

---

## SCIENCE AND TECHNOLOGY

---

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

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.

Information on scientific and technological activities presented in this chapter includes:

- Australian Bureau of Statistics data on resources devoted to research and experimental development (R&D) and other innovative activities. The R&D surveys cover organisations in the business enterprise, general government, private non-profit and higher education sectors.
- Department of Industry, Technology and Commerce statistics on expenditure on R&D and other scientific and technological activities carried out or funded by Commonwealth Government organisations.
- Australian Bureau of Statistics information on manufacturing industry technology operations and trade categorised into high technology, medium technology and low technology (industries or commodities).

### **The Department of Industry, Technology and Commerce—DITAC**

Following the Administrative Arrangements Order of 24 July 1987, the Industry, Technology and Commerce portfolio has primary responsibility for advising the government and implementing policy in relation to Australian science and technology; manufacturing and service industries; export services and customs and excise.

Within the portfolio, DITAC is the central point of contact for industry, unions, other Commonwealth departments, and State and local governments on matters relating to manufacturing, and service industries. DITAC incorporates parts of the former Departments

of Science, Trade, and Housing and Construction. The major scientific and technological aspects of the portfolio include the following bodies and activities.

### **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;
- 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 and Communications Technologies:* 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; Biotechnology.

*Institute of Minerals, Energy and Construction:* Divisions of Building, Construction and Energy (now incorporates National Building Technology Centre); Exploration of Geoscience; Mineral and Process Engineering; Mineral Products; Coal Technology; Fuel 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 1988-89 was \$466 million.

## **The Australian Nuclear Science and Technology Organisation—ANSTO**

ANSTO was established on 27 April 1987 as a statutory authority by the Commonwealth Parliament under the *Australian Nuclear Science and Technology Organisation Act Number 3 of 1987*. ANSTO replaces the Australian Atomic Energy Commission, which had been in existence since 1953.

ANSTO has its headquarters at the Lucas Heights Research Laboratories, 30 kilometres south-west of Sydney. Of its staff of some 800, about 250 are qualified scientists and engineers. 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. In this mission, ANSTO maintains a high regional and international standing in nuclear matters and both provides advice to and carries out tasks as required by the Commonwealth Government.

The five major research program areas of ANSTO are:

- isotope technology;
- the application of nuclear physics;
- biomedicine and health;
- environmental science; and
- advanced materials.

ANSTO is broadening its commercial ethos with research being directed to achieve the Organisation's social and corporate goals. Because its multidisciplinary body of expertise is located at one centre, together with its two nuclear research reactors and other specialised laboratory equipment, ANSTO can provide a range of unique and essential techniques and services to the Australian community. Established under the ANSTO legislation is the independent Nuclear Safety Bureau which is responsible for monitoring and reviewing the safety of nuclear reactor plant operated by ANSTO. The Bureau reports to the Minister responsible for administration of the ANSTO Act. ANSTO's annual expenditure is in the order of \$67 million with sales revenue of approximately \$7.5 million.

## **The 150 per cent Tax Concession for Research and Development**

The 150 per cent Tax Concession for Research and Development (R&D) is the major initiative in the Government's package of measures to encourage industrial R&D in Australia. The incentive which commenced in July 1985, was originally due to end on 30 June 1991. In May 1989, the Government announced that the concession will be available at 150 per cent until 30 June 1993. A reduced incentive of 125 per cent will then be available until 1995.

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.

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 R&D expenditures range from \$20,000 to \$50,000.

Where eligible R&D is contracted to an approved Registered Research Agency (RRA) the expenditure threshold is waived with all expenditure attracting the full 150 per cent concession.

## **National Teaching Company Scheme**

### **Background**

The National Teaching Companies Scheme (NTCS), which is administered by the Commonwealth Department of Industry, Technology and Commerce, was started in Australia in 1984 as an adaptation of the British Teaching Company Scheme.

The NTCS is part of the Australian Government's program to facilitate the growth and competitiveness of Australian industry. The Scheme encourages links between companies and supporting institutions such as tertiary educational institutions and public research agencies, by subsidising the cost of employing and supervising high calibre graduates in projects designed to improve company performance.

#### **Aim**

The aim of the Scheme is to promote the development and improve the efficiency and international competitiveness of Australian industry by developing lasting working relationships between supporting institutions and companies in the manufacturing service and information industries, as well as providing graduates with industry experience and possible career and employment opportunities.

#### **How NTCS works**

A company and an institution (which are within easy commuting distance) lodge a joint application for NTCS support to undertake a particular project requiring the expertise of a graduate with specific and relevant qualifications.

Applications, which are called for on an annual basis, are considered by an independent committee of business people and academics. The Australian Government is the primary source of funding with \$1.6 million being allocated for the 1989-90 round of grants. Most State governments are now providing additional funding to support particular eligible projects which were unable to be funded by the Commonwealth government due to limited funds.

Once funding is approved, a graduate is appointed and is jointly supervised on the project by the project managers of the company and institution. During the project, the institution's facilities are made available to the graduate and the company as required.

#### **Funding**

NTCS provides \$50,000 grant support over a maximum of two years. Of this, \$34,000 is paid to the company towards the salary of the graduate, \$10,000 is paid to the supporting institution for academic support costs and an additional \$6,000 is paid to the employer (i.e. either the company or institution) towards administrative costs of employing the graduate.

#### **Support to date**

Since the commencement of the NTCS, the Australian Government has provided \$6 million support to 157 projects in the areas of biotechnology, aqua-culture, horticulture, mechanical and structural engineering, computing science, shipbuilding, mining, electronics, veterinary science, information and communications technology, metals manufacture, membrane technology, management, marketing, improved manufacturing processes, etc.

#### **National Procurement Development Program—NPDP**

Acting on the recommendations of the Inglis Committee of Review of Government High Technology Purchasing Arrangements, the Commonwealth agreed to establish the Program to fund research, development, trials and demonstration projects to encourage government departments and agencies to seek new Australian solutions for their forward procurement needs.

The NPDP differs from other Board schemes by providing assistance for industry to undertake trials and demonstrations, as well as research and development.

#### **Patent, Trade Marks and Designs Offices**

The Offices, through their Central Office in Canberra and Sub-offices in each State capital, administer Australia's industrial property systems for the protection of patents, designs and trade marks. These systems encourage investment in, and innovations based on, new technology and industrial designs, and promote orderly marketing through registered trade marks.

The Offices maintain an information data base on inventions and industrial designs to facilitate the transfer and diffusion of technology. A data base of registered trade marks is also maintained. This information is available to the public through the Offices' Sub-offices.

### **The National Industry Extension Service—NIES**

The competitive edge for Australian manufacturing industry lies as much in the quality of its management as it does in other economic factors. In pursuing an export culture, the Australian government in partnership with each of the State and Territory governments has established the National Industry Extension Service (NIES) to deliver the best management advice and assistance to Australian manufacturers.

NIES encourages Australian manufacturers to take a strategic view of their enterprises and to implement strategies for marketing, manufacturing, product innovation, human resources and quality. Companies are assisted by a network of service providers including private sector consultants, academic institutions and government agencies. NIES expects a long term association with companies and works collaboratively with AUSTRADE to prepare companies to meet the rigours of international markets.

### **The Management and Investment Companies Program**

In 1984, the Government established the Management and Investment Companies Licensing Board to encourage the development of venture capital industries in Australia. The main objective of the program is to attract management and financial support for the start-up and early growth of those Australian based enterprises which have the potential to grow rapidly into substantial businesses, are export oriented and use innovative technology.

### **The Bureau of Industry Economics**

Primary responsibility for the Department's Industry Research Program lies with the Bureau of Industry Economics, which was established in 1977 as a centre for research into the Australian manufacturing and commerce sectors of the economy. The Bureau is assisted in devising its research program by a Council of Advice, comprising business and union leaders and prominent academics.

The Bureau's research program is concerned with a broad range of industry policy issues, including:

- individual industry studies as well as the investigations of general issues affecting a broad range of manufacturing and service industries;
- forward-looking studies on the likely future development of Australian industry, as well as detailed investigations of the factors responsible for the performance of industry in the recent past;
- aspects of industrial technology and production as well as pricing and marketing issues.

Evaluation of the effectiveness of existing government policies and programs is an important part of the Bureau's research. The Bureau also contributes to policy reviews, including Industries Assistance Commission and other public inquiries, and assesses the economic aspects of papers put to it by industry and trade unions.

### **The Snowy Mountains Engineering Corporation—SMEC**

SMEC is a public company fully owned by the Australian Government which operates as engineering consultants and project managers in Australia and Overseas. Since its development from the Snowy Mountains scheme in 1970, SMEC has now grown into a multidisciplinary consulting organisation of international standing in civil, electrical and mechanical engineering. SMEC has completed some 1,350 projects in 48 countries, including Australia. These projects have a capital value of \$A4,500 million and involved fees of \$A320 million.

A full range of expert engineering consulting services are provided by SMEC for pre-feasibility investigations, feasibility studies, field and laboratory investigations, design,

project management, construction supervision, operation and maintenance, training and many individual tasks.

Projects have included hydro-electric and multipurpose water resources development, river basin studies, dams and power stations, power transmission and distribution, irrigation and flood control, roads and bridges, tunnels, shafts and underground works and pipelines.

SMEC, as well as working on projects in all States of Australia, has provided consulting services for projects throughout Asia and the Pacific islands, in Africa, the Middle East, and in North and South America.

SMEC is registered as an Engineering Consultant with United Nations agencies, World Bank, Asian Development Bank, Commonwealth Fund for technical cooperation, Kuwait Fund for Arab Economic Development, Arab Bank for Economic Development in Africa and the Australian International Development Assistance Bureau. Projects have been successfully carried out in many countries, using finance from these donor and lending institutions.

The Corporation was a recipient of two Australian Government Export Awards in 1977 and 1982, and the Governor-General's Award for Export Excellence in 1984.

SMEC has a staff of over 220 professionals, technical and administrative support staff. Its headquarters are in Cooma, NSW. Branch offices are located in Sydney, Brisbane and Canberra. International branch offices are located in Dhaka, Gaborone, Jakarta and Kuala Lumpur, with project offices in many other locations.

### **The Australian Institute of Marine Science—AIMS**

AIMS was established as an independent statutory authority by the *Australian Institute of Marine Science Act 1972*. Its functions are to carry out research into marine science and the Institute is located at Cape Ferguson, 50 kilometres east of Townsville.

The Institute's research and development activities involve biological, chemical and physical oceanographic studies concentrated mainly on the Great Barrier Reef, other coral reefs, mangroves, estuaries and continental shelf waters of northern Australia. It operates four research vessels for these activities. Significant topics include research on the crown-of-thorns starfish phenomenon, ultra-violet blocking agents in corals, climatic records in corals, mangrove and billfish food chains, and use of remote sensing for analyses of marine systems. Recent developments include isolating substances from marine organisms for potential anti-cancer and therapeutic value and conducting genetic research into prawn stocks to assist the prawn mariculture industry.

The Institute is funded primarily through federal appropriation and its total budget for 1989–90 was \$14.7 million of which \$2.1 million was funded from external sources.

### **The Commission for the Future**

The Commission's objective of raising community awareness of all aspects of the social and economic impacts of technological change is based on the premise that industrial restructuring and technological development alone are insufficient for the development of a productive Australian culture. A need exists for an information and education program directed at increasing support for, and understanding of, scientific and technological change and long-term options for Australia.

### **The Australian Space Board**

The Board was established in September 1986 to spearhead Australia's development of its space industry. The six member Board has as its main functions:

- advising the Government on space R&D priorities;
- acting as a focal point for liaison with international agencies;
- supervising and managing the national space program;
- liaising with research institutions, industry and user groups to establish long term national space needs;

- gathering and coordinating information on Australia's space related research and industrial capabilities and providing an information referral service to potential users; and
- reporting annually on both government and industry space matters.

### **The Australian Space Office**

The Office was established in 1987 to oversee Australia's general space effort under the guidance of the Australian Space Board. It is responsible for developing an Australian space industry and managing the \$4.4 million National Space Program. It provides policy and secretariat support for the Space Board and implements agreements for the support of foreign civilian space programs, particularly for NASA and ESA.

A space industry development strategy has been prepared and is now being implemented. The strategy focuses on the priority areas of remote sensing, satellite based communications and launch site services. The Office is also examining a number of potential 'national interest' space projects.

The Office is coordinating Federal involvement in the proposal by Cape York Space Agency to build a spaceport at Cape York.

### **The National Standards Commission**

The Commission is a Commonwealth Statutory Authority established in 1948 and presently located at North Ryde, Sydney. The Commission operates under the National Measurement Act and is directed by a Board comprising a part-time chairman and seven commissioners. The Commission has responsibility for advising the Government on the scientific, technical and legislative requirements of the Australian National Measurement System and for coordinating that system. In addition the Commission has specific responsibilities for legal metrology, the completion of metrication, and uniformity of trade measurement. The Commission also examines and approves the patterns of measuring instruments used for trade to ensure the instruments will maintain their calibration and will not be affected by environmental factors (e.g. temperature, humidity or electromagnetic interference).

The Commission provides Australia's representative on the International Committee of Legal Metrology and ensures that Australian legal measurement requirements are nationally uniform and internationally harmonised. Through conferences and liaison with government authorities the Commission aims to ensure the traceability of all legal measurements to Australia's primary standards of measurement.

The Commission maintains close liaisons with government authorities, industry and commerce and consumer groups to ensure adequacy of measurement throughout Australia. The Commission provides the Chairman and secretariat for the Standing Committee on Trade Measurement, the Trade Measurement Consultative Committee and Working Parties on oil and gas flow measurement and time measurement.

The Commission is currently developing a National Metrology Policy that will include a policy for the training of metrologists and calibration technicians.

## **Other Commonwealth Government Science and Technology Activities**

Many other Commonwealth Government agencies play a significant role in the science and technology area. A number of these agencies are involved with R&D activities either as funders, performers or both; others are active in the S&T areas of information dissemination, scientific services and scientific training.

Total Commonwealth Government expenditure on research and development measured in the ABS Research and Development Survey for 1987-88 amounted to \$807 million.

### **State government science and technology activities**

State governments are major performers and supporters of scientific and technological activities. Many States have particular departments established for the purpose of encouraging and coordinating the use of technology in industry (e.g. the Victorian Department of Industry, Technology and Resources). Several States (New South Wales, Queensland, Western Australia and South Australia) have also established science and technology councils which provide advice to State governments on science and technology matters and promote the expansion of technology.

In addition to fostering science and technology, many State government departments are large performers of scientific and technological activities. Traditionally, for instance, those departments involved with agriculture (e.g. the Victorian Department of Agriculture and Rural Affairs and various State departments of agriculture) spend large sums on the R&D which they perform and also have a high profile in the general S&T activities of extension and laboratory services.

The total 1987-88 expenditure for R&D carried out by State government organisations measured in the ABS Research and Development Survey was \$378 million.

### **Tertiary education institutions' science and technology activities**

Tertiary education institutions play a vital role in the two major S&T areas. These being R&D and scientific and technical training.

Universities receive direct funding for research purposes from a number of sources, the major one being the Commonwealth Government. Commonwealth funds include those administered by the Commonwealth Tertiary Education Commission (special research grants, research equipment grants); those grants and awards distributed through the Australian Research Council; and grants awarded by the National Health and Medical Research Council and through the National Energy Research, Development and Demonstration Program.

Indirect research funding for universities includes both the proportion of general funds from the States Grants (Tertiary Education Assistance) Act allocated by universities to research and the amount attributable to research but coming from general teaching-and-research funds (e.g. the estimated research portion of the salaries of teaching-and-research staff). The latest available figures for total university research expenditure (direct plus indirect sources) came from the ABS Research and Development Survey for 1987 which gives an estimated expenditure of \$930 million.

CAEs and institutes of TAFE receive very little research funding from the Commonwealth. The Australian Bureau of Statistics measures R&D effort for CAEs (\$54 million in 1987) but does not survey institutes of TAFE.

Data on university, advanced education and TAFE enrolments are presented in Chapter 10, Education. That chapter also gives a more detailed picture of higher education facilities in Australia.

### **Other Organisations' Science and Technology Activities**

There are many other non-government organisations playing an important part in Australia's scientific and technological development. They include various learned and professional bodies such as the Australian Academy of Science, the Australian Academy of Technological Science, the Academy of Social Sciences in Australia and the Australian and New Zealand Association for the Advancement of Science. Their activities include provision of advice in the relevant scientific fields, dissemination of scientific information and enhancement of communication on scientific matters.

A number of private organisations from time to time provide advice to government on specific matters relating to science and technology. Examples from the business sector are



the Australian Chamber of Manufacturers, the Business Council of Australia and the Confederation of Australian Industry. Other organisations with an interest in scientific and technological issues include trade unions, industry groups with an interest in specific technologies and individual private organisations.

As performers of research and experimental development, private organisations in Australia are making an increasingly important contribution to Australia's R&D effort. Private business enterprises, for instance, spent an estimated \$1,218 million on R&D in 1987-88, a figure which, whilst still relatively low compared with the spending of comparable OECD countries, represents an increase of 14 per cent over 1986-87 expenditure. Private non-profit organisations in 1987-88 spent \$50 million on R&D.

## Statistics on Science and Technology

### Expenditure and human resources devoted to research and experimental development

The Australian Bureau of Statistics' Surveys of Research and Experimental Development provide comprehensive data on research and experimental development activities in Australia by organisations in the business enterprise, general government, higher education and private non-profit sectors. They also provide some data on other innovative activities, such as technical know-how payments and receipts and patenting activity. Activities not covered by the survey include scientific or technological services, extension services, education and training, etc.

The first comprehensive survey on R&D was carried out for the financial year 1968-69. There have been six major surveys since then, the latest for which comprehensive results are available being in respect of 1986-87 (1986 calendar year for the Higher Education Sector). Less detailed data in respect of 1987-88 are available from the smaller 'inter year' R&D survey conducted by the Bureau.

The estimate of gross expenditure on R&D (GERD) carried out in Australia, as derived from the results of the 1987-88 survey, is \$3,546 million. This represents a 9 per cent increase compared with the 1986-87 survey. At constant (1984-85) prices, GERD increased by 2 per cent over the same period. The total estimate of human resources devoted to R&D during 1987-88 in Australia was 60,907 person years; this represented a 4 per cent increase compared with the 1986-87 survey.

See *Year Book* No. 70 for a detailed description of survey methods and concepts.

#### Definitions

The survey's definitions follow guidelines described by the OECD for national R&D surveys. The OECD defines R&D as comprising 'creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications'. The Bureau provides sector specific definitions which clarify the OECD definitions for respondents and users (see ABS catalogue 8112.0).

#### Survey results

A summary of results from the 1984-85, 1986-87 and 1987-88 surveys is presented below.

**HUMAN RESOURCES OF EFFORT DEVOTED TO RESEARCH AND EXPERIMENTAL  
DEVELOPMENT, AUSTRALIA**  
(person years)

<i>Sector</i>	<i>1984-85</i>	<i>1986-87</i>	<i>1987-88</i>
Business Enterprises—			
Private Sector	11,001	14,919	15,535
Public Sector	1,238	1,375	1,327
General Government—			
Commonwealth	11,119	11,429	11,706
State	6,018	6,588	7,046
Higher Education—			
Universities	19,814	21,710	22,435
CAEs	1,030	1,529	1,888
Private non-profit	712	946	970
<b>Total</b>	<b>50,932</b>	<b>58,495</b>	<b>60,907</b>

**GROSS EXPENDITURE ON RESEARCH AND EXPERIMENTAL DEVELOPMENT (GERD)  
CARRIED OUT IN AUSTRALIA**  
**GERD AT CURRENT AND AVERAGE 1984-85 PRICES**  
(\$ million)

<i>Sector</i>	<i>1984-85</i>	<i>1986-87</i>	<i>1987-88</i>
<b>AT CURRENT PRICES</b>			
Business Enterprises—			
Private Sector	644	1,070	1,218
Public Sector	77	121	109
General Government—			
Commonwealth	669	782	807
State	286	355	378
Higher Education—			
Universities	663	846	930
CAEs	23	37	54
Private non-profit	43	49	50
<b>Total</b>	<b>2,406</b>	<b>3,260</b>	<b>3,546</b>
<b>AT AVERAGE 1984-85 PRICES</b>			
Business Enterprises—			
Private Sector	644	919	973
Public Sector	77	104	91
General government—			
Commonwealth	669	690	663
State	286	311	311
Higher Education—			
Universities	680	752	789
CAEs	23	32	40
Private non-profit	44	45	44
<b>Total</b>	<b>2,423</b>	<b>2,853</b>	<b>2,909</b>

**GROSS EXPENDITURE ON RESEARCH AND EXPERIMENTAL DEVELOPMENT (GERD)  
CARRIED OUT IN AUSTRALIA  
GERD BY SECTOR BY SOURCE OF FUNDS  
(\$'000)**

Sector	Total	Common-	State	Business	Higher	Private	Overseas
		wealth	government	enterprises	education	non-profit and other Australian	
1986-87							
Business Enterprises—							
Private Sector	1,069,576	52,861	} 3,925	999,658	} 269	} 329	13,530
Public Sector	120,715	8,664		111,055			—
General Government—							
Commonwealth	782,298	750,756	3,833	22,881	108	347	4,374
State	354,747	30,967	291,636	17,479	413	13,450	802
Higher Education							
Universities	846,377	790,400	9,010	9,659	8,943	22,120	6,245
CAEs	36,723	6,305	2,975	8,805	17,291	1,167	180
Private non-profit	49,107	19,843	6,705	2,211	411	15,468	4,468
<b>Total</b>	<b>3,259,542</b>	<b>1,659,796</b>	<b>318,084</b>	<b>1,171,748</b>	<b>27,436</b>	<b>52,881</b>	<b>29,600</b>
1987-88							
Business Enterprises—							
Private Sector	1,217,958	47,541	1,772	1,147,615	197	553	20,279
Public Sector	109,322	6,317	1,100	101,723	—	162	20
General Government—							
Commonwealth	807,239	767,986	3,046	31,845	20	290	4,052
State	377,891	35,189	300,372	22,443	474	18,210	1,202
Higher Education							
Universities	929,842	865,948	10,908	11,386	8,923	25,805	6,872
CAEs	53,807	10,694	5,269	11,567	24,807	1,043	426
Private non-profit	49,873	17,859	4,046	5,366	782	17,551	4,270
<b>Total</b>	<b>3,545,933</b>	<b>1,751,534</b>	<b>326,512</b>	<b>1,331,946</b>	<b>35,204</b>	<b>63,614</b>	<b>37,121</b>

### Business enterprise sector

The estimate of expenditure on R&D carried out in Australia by private and public business enterprises during 1986-87 is \$1,327 million at *current* prices. This represents a 11 per cent increase in expenditure compared with 1984-85. At average 1984-85 prices, R&D expenditure is estimated to have increased by 4 per cent over the same period.

**RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY BUSINESS ENTERPRISES (a), AUSTRALIA DETAILS OF RESOURCES  
DEVOTED TO R&D BY INDUSTRY OF ENTERPRISE**

Industry of enterprise ASIC Code	Description	Enterprises (number)		Expenditure on R&D (\$m)					Person years of effort on R&D					
		1984-85r	1986-87	1984-85r	1985-86(b)r	1986-87	1987-88(b)	1984-85r	1985-86(b)r	1986-87	1987-88(b)	1984-85r	1985-86(b)r	1986-87
11-15	Mining (excluding services to mining)	31	37	29.8	n.a.	51.1	n.a.	297	n.a.	347	n.a.	n.a.	n.a.	n.a.
	Manufacturing—													
21	Food, beverages and tobacco	92	98	30.9	n.a.	55.0	n.a.	658	n.a.	780	n.a.	n.a.	n.a.	n.a.
23-24	Textiles, clothing and footwear	27	35	5.6	n.a.	12.9	n.a.	57	n.a.	119	n.a.	n.a.	n.a.	n.a.
25	Wood, wood products and furniture	29	46	3.4	n.a.	6.3	n.a.	69	n.a.	118	n.a.	n.a.	n.a.	n.a.
26	Paper, paper products, printing and publishing	22	31	6.4	n.a.	9.9	n.a.	139	n.a.	157	n.a.	n.a.	n.a.	n.a.
27	Chemical, petroleum and coal products	180	268	91.1	96.8	120.1	133.9	1,576	1,596	1,841	1,861	1,861	1,861	1,861
28	Non-metallic mineral products	33	37	12.9	n.a.	14.9	n.a.	223	n.a.	172	n.a.	n.a.	n.a.	n.a.
29	Basic metal products	32	45	46.1	66.7	63.2	80.8	681	889	861	879	879	879	879
31	Fabricated metal products	92	125	15.6	n.a.	21.5	n.a.	309	n.a.	379	n.a.	n.a.	n.a.	n.a.
32	Transport equipment	65	96	90.1	124.3	127.3	141.7	1,476	1,702	1,552	1,701	1,701	1,701	1,701
334	Photographic, professional and scientific equipment	30	64	16.5	n.a.	25.3	n.a.	283	n.a.	426	n.a.	n.a.	n.a.	n.a.
335	Appliances and electrical equipment	286	581	84.4	117.0	173.3	196.0	1,611	1,982	2,814	2,989	2,989	2,989	2,989
336	Industrial machinery and equipment	177	244	28.5	n.a.	41.8	n.a.	566	n.a.	694	n.a.	n.a.	n.a.	n.a.
34	Miscellaneous manufacturing	77	97	8.5	n.a.	19.9	n.a.	178	n.a.	313	n.a.	n.a.	n.a.	n.a.
C	Total manufacturing	1,142	1,767	440.1	555.4	691.3	n.a.	7,824	8,824	10,226	n.a.	n.a.	n.a.	n.a.
	Other industries—													
F	Wholesale and retail trade	194	287	36.5	n.a.	70.2	n.a.	641	n.a.	1,033	n.a.	n.a.	n.a.	n.a.
63	Property and business services	450	567	82.2	n.a.	163.4	n.a.	1,311	n.a.	2,141	n.a.	n.a.	n.a.	n.a.
8461	Research and scientific institutions	43	79	28.8	n.a.	44.8	n.a.	497	n.a.	636	n.a.	n.a.	n.a.	n.a.
(c)	Other n.e.c.	125	201	105.7	n.a.	169.5	n.a.	1,691	n.a.	1,911	n.a.	n.a.	n.a.	n.a.
16, D-L	Total other industries	812	1,134	253.1	n.a.	447.8	n.a.	4,140	n.a.	5,721	n.a.	n.a.	n.a.	n.a.
	Total all industries	1,985	2,938	723.0	922.1	1,190.3	1,327.3	12,260	14,128	16,294	16,861	16,861	16,861	16,861
	Private Sector Contribution	1,938	2,879	645.7	826.4	1,069.6	1,218.0	11,022	12,775	14,919	15,535	15,535	15,535	15,535
	Public Sector Contribution	47	59	77.3	95.7	120.7	109.3	1,238	1,353	1,375	1,326	1,326	1,326	1,326

(a) Excludes enterprises in ASIC Division 'A'. (b) Represents the most detailed data available for 1985-86 and 1987-88. Manufacturing total not equal to sum of manufacturing component.  
(c) ASIC codes 16,D,E,G,H,I,61-62,J,8141-8306,8462-8495,L.

## Payments and receipts for patent licence fees and other technical know-how

Many Australian business enterprises supplement their R&D efforts by either purchasing or licensing foreign or Australian technology. Data for 1984-85 and 1986-87 are presented below.

### PAYMENTS AND RECEIPTS FOR TECHNICAL KNOW-HOW BY BUSINESS ENTERPRISES(a), AUSTRALIA, PAYMENTS AND RECEIPTS BY INDUSTRY OF ENTERPRISES (\$ million)

Industry of enterprise		Payments for technical know-how		Receipts for technical know-how	
		1984-85	1986-87	1984-85	1986-87
<i>ASIC</i>					
<i>Code</i>	<i>Description</i>				
Manufacturing—					
21	Food, beverages and tobacco	16.8	23.9	1.1	3.5
23-24	Textiles, clothing and footwear	8.9	n.p.	n.p.	n.p.
25	Wood, wood products and furniture	0.1	0.2	.p.	0.6
26	Paper, paper products, printing and publishing	4.1	4.0	n.p.	n.p.
27	Chemical, petroleum and coal products	39.1	53.3	6.6	6.2
28	Non-metallic mineral products	7.8	1.4	n.p.	n.p.
29	Basic metal products	4.7	9.8	6.1	n.p.
31	Fabricated metal products	2.3	3.9	1.1	1.2
32	Transport equipment	17.4	35.5	n.p.	1.0
334	Photographic, professional and scientific equipment	n.p.	n.p.	n.p.	n.p.
335	Appliances and electrical equipment	28.3	48.5	n.p.	3.8
336	Industrial machinery and equipment	n.p.	8.3	1.4	n.p.
34	Miscellaneous manufacturing	4.9	10.9	n.p.	n.p.
C	<i>Total manufacturing</i>	146.6	236.2	23.8	44.9
Other industries—					
F	Wholesale and retail trade	4.3	11.5	0.5	6.2
63	Property and business services	8.0	7.7	6.2	43.5
8461	Research and scientific institutions	n.p.	n.p.	n.p.	3.0
(b)	Other n.e.c.	n.p.	n.p.	n.p.	8.7
11-16, D-L	<i>Total other industries</i>	19.9	41.2	12.3	61.5
<b>Total all industries</b>		<b>166.5</b>	<b>277.4</b>	<b>36.1</b>	<b>106.4</b>

(a) Excludes enterprises in ASIC Division 'A'. (b) ASIC Codes 11-16, D, E, G, H, 61-62, J, 8141-8306, 8462-8495, L.

## General government sector

The estimate of expenditure on R&D carried out in Australia by organisations in the general government sector during 1987-88 was \$1,185 million at *current* prices. This represents a 4 per cent increase in expenditure compared with 1984-85. At average 1984-85 prices, R&D expenditure is estimated to have decreased by 3 per cent over the same period.

**RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY GENERAL  
GOVERNMENT ORGANISATIONS, AUSTRALIA  
DETAILS OF RESOURCES DEVOTED TO R&D BY SOCIO-ECONOMIC OBJECTIVE**

<i>Socio-economic objective</i>	<i>Expenditure on R&amp;D (\$m)</i>		<i>Person years of effort on R&amp;D</i>	
	<i>1984-85</i>	<i>1986-87</i>	<i>1984-85</i>	<i>1986-87</i>
<i>National security (Defence)</i>	<i>151.0</i>	<i>175.1</i>	<i>3,232</i>	<i>3,146</i>
<b>Economic development—</b>				
Agriculture	321.0	388.0	5,850	6,491
Forestry and fisheries	48.1	63.3	924	1,055
Mining (prospecting)				
Energy sources	12.8	15.5	202	196
Other	23.2	28.5	344	393
Mining (extraction)				
Energy sources	7.9	2.8	120	42
Other	8.4	7.6	138	127
Manufacturing	103.8	119.1	1,725	1,697
Construction	13.3	14.3	265	261
Energy	51.8	45.7	644	541
Transport	16.9	16.5	220	280
Communications	0.3	1.3	6	10
Economic services n.e.c.	20.2	14.4	404	324
<i>Total economic development</i>	<i>627.5</i>	<i>716.9</i>	<i>10,840</i>	<i>11,415</i>
<b>Community welfare—</b>				
Urban and regional planning	0.4	1.7	12	40
Environment	36.0	42.6	692	640
Health	42.8	56.9	1,067	1,192
Education	5.9	6.7	145	151
Welfare	3.7	7.1	86	118
Community services n.e.c.	9.1	19.1	175	227
<i>Total community welfare</i>	<i>97.9</i>	<i>134.2</i>	<i>2,177</i>	<i>2,366</i>
<b>Advancement of knowledge—</b>				
Earth, ocean and atmosphere n.e.c.	72.7	102.5	778	914
General advancement of knowledge	6.2	8.4	109	176
<i>Total advancement of knowledge</i>	<i>78.9</i>	<i>110.9</i>	<i>887</i>	<i>1,090</i>
<b>Total</b>	<b>955.3</b>	<b>1,137.0</b>	<b>17,136</b>	<b>18,017</b>

### Higher education sector

The estimate of expenditure on R&D carried out in Australia by higher education organisations during 1986 is \$882 million at *current* prices. This represents a 29 per cent increase in expenditure compared with 1984. At average 1984-85 prices, R&D expenditure is estimated to have increased by 11 per cent over the same period.

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

<i>Socio-economic objective</i>	<i>Expenditure on R&amp;D (\$m)</i>					
	<i>1984</i>			<i>1986</i>		
	<i>Total</i>	<i>Universities</i>	<i>CAEs</i>	<i>Total</i>	<i>Universities</i>	<i>CAEs</i>
<i>National security (Defence)</i>	1.2	1.2	—	1.9	1.7	0.2
<i>Economic development—</i>						
Agriculture	58.9	57.3	1.5	74.2	72.2	2.0
Forestry and fisheries	8.2	8.0	0.2	9.0	8.6	0.4
Mining (prospecting)						
Energy sources	1.8	1.7	0.1	4.0	3.7	0.3
Other	3.4	3.2	0.1	7.2	7.0	0.2
Mining (extraction)						
Energy sources	1.0	1.0	0.1	0.8	0.8	—
Other	3.6	3.3	0.3	6.9	5.8	1.1
Manufacturing	18.6	16.1	2.4	29.5	24.9	4.6
Construction	7.2	6.9	0.3	8.9	8.0	0.8
Energy	25.4	23.7	1.7	27.6	25.6	1.9
Transport	3.7	3.2	0.5	4.2	3.6	0.6
Communications	6.0	5.5	0.4	9.4	8.4	1.0
Economic services n.e.c.	18.6	17.5	1.1	34.0	31.2	2.7
<i>Total economic development</i>	<i>156.4</i>	<i>147.6</i>	<i>8.8</i>	<i>215.7</i>	<i>200.0</i>	<i>15.7</i>
<i>Community welfare—</i>						
Urban and regional planning	4.3	4.1	0.2	6.0	5.6	0.3
Environment	12.6	11.5	1.0	17.2	15.6	1.6
Health	139.8	134.8	5.0	186.4	179.4	7.0
Education	26.6	23.6	3.0	35.5	31.6	4.0
Welfare	8.3	8.0	0.3	10.0	9.1	0.9
Community services n.e.c.	13.3	12.5	0.8	19.2	17.6	1.6
<i>Total community welfare</i>	<i>204.8</i>	<i>194.5</i>	<i>10.4</i>	<i>274.3</i>	<i>258.9</i>	<i>15.4</i>
<i>Advancement of knowledge—</i>						
Earth, ocean and atmosphere n.e.c.	42.3	41.8	0.6	49.2	48.6	0.6
General advancement of knowledge	281.0	278.1	2.9	340.8	336.0	4.8
<i>Total advancement of knowledge</i>	<i>323.3</i>	<i>319.9</i>	<i>3.5</i>	<i>390.0</i>	<i>384.6</i>	<i>5.4</i>
<b>Total</b>	<b>685.7</b>	<b>663.1</b>	<b>22.7</b>	<b>881.9</b>	<b>845.2</b>	<b>36.6</b>

**RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY HIGHER  
EDUCATION ORGANISATIONS, AUSTRALIA  
HUMAN RESOURCES DEVOTED TO R&D BY SOCIO-ECONOMIC OBJECTIVE**

<i>Socio-economic objective</i>	<i>Person years of effort on R&amp;D</i>					
	<i>1984</i>			<i>1986</i>		
	<i>Total</i>	<i>Universities</i>	<i>CAEs</i>	<i>Total</i>	<i>Universities</i>	<i>CAEs</i>
<i>National security (Defence)</i>	29	28	1	52	39	12
<b>Economic development—</b>						
Agriculture	1,922	1,863	59	2,031	1,969	62
Forestry and fisheries	282	265	17	256	237	19
Mining (prospecting)						
Energy sources	71	56	15	110	93	17
Other	108	96	12	206	194	12
Mining (extraction)						
Energy sources	34	33	1	23	21	2
Other	128	110	18	202	165	37
Manufacturing	625	522	103	922	710	212
Construction	225	210	15	240	214	26
Energy	769	706	64	729	653	76
Transport	129	108	22	118	89	29
Communications	196	175	21	306	249	58
Economic services n.e.c.	443	399	45	736	630	106
<i>Total economic development</i>	<i>4,933</i>	<i>4,542</i>	<i>391</i>	<i>5,879</i>	<i>5,222</i>	<i>657</i>
<b>Community welfare—</b>						
Urban and regional planning	116	107	9	149	134	16
Environment	422	377	45	490	424	66
Health	4,140	3,902	238	4,778	4,492	285
Education	891	767	124	947	805	141
Welfare	245	232	13	269	229	41
Community services n.e.c.	337	304	33	472	398	75
<i>Total community welfare</i>	<i>6,151</i>	<i>5,688</i>	<i>462</i>	<i>7,106</i>	<i>6,482</i>	<i>624</i>
<b>Advancement of knowledge—</b>						
Earth, ocean and atmosphere n.e.c.	1,135	1,097	38	1,163	1,136	26
General advancement of knowledge	8,597	8,458	139	9,043	8,834	209
<i>Total advancement of knowledge</i>	<i>9,732</i>	<i>9,556</i>	<i>176</i>	<i>10,205</i>	<i>9,970</i>	<i>235</i>
<b>Total</b>	<b>20,844</b>	<b>19,814</b>	<b>1,030</b>	<b>23,242</b>	<b>21,710</b>	<b>1,529</b>



### Private non-profit sector

The estimate of expenditure on R&D carried out by private non-profit organisations during 1986-87 was \$49.1 million at *current* prices. This represents a 13 per cent increase in expenditure compared with 1984-85. At average 1984-85 prices, R&D expenditure is estimated to have increased by 2 per cent over the same period.

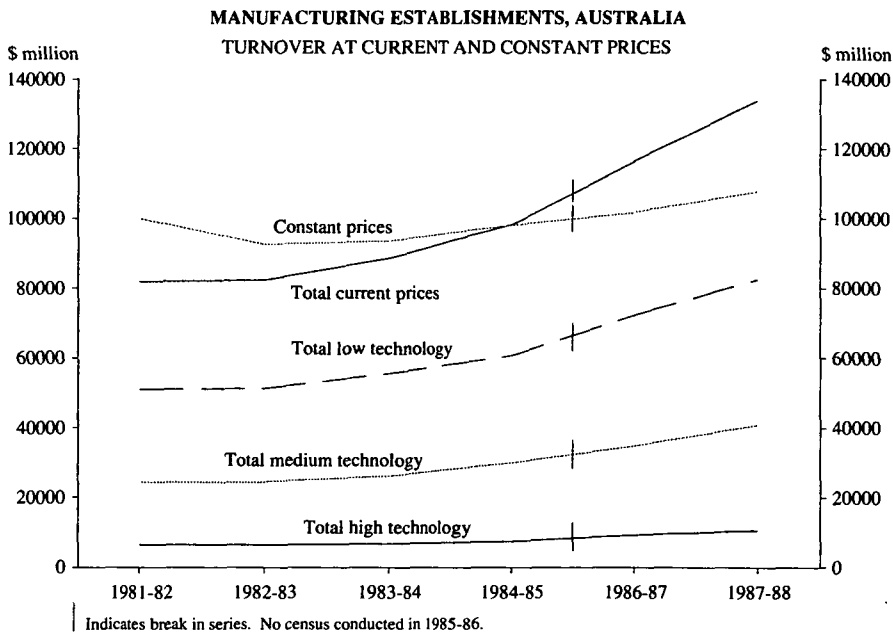
#### RESEARCH AND EXPERIMENTAL DEVELOPMENT CARRIED OUT BY PRIVATE NON-PROFIT ORGANISATIONS, AUSTRALIA DETAILS OF RESOURCES DEVOTED TO R&D BY SOCIO-ECONOMIC OBJECTIVE

<i>Socio-economic objective</i>	<i>Expenditure (\$'000)</i>		<i>Person years of effort on R&amp;D</i>	
	<i>1984-85</i>	<i>1986-87</i>	<i>1984-85</i>	<i>1986-87</i>
<i>National security (Defence)</i>	—	—	—	—
<i>Economic development—</i>				
Agriculture	55	69	2	3
Forestry and fisheries	—	35	—	1
Mining (prospecting)				
Energy sources	—	—	—	—
Other	n.p.	—	n.p.	—
Mining (extraction)				
Energy sources	—	—	—	—
Other	—	—	—	—
Manufacturing	—	267	—	3
Construction	n.p.	—	n.p.	—
Energy	535	303	8	4
Transport	n.p.	52	n.p.	1
Communications	3	—	1	—
Economic services n.e.c.	780	1,363	18	28
<i>Total economic development</i>	<i>2,116</i>	<i>2,089</i>	<i>41</i>	<i>40</i>
<i>Community welfare—</i>				
Urban and regional planning	397	358	6	4
Environment	4	564	—	16
Health	38,801	43,496	615	833
Education	1,228	1,200	24	20
Welfare	558	882	16	23
Community services n.e.c.	88	10	2	—
<i>Total community welfare</i>	<i>41,075</i>	<i>46,511</i>	<i>662</i>	<i>896</i>
<i>Advancement of knowledge—</i>				
Earth, ocean and atmosphere n.e.c.	45	48	1	2
General advancement of knowledge	251	459	8	8
<i>Total advancement of   knowledge</i>	<i>296</i>	<i>507</i>	<i>9</i>	<i>10</i>
<b>Total</b>	<b>43,488</b>	<b>49,107</b>	<b>712</b>	<b>946</b>

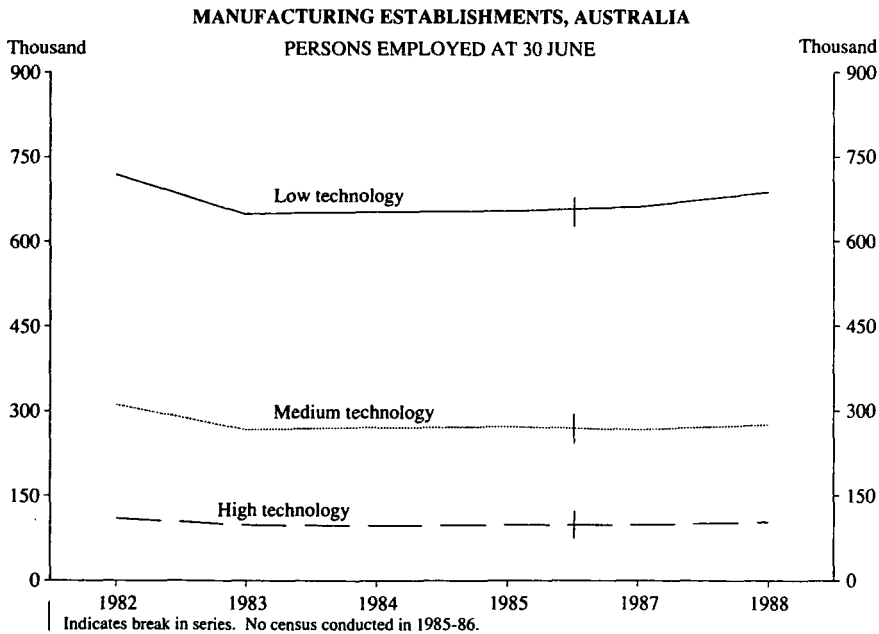
### Statistics on manufacturing industry technology

The level of technological development in manufacturing industry can be viewed by classifying industries to high, medium and low technology according to the intensity of their R&D effort. Using the OECD classification by this method, high technology industries are defined as those manufacturing establishments classified to aircraft (Australian Standard Industrial Classification (ASIC) Class 3244); communications and other electronic equipment (ASIC Classes 3351 and 3352); electrical appliances and machinery (ASIC Classes 3353-3357); pharmaceutical and veterinary products (ASIC Class 2763); and photographic, professional and scientific equipment (ASIC Group 334). Medium technology covers chemicals (apart from ASIC Class 2763); petroleum and coal products; non-ferrous metals and basic products; motor vehicles and parts, railway equipment and other transport equipment (ASIC Class 3245); industrial machinery; rubber and plastic products; and, other manufacturing (ASIC Group 348). Low technology covers food, beverages and tobacco; textiles, clothing and footwear; wood and wood products; paper and paper products, etc.; petroleum refining; non-metallic mineral products, basic iron and steel products; fabricated metal products; ships and boats; and, leather products.

The figure below shows that high technology industries as a group showed current price growth in turnover in the six year period from 1981-82 to 1987-88 (64 per cent). Low and medium technology groups have performed comparably with growths of 62 per cent and 67 per cent respectively. In constant prices terms, total manufacturing industry turnover has shown growth of (8 per cent over the period), with most of this growth occurring between 1986-87 and 1987-88.

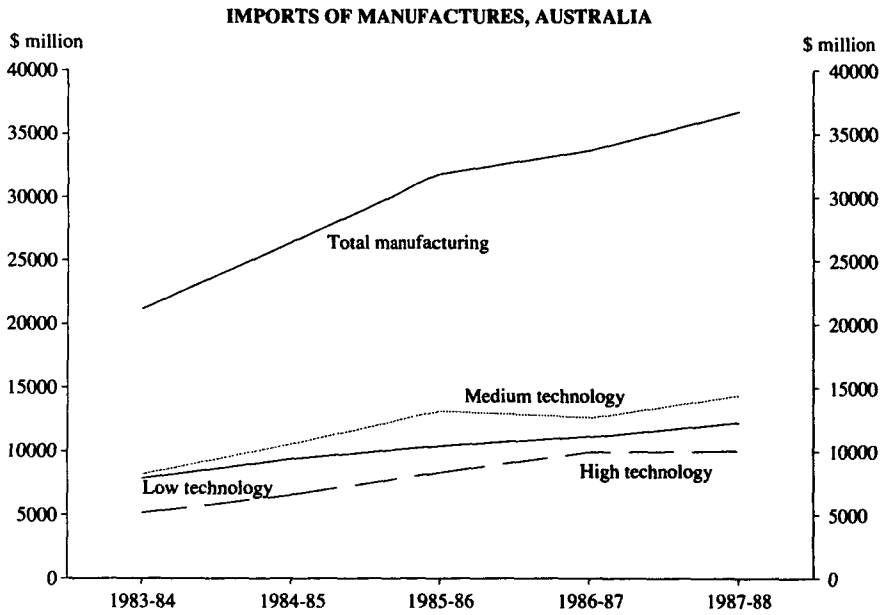
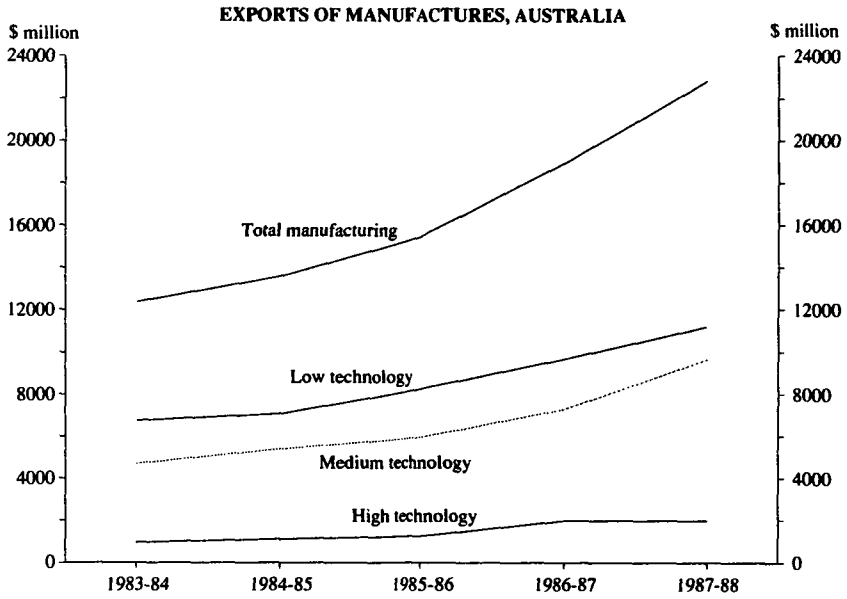


The following figure shows a downturn in manufacturing industry employment levels (net drops of 6 per cent, 12 per cent and 4 per cent for high, medium and low technology industries respectively). Data for the latest year available show rises between 30 June 1987 and 30 June 1988 for high, medium and low technology industries (4.8 per cent, 3.1 per cent and 3.9 per cent respectively).



### Other Activities

For information on other activities related to science and technology, see *Year Book* No. 70. That edition contains information on scientific and technological information services (page 640), social science and humanities research (page 652) and international activities (page 653).



---

### 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, the Australian Nuclear Science and Technology Organisation, the Department of Defence, 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, 1984-85, 1985-86 and 1986-87 may be obtained from the Australian Bureau of Statistics (ABS). Further statistical information on higher education is obtainable from the Commonwealth Tertiary Education Commission. Trade and industry operations data are available from the ABS.

The Department of Industry, Technology and Commerce's *Australian Science and Technology Indicators Report*, published in 1988, uses 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, literature-based S&T measures, patent activity, technology training, financial support for technological development, industry operations and trade by level of technology, and transfer of technical knowledge.

---

### BIBLIOGRAPHY

#### ABS Publications

- Research and Experimental Development, Business Enterprises, Australia, 1986-87* (8104.0)  
*Research and Experimental Development, General Government and Private Non-profit Organisations, Australia, 1986-87* (8109.0)  
*Research and Experimental Development, Higher Education Organisations, Australia, 1986* (8111.0)  
*Research and Experimental Development, All Sector Summary, Australia, 1986-87* (8112.0)  
*Research and Experimental Development, All Sector Summary (Inter Year Survey), 1987-88* (8122.0)  
*Manufacturing Establishments, Details of Operations by Industry Class, Australia* (8203.0)

#### Other Publications

- COMMONWEALTH TERTIARY EDUCATION COMMISSION. *Selected University Statistics, Australia, 1986*  
 COMMONWEALTH TERTIARY EDUCATION COMMISSION. *Selected Advanced Education Statistics, Australia, 1986*  
 INDUSTRY, TECHNOLOGY AND COMMERCE, DEPARTMENT OF. *Measures of Science and Innovation, Australian Science and Technology Indicators Report, 1987*. Canberra, 1987  
 INDUSTRY, TECHNOLOGY AND COMMERCE, DEPARTMENT OF. *Science and Technology Statement, 1987-88*. Australia, 1988