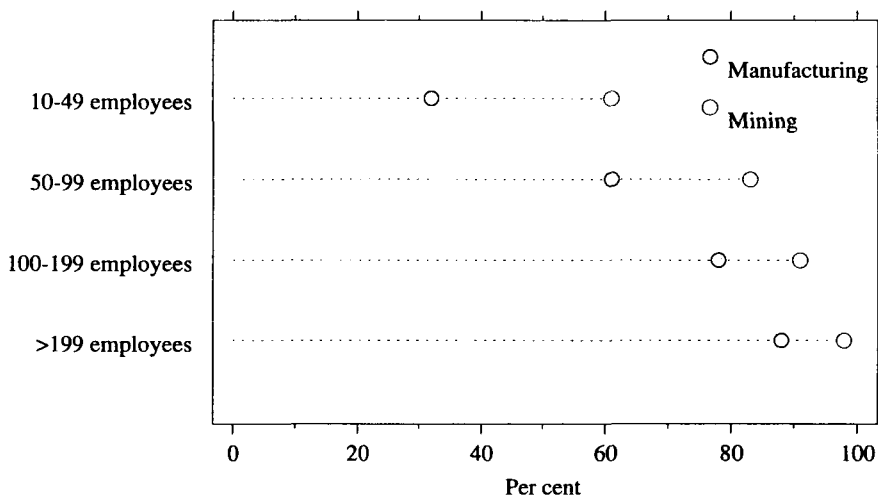
and/or engineering followed by stand-alone numerically controlled machines and programmable logic controllers with 18 per cent and 17 per cent of establishments having each technology, respectively. The most common mining technologies were non-core drilling followed by rehabilitation design with 52 per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

22.13 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, Science and Technology, 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 1991–92 may be obtained from the Australian Bureau of Statistics. Further statistical information on higher education is obtainable from the Department of Employment, Education and Training.

The Department of Industry, Technology and Regional Development's *Australian Science and Innovation Resources Brief 1992*, published in 1992, uses science and technology 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 work force; science and technology 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*.