Ministry of State
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Canada

Federal Science Activities

1979-80

Errata

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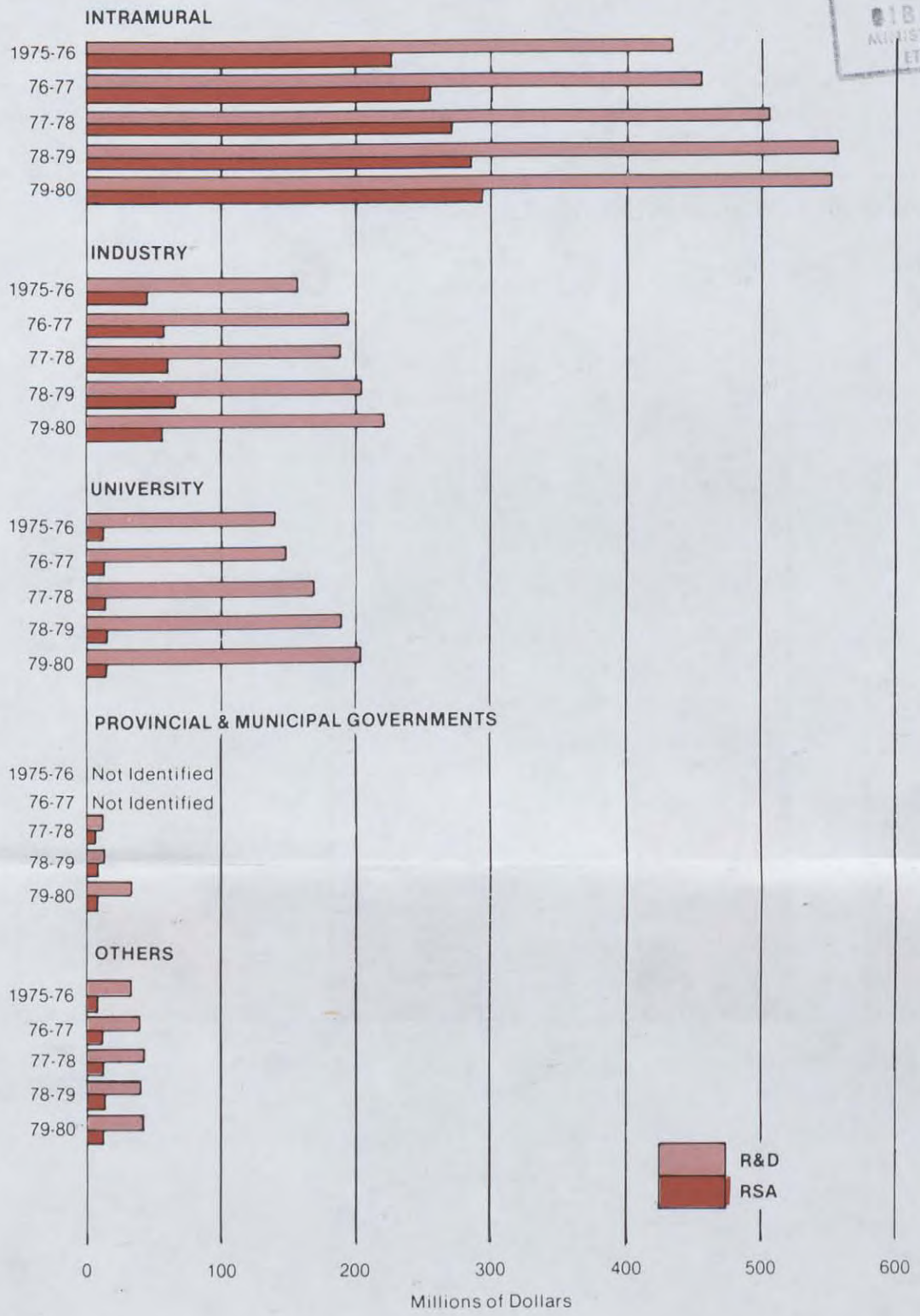

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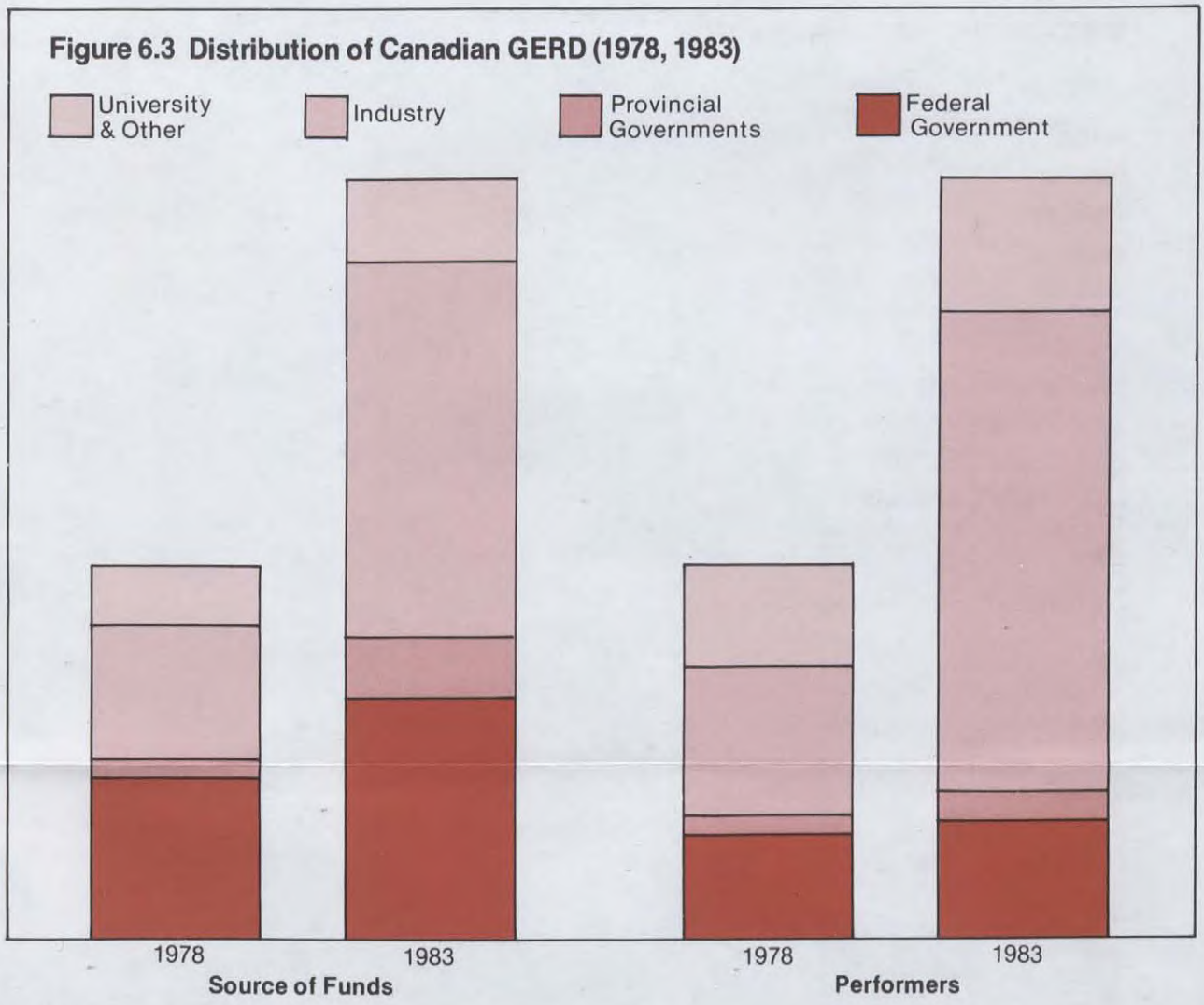

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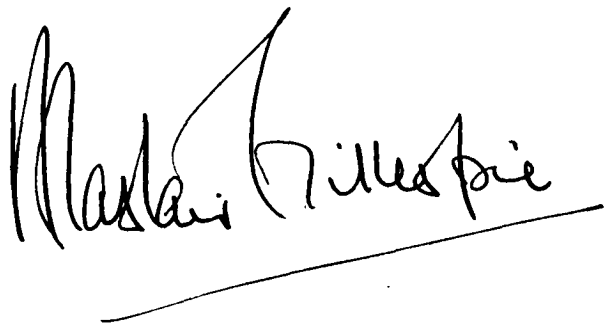
Foreword

This third annual publication reports on the scientific and technical activities to be funded by the government during the fiscal year 1979/80.

The 1979/80 Main Estimates present the proposed total programs of departments and agencies. This report provides additional information on the government's expected activities in science and technology, using descriptive narratives along with supporting budgetary data. Its purpose is to assist in expenditure decisions by providing members of the House of Commons and the Senate, as well as the general public, with a context for viewing the government's proposed activities in science and technology. More numerical data is available in a companion report "Federal Science Expenditures and Personnel, 1977/78 — 1979/80".

This overview of the government's science programs is made possible through the activities of the Ministry of State for Science and Technology in developing science and technology policy and in providing advice to the government on the application of science and technology for optimum benefit to Canada. Nevertheless, the cooperation of all departments and agencies which fund scientific and technological activities has been essential, and their assistance is gratefully acknowledged. Special thanks are due the Treasury Board Secretariat and Statistics Canada since the report would have been later and less complete without their assistance.



Contents

1. Introduction

This report is a companion publication to the 1979/80 Main Estimates, and consequently departmental and agency programs are listed according to the format used in the Estimates. In particular, agencies are grouped under the department of the Minister to whom they report or are responsible, for example Statistics Canada under the Department of Industry, Trade and Commerce, the Medical Research Council under the Department of National Health and Welfare.

The term, *science and technology* (S&T), or more exactly, *science and technological development*, is used to mean those activities which involve the generation, dissemination and initial application of new scientific knowledge and technology. It is useful to further characterize S&T by a matrix of two sets of criteria. The first set distinguishes between *research and experimental development* (R&D) and *related scientific activities* (RSA). R&D, the central activity, is creative work undertaken on a systematic basis to increase the stock of scientific knowledge and technology. Closely related ancillary activities, such as scientific data collection, economic and feasibility studies, operations and policy studies, and education support collectively are termed RSA.

The second set of criteria distinguishes between Natural Sciences and Human Sciences. The *natural sciences* are concerned with understanding, exploring, developing or utilizing the natural world; included are the engineering, mathematical, life and physical sciences. The term *human sciences* is synonymous with the social sciences and humanities and embraces all disciplines involved in the study of human actions and conditions, and the social, economic and institutional mechanisms affecting humans, for example, anthropology, business administration and commerce, communications, criminology, demography, geography, history, law, political science, psychology, social work, sociology and urban studies.

The following terms have specific meanings in the text.

a) *performer* versus *funder* — the former refers to the organization or sector conducting S&T activities, the latter to the organization or sector which provides, or has the responsibility for budgeting for the required funds.

b) *contracts* versus *grants* or *contributions* — contracts are legal undertakings between two or more parties for the conduct of S&T activities and the provision of the results of those activities according to an agreed schedule and cost. For most departments, the Department of Supply and Services acts as the contract manager, with the other department providing the scientific or engineering manager. A contribution also requires an arrangement between the government and the recipient identifying the terms and conditions governing the payment of funds to the recipient. The payments are conditional on performance or achievement and the recipient's use of the funds is subject to audit. A grant is an unconditional payment by the government to a recipient, from which the government does not receive any goods or services.

The first section of the report is an *Overview* of expenditures for the 5-year period, 1975/76 to 1979/80, indicating aggregate changes in expenditures. The second section, *Special Applications,* discusses science activities which although they are funded through a single department or agency, are relevant to the objectives of more than one department and/or involve areas of national concern.

The report contains a section entitled *Extramural Activities*. Government-supported S&T can be divided into intramural and extramural activities. Intramural is the term applied to those government-funded activities conducted within the government's own laboratories and by its own staff. Government-funded extramural activities are carried out by the private sector (including industry, universities, private non-profit organizations), by other levels of government, or in other countries.

A *Major Funders* section follows which essentially describes the organization and expenditures of the scientific and technological programs of those departments and agencies which have the largest science expenditures or whose activities are nearly all scientific and technological.

The section, *Perspective on Science in Canada,* examines gross expenditures on research and development in Canada compared to other industrialized countries and includes a 10-year retrospective of these expenditures. Also discussed are the implications for future funding of R&D from the adoption of a target for Gross Expenditures on R&D to reach 1.5% of Gross National Product by 1983.

Three *Special Topics* are included in this year's report, *Management of Federal Science Activities, Regional Expenditures* and *International Development and Canadian R&D.* The first describes the planning and resource allocation process with particular reference to S&T. The second reviews government spending in 1977/78 in the Atlantic Region, Quebec, Ontario, the National Capital Region, the Prairie Region, and British Columbia. The third discusses the forthcoming UN Conference on Science and Technology for Development and Canada's preparations for the conference.

2. Overview

In June 1978 a number of measures to strengthen and encourage research and development in Canada, particularly in the industrial sector, were announced by the Minister of State for Science and Technology, including new incentives to encourage greater private sector spending on R&D, creation of industrial research and innovation centres, the development of regional centres of excellence, increased funding for university research, use of government procurement to stimulate industrial R&D in Canada, increased technology transfer from government departments, and a target for Canadian R&D expenditure of 1.5% of Gross National Product by 1983.

Increased budgetary expenditures for specific R&D initiatives included in the announcement, plus subsequent initiatives announced by the ministers of Communications; Energy, Mines and Resources; and Industry, Trade and Commerce, along with smaller increases in other departments, increased 1978/79 forecast spending on all science activities to $162 million over the 1977/78 level, and a further increase of $18 million is estimated for 1979/80. These initiatives were financed in part from expenditure reductions in lower priority programs. This reallocation of resources has caused significant shifts in funding patterns in 1978/79 and 1979/80. Expenditures from 1975/76 to 1979/80 by individual departments and agencies for total science activities are given in Table 2.1.

With respect to science expenditures in 1978/79 and 1979/80, major increases have occurred since 1977/78 in the Department of Energy, Mines and Resources and the National Research Council. For the former there was an increase of $11 million in 1978/79 over 1977/78, and a further increase of $26 million is estimated for 1979/80. For the National Research Council 1978/79 expenditures are forecast to be $37 million higher than in 1977/78 and a further increase of $4 million is estimated for 1979/80. Science expenditures in the Department of Industry, Trade and Commerce dropped significantly in 1978/79 because of program restructuring, but are estimated to increase nearly $23 million in 1979/80. Major decreases are shown for Statistics Canada and Transport Canada. As part of the government's program of expenditure restraint, Statistics Canada will be curtailing a selected range of ancillary surveys and Transport Canada is phasing out its urban transportation research program and reducing other S&T expenditures.

Concerning science expenditure patterns over the 5-year period from 1975/76, science spending by the Department of the Environment — the largest of the major funders of scientific activities — has remained relatively constant. As a proportion of the government's total science expenditures, it was 19% in 1975/76 and will be about 16% in 1979/80. There have been substantial increases in the expenditures of the National Research Council, and the departments of Agriculture and Energy, Mines and Resources, reflecting the priority accorded to the support of industrial, energy and agricultural S&T. The S&T expenditures by the National Research Council have increased about 89%, mainly for research in energy and in support of industry and for technology transfer to industry. The increase for the Department of Energy, Mines and Resources has been about 101%, mainly for energy R&D. The Department of Agriculture's S&T expenditures have increased about 35% since 1975/76.

The government's commitment to maintaining a healthy university research community is reflected in increased funding for the three granting councils, which fund most of the government's direct support of university research. The Natural Sciences and Engineering Research Council's estimated expenditures in 1979/80 are $121 million, an overall

Table 2.1

Federal Expenditures on the Natural and Human Sciences by Major Funding Departments

Department	1975/76	1976/77	1977/78	1978/79	1979/80
			(millions of dollars)		
Total Science	**1,380.1**	**1,577.9**	**1,673.0**	**1,835.2**	**1,853.4**
Total Major Funders	1,239.0	1,424.3	1,511.5	1,644.7	1,661.2
Agriculture	106.0	106.5	117.9	133.0	142.6
Communications	27.7	17.8	30.3	49.3	40.2
Energy, Mines & Resources	77.6	95.4	118.4	129.7	155.8
Atomic Energy of Canada Ltd.	86.0	99.6	77.2	92.5	85.3
Environment	258.2	269.3	290.3	295.8	289.0
External Affairs					
Canadian International Development Agency	33.7	22.6	25.3	30.9	30.8
International Development Research Centre	30.1	32.4	34.5	36.9	36.9
Industry, Trade & Commerce	99.6*	115.2*	92.8*	66.2	88.9
Statistics Canada	106.7	145.4	130.0	139.9	127.7
National Defence	66.7	74.4	83.2	88.8	99.5
National Health & Welfare	42.2	49.5	62.7	60.6	47.3
Medical Research Council	48.4	51.9	57.9	64.4	70.1
Science & Technology					
National Research Council	113.1	145.3	172.6	210.2	213.9
Natural Sciences and Engineering Research Council	80.4	94.3	99.5	112.0	121.0
Secretary of State					
National Museums of Canada	9.7**	42.2	45.7	53.9	46.1
Social Sciences and Humanities Research Council	26.7	29.2	33.2	34.1	36.0
Transport Canada	26.2	33.3	40.0	46.6	30.1
Others	141.1	153.6	161.5	190.5	192.2

* Includes payments under the Industrial Research and Development Incentives Act: 1975/76 $33 million; 1976/77 $45.9 million; 1977/78 $16.4 million.

** Prior to 1976/77, not all of the expenditures of the National Museums of Canada were reported as S&T.

increase since 1975/76 of about 50%. The Medical Research Council's estimated expenditures in 1979/80 are $70 million, representing a total increase since 1975/76 of 45%. Estimated expenditures in 1979/80 by the Social Sciences and Humanities Research Council are $36 million, representing a 5-year increase of 35%.

Departmental and agency personnel engaged in scientific activities are shown in Table 2.2. For the past 4 years there has been a steady decline in person-years with the 1979/80 level estimated to be 33,000, about the same number as in 1975/76. This reflects the government's policies of expenditure restraint and restraint in the growth of the Public Service. The departments of Agriculture, Environment, National Health and Welfare and Statistics Canada estimated significant curtailment of intramural scientific activities as reflected in their estimated person-years for 1979/80.

The government's expenditures on S&T according to performer are shown in Table 2.3. Expenditures on intramural science for 1978/79 and 1979/80 have declined as a proportion of the total science spending. In extramural support a significant increase has occurred in the payments to provinces to undertake research of interest to them, with an increase from 1978/79 of $16 million to $45 million in 1979/80. As a portion of total science spending government support for S&T in the industrial and university sectors has changed little over the past 5 years, with payments to industry for S&T having increased by 37%, and those to universities by 39%.

Table 2.2

Person Years Devoted to Activities in the Natural and Human Sciences by Major Funding Departments

Department	1975/76	1976/77	1977/78	1978/79	1979/80
			(person-years)		
Total Science	**33,989**	**35,496**	**34,726**	**34,413**	**33,070**
Total Major Funders	29,958	31,188	30,409	30,021	28,775
Agriculture	4,274	4,186	4,176	4,238	4,128
Communications	509	422	425	425	425
Energy, Mines & Resources	2,374	2,434	2,422	2,399	2,376
Atomic Energy of Canada Ltd.	2,435	2,321	2,275	2,324	2,338
Environment	7,057	7,177	7,332	7,202	6,772
External Affairs					
Canadian International Development Agency	50	51	51	56	56
International Development Research Centre	304	331	344	355	345
Industry, Trade & Commerce	193	183	171	164	183
Statistics Canada	5,907	6,397	5,432	5,109	4,534
National Defence	2,224	2,126	2,142	2,142	2,142
National Health & Welfare	940	1,104	1,205	1,126	968
Medical Research Council	35	39	39	40	40
Science & Technology					
National Research Council	3,052	3,055	3,073	3,088	3,134
Natural Sciences and Engineering Research Council	51	48	57	59	61
Secretary of State					
National Museums of Canada	269*	997	1,002	1,025	1,006
Social Sciences and Humanities Research Council	96	96	97	98	107
Transport	188	221	166	171	160
Others	4,031	4,308	4,317	4,392	4,295

* Prior to 1976/77, not all the expenditures of the National Museums of Canada were reported as S&T.

The data on payments to industry do not include substantial foregone tax revenues resulting from R&D tax incentives.

Expenditure data on R&D and RSA in the Natural Sciences are provided in Table 2.4. Total expenditures in Natural Sciences are estimated to be $1,436 million for 1979/80, of which 74% ($1,054 million) is for R&D. The R&D expenditures are $44 million higher than forecast expenditures for 1978/79, which in turn are $92 million higher than in 1977/78. The overall increase from 1975/76 to 1979/80 will be 36%. There has been a steady change in the distribution of R&D by performer over the 5 years. Intramural R&D has dropped from 56% of the total in 1975/76 to 52% for 1979/80. The university share has remained unchanged at 19% while R&D performed by industry for the government is now at the same level (21%) as it was in 1975/76.

The estimated expenditures for RSA of $382 million in 1979/80 represents an increase of 32% since 1975/76. The share performed intramurally has remained essentially unchanged at about 78%. Nearly one-half ($183 million) of the RSA is conducted by the Department of the Environment. Other major RSA expenditures are by the Department of Energy, Mines and Resources (about $42 million), the National Research Council (about $31 million) and the Department of National Health and Welfare (about $16 million).

Expenditure data on R&D and RSA in the Human Sciences are provided in Table 2.5. Human Sciences expenditures represent about 23% of the

Table 2.3

Federal Expenditures on Scientific Activity by Performer

Performer	1975/76		1976/77		1977/78		1978/79		1979/80	
	(millions of dollars and (%))									
Total	**1,380.1**	**(100)**	**1,577.9**	**(100)**	**1,673.0**	**(100)**	**1,835.2**	**(100)**	**1,853.4**	**(100)**
Intramural	888.2	(64)	1,010.5	(64)	1,070.0	(64)	1,170.1	(64)	1,160.2	(63)
Extramural	492.0	(36)	567.4	(36)	603.0	(36)	665.1	(36)	693.2	(37)
Industry	215.9*	(16)	268.2*	(17)	262.2*	(16)	291.4	(16)	295.6	(16)
University	187.9	(14)	197.6	(13)	223.8	(13)	248.2	(14)	261.3	(14)
Private Non-Profit	13.5	(1)	21.9	(1)	23.4	(1)	27.3	(1)	23.7	(1)
Provincial & Municipal Governments	25.8**	(2)	32.7**	(2)	24.9	(1)	29.7	(2)	45.2	(2)
Other Canadian					23.5	(1)	24.0	(1)	20.0	(1)
Foreign	49.0	(4)	47.1	(3)	45.1	(3)	44.5	(2)	47.3	(3)

* Includes payments under the Industrial Research and Development Incentives Act (IRDIA) program which was replaced by tax incentives. Expenditures in 1975/76 $33 million, 1976/77 $45.9 million and 1977/78 $16.4 million.

** Prior to 1977/78 payments to provincial and municipal governments were not separately identified.

government's total S&T expenditures, a proportion which has remained essentially unchanged since 1975/76. With estimated expenditures of $418 million in 1979/80, the overall increase in 5 years will be about 31%. The bulk (73%) of Human Sciences expenditures are for RSA, with estimated expenditures of $304 million in 1979/80. With 85% ($258 million) to be performed intramurally, there is a slight trend of increased intramural share from 1975/76 (83%). Statistics Canada will account for $119 million or 39% of expenditures on RSA.

On the other hand more than one-half of the expenditures for R&D in the Human Sciences are for extramural work, and nearly one-half of this is performed by universities. Although R&D has only increased about 15% since 1975/76, the university sector's share has increased from 20% then to 26% in 1979/80, showing that the government is increasingly relying on university research in the Human Sciences.

Figure 2.1
Federal S&T Activities by Performer

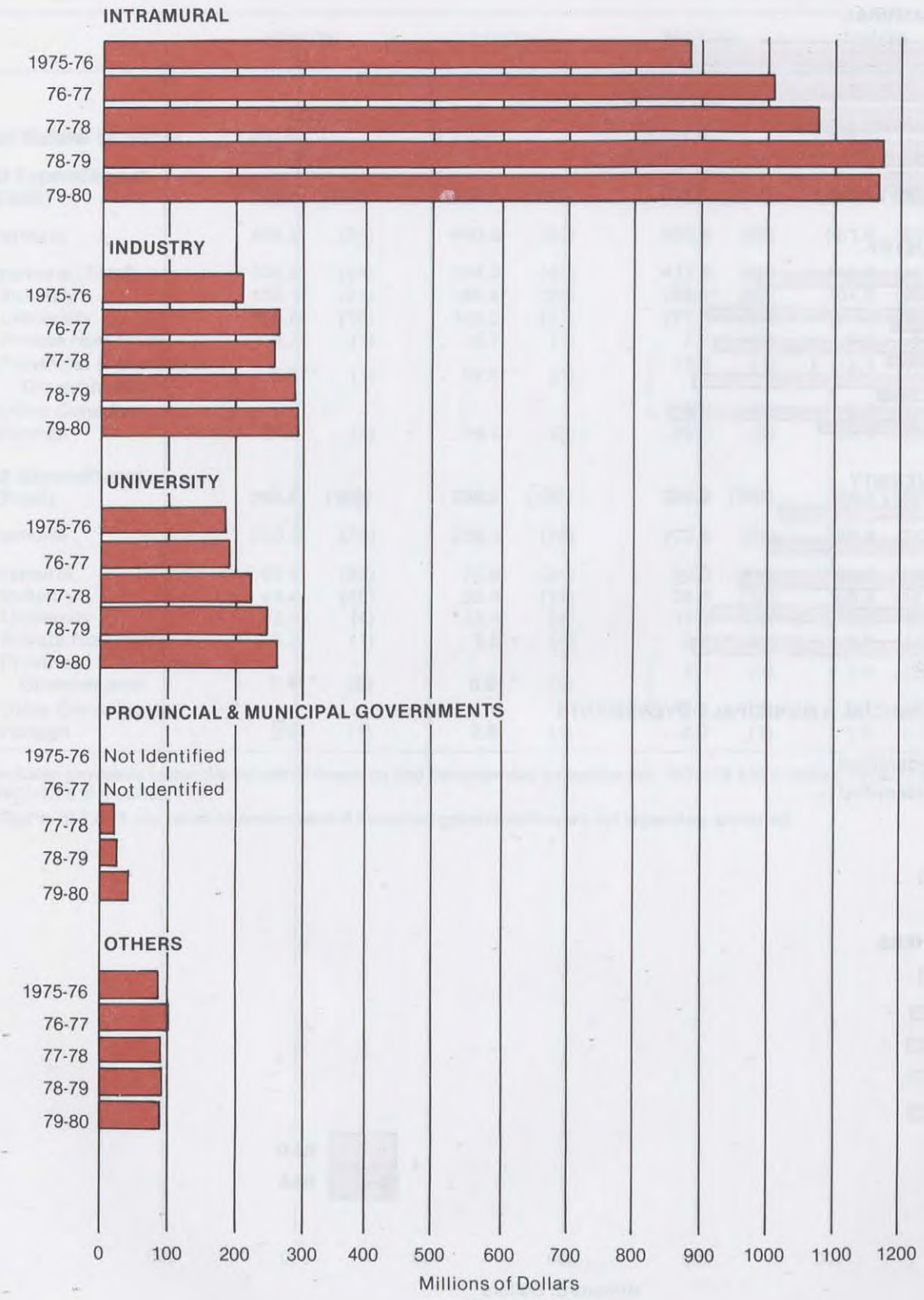


Figure 2.2
Federal Expenditures in Natural Sciences

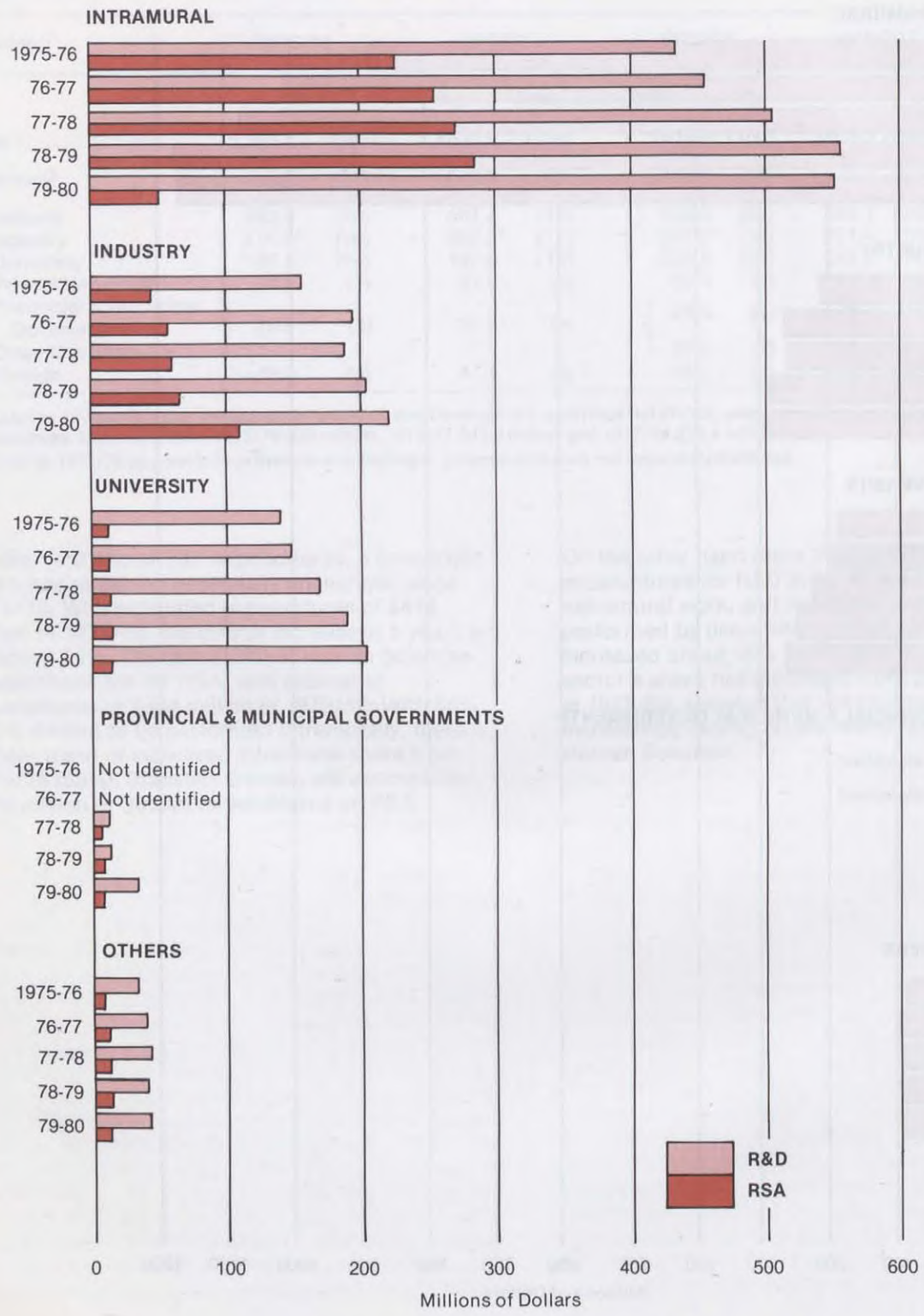


Table 2.4

R&D & RSA Expenditures—Natural Sciences

	1975/76		1976/77		1977/78		1978/79		1979/80	
	(millions of dollars and (%))									
Total Natural Sciences	**1,060.6**		**1,190.8**		**1,277.9**		**1,396.0**		**1,435.7**	
R&D Expenditures (Total)	**772.2**	**(100)**	**855.5**	**(100)**	**918.0**	**(100)**	**1,009.6**	**(100)**	**1,054.0**	**(100)**
Intramural	435.5	(56)	460.8	(54)	506.4	(55)	561.6	(56)	553.1	(52)
Extramural (Total)	336.8	(44)	394.8	(46)	411.6	(45)	448.0	(44)	500.8	(48)
Industry	159.1*	(21)	198.4*	(23)	186.4*	(20)	204.9	(20)	222.6	(21)
University	139.6	(18)	148.5	(17)	171.1	(19)	191.9	(19)	202.4	(19)
Private Non-Profit	4.7	(1)	8.7	(1)	7.2	(1)	7.9	(1)	8.0	(1)
Provincial & Municipal Governments	6.0**	(1)	10.5**	(1)	11.9	(1)	12.1	(1)	33.9	(3)
Other Canadian					6.4	(1)	5.0	(–)	4.3	(–)
Foreign	27.4	(4)	28.7	(3)	26.6	(3)	26.1	(3)	29.6	(3)
RSA Expenditures (Total)	**288.4**	**(100)**	**335.2**	**(100)**	**359.8**	**(100)**	**386.4**	**(100)**	**381.7**	**(100)**
Intramural	225.3	(78)	256.4	(76)	273.6	(76)	286.8	(74)	295.1	(77)
Extramural	63.0	(22)	78.9	(24)	86.3	(24)	99.6	(26)	86.6	(23)
Industry	44.4	(15)	55.4	(17)	56.6	(16)	65.5	(17)	54.4	(14)
University	12.0	(4)	12.4	(4)	13.3	(4)	13.3	(3)	13.9	(4)
Private Non-Profit	1.3	(1)	1.5	(–)	2.2	(1)	2.3	(1)	2.3	(1)
Provincial & Municipal Governments	3.4**	(2)	6.8**	(2)	5.1	(1)	7.9	(2)	7.0	(2)
Other Canadian					7.2	(2)	8.7	(2)	7.3	(2)
Foreign	2.0	(1)	2.8	(1)	2.0	(1)	1.9	(–)	1.8	(–)

* Includes payments under the Industrial Research and Development Incentives Act: 1975/76 $33.0 million; 1976/77 $45.9 million; 1977/78 $16.4 million.

** Prior to 1977/78 payments to provincial and municipal governments were not separately identified.

Figure 2.3
Federal Expenditures in Human Sciences

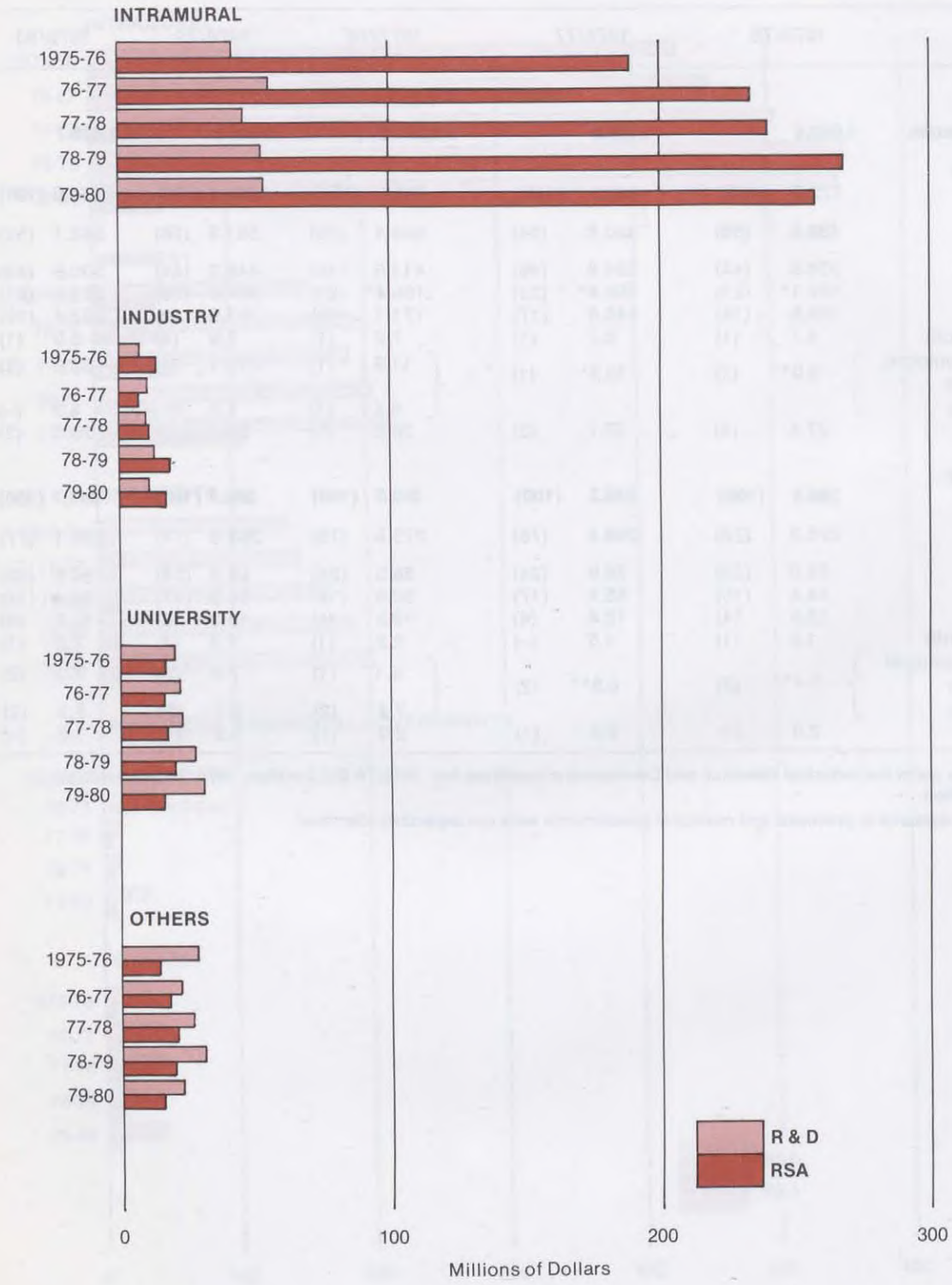


Table 2.5

R&D & RSA Expenditures—Human Sciences

	1975/76	1976/77	1977/78	1978/79	1979/80
			(millions of dollars and (%))		
Total Human Sciences	**319.5**	**387.2**	**395.1**	**439.2**	**417.7**
R&D Expenditures (Total)	**99.3 (100)**	**107.6 (100)**	**101.0 (100)**	**118.8 (100)**	**114.0 (100)**
Intramural	44.9 (45)	55.9 (52)	47.6 (47)	52.1 (44)	53.6 (47)
Extramural (Total)	54.4 (55)	51.7 (48)	53.3 (53)	66.6 (56)	60.3 (53)
Industry	5.4 (5)	6.6 (6)	5.7 (6)	7.2 (6)	5.9 (5)
University	19.6 (20)	21.4 (20)	21.6 (21)	27.1 (23)	29.9 (26)
Others	29.4 (30)	23.7 (22)	26.0 (26)	32.3 (27)	24.5 (21)
RSA Expenditures (Total)	**220.2 (100)**	**279.6 (100)**	**294.1 (100)**	**320.4 (100)**	**303.7 (100)**
Intramural	182.4 (83)	237.5 (85)	242.4 (82)	269.5 (84)	258.2 (85)
Extramural (Total)	37.8 (17)	42.1 (15)	51.7 (18)	50.9 (16)	45.5 (15)
Industry	7.1 (3)	7.8 (3)	11.6 (4)	13.8 (4)	12.8 (4)
University	16.7 (8)	15.3 (5)	17.8 (6)	15.9 (5)	15.1 (5)
Others	14.0 (6)	19.0 (7)	22.4 (8)	21.2 (7)	17.5 (6)

3. Special Applications

Introduction

Science activities carried out by departments and agencies in direct support of their objectives and missions are reported in the Major Funders section. This section discusses those science programs which involve areas of national concern and/or cross the mandates of more than one department.

Scientific activities carried out by departments in support of their particular objectives are increasingly seen to be in support of, and affected by other governmental concerns, objectives and policies. As an aid to policy- and decision-makers, expenditure data are now being collected on an expanded list of S&T application areas. A 3-year summary of expenditures is given in Table 3.1 for those areas discussed in detail. Revisions to the data base, particularly in new categories, are likely in the first 2 or 3 years, until a reasonably uniform interpretation of the new categories is achieved among the numerous departmental respondents.

Although individual departments and agencies normally determine the allocation of their resources, there clearly is a need in the cross-departmental application areas for coordinating and management mechanisms to establish priorities among the contributing activities and to provide advice on how resources should be allocated. Interdepartmental committees, which have been formed for this purpose, have emerged independently and at different times and have been structured and given mandates to meet differing needs.

For example, the Department of Energy, Mines and Resources, as the lead department, chairs and provides the secretariat for the Interdepartmental Panel on Energy R&D, whose objective is to develop proposals for an integrated program of energy R&D. It is required to report to Cabinet and the Treasury Board on the utilization of existing resources and to recommend changes of priority for new or existing

Table 3.1

Federal Scientific Expenditures by Application Area

Application Area	1977/78	1978/79	1979/80
		(millions of dollars)	
Communications	20.1	28.2	26.1
Developing Nations	59.7	67.7	67.7
Energy	147.3	186.2	207.4
Environmental Issues	72.7	78.6	73.3
Food	167.3	180.7	189.2
Health	112.6	121.4	116.7
Natural Resources	71.5	74.7	77.0
Oceans	38.9	36.5	36.5
Space	55.8	70.0	44.1
Transportation	102.2	113.3	98.9

resources where appropriate. The panel has influenced budgetary decisions since 1976/77. The recently organized Interdepartmental Committee on Transportation R&D has a similar mandate. The Interdepartmental Committee on Space, originally created as a coordinating body, is now required, beginning with the 1979/80 fiscal year, to establish priorities for the various space systems development projects (and to submit for approval an integrated program), taking into account departmental requirements and space industry development. In other areas which are discussed in this section, those committees which exist have an information exchange and a coordinating role only.

Communications

Easy communications are at the heart of any industrialized nation's progress; thus it is not surprising that Canada has vast networks devoted to the exchange of data and voice communications. From the first years of the telephone, the search for better and less costly means of transmission has continued. Canada has been a leader in the development of reliable, efficient, high frequency sources and amplifiers, as well as carrier systems employing wire, multi-conductor cable, co-axial cable and radio transmissions. As higher frequencies of the spectrum were exploited, more information capacity became available through the use of greater band widths. Radio became increasingly attractive for both short and long distance communications, as better, more efficient radio frequency sources and devices emerged, making long distance, wide band communications more economic. The development of space technology in the 1960s revealed two possibilities for long distance telecommunications. Satellites became regarded as economically practicable repeater stations, and they proved feasible means of providing reliable, low cost communications throughout Canada, and especially to far northern communities.

The orderly development of communications in Canada is the responsibility of the Department of Communications. Other agencies, particularly the Canadian Broadcasting Corporation and the National Research Council, are also involved in communications research. This section will concentrate on the activities of the Department of Communications and the National Research Council and will touch briefly on the activities of the Canadian Broadcasting Corporation.

Expenditures on communications science are given in Table 3.2. The Department of National Defence, although not listed in the table, will also spend $1.8 million on communications S&T in 1979/80, 97% in the extramural sector.

In 1977/78 and 1978/79, most federal science expenditures in communications were intramural (60% and 65% respectively). In 1979/80 however, although the total spending will be down slightly due to budgetary restraint, extramural funding is increasing to 52% of the total, with intramural dropping to 48%.

The Department of Communications is the major spender in this area. Research within the department is focused both on technological and industrial applications, and on social, economic, regulatory and policy issues. The department's research in three areas — rural communications, management of the radio frequency spectrum and technology development — is discussed below.

Table 3.2

Federal Science Expenditures in Communications

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**20.1**	**28.2**	**26.1**
Communications	12.3	19.0	15.8
National Research Council	2.5	3.4	3.7
Canadian Broadcasting Corporation	2.8	3.0	3.4
Others	2.5	2.8	3.2

The department's rural communications program began in mid 1976, with the objective of closing the urban-rural telecommunications gap. About 60% of program funds are spent extramurally on consultations with industry, research and development contracts, field trials and the examination of techniques to optimize the effectiveness of existing systems for rural use.

The technology of fibre optics is very new and holds great promise for both rural and urban communications. Scientists predict that within a few years it will be possible to run a glass fibre to a telephone subscriber for the same cost as conventional copper wire. This glass fibre connection will also be able to deliver cable television and other information, education and entertainment services. The department is co-sponsoring, with the Canadian Telecommunications Carriers Association, a $5 million, 5-year field trial of a distribution system based on fibre optics, bringing single party telephone service, several TV channels, FM radio and interactive data signals from a central distribution point into 150 homes in Elie, Manitoba, 100 km west of Winnipeg. The program is also being supported by the federal Department of Industry, Trade and Commerce. The Elie field trial will help to stimulate the development of fibre optic technology in Canada and stimulate Canadian industrial capability in the field.

The department is also conducting research to improve the management of the radio frequency spectrum. Demands for channels in the radio frequency spectrum are growing at an accelerating pace. For example the number of radio licences, which is growing by approximately 12% annually, reached over 500,000 in 1977. Some 50% of these were for land-based mobile communications. As a consequence, the portion of the spectrum used by land-based mobile services (taxis, police and other municipal services, delivery companies and so on) is at or near the saturation point in southwestern Ontario. A similar situation will likely arise in Montreal and Vancouver by about 1981.

The department is conducting spectrum research in three areas: radio propagation research, radio environment studies and systems studies. The first is concerned with the interaction between radio waves and the propagating medium, as well as the effect of this interaction on the performance of communications systems. The second examines problems of radio noise and interference, attempting to characterize noise sources and assess their effects on communications systems. The last touches all aspects of communications systems, including their technical, economic and social implications, alternatives to their use, demand analysis, future requirements and utilization strategies. Some highlights of the research to improve management of the radio spectrum are given in the following paragraphs.

One example is a project to investigate effects of the radio environment on radio communications and consumer-type electronics equipment and to foster development (particularly in Canadian industry) of radio communications technology. Immediate objectives of the project include investigation of error rate performance of digital communications systems in the presence of man-made radio noise and interference, and the quantitative assessment of power line and ignition noise effects on TV reception. A long-term objective is research into the electromagnetic susceptibility and compatibility of electronic equipment, and the development of a test and simulation capability.

Other work in this field involves systems designed by the department for extending and optimizing terrestrial radio coverage for remote communities. A prototype system enabling scouting or hunting parties to keep in touch with their base communities has been installed at Koartak, northern Quebec, for extended field testing.

Spectrum systems research involves the analysis of other possible ways of managing the radio spectrum. The results are used as a basis for the department's policy formulation. This new research activity is focusing first on developing the necessary expertise in demand analysis, technology forecasting, engineering, and economic and social value analysis. A sophisticated computerized spectrum management system is being developed, both to assure more effective sharing of increasingly scarce channels and to cope with the heavy engineering and other workloads resulting from band congestion in urban areas.

The department's Communications Research Centre is developing a technique to monitor the crowded land-based mobile bands, as well as specifying for the first time quantitative definitions of channel performance and capacity. Monitoring plans and analysis procedures are being designed for several major urban areas, in order to provide input for the spectrum management system data base. This will enable the department to manage the land-mobile bands more efficiently. Work is also proceeding on the development of suitable parameters for

quantitative descriptions of channel usage, capacity and quality of service.

In the area of technology development, the department in 1978 unveiled its Videotex system, now renamed Telidon. This exciting development turns an ordinary TV set into an information retrieval centre displaying, at the user's command, a virtually unlimited amount and variety of information from any one of a number of data banks. Telidon incorporates a major advance in computer imaging which removes the "chunkiness" characteristic of existing video terminals. For example, a map of Canada on Telidon looks very much as a normal map does, whereas on competitive terminals it looks as if it were made with bricks. Telidon has been designed to accommodate foreseeable changes in television technology. It can also handle terminal-to-terminal operations without requiring connection to a central Telidon computer. The Telidon system should be in commercial operation by 1983, both in homes and in business premises.

The department's research in technology development has been affected by recent advances in solid-state technology and the popularity of the General Radio Service (generally known as Citizen's Band radio). The advances in solid-state technology have spurred evolution of new, more reliable telecommunications services. Large scale integration techniques have resulted in enormous reductions in the size and weight of electronic components. These techniques have led to more sophisticated circuits with better performance and lower cost than previously attainable. In addition, microprocessors may well transform telecommunications and permit significant improvements in mobile radio communication systems. They permit increased capacity, more reliable selective signalling and greater frequency stability with improved audio quality. Such devices will be fundamental in the development of efficient cellular networks for land-mobile communications.

The revolution in personal communications represented by the boom in GRS radio seems destined to have a major impact on the evolution of future communications systems and techniques, particularly in areas such as that of the "cordless" telephone.

The National Research Council expects to spend $3.7 million in the communications field in 1979/80, continuing long-standing programs in computer-aided learning and associated hardware and software development, in radio antenna development and in basic research. The majority of this work is in the technology transfer phase, using the Program of Industry/Laboratory Projects (PILP) and the Industrial Research Assistance Program (IRAP). Due to the nature of these programs the details of any particular project may be proprietary information. Two projects, however, have been made public and are indicative of the type of work sponsored. Under PILP, a Quebec company is utilizing National Research Council research in the development and production of terminals for use in computer-aided learning. Under IRAP, an Ontario company has produced the first all solid state PABX (private automatic branch telephone exchange). It includes an innovative transformerless line circuit and trunk circuit and a switching array using complementary metal oxide semi-conductors.

The communications activities of the Canadian Broadcasting Corporation are mainly in the area of human sciences. Its research department in Ottawa contracts out surveys and audience rating analyses and determinations while intramurally it performs some specialized surveys and develops statistical information. Any physical science communications work is performed at the corporation's engineering headquarters in Montreal. There is no research department as such, but the engineering staff develop technical modifications to improve the CBC's transmission lines and distribution systems.

Developing Nations

Most of the government's research aid to developing nations is administered by two agencies, the Canadian International Development Agency (CIDA) and the International Development Research Centre (IDRC). Their expenditures are shown in Table 3.3. CIDA has a wide-ranging interest in many areas including health ($4.3 million), communications ($6.4 million) and mineral resources ($2.6 million). In the health area, projects of interest include the training of auxiliary health workers in Nepal, including the development of the training curriculum, control of disease vectors in Burma and the provision of a regional drug laboratory in the Caribbean. In addition assistance is being continued to multilateral and international non-governmental institutions for research and training programs in health and family

Table 3.3

Federal Science Expenditures for Developing Nations

Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**59.7**	**67.7**	**67.7**
Canadian International Development Agency	25.3	30.9	30.8
International Development Research Centre	34.5	36.9	36.9

planning, such as the World Health Organization, the United Nations Fund for Population Activities, the International Planned Parenthood Federation and the International Union for Scientific Study of Population.

In the communications field, a project of interest is the Tanzanian Transportation Study involving an assessment of land transportation and related telecommunications requirements. Another project is studying the development of a Pan African telecommunications system to serve a number of West African countries.

In the resources field, CIDA has been funding aerial surveys for the purposes of preparing inventories, obtaining data for analysis and mapping. In the area of renewable resources, Canadian and Peruvian scientists are working together to improve the regulations governing the catch of local anchovies. In El Salvador an experimental project aims at increasing the production of inland fish species through artificial means. Both projects have important training components and are expected to have a favourable ecological and socio-economic impact.

The International Development Research Centre was founded on the belief that the best way to provide developing countries with the science and technology that meets their needs is to enable those countries to carry out their own research, to train their own scientists and to share the resulting knowledge amongst themselves as widely as possible. IDRC provides financial assistance to researchers in developing regions and supports programs that help these regions to build both the human and institutional capacity for bringing the methods of scientific enquiry to bear on the solution of their own problems. In 1979/80 IDRC will spend $36.9 million on scientific activities.

The largest part of IDRC support is channelled through its Agriculture, Food and Nutrition Sciences Division which concentrates its activities in improving staple food crops and cropping systems, savanna forestry, aquaculture research, postharvest systems and animal production systems.

An important example of the work being funded is the cooperative network of some 20 projects in savanna forestry in a dozen countries of Africa and the Near East. Trees are invaluable in semi-arid regions because they protect the soil against erosion and produce firewood, food and forage for animals. In Sudan, for instance, the Ministry of Agriculture, Food and Natural Resources has been experimenting since 1974 with shelterbelts to reclaim land in the Kerma Basin of the Nubian Desert. A new project is now enabling the Sudanese to investigate how large-scale reforestation can be achieved using new planting techniques. The project should benefit other countries in the region, which are testing various tree species in shelterbelt and windbreak plantations to protect food crops from the desert's encroachment.

The semi-arid tropics are also benefiting from IDRC's crop improvement program, and a network of projects aimed at breeding and selecting high-yielding, disease and pest resistant varieties of cowpeas — a food legume that provides as much as 70% of the protein intake of the people in some countries of the region — has recently been launched in Mali, Niger, Sierra Leone and Upper Volta. Complementing the crop improvement program is the development of improved cropping systems to enable small farmers to obtain greater benefits from the new crops and technologies.

The Health Sciences Division of IDRC concentrates its support in basic health services, particularly the delivery of health care in rural areas, the control of major tropical diseases, water supply and sanitation systems, and studies of more effective methods of fertility regulation.

An early supporter of the World Health Organization's Special Programme for Research and Training in Tropical Disease, IDRC has also supported individual projects whose objectives fall within the special programme's scope. In Egypt, for example, bilharziasis affects up to 50% of the population. Primarily a rural disease, bilharziasis is transmitted by snails living in irrigation canals, rice fields, lakes and streams. To date, no effective means of providing mass treatment exists and the available drugs are difficult to administer and have serious side effects. Researchers at the High Institute of Public Health in Alexandria, aided by an IDRC grant, have discovered, however, that a common weed growing throughout Egypt and the Mediterranean could hold the key to controlling the snail hosts of this debilitating disease. Damassissa (*Ambrosia maritima*), a part of the ragweed family, produces a powerful molluscicide in its leaves and flowers. Laboratory experiments have shown that infusions of damassissa effectively killed the snails as well as the eggs and larvae of the parasite. It does not appear to have harmful effects on other animal life. Field tests are now being carried out to develop this plant into a cheap, safe and easily applicable method of snail control.

The Social Sciences Division provides financial support for research into the impact of modernization on the developing world. This research includes multicountry studies such as the Science and Technology Policy Study, which is looking at the science policies of 10 countries of Latin America, Asia and the Middle East. The project is now in its second phase: researchers, planners and decision-makers are discussing results for each country with a view to fostering indigenous scientific and technological activity.

Projects involving individual countries, supported by the Social Sciences Division, range from the study of the likely social and economic impact of the construction of a major dam in Paraguay to problems of managing resettlement schemes in Sudan. In educational research, the experimental mass primary education project supported in Indonesia and the Philippines continues to attract international attention and is providing the model for a new project in Jamaica.

To ensure that the results of scientific research carried out the world over are available to those who most need them, the Information Sciences Division's main thrust continues to be to support international bibliographic information systems and to assist regional groups and individual countries to participate in these systems. A few projects involve the techniques of gathering data and information for development purposes. In Togo, for example, IDRC is providing funds for mapping the coastal areas, where half the population lives, so that a regional development plan can be prepared.

Finally, in keeping with its commitment to disseminate information, the Communications Division of IDRC publishes a wide range of scientific monographs, technical studies and more general publications on IDRC-supported research and produces films and other audio-visual materials.

In addition to these two main agencies, other government departments have projects in developing countries. The Department of Agriculture is initiating a new research program on "rain-fed food production" in Pakistan and has recently issued contracts for training farm-equipment operators in Tanzania. Other projects involve assisting a food and vegetable processing laboratory in Colombia, establishing a training program involving the Swine Research Institute of Cuba and the Lacombe Research Station, Alberta, and investigating the possibility of large-scale cereal production in Sudan.

The Department of Energy, Mines and Resources has an on-going project to assist Peru in developing and sustaining a national program of remote-sensing applications. Specific forms of assistance include scientific and management training in Canada involving research and planning experience, and a modest program of equipment acquisition. The research and training components of the cooperatively managed project have been successfully completed. Final laboratory design and equipment acquisition are expected to be completed early in 1979.

Energy

Most of the energy science and technology supported by the government is monitored and coordinated by the Interdepartmental Panel on Energy R&D, which has been assigned responsibility for analysing the S&T opportunities and problems of the various energy delivery systems available to

Canada, and for recommending a coordinated and priority-ranked energy S&T program. The remainder of the energy S&T supported by the government involves such activities as environmental impact and resource assessments and socio-economic studies. This section concentrates on those activities which are monitored by the Panel on Energy R&D.

The world, and Canada, face increasingly costly energy supplies. Despite recent encouraging finds of Canadian oil and gas, any permanent protection for Canadians from higher costs of energy will come from the development and application of technology. In recognition of this, the government has provided increasing amounts of incremental funding, i.e., new resources, for energy S&T since 1976/77. Within this incremental funding, priority has been accorded to projects aimed at energy conservation and the development of renewable energy resources. Of the total of $34 million in incremental funds provided from 1976/77 to 1978/79, $10 million has been spent on development of renewable energy resources and $10.5 million on energy conservation S&T.

In further support of the development of renewable energy resources and to stimulate industrial participation and technology transfer, the Minister of Energy, Mines and Resources announced, in July 1978, plans by the government to spend $380 million over the next 5 years on such renewable energy resources as solar energy, energy from forest biomass and energy from urban wastes. Included in this amount is an increase for related S&T activities of $37.7 million over the 5-year period. The increase for 1979/80 is estimated to be $5.3 million: $3.5 million related to the development of solar energy and $1.8 million to the development of forest biomass as an energy source.

These increases bring the total incremental funding from 1976/77 to 1979/80 to an estimated $37.4 million, a net increase of $3.4 million over 1978/79. As a result, the total energy S&T resources monitored by the Panel on Energy R&D will reach an estimated $136.2 million in 1979/80. The total of all energy S&T funded by the government for the same period is estimated to be $207.4 million. Table 3.5 shows expenditures by department.

As shown in Table 3.4, the S&T activities monitored by the panel are organized into five tasks plus the coordination and review activity, centred in the Office of Energy R&D in the Department of Energy, Mines and Resources, the lead department overall in energy S&T.

The target of energy conservation S&T is to reduce the high per capita energy consumption in Canada. Building insulation and energy and transportation efficiency are high priority areas. Of particular interest are the development of energy-conserving building codes for residences and examination of alternative fuels for various sectors of the transportation system. Other work in conservation includes district-heating studies, devices for domestic furnaces and storage (through batteries, flywheels, and so on) of energy that would otherwise be lost as its availability is not coincidental with demand.

In the fossil fuel area, research continues on conventional oil and gas, including studies of "tight" gas from sandstone reservoirs of low permeability; on oil sands and heavy-oil mining, separation and up-grading; on coal mining, including studies on advanced mining methods applicable to plains, and

Table 3.4

Expenditures Under the Federal Energy R&D Panel

Tasks	1977/78*	1978/79*	1979/80
		(millions of dollars)	
Total	**113.8**	**132.8**	**136.2**
Energy Conservation	6.8	13.3	12.5
Fossil Fuels	8.5	11.0	11.0
Nuclear Energy	87.2	88.1	87.1
Renewable Energy Resources	5.5	12.7	18.0
Transportation and Transmission	4.8	6.4	6.3
Coordination and Review	1.0	1.3	1.3

* Variations from figures published earlier are the result of redefinitions and of the completion of certain projects.

on low-rank coals; on coal conversion to synthetic liquid and gaseous fuels; and finally, on coal combustion. With respect to combustion, the government is funding the construction of a demonstration fluidized-bed combustion boiler at the heating plant of the Canadian Forces Base Summerside, Prince Edward Island. In addition, it is providing a total of $96 million for R&D through the Alberta-Canada Resource Research Fund, of which $24 million is the 1979/80 contribution, compared to $10 million in 1978/79.

The decrease in the Nuclear task is the result of a reduction of $1.0 million for the uranium reconnaissance program, terminated as part of the government's expenditure reduction measures.

With respect to renewable energy resources, biomass and solar energy have been identified as having the biggest supply potentials and this is reflected in the new initiatives to develop the solar heating industry through a government purchase program, and to develop the use of wood and forest waste as an energy source for the forest industry by means of an incentive program for capital projects in the forestry industry.

Additional solar R&D to be carried out by the National Research Council is to support industrial development and prototype systems suitable for mass production. This will involve technical development of components and systems; technical certification of the components, requiring test facilities and standards development; analytical support in the assessment, purchase, installation and evaluation of solar equipment; and the design, construction and evaluation of prototype systems.

Expanded R&D on forest biomass will proceed on two fronts: the growth and production of forest biomass itself, and the use of the biomass either by conversion into products which are compatible with the current and future hydrocarbon economy or directly to supply process heat and electricity. R&D on the growth and production aspects will be directed to resource estimation, the development of specialized harvesting equipment and agroforestry, and the associated environmental impact assessment. R&D on conversion processes aims to develop clean gaseous and liquid fuels or chemical intermediates in the production of tonnage quantities of chemicals, and to develop systems for process heat and electricity generation. The majority of this work will be carried out under contract by the private sector and will be sponsored by the new Energy from Forest (ENFOR) program of the Canadian Forestry Service of the Department of the Environment. The demonstration of conservation and renewable energy technologies will be funded on a cost-shared basis with the provincial governments. The federal government's contribution will be $114 million over the 5-year program, which will be managed jointly with provincial governments, and with technical assistance from the federal R&D activities. The Department of the Environment also manages a $0.5 million program for the development and demonstration of resource and energy conservation technology.

A total of $6.2 million is expected to be spent in 1979/80 in the Energy Transportation and Transmission task. The task comprises two main programs: Transportation of Energy Commodities, and Electrical Transmission and Distribution. For 1979/80, R&D on the transportation of energy will continue to involve systems studies on the feasibility and economics of transporting coal in southern Canada, and of moving oil and gas via pipeline or tanker from the Arctic. Transport Canada is cooperating with the departments of Energy, Mines and Resources (Canada Centre for Mineral and Energy Technology) and the Environment (Atmospheric Environment Service) in several areas: design parameters for icebreakers and oil and gas carriers with icebreaking capability, navigation through ice, and so on. Future work will involve more ice research, bathymetrics, oceanography and such environmental studies as the problem of frost heave and pipeline installations.

Most of the government's expenditures in 1979/80 in the Electrical Transmission and Distribution program will support a joint funding program with the Canadian Electrical Association. A joint government-industry committee will choose and monitor a variety of projects: for example, effects of Extra High Voltage lines and insulation in contaminated conditions. The remainder of the expenditures will support an in-house project in the National Research Council, carrying out research on cryogenic transmission lines.

Details of the total energy-related S&T expenditures by department and agency are given in Table 3.5. The Department of National Defence, although not included in the table, estimates an expenditure of $1.6 million on energy S&T in 1979/80, with 44% being contracted out.

Table 3.5

Federal Science Expenditures on Energy

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**147.3**	**186.2**	**207.4**
Energy, Mines and Resources			
Earth Science Services Program	15.6	16.4	16.0
Energy Program	28.4	33.1	57.0
Atomic Energy Control Board	0.7	0.8	1.0
Atomic Energy of Canada Ltd.	75.2	90.3	83.3
Environment	6.9	9.2	8.2
National Research Council	15.1	26.8	31.5
Public Works	0.4	1.6	2.5
Transport	1.6	2.9	3.1
Others	3.3	5.2	4.8

Environmental Issues

This section includes federally-funded S&T activities which address issues concerning the various components of the environment: weather, air, land, water, ice, wildlife, forests. Since much of our industry is based upon our resources, and thus affects the environment, for our economic well-being as well as our enjoyment of life, we must be able to predict the effects on the environment, and to protect or sometimes rescue it from pollution, and from activities which limit or destroy its renewable or productive capacity.

It is difficult to distinguish environmental research from research for resource management. Modern resource management techniques strive to incorporate environmental impact into the decision-making process, although in practical terms this has yet to occur to any significant degree. For this reason expenditures related both to the use of water as a resource, and to the consideration of issues concerning water as part of our environment, have been aggregated in Table 3.6, and are discussed in this section. In contrast, forestry and its related S&T expenditures are covered in the Natural Resources section.

The major departmental funder of S&T related to environmental issues is the Department of the Environment, with estimated expenditures of $60.7 million for 1979/80. Within its Environmental Services Program and subject to the limitations of the government's mandate, the Environmental Management Service is concerned with the management, protection and utilization of Canada's forests, wildlife and fresh water, and with the use of land for various purposes; the Environmental Protection Service regulates the discharge of contaminants into the environment, in order to reduce or control air and water pollution; and the Atmospheric Environment Service is charged with providing up-to-date, nation-wide information and forecasts on weather, climate, air quality and atmospheric criteria. The Fisheries and Marine Program, estimating an expenditure of $2.2 million in 1979/80, is primarily interested in the study and alleviation of the impact of water pollution upon the fisheries resource, both in fresh and in salt waters.

The Department of Agriculture, which plans to spend $2.3 million in this area in 1979/80, involves itself with those environmental issues directly related to farming, such as the effects of chemical fertilizers and insecticide sprays.

The National Research Council will spend $3.8 million on a wide range of environmental issues, mainly on fundamental biological research and on providing opportunities for discussion and coordination through its Associate Committee on Scientific Criteria for Environmental Quality. In support of the missions of other departments, for example, the council has a continuing program at its Atlantic Regional Laboratory to develop a set of marine analytical standards.

Table 3.6

Federal Science Expenditures on Environmental Issues

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**72.7**	**78.6**	**73.3**
Agriculture	2.1	2.3	2.3
Energy, Mines and Resources	2.9	3.0	3.1
Environment (Total)	62.8	66.2	60.7
Fisheries and Marine	2.9	2.4	2.2
Environmental Services			
Environmental Management Service	50.4	52.2	50.3
Environmental Protection Service	7.3	9.3	5.9
Atmospheric Environment Service	2.2	2.3	2.4
National Research Council	2.5	3.6	3.8
Others	2.4	3.5	3.4

Water

In 1979/80 the government's expenditures on water-related environmental issues will amount to $40.3 million, or 55% of the total shown in Table 3.6. Of this amount the largest component, $36.4 million, will be funded through the Environmental Management Service of the Department of the Environment. The department's Fisheries and Marine Service will spend $2.2 million.

On 22 November 1978, Canada and the United States entered into a new Great Lakes Water Quality Agreement. Based on the 1972 agreement, the new pact calls for stronger pollution control measures, more precise water quality objectives, activities relating to an ever-increasing host of toxic contaminants, and an expanded role for the International Joint Commission in surveillance and monitoring. In support of the agreement, the Department of the Environment plans to spend $2.0 million in new resources in 1979/80 over and above $8.0 million currently allocated to this work both directly and indirectly.

The Department of the Environment has also begun programs to examine the environmental impact of nuclear projects, including the problem of radioactivity in ground water; to conduct research on the contaminants covered by the Environmental Contaminants Act and on the control or eradication of rapidly spreading aquatic weeds; and to fund cost-shared projects with industry for the development and demonstration of innovative technology for the control of water pollution. Because of the current restraints on government spending, these programs are being funded through reallocation of resources from projects of lower priority.

Air

Air-related environmental issues will account for government spending of $4.7 million in 1979/80, over 6% of the total shown in Table 3.6. The Environmental Protection Service of the Department of the Environment will spend $2.0 million on problems directly related to the control of air pollution. In support of its continuing activities to control hazardous air pollutants, the service will pursue the development of new technology for the containment of mercury and arsenic from non-ferrous smelters.

The Atmospheric Environment Service will spend $2.0 million on such activities as the development of an integrated program to deal with the problem of long range transport of air pollutants, with emphasis on the increasing acidity of precipitation in eastern Canada. A 50-station network for sampling precipitation has been established to investigate regional differences in wet disposition of pollutants.

This program is an important example of cross-linkage between air-related and water-related issues. Pollutants are carried long distances by winds and then fall to earth with precipitation (the so-called "acid rain") resulting in deterioration of the water quality in streams and lakes, a depletion of fish stocks and economic damage to Canada's fishing and tourist industries.

The Atmospheric Environment Service is undertaking baseline studies of ambient air pollution and related air quality which will have significant future impact on environmental assessment studies. The long-range plan by this service is to be able to forecast ambient air quality through its modelling techniques, based on its monitoring network. A variety of projects will be undertaken in the general area of air quality monitoring: they include studies on ozone and nitric oxides in Toronto, and plume dispersion and transport of sulphur dioxide in Sudbury, both serious concerns because of the effects on human health of the substances involved. Computer models for predicting concentrations of pollutants are being developed to improve the capability for impact assessments. Modelling studies of the impact of chloro-fluoro-methanes on the ozone layer and on the thermal balance of the earth are also being carried out. The Atmospheric Environment Service continues to operate the World Ozone Data Centre on behalf of the World Meteorological Organization, and through its Canadian Climate Centre is the government's lead agency in climate studies.

Land

The government's S&T expenditures in 1979/80 on environmental issues related to land are estimated to be $6.3 million, or 9% of the total shown in Table 3.6. The largest spender will be the Department of Energy, Mines and Resources ($2.7 million), investigating the impact of energy development and mining activities on the land.

Another major funder on land-related issues is the Environmental Management Service of the Department of Environment which will spend a total of $2.2 million. Priority will be given to the complex social and economic problems arising from conversion of agricultural land to airports, factory complexes, residential suburbs and highways. Much of the research in this area involves computerized land inventories and numerical modelling of physical, environmental, social and economic phenomena.

The Department of Agriculture will also conduct about $2.3 million worth of R&D related to the control of pollution caused by agricultural practices, such as use of fertilizers and pesticides, and waste products from agriculture. In addition, the department will study erosion, flooding and related problems which result from changing the natural state of the land in converting it to farm use.

Other

The Department of the Environment under its Environmental Management Service estimates an expenditure of $11.7 million on other environmental issues, including those which involve wildlife. The department is giving priority to a "baseline" study of the ecology of the James Bay region, with a view to protecting millions of migratory birds and other indigenous wildlife. Studies are also being made of the distribution and population of seabirds on the Pacific Coast and shorebirds on the Upper Bay of Fundy. Herring gull eggs are monitored annually to follow trends of contamination in all the Great Lakes. Reproductive failure of Lake Ontario herring gulls is caused partly by poor incubation by adults having a high toxic chemical intake in their food, and partly by a toxic effect on the embryo itself. Research on Canadian waterfowl will be an important component in the development of a National Waterfowl Management Plan.

Food

Food science is a term used to encompass those S&T activities concerned not only with the primary production of food but also with its subsequent processing, distribution and retailing, including such aspects as nutrition, safety and quality. Food science in both the primary and secondary sectors is one of Canada's priority science areas. The Canadian climate is generally unfavourable to agricultural production in comparison to the climates of other major food-producing areas. The Canadian food industry, however, uses a relatively high level of technology to achieve good yields and higher labour productivity, despite constraining climate and soil conditions.

The document "Food Strategy for Canada", released by the government in 1977, reaffirmed that "Government policies must continue to develop and expand Canada's production and export strengths to ensure the adequacy of safe and nutritious food supplies which are responsive to competitive forces over time." It also identified research on the

processing, distribution and retailing of food as essential to improving the efficiency of our food distribution system. The government has provided additional funds, beginning with $0.7 million in 1978/79, to initiate a coordinated research program involving the six departments concerned with one or more aspects of food production, processing, distribution and retailing.

It is estimated that Canadian governments, universities and industries spend at least $220 million annually on food science, which represents about 10% of the Canadian gross expenditures on R&D. The Government of Canada is the major funder of food science; details of its expenditures are given in Table 3.7.

Intramural S&T expenditures on food in 1979/80 will increase by 4% to $168.9 million whereas extramural spending will reach $20.3 million, an increase of 8%.

Over 70% of the government's support for food science in Canada is funded through Agriculture Canada, whose estimated S&T expenditures in 1979/80 will be $135.0 million. As shown in Table 3.7 the preponderance (88%) of the department's S&T activities are carried out in the Research Branch, whose program has been organized into 14 major research areas, listed here in descending order of effort: horticultural crops, cereal crops, forage crops, beef cattle, biosystematics, oil-seed crops, land and water resources, field crops, dairy cattle, environmental quality, poultry, swine, sheep, and honey bees and other animals. Activities in the new area of processing, distribution and retailing, were initiated in 1978, in response to the Food Strategy document mentioned above. The branch operates 47 research stations across Canada, sited so that local factors in production and utilization of agricultural products can be taken into account in the research projects. To improve the response to local needs the branch moved to a regional management structure in 1978, consisting of the Eastern Region centred in Quebec, the Central Region centred in Ottawa and the Western Region centred in Saskatoon.

The department's Health of Animals Program conducts research on animal diseases, including the causative agents and methods of transmission. These activities are carried out by the Animal Pathology Division in Ottawa and by eight regional laboratories. The activities also include the development and improvement of diagnostic tests and reagents, of treatment products, and of qualification tests for breeding stock, embryos and semen. Quality and diagnostic testing procedures are essential to the export of meat products and the importation of foreign animals.

The science activities of the Administration Program involve the operation of the department's central library service and research on economic and social variables affecting the food industry, with particular emphasis on issues affecting policy development and implementation.

The following paragraphs give highlights of the Research Branch's work in three of 14 research areas: horticultural crops, cereal crops and beef cattle.

Table 3.7

Federal Expenditures for Food Science

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**167.3**	**180.7**	**189.2**
Agriculture (Total)	112.8	127.0	135.0
Research Branch	99.3	112.1	118.4
Other Branches	13.5	14.9	16.6
Environment (Total)	29.7	27.5	28.7
Fisheries and Marine	28.9	26.7	27.9
Industry, Trade and Commerce	3.0	2.4	2.0
Statistics Canada	5.8	5.8	5.3
National Health and Welfare	7.2	7.4	6.8
National Research Council	7.9	9.4	10.0
Others	0.9	1.3	1.3

The annual value of fruits and vegetables grown in Canada is $735 million. Because of restricted production due to the Canadian climate and topography, however, annual imports amount to over $400 million. Major research objectives are to develop or improve strains which are particularly adapted to our climate and ecology, and to develop or improve chemical and biological methods for controlling plant diseases and pests. For example, new varieties of peaches and apricots developed at the Harrow and Summerland research stations are performing well in commercial orchards. The Totem strawberry, developed by the Vancouver Research Station, has become the most important variety in British Columbia. A process of dipping Spartan apples into a calcium solution containing a thickening agent has been found to control storage deterioration. An improved food blancher that will result in higher quality processed products has been developed in Nova Scotia.

The total farm value of cereal crops is estimated at $5 billion annually, which makes them an important component of the Canadian economy. The Research Branch aims at producing better grain varieties, developing and disseminating information on improved growth regimes and on pest and weed control. In the biosystematics of oats production, for example, basic research has led to the incorporation of genetic factors into the breeding stock to improve disease resistance, diurnal response and quality. Another very promising project is developing a strain of wheat whose roots can establish a symbiotic relationship with nitrogen-fixing bacteria.

The beef production, processing and marketing industry has a significant influence on the health, income and well-being of most Canadians. It is essential to develop beef cattle that are better suited to the harsh Canadian environment. More and better quality forages are being developed to support the expanding beef herds and reduce feed grain consumption. Progress in harvesting, conservation and utilization of forages has had a significant impact on reducing beef production costs. In the meats utilization program, major contributions have been made in carcass handling and developing new criteria for assessing meat product quality.

Canada's ocean and freshwater fisheries represent a valuable food resource which is underutilized by most Canadians. Significant scientific activities are carried out by the Fisheries & Marine Service of the Department of Environment, aimed at increasing the use of fish as a Canadian food source. These include research designed to ensure the adequate assessment of fish stocks both within and adjacent to Canada's 200-mile fisheries management zone, declared on 1 January 1977. This is essential to the proper management of the fisheries resource, since errors in assessment which result in establishment of total allowable catches at too high a level will cause decreased yields in subsequent years. Conversely, the setting of total allowable catches at levels below optimal will result in a loss of yield. Increased attention is also being paid to research on the relationships among species as competitors, predators and prey, in order to assess the impact of the removal of one species in the system upon production of other species. Other major projects are concerned with the study of trends and projected changes in resources on a national basis, including the effects of alternative harvesting strategies upon yields and other implications of these alternative strategies for the fisheries sector. Research is underway aimed at strengthening the stocks of Pacific salmon and lobster. The department is also investigating ways of improving the pick-up of fish from fishing boats at sea. It is also developing processing technologies applicable to specific regions, and technology which will reduce spoilage of highly perishable fish products. Finally, Canada also participates in joint research programs with other countries which fish within its fishery zone, particularly concerning species for which there are significant foreign fisheries.

The role of the Department of Consumer and Corporate Affairs in Canadian food science is concerned with improving the food value per dollar of consumer expenditure. Studies are underway to provide a better understanding of the structure of the food industry as an aid to improving pricing efficiency: economic models for the analysis of aggregate food price changes have been developed. Since two-thirds of the retail food dollar can be attributed to the costs of marketing services, improvements in these services could have a noticeable effect on food prices. The required decision-making is located in the highly-disaggregated private sector. To assist in this area; increased emphasis in the government's food science is being directed to market research and to processing, distribution and retailing, as mentioned previously. Research in this area requires considerable interdepartmental coordination.

The food science activities of the Department of National Health and Welfare support its responsibilities for public health, and for the safety and nutritive quality of food under the Food and Drugs Act. They include studies of the role of various

types of diet and dietary constituents in cardio-vascular disease, as well as research related to acute food poisoning and to possible behavioural, reproductive and carcinogenic effects of high-priority agents among the ranks of additives, pesticide residues, contaminants and mycotoxins.

Microbial food poisoning remains an area in which National Health and Welfare scientists make contributions to scientific knowledge that are integrated with operational goals such as the confirmation and investigation of a harmful product, and advice on recall actions. For example, research undertaken for the Food-borne Disease Reporting Centre has involved studies on *Staphylococcus aureus* toxins in various foods. The growth requirements of a highly atypical toxin-producing strain of the bacteria found in an imported cheese are under investigation. Research has resulted in improved procedures for the isolation and enumeration of *Salmonella*, *Shigella* and *Clostridium perfringens* and for measuring enterotoxins and heat-stable ribonuclease (TNase) in foods. As a result of the TNase work, a new test is now being used by the Health Protection Branch's regional laboratories for monitoring foods for contamination by *Staphylococcus aureus*. In cooperation with the International Commission on Microbiological Specifications for Foods, the branch is coordinating comparative testing of microbiological methods involving laboratories around the world. Studies are also in progress to automate methods for enumerating bacteria in foods.

Powerful antiviral inhibitors have been discovered in various fruits including apples and grapes. The effect of these inhibitors on the isolation of viruses in these foods and their potential for preventing infection by food-borne enteroviruses is being investigated.

The National Research Council is studying fermentation technology as a means of producing such products as starches, single-cell protein, antibiotics and ethanol from materials such as grains, cereal straws, aspen cellulose and animal wastes. Additional funding of up to $1 million annually has been made available, beginning in 1978/79, to develop a centre of excellence in fermentation technology.

Health

Health science has the ultimate goal of improving the general health of the population. In its broadest terms it includes basic, clinical, socio-medical and organizational research. Within the federal government research is needed in six main areas:

- to add to the store of knowledge of basic human biology;
- to determine and measure the effects of various environmental hazards to mental and physical health;
- to identify the links between the living habits, or lifestyle, of individuals and the levels of both mental and physical health;
- to apply knowledge of human biology to personal health care;
- to reduce the cost and improve the accessibility and effectiveness of the health care system;
- to find out how Canadians can be influenced to take more individual responsibility for their physical and mental health, and for reducing the risks which they incur by neglecting important lifestyle health factors.

As can be seen in Table 3.8, the Medical Research Council is the leading funder of health research, nearly all of which is performed in university medical facilities and hospitals. Its program is discussed in more detail in the Extramural-University section.

The Department of National Health and Welfare is the next largest spender in the health area. Through its National Health Research and Development Program, which is described in the Extramural-University section, the department assists activities which complement its extensive in-house research program. The department has recently undergone substantial changes, and these are detailed in the Major Funders section.

While continuing to support the provincial health care systems through more flexible financial arrangements, the government is now shifting its emphasis toward reducing demands on these systems. New initiatives are emphasizing the improvement and the cost-effectiveness of the health care system and the promotion of more

Table 3.8

Federal Science Expenditures on Health Science

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**112.6**	**121.4**	**116.7**
Energy, Mines and Resources			
Minerals Program	1.0	1.0	1.1
Atomic Energy of Canada Ltd.	2.0	2.2	2.0
Statistics Canada	5.1	5.7	4.2
National Health and Welfare (Total)	39.5	39.8	30.1
Health Care	22.0	22.3	14.3
Health Protection	17.0	17.3	15.7
Medical Research Council	57.9	64.4	70.1
National Research Council	6.7	7.9	8.7
Others	0.4	0.5	0.5

positive individual and societal attitudes towards health. The latter emphasis is to be implemented, in part, by attacking the causes of major conditions leading to premature mortality and avoidable morbidity, such as accidents, mental illness, cardio-vascular diseases and cancer. In particular, the effort will be directed toward the social and cultural causes, such as risk-taking, alcoholism, inappropriate diets and lack of physical exercise. The research projects are conducted both in the department and in universities across the country.

One such project, currently underway at the University of Moncton, is concerned with the development of a behaviour modification and nutrition education programme for obese people, based on an in-depth study of the lifestyles associated with obesity.

Among the projects that the department is sponsoring to investigate the effects of smoking on health, one being undertaken by a group of University of Toronto researchers on the interaction of cigarette smoking and ozone exposure is of particular interest.

During the past two decades Canada has developed an excellent, easily accessible health care system. But this has created a new problem. People expect the system to cure them when they get sick, and they tend to be less concerned about maintaining good health. Although the system can often provide adequate therapy, health care costs have become a significant national burden. At the University of Manitoba researchers are presently studying tonsillectomies and adenoidectomies performed in that province to determine the number of such operations which may have been performed unnecessarily. Meanwhile, a project underway at Dalhousie University in Halifax is aimed at helping people assess the consequences to their health of the risks they take and, through an educational program, it also aims at encouraging the adoption of lifestyles which place fewer demands on the health care delivery system.

The health of Indians and Inuit is an on-going concern of the department. There are serious problems of alcohol abuse and unemployment amongst our native peoples. One way these problems can be overcome is by helping these people to take control of their own health and welfare. To begin this process, the department has instituted a system of health workers who visit the communities and help to set up community-health programs, which are then taken over by native people themselves.

Epidemiological research has become a vital tool in establishing health policies and programs. For example, studies have shown a relationship between living conditions and certain types of disease. Consequently, efforts to improve living conditions may also improve health. Thus the department through its income maintenance programs, contributes to the improved health of elderly people and other disadvantaged groups.

An important initiative of the departments of Labour and National Health and Welfare is the establishment of the Canadian Centre for Occupational Health and Safety. This aspect of

public health has become increasingly important in view of recent controversies surrounding the effects of mercury, arsenic and asbestos in the environment. The centre is a non-governmental agency concerned solely with the exchange of knowledge in the occupational health field. It will award grants to investigate the effects of various contaminants in the work place.

Interdepartmental consultation and coordination of research is also necessary where situations occur in which the pressure of a department's objectives raises health concerns. For example, the Department of Agriculture may be interested in using food additives to prolong storage of food, while the Department of National Health & Welfare is responsible for assessing the potential effect of these additives on humans.

The National Research Council has a very active program of health-related research. It has, for example, developed a small, inexpensive heart rate meter which is now being manufactured commercially. The Division of Electrical Engineering is investigating the use of ultrasonic sound to detect heart disease, and computer graphic techniques are being used to provide cardiologists not only with a better assessment of the nature of heart disease in a patient, but also the extent of the disease. Using techniques developed at NRC, the surgeons are also able to gauge their surgical success.

The Division of Biological Sciences, in cooperation with the Department of National Health and Welfare, has been conducting research on vaccines for the prevention of meningitis and venereal diseases. The results have been provided to pharmaceutical companies for further development under the Program for Industrial Laboratory Projects.

Researchers in the photogrammetry section of the Division of Physics have contributed to a unique screening procedure for the detection of scoliosis — a disease of unknown cause which results in a deformed spine. Scoliosis is relatively common, affecting one out of every 10 children. Out of this affected group, 10% of patients require some corrective treatment. If left unattended the deformity can progress to the point where major surgery is required to straighten the spine. The division, in collaboration with an orthopaedic surgeon, has developed and tested a simple device which to date has had a high success rate in the accurate diagnosis of this disease. The prototype equipment is now being manufactured commercially and test marketed throughout Canada and the United States.

The council is also investigating certain aspects of building design (including hospitals) for their health-related effects, for example, air-conditioning and air-flow.

Statistics Canada plays an significant role in the provision of health data to support scientific and research activities in Canada. Until recently, the agency was a large spender in this field. Budgetary reductions, however, including the cancellation of a major household survey on health, have reduced the available resources by almost 25%.

The agency collects and disseminates health data largely derived from administrative records on vital events, cancer, tuberculosis and other notifiable diseases, hospital admissions and separations, health personnel and the characteristics of all health institutions including hospitals and nursing homes. One year's data derived from a major household survey will be available for analysis in late 1979, and will be used by researchers assessing the impact of living conditions, including lifestyle, on health.

Such data are used widely in Canada by researchers and policy analysts. The data are supplied in a variety of formats that allow direct manipulation by the analysts. Statistics Canada also carries out research to illustrate the uses that can be made of the data collected. For example, environmental impacts upon health are determined by relating files of persons exposed to environmental hazards to the mortality file held by Statistics Canada. Such follow-up studies hold great promise for the future. Work is also being carried out to relate the morbidity and mortality files with indicators of economic activity to assess the impact of the business cycle upon health.

Although not listed in the table, the Department of National Defence is heavily involved in health-related S&T, in regard to keeping the armed forces fit and healthy. Estimated expenditures in 1979/80 are $6.3 million, of which 18% will be spent extramurally. Some of this S&T is carried out under a cooperative program with the Department of National Health and Welfare, conducted by the Civil Aviation Medical Unit, which is located in the Defence and Civil Institute of Environmental Medicine in Toronto. Work in 1979/80 will include flight safety and accident investigations, civil aviation medicine and aviation medical education. In another health-related project, the department and NRC are jointly studying protection against non-ionizing radiation.

Natural Resources

This section is concerned mainly with S&T activities related to the evaluation, development and management of forestry and mineral resources from a national perspective. Those activities relating to Canada's water resources are discussed in the section on Environmental Issues.

Forestry Resources

Forests, one of the most valuable renewable resources, play an important role in Canada from an economic, ecological and recreational viewpoint. Forest products exceed $16 billion in value annually and make up the largest single export commodity in Canada. The survival of many game species, both fish and wildlife, depends upon the existence of properly managed forests.

Virtually all of the S&T expenditures in forestry resources, as shown in Table 3.9, are made by the Canadian Forestry Service, part of the Environmental Management Service of the Department of the Environment.

It is estimated that the government will spend $23.3 million in 1979/80 for forest-related science, virtually unchanged from 1978/79. A significant change in the program for 1979/80 is the privatization of the Eastern and Western Forest Products laboratories located in Ottawa and Vancouver respectively. Under discussion for some time, the privatization reflects the government's desire both to reduce its own expenditures and to encourage involvement by industry and provincial governments, while maintaining or increasing the laboratories' ability to respond to the needs of their clients.

The S&T activities of the Canadian Forestry Service are aimed at promoting the wise management and use of Canada's forest resources so as to ensure their continued productivity and the efficient utilization of their products. Because trees take many years to reach maturity, forestry research projects are usually long term. The program is extensive and the following examples only indicate its nature.

Roughly 1 million hectares of forest are logged annually in Canada; forest fires burn over a similar area and millions of hectares of forest are attacked by insects and disease. Much of the research, therefore, is aimed at improving methods of reforestation, breeding better trees and developing better methods for combatting fire, insects and diseases. For example, the current spruce budworm epidemic covers more than 50 million hectares of forest. Aerial spraying with insecticides is at present the only effective operational means of keeping badly infested stands alive, but much research is being devoted to developing alternative methods of control that are environmentally more acceptable. *Bacillus thuringensis* is an effective biological control agent under some conditions. Trials of viruses and hormones that only affect the budworm are in progress.

Attention is being directed to developing ecologically effective and sound practices for forest management for recreational as well as commercial use. Reforestation of cutover or burnt land is often difficult and work on developing planting machines suitable for rough terrain is being conducted in collaboration with Ontario and British Columbia.

Because of the potential of remote sensing for acquisition and analysis of forestry data, high technology equipment for rapid information retrieval and data processing from satellite-based sensors has been developed under contract. Remote sensing technology, operations research and studies of forest fire behaviour are contributing toward development of more effective forest fire control

Table 3.9

Federal Science Expenditures for Forestry Resources

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**22.9**	**23.0**	**23.3**
Environment	22.8	22.8	23.2
Others	0.1	0.1	0.1

systems, which are being tried operationally in Quebec, Ontario and British Columbia.

Research at the Forest Products Laboratories on efficient utilization as well as new and improved uses of wood has resulted in a number of new developments. A new finger-jointing process has been successfully commercialized. Similarly the technology for producing thick panels from wood particles and by-products is sufficiently developed that the production machinery is now being manufactured by the private sector. Finally a wood slicing process has been demonstrated which produces little or no sawdust or waste, which is relatively energy saving, and which reduces the ambient noise level far below that commonly found in sawmills.

Mineral Resources

Exploration for Canada's mineral resources is an important factor in our economic prosperity; in 1977 mineral processing and products contributed about $18 billion, 30% of which was export business.

As can be seen from Table 3.10, essentially all of the government's reported science expenditures for mineral resources are under the aegis of the Department of Energy, Mines and Resources, in support of its responsibilities for national mineral management and coordination. These responsibilities include economic analysis and assessment, transportation and environmental considerations, technology development and policy recommendations.

The Earth Science Services program collects and disseminates a wide range of geoscience information about the Canadian landmass and continental shelf.

The Canada Centre for Mineral and Energy Technology, in support of the department's Minerals and Energy programs, conducts the following activities:

- it performs, contracts, and coordinates research on the mining, extraction, utilization and conservation of minerals, metals and fuels, and on environmental problems associated with these operations;
- it provides a technical knowledge base as an aid to the development of government policies and plans; and
- it disseminates information on advanced technology related to mineral and energy resources to the public, government agencies, industry, and researchers and technologists throughout Canada.

Most of the R&D in mineral technology is carried out by the centre.

The centre's mineral research program is concerned with non-energy minerals and metals. Involving some $17.4 million, the 1979/80 program will see continuation of a major project, begun in 1976, to improve recovery rates from complex zinc-lead-copper sulfide deposits. The research currently is concentrating on New Brunswick ores; deposits are known to occur also in Ontario and the Yukon.

The Pit Slope project, a major undertaking over a 5-year period, was completed in 1978 and resulted in the publication of a comprehensive manual on open-pit mining. Research into other health, safety and environmental problems will continue at the accelerated level of recent years, embracing such topics as improved methods of land reclamation,

Table 3.10

Federal Science Expenditures for Mineral Resources

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**35.4**	**38.1**	**37.5**
Energy, Mines and Resources			
Earth Science Services Program	17.6	18.8	19.2
Minerals Program	17.2	18.4	17.4
Others	0.6	0.9	1.0

safe disposal of mine wastes, control of particulate emission and radiation exposure.

The Canada Centre for Mineral and Energy Technology also has a continuing program of R&D concerned with the utilization of mineral-based materials. Its objectives are expanded usage of minerals, improved product quality and diversification in the metals industry. In addition to research on corrosion, welding and non-destructive evaluation, there is technology development in moulding and casting, continuous casting, and metal forming. At the same time, research is underway on improving the efficiency of mineral conversion processes in developing substitute materials and uses for waste products and recycled materials.

Although the Earth Science Services Program comprises nine component activities, only the Geological Survey is discussed here, because practically all of its work is concerned with generating the knowledge base which is of fundamental importance to mineral resource policies. Some of the R&D performed by the Canada Centre for Remote Sensing is also relevant to mineral resource development.

The Geological Survey activity is designed to provide, by means of geoscience surveys and research, an increasingly comprehensive knowledge of the geology of Canada, including its surrounding off-shore areas. The knowledge base, disseminated mainly as geological, geophysical and geochemical maps, reports and open files, is directly used by industry as an aid to the discovery and development of mineral and energy resources. The mineral industry has repeatedly declared that the high level of information provided by government agencies continues to make Canada attractive for resource exploration.

The primary sources of data are the country-wide geochemical and airborne radiometric and aeromagnetic surveys, usually conducted as shared-cost, federal-provincial ventures. Geological maps are interpretative and reflect the concepts current when they were prepared. As concepts evolve the maps become obsolete; at present the rate of obsolescence requires map revisions about every quarter century. Furthermore, resource analysis and exploration are iterative processes; each iteration reveals the need for more information or for refinement and changes in methodology.

Oceans

This application area involves both research on the ocean itself, including the special field of ice-covered waters, and development of ocean technology, so that Canada may exploit and utilize her ocean-related resources to achieve national goals. The following paragraphs discuss the importance of Canada's ocean-related R&D program, the overall expenditures and how they are distributed among government departments and agencies. Finally two major programs are highlighted as examples of government-supported ocean technology development.

Canada has a longer coastline than any other country. Our continental shelf covers about 2.6 million square kilometres, which is larger than the land area of most other countries. Ocean-related research is becoming increasingly important since the extension of fisheries jurisdiction to a 200-mile limit on 1 January 1977. The drilling of off-shore oil and gas wells, both exploratory and production, and the proposed transport of these hydrocarbon resources by tanker or undersea pipeline, have raised the possibility of potentially disastrous spills or releases. Better knowledge of how to avoid or to cope with such emergencies in Canada's oceans has become imperative from both a domestic and international viewpoint.

Most of Canada's coastline lies in the Arctic or sub-Arctic and most of her ocean is either ice-covered or ice-infested for at least a part of each year. For this reason the government has considered it important that Canada should achieve excellence in her ability to carry out marine operations in and under ice-covered waters.

The various programs in ocean science and technology are managed and funded by the responsible departments and agencies. In response to the growing interdependence of the government's ocean activities, however, the Panel on Ocean Management was established early in 1976 as a coordinating and advisory body. The panel's membership comprises senior officials from 12 agencies, under the chairmanship of the Fisheries and Marine Service, the lead agency in ocean policy matters. The panel has defined the ocean management functions and the supporting systems Canada will require over a period of 10 years. Six

main areas of responsibility have been identified: renewable resources (primarily fisheries), non-renewable resources (primarily off-shore hydrocarbons), protection of the marine environment, development and control of navigation, defence, and international concerns.

Table 3.11 gives details of how expenditures on ocean science and technology are divided among government departments.

Within the Department of the Environment's Fisheries and Marine Service, the Oceans and Aquatic Sciences activity is concerned with scientific activities related to preserving and enhancing the quality of fresh and marine waters and contributing to the effective use of these resources. Oceans and Aquatic Sciences conducts research in physical, chemical and biological oceanography and limnology, and is responsible for hydrographic surveys, charting and various related publications. The management and scientific programs of the department are supported by a fleet of more than 600 vessels, ranging in size from major ships to launches.

The Department of Energy, Mines and Resources carries out research and field surveys in the coastal areas and on the continental shelf as part of its Earth Science Services Program, an activity whose importance has greatly increased because of the offshore oil and gas potential. In addition, through its Canada Centre for Remote Sensing, the department contributes to the development of effective information and management systems for Canada's ocean resources and environment, by developing and demonstrating systems, methods and instruments to acquire, disseminate and analyze remote-sensing data which have been obtained from aircraft and satellites.

The National Research Council carries out ocean-related R&D as part of its mandate to apply knowledge derived from the natural sciences and engineering to the solution of problems of national concern, and to assist Canadian industry. The council's involvement in the Canadian Ocean Data System project is described in more detail below.

At the international level, Canada participates in and supports programs of the Intergovernmental Oceanographic Commission, an agency affiliated with the United Nations. For the next 2 years Canada will act as the vice-chairman of the commission. Under the Ocean and Aquatic Sciences activity of Fisheries and Marine Service of the Department of the Environment, Canada is supplying drifting buoys for the First GARP Global Experiment, a weather monitoring project organized by the World Meteorological Organization and the Intergovernmental Oceanographic Commission; it is part of the long-term Global Atmospheric Research Program (GARP). In addition, as a part of the Integrated Global Ocean Stations System, Canada regularly transmits and receives data on sea surface temperature, salinity and ocean currents through the World Ocean Data Centre in Washington.

Beginning in January 1979, and continuing during 1979/80, Fisheries Management and Ocean and Aquatic Sciences will collaborate in a detailed study of the biological and oceanographic parameters of the waters of the Flemish Cap. This is a relatively shallow spot in the North Atlantic off Newfoundland, a few hundred kilometres in extent, and located about 500 km east of the Grand Banks. Known for hundreds of years as a productive area, the Flemish Cap will now be the subject of a comprehensive and intensive survey, with many different disciplines being brought to bear in the study of the factors that determine its marine ecology. An expenditure of $0.5 million is estimated for 1979/80.

Table 3.11

Federal Expenditures for Oceans Science

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**38.8**	**36.5**	**36.5**
Energy, Mines and Resources	4.2	4.7	5.6
Environment			
Fisheries and Marine	27.9	26.0	25.5
National Research Council	4.0	3.4	3.0
Others	2.6	2.5	2.3

For many years Canada has collected meteorological and oceanographic data at a location in the North Pacific Ocean (latitude 50°N, longitude 145°W) called Weather Station Papa. The expense of this monitoring operation is jointly borne by the Atmospheric Environment Service and by Ocean and Aquatic Sciences. In an effort to reduce expenditures, and also because the weatherships are steadily aging, Canada plans to phase out the use of ships at Weather Station Papa between 1 July 1980 and 1 July 1981. Both agencies are currently investigating alternatives to the use of weatherships, including the use of different types of data buoys. Consideration will be given to systems involving drifting or moored buoys, and even manned buoys. The two agencies together will spend $1 million on these design studies in 1979/80.

In addition to the data shown in Table 3.11, the Department of National Defence will spend a total of $3.9 million on ocean-related S&T in 1979/80, with 17% being performed extramurally. Ocean science and technology is performed by the department largely in support of the operational requirements of Maritime Command. Research ranges from ship propulsion and efficient hull design, through underwater acoustics, to studies of human performance in the ocean depths, using the world's "deepest" diving simulation facility at the Defence and Civil Institute of Environmental Medicine in Toronto.

In November 1974, Hermes Electronics Ltd. of Dartmouth, Nova Scotia, submitted an unsolicited proposal for the development of a Canadian Ocean Data System (CODS) in response to the announcement in July 1973 of the National Oceans Policy. The project, initially supported by the Department of Supply and Services through bridge funding, and subsequently by the Department of the Environment and the National Research Council, is now entering its fifth year.

In 1978/79 government support of approximately $0.5 million for the CODS project was shared equally between the Department of the Environment and the National Research Council. It is estimated that the government will spend $0.5 million on the project in 1979/80. In addition to this direct funding, the council has contributed scientific and technical expertise in the fields of sensor development and hydraulic analysis of buoy motion. It is significant that technology transfer in the CODS project is now a two-way street. Not only is the National Research Council able to advise and help Hermes Electronics Limited, but field data collected during experiments at sea by Hermes' engineers are proving valuable to NRC scientists in their laboratory studies. This technology interchange has become profitable to both parties.

The key question for any project involving technology transfer and industrial support is whether the company's sales will improve. As a result of the Canadian Ocean Data System project, Hermes Electronics Ltd. has been able to establish an international reputation in this field and to assemble a scientific and engineering group within the company. The company has penetrated the world market, making sales worth several million dollars to various countries and multi-national corporations, mainly for data buoys in support of off-shore drilling operations. After several years of government support under a carefully planned program, Hermes is entering 1979/80 as a viable, high-technology firm with international credibility.

The Canadian Hydrographic Service, part of Ocean and Aquatic Sciences, is supporting the development of a bathymetric sounder capable of obtaining depth measurements through ice while the survey vehicle is in continuous motion over the ice surface. This project is the result of an unsolicited proposal submitted by Caulfield Liron Consultants Ltd., a wholly-owned Canadian company. The work will be carried out in five phases at a total estimated cost of $0.9 million.

Phase one of the program involves acoustic and electromagnetic modelling of ice to obtain theoretical models representing those properties of sea ice relevant to the transmission and reception of sound. Phase two will develop field testing equipment and acquire field data from an extensive program of acoustic and electromagnetic experiments. The field trials will be based at the Polar Continental Shelf Project, Resolute, N.W.T.

Phase three involves the completion of the system design for a production prototype and in phase four a prototype field system will be constructed, incorporating any necessary redesign and/or improvements resulting from phase three.

Final field testing of the completed system will be performed in phase five. Production prototypes will be field-tested, including calibration and optimization of both transmitter and receiver systems, with measurements of beam pattern, accuracy and resolution. A final report will document all findings and activities and will include a

comprehensive operation and maintenance manual for the system.

If successful, the advantage of this new system is that Arctic bathymetric data will be obtained at a much faster rate than is possible with current technology, with the result that accurate charts could be produced at an accelerated rate in an area of the Arctic where rapid growth in shipping is anticipated.

Space

This application area embraces two distinct kinds of scientific activity: first, the development of satellite systems for various applications, including space science, and second, space science itself, such as research in astronomy, upper atmosphere research, planetary research and cosmology.

The first artificial satellite went into orbit about two decades ago. Canada recognized the potential of satellite technology to solve some distinctly Canadian problems deriving from our severe climate, vast land and coastal area, and scattered population and was the third nation to have in orbit its own domestically-developed satellite. In particular, our satellite development activities aim to improve and develop communication systems, weather forecasting and surveillance of land and ocean areas, and to support search and rescue missions and space-related scientific research.

Nearly all of our space research has as its objective the advancement of fundamental knowledge. While Canadian scientific satellites such as the Alouette and ISIS series have had a proud history of achievement, the Cabinet decision of 1974 to concentrate Canadian space-oriented efforts on communications and remote-sensing satellites has resulted in most of our space research being performed with ground-based and balloon- or rocket-borne instrumentation.

After discussion of the overall expenditure pattern, this section presents satellite development and space research activities by department, followed by some highlights of the communications satellite program in the Department of Communications and of the Advanced Teleoperator System project at the National Research Council.

In 1979/80 some significant changes will occur in space technology expenditures. The reduction in the National Research Council's spending from $37.0 million in 1978/79 to $16.9 million in 1979/80 is due to the near completion of the Advanced Teleoperator System project.

The Department of Communications' expenditures in 1979/80 will be reduced by approximately $6 million relative to 1978/79. In October 1978, the government approved the expansion of the David Florida Laboratory at the Communications Research Centre to accommodate the requirements of Canadian industry for integration and testing of complete spacecraft, including future spacecraft designed for launching from the Space Shuttle. Total estimated cost for expansion of the David Florida Laboratory is $18 million. In addition, as part of the development of a prime contractor capability in Canadian industry, approval was given to perform the integration and testing of the third ANIK-C

Table 3.12

Federal Science Expenditures on Space Science and Satellite Technology

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**55.8**	**70.0**	**44.1**
Communications	18.0	30.3	24.4
Energy, Mines and Resources	0.1	0.2	0.2
Environment	2.3	2.0	2.2
National Research Council	35.1	37.0	16.9
Other	0.3	0.4	0.5

satellite in Canada at a total cost of $2.3 million. This new funding, which totals $11 million in 1979/80, partially offsets the drop of $17 million in ANIK-B program funding, and other program reductions (see Major Funders-Communications section).

Space-related government activities are distributed among various departments and agencies. While each department and agency retains responsibility for the formulation and implementation of its own program, overall cooperation, coordination and integration of the government's efforts are exercised through a committee of senior officials, the Interdepartmental Committee on Space, which reports to the Minister of Communications. This committee has set up special sub-committees to deal with the scientific, industrial and international aspects of space programs.

The Department of Communications relies heavily on the use of space technology to extend and improve services especially in rural and remote areas. For many years it has been a leader in the use of satellites, firstly as vehicles for research on the effects of the ionosphere on radio communications, and then as geostationary relay platforms for reliable data, video and speech transmission. Most of the department's space-related research and development is carried out at its Communications Research Centre in Ottawa. Satellite ground control facilities at the centre are used to operate Canada's HERMES and ISIS satellites. The David Florida Laboratory, located at the centre, is a national facility for the integration and environmental test of satellites and space hardware, enabling the Canadian space industry to compete in domestic and export markets. Project management of major space projects and of industrial contracts is also carried out at the centre. Research and development in space components, sub-systems and systems supports major space projects, establishes the feasibility of future projects and develops technology which is subsequently transferred to Canadian industry.

Energy, Mines and Resources, through the Canada Centre for Remote Sensing (CCRS), has a mandate to develop and to facilitate the acquisition and dissemination of remotely-sensed data on the Canadian landmass. Much of this data is obtained from satellite-based sensors, and so CCRS maintains a lively interest in ongoing developments in space technology. It operates two ground stations for receiving satellite data, a data-processing and display centre, and four fully-equipped research aircraft.

The Department of the Environment has space-related regulatory and research missions which include the following:

- the reception and distribution of data from U.S. metereological satellites;
- the evaluation and use of satellite-borne remote sensors for environmental monitoring, land use mapping, forest land classification and inventory, detection of forest pest infestations and fisheries surveillance; and
- the use of satellites to communicate with, and relay data from, remote sites and field parties in isolated areas.

The role of the National Research Council is to provide a national foundation for the development of space science. The Space Research Facilities Branch provides national facilities, such as the balloon and rocket launching facility at Fort Churchill, and portable launchers used at various sites in the Arctic. The Herzberg Institute of Astrophysics carries out research including laboratory work on the spectra of molecules, astronomical observations using ground-based radio and optical telescopes, and studies of the near-earth space environment using rockets and satellites.

Transport Canada is involved with the regulation and the provision of navigation, communication and surveillance services, all of which are currently provided by ground-based systems. The application of satellite technology to these areas might significantly improve the safety of these operations, and the department is currently examining the feasibility of employing satellite systems in these areas.

In addition to the expenditures shown in Table 3.12, the Department of National Defence will spend $5.7 million on space-related S&T in 1979/80, with over 95% ($5.5 million) to be spent extramurally. The department maintains an up-to-date knowledge of space and space-related systems development in order to identify space systems which offer the most cost-effective method of meeting its space objectives in electronics, data processing and physiology.

The following paragraphs highlight some of the government's space technology developments.

Canada's involvement in space technology development began with rocket and balloon

experiments in the 1950s and continued with the inception of a satellite program in 1959. Close cooperation with the National Aeronautics and Space Administration (NASA) in the United States has characterized Canada's satellite efforts and resulted in the use of American launch vehicles for all of our satellites.

Canada's first four satellites — Alouettes I and II, and ISIS I and II — were part of an ionospheric research program, indicative of the importance of ionspheric effects upon long distance communications. The increasing emphasis, however, on the use of geostationary satellites to provide more reliable telecommunications systems resulted in a strikingly-modified mission for the projected ISIS III satellite: instead of being another ionospheric research platform, it was designed as a highly sophisticated communications technology satellite. Launched in 1976, and named HERMES, it is currently the world's most powerful communications satellite.

HERMES operates in the 14/12 Gigahertz (GHz) frequency bands, which are allocated solely to satellite communications. In the HERMES experimental program new applications and techniques of satellite communications have been and are being investigated, including point-to-point service and direct broadcasting to small low-cost earth stations. Experiments have been carried out in the fields of telehealth, tele-education, community interaction, TV broadcast, government services and advanced technology, by universities, hospitals, federal and provincial departments, native institutions and industry. A program of experiments and demonstrations, using the unique capabilities of HERMES, will continue into the fourth year (1979/80) of operations, including direct TV demonstrations in collaboration with the Ontario Educational Communications Authority and the CBC.

As originally anticipated, a follow-on program of extensive pilot projects and further development of the more promising communications services identified with HERMES has proved to be well worthwhile. Telesat Canada has provided, under a contract totalling $34 million ($20.1 million during 1978/79), the required 14/12 GHz capability on its ANIK-B satellite, launched in December 1978. The 14/12 GHz equipment was developed and built largely by Canadian industry using technology developed in the HERMES project. These projects will continue for an extended period, probably 1 to 2 years, so that user agencies can determine how to make the most effective use of the satellite communications medium and can evaluate benefits and limitations with respect to their particular operations. The projects are being developed cooperatively by appropriate federal and provincial agencies, and carriers. In addition to pilot projects, a number of more exploratory social and technological experiments are planned.

Canada's close cooperation with NASA has extended to joint development of other satellite systems. Since 1972, the government has approved Canadian participation in AEROSAT, the international air traffic control satellite program; remote sensing satellite programs (LANDSAT and SEASAT); a search and rescue satellite program (SARSAT); and a marine communications satellite program (INMARSAT).

In order to assure their continued economic growth most nations (including the United States) must import technologies as well as products. Other technologies are being demanded as a "quid pro quo" for the transfer of high technology, and this requirement now forms part of international trade negotiations. Thus the United States and Canada negotiated an agreement that a Canadian contribution to the NASA Space Shuttle would ensure Canada a preferred position in the purchase of NASA launch services, and that this contribution would be a technology contribution as well as a sub-system for the Space Shuttle. Canada entered into a formal cooperative arrangement with NASA to produce the Shuttle Remote Manipulator System, which has recently been renamed the Advanced Teleoperator System (ATS).

The ATS is an arm-like device with electro-mechanical joints which will be the Space Shuttle Orbiter's major cargo-handling device while in orbit. It will be used primarily for deployment and retrieval of satellites being launched by the shuttle. The design, development, construction and flight-qualification of the ATS is being carried out by Canadian industry, using a Canadian prime contractor under NRC project management.

The ATS project has been the largest single Canadian space technology project with a total estimated cost of $95.4 million. As indicated earlier, it is now nearing completion. It is expected that, following delivery of the initial ATS to NASA, several additional units will be purchased by the United States. Spin-off development in non-space fields (for example, underwater operations) is also being actively pursued.

Transportation

This section contains a brief discussion of the importance of transportation S&T to Canada, as well as a description of how it is organized and managed under the three modes of surface, marine and air transportation. A breakdown of government expenditures on transportation S&T is then followed by brief descriptions of the programs of the major funders. Finally, two large research projects are described as highlights of Canada's efforts in the development of marine transportation in ice-covered waters.

Transportation is an essential thread in the social and economic fabric of any country, but our large, sparsely populated land depends particularly heavily on effective transportation. The very fact of Confederation was contingent upon the existence of a railway extending from the Atlantic to the Pacific Ocean. The successful exploitation and marketing of Canada's natural resources hinge upon efficient air, surface and marine transportation. Our extreme climate and physiography have always required uniquely Canadian innovations in transportation, and the demands of our society for high-speed travel, environmental protection and energy conservation have further increased the need for research and development. In 1979/80 the government will spend $98.9 million on science and technology for transportation. In addition, many transportation-related research activities are reported in the sections dealing with energy, oceans, and extramural activities.

Starting in 1978/79, an Interdepartmental Panel on Transportation R&D is coordinating the government's activities in transportation R&D. Its main responsibilities are to develop R&D objectives to meet the country's transportation requirements, develop the outlines of an R&D program and recommend the assignment of coordinating responsibility for particular elements of the program to specific departments. Details of the major departmental expenditures are given in Table 3.13.

Transport Canada is traditionally a major funder of transportation research. The department will spend $26.8 million or 27% of the transportation research funds in 1979/80. Its projects include improvements to existing systems as well as research and development on advanced systems and components not yet in operation. It also studies the integration of new technology into existing transportation services through analysis, testing and demonstrations.

The Department of the Environment's Ocean and Aquatic Sciences activity undertakes research and development in the general field of ocean technology, which supports Canada's marine transportation industry. Its surveys and charting of inland and marine waters are in direct support of the navigational requirements of vessels of all sizes, both commercial and recreational. The department's Atmospheric Environment Service provides support to the marine, air and land transportation industries through meteorological and ice forecasting services and other related scientific activities. The department will spend approximately $35.6 million in 1979/80 on these activities.

Improved methods of transport and technical assistance to the transportation industries are important elements in the research programs of the National Research Council's engineering divisions. Major projects, with total estimated expenditures of

Table 3.13

Federal Science Expenditures on Transportation

Department/Agency	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**102.2**	**113.3**	**98.9**
Energy, Mines and Resources	1.6	2.0	2.1
Environment	37.6	37.1	35.6
Atmospheric Environment Service	15.8	15.8	13.8
Fisheries and Marine	21.7	21.3	21.8
National Research Council	15.5	18.6	23.3
Transport	38.3	43.7	26.8
Others	9.2	11.9	11.2

$23.3 million in 1979/80 are underway in all modes of transportation. The council's research facilities include wind tunnels, towing tanks for testing ship designs, railway track simulators and large scale models of Canada's rivers, estuaries and harbours to assist in the management of shoreline and dock facilities. In 1978, the council announced an important new thrust, the establishment of the Arctic Vessel and Marine Research Institute on the campus of Memorial University of Newfoundland at St. John's. The institute is discussed in more detail later in this section.

Science activities at Energy, Mines and Resources help in solving Canada's transportation problems in various ways. The department provides physiographic information to assist in making decisions on construction or operation of transportation systems, for example, permafrost data for northern routes. The Canada Centre of Mineral and Energy Technology investigates various materials problems of interest to transportation. Other departmental research efforts are aimed at improving fuel efficiencies and other energy-saving measures in transportation systems. It is estimated that expenditures for these activities will be $2.1 million in 1979/80.

In addition to the expenditures given in Table 3.13, the Department of National Defence estimates 1979/80 expenditures of $13.1 million related to transportation S&T, with 73% being spent extramurally. The safe, rapid and efficient transportation of personnel, equipment and supplies is of great importance to Canada's armed forces, and the Department of National Defence therefore carries out a specialized research and development program designed to satisfy its particular requirements. The department conducts research related to transportation at two of its six research laboratories; those at Toronto and at Suffield, Alberta. In addition, the department operates test facilities applicable to some aspects of transportation in its maritime, land and aeronautical engineering divisions.

Many of our major ports and inland waterways, and much of our coastline are subject to the icy grip of the Canadian winter. The economic need for year-round navigation in these harbours and waters led to the government's approval in 1977/78 of a policy with the objective of developing Canadian excellence in operating on and in ice-covered and ice-infested waters. The following paragraphs describe two major projects aimed at developing this excellence.

The first, a research and development program involving the M/V Arctic, is funded and managed by the Transport Canada Research and Development Centre (TDC) located in Montreal. The centre plans to spend about $1.9 million on this program over the next 5 years.

M/V Arctic is a pioneer in the all-purpose bulk carrier field. Launched in 1978, under joint government/industry ownership, and managed and operated by North Water Navigation Ltd. of Montreal, she is the world's first heavy icebreaking cargo vessel, designed to operate in high arctic waters independently of icebreakers. With an overall length of 210 m, a breadth of 23 m and a design draft of 11 m, M/V Arctic has a deadweight of 28,000 metric tons.

The vessel is double-skinned for protection against ice damage and oil spillage, and is fitted with an air-bubbler system around her hull to decrease skin friction and thus to facilitate forward motion in ice. She is equipped with a helicopter landing pad and complies with the requirements of the Canadian Arctic Shipping Pollution Prevention Regulations — Arctic Class 2.

The primary tasks of the M/V Arctic are to introduce Canadian-built and Canadian flag shipping to the arctic trade, and to extend the arctic navigation season. The M/V Arctic can also be considered to be a floating research project. In a full scale experiment beginning in 1979/80 and expected to last 5 years the ship, as an instrumentation platform, will be used to evaluate her own overall design while on commercial cargo-carrying voyages. Strain gauges have been fitted to the hull, thrust sensors are mounted on the engines, and the ship carries a full complement of meteorological instruments. Outputs from all these transducers are carried on a digital data bus system running throughout the vessel, and preliminary data processing will be done in real time using an on-board computer.

It is intended to develop, install and evaluate additional new equipment on board M/V Arctic. Proposed instrumentation includes side-looking sonar, to permit the avoidance of underwater hazards, and other systems (as yet undefined), to permit remote electronic measurement of ice thickness in the vicinity of the ship.

The second major project is the Arctic Vessel and Marine Research Institute, to be established by the National Research Council on the campus of Memorial University of Newfoundland. Approved by

the government in June 1978, it will cost approximately $46.8 million in capital expenditures over the period 1978 to 1984, with an estimated $4.5 million in capital and operational requirements for 1979/80. An operating staff of about 100 is envisioned by 1982/83.

The institute will eventually have an 80-m long ice towing tank, a 220-m open water towing tank and support facilities (design office, machine shops, data processing systems, etc.) which will complement Memorial University's already partially completed 67-m open-water towing tank. The ice towing tank, filled with salt water to a depth of 4 m, will have associated with it appropriate cold rooms and refrigeration equipment for related experiments on sea ice. It will be the world's largest ice tank facility, and will represent a major step forward in Canada's pursuit of excellence in operations on and in ice-covered waters.

In order to avoid the enormous expenditures that would be involved in building, testing, evaluating and redesigning full-sized ships or other marine structures, it has been customary for many years to make use of performance studies of ship models in a towing tank, a maneuvering pond or a water tunnel. Using highly refined analytical techniques, it is possible to "scale up" model results to obtain information applicable to full-scale vessels of the same design.

Facilities of the Canadian Coast Guard Hydraulics Laboratory in Montreal, the National Research Council in Ottawa and various industrial consulting firms have provided the capability to carry out such model tests. The construction of the new facility at the Arctic Vessel and Marine Institute will extend this capability in modelling ice-covered or ice-infested waters.

4. Extramural Activities

Introduction

Extramural S&T activities are those activities funded by the federal government but performed in the business sector, universities, other levels of government or other countries. In addition to funding of extramural activities as a means of stimulating S&T activities in the private sector, the government also attempts to create an enhanced capability for innovation through tax, tariff, patent, competition, trade and special procurement policies and special transfer payments to the provinces.

As part of the package of measures to strengthen and encourage R&D in Canada announced in 1978, the government established a target for Gross Expenditures on R&D to be 1.5% of Gross National Product by 1983. The target has been identified as a means of stimulating an increase in the total Canadian R&D capability particularly in the business sector, and of increasing Canada's competitiveness in world markets. The achievement of this target will require close collaboration among governments, the business sector and universities to define priorities, issues and policies. In November 1978 the Minister of Science and Technology met with his provincial counterparts to initiate this collaboration.

At the meeting, the Ministers agreed that Canada is not investing enough in industrial R&D. This deficiency in R&D investment seriously affects price stability, employment, productivity, total output and medium- and long-term economic objectives. More specifically they agreed that

- specific measures are required to stimulate R&D;
- tax incentives are an important means of stimulating R&D and should be extended to apply to other stages in the innovation process;
- special consideration should be given to small firms; and,
- government procurement should be used to promote and strengthen research-intensive industries.

As an indication of its commitment to this target the government has also announced a series of measures to aid the private sector in enhancing its innovative capacity. These measures include: increased tax incentives; improved procurement policies; an enhancement of technology transfer from government laboratories; improved interfaces among government, industry, and university laboratories; science and technology employment initiatives; and further enhancement of university research in areas of national concern.

With respect to tax incentives, in the 1977/78 budget, investment tax credits of 5% to 10% (depending on the region) were provided for both current and capital R&D expenditures made between 31 March 1977 and 1 July 1980. The April 1978 budget permitted a further tax deduction of 50% of R&D expenditures in excess of such expenditures in the preceding 3 years. This reduction is in addition to the 100% tax deduction of science expenditures already allowed.

The 1978 Fall budget provided further tax incentives for small business firms and a new investment tax credit of 25% on all R&D expenditures is now allowed. For larger firms the investment tax credit was doubled and is now 10-20%, the rate varying according to region. The Department of Finance estimates that the foregoing tax measures for the encouragement of industrial R&D will provide an estimated $110 million in federal tax relief.

The government has announced its commitment to use federal procurement to stimulate industrial research and development in Canada. There are many facets to this commitment, including consideration of ways to aggregate the procurement actions of several departments in line with identified industrial targets. The additional financial costs of such procurements to attain industrial targets have to be considered in the light of longer term industrial policies, employment and other benefits. Federal and provincial industry and science ministers have approved the formation of a joint federal/provincial working group to assess the potential for cooperation in procurement policy. A sub-working group will be focusing on the use of procurement policies and practices to stimulate industrial R&D.

The transfer of technology from government laboratories to the private sector is recognized as an important contribution to industrial innovation. In 1975 the National Research Council began the Program of Industry/Laboratory Projects (PILP) to assist the transfer of the council's technology to the private sector. In 1978/79 the program was accelerated and expanded to initiate technology transfer projects in other departments. As part of the new initiatives for technology transfer there is an expanded role for Canadian Patents and Developments Ltd. In addition to its role as the government's patent agent, it is to act as a clearing house for information exchange where government laboratories can identify needs of industry and where industry can keep abreast of technological developments in government laboratories.

A related measure has been introduced to strengthen the government/industry/university interfaces through the implementation of a policy to create centres of scientific excellence in areas of national concern and in line with regional interests. Several centres of excellence have already been proposed: cold water engineering in St. John's, Newfoundland; coal research in the Maritimes and British Columbia; materials research at the National Research Council's new *l'Institut de génie des matériaux* in the Montreal area; fermentation development in Saskatchewan (in collaboration with the National Research Council's Prairie Regional Laboratory and the Saskatchewan Research Council); and organic soils research in St. Jean, Quebec.

Another initiative in 1978/79 was the development of a Scientific and Technological Employment Program (STEP), administered by the National Research Council and financed from the Economic Growth Component in the Canada Works program of the Canadian Employment and Immigration Commission. This program pays salaries of research workers in industry and in universities for research undertaken on behalf of the business sector. A total of $8.5 million is expected to be spent during 1978/79 and 1979/80.

In the university sphere, the Natural Sciences and Engineering Research Council, the Social Sciences and Humanities Research Council and the Medical Research Council are the major funders for university research grants. An increase of $10 million was made available in 1978/79, to extend the program of funding research in areas of national concern. Since there are increasing numbers of problems that require multi- or inter-disciplinary approaches an Inter-Council Coordinating

Table 4.1

Federal Extramural Science Expenditures

	1977/78		1978/79		1979/80	
			(millions of dollars)			
Total	**603.0**	**(100%)**	**665.1**	**(100%)**	**693.2**	**(100%)**
% of Total S&T	*36%*		*36%*		*37%*	
Industry	262.2	(43%)	291.4	(44%)	295.6	(43%)
University	223.8	(37%)	248.2	(37%)	261.3	(38%)
Canadian Non-Profit Institutions	23.4	(4%)	27.3	(4%)	23.7	(3%)
Provincial and Municipal Governments	24.9	(4%)	29.7	(4%)	45.2	(7%)
Foreign	45.1	(7%)	44.5	(7%)	47.3	(7%)
Others	23.5	(4%)	24.0	(4%)	20.0	(3%)

Committee, under the chairmanship of the Ministry of State for Science and Technology, has been established to coordinate and provide advice on matters transcending the concerns of the individual councils.

The Canadian Committee on Financing of University Research was established to provide a focal point for the exchange of information among the universities and the federal and provincial governments. The committee will continue its function of recommending policies, programs and procedures affecting the financing of university research.

The extramural activities financed by the federal government are given in Table 4.1 and are discussed in further detail in this section.

Industry

The government's payments to industry include contracts for science and technology in support of the missions of departments and agencies, payments to assist in the transfer of technology from government laboratories to the private sector, grants and contributions to assist industry with R&D aimed at developing new or improved products and industrial processes, and grants and contracts for the support of various related scientific activities. Government expenditures in these four categories are shown in Table 4.2. It should be noted that following the repeal of the Industrial Research and Development Incentives Act (IRDIA), the government introduced tax incentives for R&D which are not reported as S&T expenditures.

Government expenditures in industry are estimated at $295.6 million in 1979/80, an increase of $33.4 million from 1977/78. The expenditures in 1978/79 were increased largely as the result of a number of special initiatives announced by the government including the Minister of Science and Technology's R&D measures, the Minister of Energy, Mines and Resources' renewable energy program and the Minister of Communication's space industry assistance and rural field trial packages. The continuing effect of these initiatives, along with other decisions, have increased R&D funding to industry by $16.3 million to $228.4 million, compared to the forecast expenditures for 1978/79. R&D contracts to industry (exclusive of those whose specific purpose is technology transfer) are expected to decrease by $7.2 million to $109.0 million, as explained below.

The National Research Council will spend $19.3 million in 1979/80, down $16 million from 1978/79, in large part because the contract for the Advanced Teleoperator System is nearing completion. Expenditures on this contract will fall to $8.6 million in 1979/80 from $28.0 million in 1978/79. The Prairie Regional Laboratory has for some time been working on the development of fermentation technology aimed at the conversion of biomass (biological materials) to useful products. Estimated funding for fermentation research will be in the order of $1.5 million, an increase of $1 million over the previous level of expenditure.

For 1979/80 the Department of Communications has obtained approval for three communications programs which will involve substantial expenditures in industry. The development of the Anik C satellite is estimated to cost $2.3 million, of which $1.3 million will be spent in 1979/80. To maintain a viable space industry in Canada a significant extension to the David Florida Laboratory was deemed necessary, to enable satellite integration and testing to be carried out in Canada. The total cost of this extension is estimated to be $18 million of which $9.7 million will be spent in 1979/80. The third program is a fibre optics field trial in a rural telephone system at Elie, Manitoba, funded equally by the department and industry to a total of $9.6 million of which $1.2 million will be spent in 1979/80.

Almost all of the Department of National Defence's development program is contracted out to industry, with an estimated expenditure of approximately $22 million in 1979/80. In addition research contracts in industry will be in excess of $6 million for a total of about $28 million in extramural support.

Contractual links between government departments and Canadian industry are facilitated by the Science Centre of the Department of Supply and Services, in its role as manager of science contracts with the private sector on behalf of other departments and agencies. It is also a focal point for consideration of unsolicited proposals for the conduct of scientific activities. The department manages an Unsolicited Proposals Fund, now totalling $15.0 million as the result of increases of $1.5 million in each of 1978/79 and 1979/80. This fund provides interim financing

Table 4.2

Federal Science Expenditures in Industry

	1977/78	1978/79	1979/80
		(millions of dollars)	
Total Payments to Industry	**262.2**	**291.4**	**295.6**
R&D Grants and Contracts (Total)	**194.0**	**212.1**	**228.4**
Mission-oriented R&D Contracts (Total)	85.8	116.2	109.0
Communications	3.5	6.3	8.8
Energy, Mines and Resources	7.4	9.8	10.5
Atomic Energy of Canada Limited	3.5	5.8	6.2
Environment	7.2	11.3	10.8
National Defence	12.7	20.6	27.6
National Research Council (excluding PILP)	29.9	35.3	19.3
Supply and Services (Unsolicited Proposal)	7.1	7.6	8.5
Transport	7.5	10.4	7.5
Others	7.0	9.1	9.8
Technology Transfer R&D contracts (Total)	4.4	10.4	11.0
National Research Council (PILP)	4.4	8.3	8.9
Cooperative Projects with Industry	—	2.1	2.1
Agriculture	—	—	0.4
Communications	—	—	0.4
Energy, Mines and Resources	—	—	0.4
Environment	—	—	0.8
National Research Council	—	2.1	—
R&D Grants & Contributions (Total)	103.8*	85.5	108.5
Communications	1.3	1.6	2.5
Industry, Trade and Commerce	85.3*	58.4	79.1
National Research Council	15.4	21.2	22.0
Natural Sciences and Engineering Research Council (Industrial Research Fellowships)	1.2	1.7	1.8
Others	0.6	2.6	3.1
RSA Grants & Contracts (Total)	**68.2**	**79.3**	**67.2**
Energy, Mines and Resources	6.7	8.8	6.3
Atomic Energy of Canada Limited	12.5	13.7	11.0
Environment	14.1	12.1	12.7
Canadian International Development Agency	14.2	16.8	15.6
Transport	8.6	11.2	4.3
Others	12.1	16.7	17.3

* Includes payments under the Industrial Research and Development Incentives Act—$16.4 million in 1977/78.

for acceptable unsolicited proposals from the private sector when a department is not able to fund the work from its current budget. Under special circumstances this can be used to fund the complete proposal. From its inception in 1974, to the end of 1978, this fund has provided a total of $45.0 million.

For 1978/79 forecast expenditures are $8.5 million in support of mission-oriented R&D in industry, $3.7 million for RSA in industry.

To facilitate the industrial use of knowledge generated in federal laboratories, the government has recently reaffirmed that the transfer of technology should be an objective of all of its laboratories. This policy renewal is intended to encourage all government laboratories to identify at an early stage any research that is of possible interest to industry, and to plan for the successful transfer to, and exploitation by, industry of the results of this research.

There have been some significant technology transfers in the past. For example, research performed by the Department of Agriculture has led to significant technological advancements on farms. Atomic Energy of Canada Limited has been instrumental in the development of a sizeable nuclear industry in Canada. The Forest Products Laboratories of the Department of the Environment have successfully transferred several technology developments to industry as described in the Special Applications-Natural Resources section. The Department of Energy, Mines and Resources has recently completed a major contribution to the technology of open-pit mining by preparing a pit-slope manual, in cooperation with industry.

In addition, the Department of Communications has been actively engaged in technology transfer to the manufacturing industry in the area of visual and interactive displays. The Communications Research Centre has cooperated with Canadian firms in the field of transponder and earth terminal development for use in Canadian satellite systems and for export. Other developments involving significant technology transfer include solar arrays, satellite control systems, microwave components, antennas and efficient battery systems.

Although many of the R&D contracts in support of a department's mission implicitly aid in technology transfer, the government decided in 1978 to expand one of its programs specifically designed to accelerate the process. In 1975 the National Research Council set up a technology transfer program, now known as the Program for Industry/Laboratory Projects (PILP). Estimated funding for 1979/80 is $8.9 million, compared to $8.3 million in 1978/79. The concept underlying PILP is that government laboratory projects are contracted out to industry for further stages of development. This approach has the advantage of allowing close cooperation between government scientists and those working in industrial R&D. It also helps to further the development of industrial R&D in Canada. Ultimately, projects whose development took place within industry stand a better chance of reaching the manufacturing and marketing stage than do results of projects entirely undertaken in government laboratories. Successful PILP projects include extraction of oil from tar sands; vertical-axis wind turbines for electric power generation; a snow- and ice-free railroad switch; and reduction of hydrogen levels in steels.

PILP has been sufficiently successful that several government departments expressed interest in adapting this program for their own use. As a consequence, the 1978 R&D package allocated an additional $5 million to the National Research Council, $2.9 million for its own PILP projects, and the remainder for related projects of four other cooperating departments, to be designated as the Cooperative Projects with Industry Program. For 1978/79 the PILP office assisted other departments to become familiar with the program, its administration and criteria. Some examples of projects being sponsored are a modified skim milk drying process; new business office computer terminals; an integrated radio telephone system; side-scan sonars; and synthetic aperture radar. In 1979/80 the departments of Agriculture; Communications; Energy, Mines and Resources; and the Environment will administer their own COPI projects and the appropriate funding has been included in their Main Estimates.

In addition to contracting out its mission-oriented S&T requirements and supporting technology transfer from its laboratories, the government also encourages and supports industrial R&D by means of contributions to companies for specific projects and by grants to universities, provincial research organizations and industrial associations for the provision of special research and technical services.

The principal source of funds for the support of industrial research is the Industrial Research Assistance Program of the National Research Council; support for the later, developmental phases is provided by the Enterprise Development Program, the Defence Industry Productivity Program and the Industrial Energy Research and Development Program of the Department of Industry, Trade and Commerce.

The purpose of the Industrial Research Assistance Program is to assist in the development of R&D capability in Canadian industry, by awarding funds to cover the salaries and wages of R&D staff working on approved projects. Canadian companies engaged in projects with significant technical content are eligible. Estimated expenditures in 1979/80 are $19.2 million compared to $18.0 million in 1978/79, and $15.4 million in 1977/78. The council estimates that a further $2.8 million will be spent in 1979/80 in other grants and contributions to industry.

The Enterprise Development Program is a multipurpose program incorporating several earlier programs of the Department of Industry, Trade and Commerce. One of the broad range of industrial development tools comprising this program is

support for introduction of new or improved products and processes which have the potential for profitable commercial exploitation. Companies in Canada which can demonstrate the need for financial assistance and the capability to pursue successful R&D projects are eligible for cost-shared assistance for process and product innovations and market research. Estimated expenditures in 1979/80 will be $47.0 million, an increase of $21 million over the previous year. The Defence Industry Productivity Program with estimated expenditures of $29 million in 1979/80 has been most effective in assisting high technology industry in several sectors including aeronautics, electronics and shipbuilding. Under the program, contributions and repayable loans are available to Canadian companies on a cost-shared basis for defence-oriented R&D, industrial source establishment and the modernization of production facilities, all aimed at export markets. The Industrial Energy Research and Development Program encourages and assists Canadian industry to undertake research and development that will reduce energy consumption and ensure the widest possible transfer and use of the results. The budget for this program in 1979/80 will be $1.5 million.

Other programs administered by the Department of Industry, Trade and Commerce assist the establishment of non-profit organizations to provide R&D and other special technical services under contract to industrial and other clients. The Industrial Research Institute Program assists the establishment of organizations at Canadian universities which arrange for university faculty to provide contract research and technical services to industry; nine industrial research institutes have been established to date. The Centres of Advanced Technology Program assists universities and provincial research organizations to develop and maintain a special competence in a specific field of technology and to provide, under contract to industry, assistance with development projects and training and evaluation services relating to that technology; eleven centres of advanced technology have been established to date. The Industrial Research Association Program assists groups of firms to undertake cooperative research on common technical problems; three industrial research associations have been established to date. The annual budget for the three programs in 1979/80 will be $1.5 million, unchanged for the past 2 years. Under these programs, the Department of Industry, Trade and Commerce supports individual institutes and centres for a maximum of 7 years, during which time they are expected to become self-supporting. Of the 23 centres and institutes established in the past 12 years, 11 are now self-supporting.

The Department of Communications administers a small program to assist Canadian industry to become more competitive in the domestic and foreign markets for space systems components. As discussed in the Introduction to the Extramural Activities section, other programs that have been initiated in 1978 are the Scientific and Technical Employment Program (STEP) and the Industrial Innovation Centre Program.

Scientific and technical information services are another means for encouraging the application of new technology in Canadian industry. Within the National Research Council's Scientific and Industrial Research Program, the Canada-wide Technical Information Service has as an objective the fulfillment of the technical information needs of industry, particularly small business, which often operates without an internal R&D capability. Annually the service receives 20,000 to 25,000 enquiries and provides in-depth assistance to 500 to 700 firms. In 1978/79 the Technical Information Service was expanded to enhance the competitiveness of small manufacturing firms lacking their own scientific and engineering staff by enabling them to undertake longer term productivity improvement projects. The service's budget for 1978/79 was increased by $0.4 million to provide financial support for the use of senior students in science and engineering in providing industrial assistance under supervision of university professors. This amount will be increased by an additional $0.4 million in 1979/80.

University

In addition to its indirect support of science and technology in the university sector through transfer payments, the government provides direct support in two forms: (a) grants and contributions, and (b) contracts for S&T activities in support of departmental missions. The total expenditures on direct support of university S&T for 1979/80 are estimated to be $261.3 million, a 5% increase from 1978/79. Further details are given in Table 4.3.

Of the total payments to universities 89% is for R&D; the remainder is for RSA. Most (80%) of the direct support is in the form of R&D grants. The three granting councils — the Medical Research Council, the Natural Sciences and Engineering Research Council, and the Social Sciences and Humanities Research Council — provide over 75% of the total support.

The amount spent by the government on R&D contracts in the university sector is estimated to increase by 11% in 1979/80, compared to a 17% increase in 1977/78 and 27% in 1978/79. Another significant avenue of R&D support is research fellowships to individuals, estimated to be $8.5 million in 1979/80, virtually unchanged from 1978/79. Of the expenditures on RSA, $22.1 million (23%) will be for education support, which covers grants to individuals or institutions intended to support the post-secondary education of students in the natural and engineering sciences. General purpose grants to institutions are not included.

Payments of $112.9 million, by the Natural Sciences and Engineering Research Council (NSERC) to individuals and institutions in the university sector, are projected in 1979/80, compared to $104.7 million in 1978/79, and $93.2 million in 1977/78. Reflecting the new policy of increased support for research in areas of national concern and interdisciplinary research, and for balancing regional research capability, most of the additional funds for program expansion in the past 2 years have been awarded in grants under the Development Grants Activity (see also Major Funders-Natural Sciences & Engineering Research Council). The proportion of total funding for this activity increased from 8.9% ($8.7 million) in 1977/78 to 13.6% ($15.0 million) in

Table 4.3

Federal Science Expenditures in Universities

	1977/78	1978/79	1979/80
		(millions of dollars)	
Total Payments to Universities	**223.8**	**248.2**	**261.3**
R&D (Total	**192.7**	**219.1**	**232.4**
R&D Grants	173.3	196.5	208.2
Medical Research Council	51.0	56.9	62.1
Natural Sciences and Engineering Research Council	84.2	95.9	103.5
Social Sciences and Humanities Research Council	8.0	11.7	14.7
National Health and Welfare	14.4	13.9	8.2
Other	15.7	18.1	19.7
R&D Contracts	11.1	14.1	15.7
Research Fellowships	8.3	8.5	8.5
RSA (Total)	**31.1**	**29.2**	**29.0**
Total Education Support	22.0	21.4	22.1
Medical Research Council	1.3	1.6	1.8
Natural Sciences and Engineering Research Council	8.1	8.0	8.5
Social Sciences and Humanities Research Council	8.1	7.3	6.9
Others	4.5	4.5	4.9
Other RSA	9.1	7.8	6.9

1978/79 and is expected to be 13.6% again in 1979/80 ($16.1 million). Of particular interest within this Activity, the new Strategic Grants Program will increase to $11.2 million in 1979/80 in comparison to the $2.4 million awarded in its first competition in 1977/78. Priority areas are energy, environmental toxicology, oceans, agriculture/food and communications.

Awards under the Peer Adjudicated Grants Activity are expected to total $87.9 million in 1979/80 (74% of total grants), maintaining the program level of 1978/79 ($81.4 million). These grants-in-aid of research are provided to selected individuals and groups for research operating expenses and ancillary equipment. The Highly Qualified Manpower Training and Development Activity will continue at the same program level, providing $13.0 million in 1979/80 ($12.1 million in 1978/79) for scholarships and fellowships awarded under national competitions to post-graduate students in science and engineering, for studies in Canada and abroad.

In Canada the major part of research in the health sciences is conducted in universities and affiliated hospitals and institutions. This is in contrast to some other western countries which have large, centralized laboratory complexes, as for example, the National Institutes of Health in the United States. This decentralized approach fosters close ties between research and health care delivery and professional training, but at the same time results in a less discernible national focus of research in the health sciences.

The Medical Research Council's support of university science in the medical and health fields is estimated to be $66.3 million in 1979/80, compared to $60.8 million in 1978/79. The council provides approximately 50% of the Canadian support to health research. (Voluntary agencies supported and financed by the public provide a significant proportion of support). The expenditure data include an additional $3.0 million made available to the council for the purpose of supporting research in areas of national concern and interdisciplinary research, and balancing regional research capability, part of the special R&D initiatives announced on 1 June 1978 by the Minister of State for Science and Technology. For 1978/79, the council allocated these additional funds as follows: $0.3 million for heart research development grants, $0.9 million for Medical Research Council groups, $1.5 million for development grants and $0.3 million for Major Equipment Grants specifically oriented to interdisciplinary or multi-user purposes.

Approximately 83% of the council's support of research and training can be identified as relevant to a specific disease. Research supported by the voluntary agencies is even more highly directed, using the council-supported activities as a base. Clinical application of research results, particularly those obtained outside Canada, is vitally dependent on the involvement of individual clinicians in research and on their collaboration with scientists in other disciplines. Forty percent of council-supported research occurs in clinical departments of university hospitals.

The support of research through the Grants Program accounts for about 80% of the council's expenditure each year. Submitted research proposals as well as awards reflect the relative importance of various health problems; in 1977/78 the Grants Program awarded $5.0 million for research related to cancer, $1.0 million to diabetes and allied disorders, $4.4 million for cardiovascular disease and $2.2 million for respiratory disease.

Subject Research Development Grants provide support for research in areas not only of national concern but also with the potential to respond to special initiatives. This is as yet a small program, with about 1% of the 1979/80 estimated expenditures to be devoted to these grants. A prerequisite for the awarding of such grants is a strong commitment by the university concerned to support continuation of the project. To date heart research is the only area designated for support through these grants; two substantial grants have been made, to Dalhousie University and to the University of Manitoba.

The Development Grant Program was established more than 10 years ago, for the purpose of strengthening health sciences research in universities in those regions where the level is not considered adequate to serve the needs of health care and professional education. About 4% of the 1979/80 expenditure will be spent on this program.

The establishment of the separate Social Sciences and Humanities Research Council, the government's new rationale for the operations of the granting councils in support of university research, the detailed approved recommendations from the Social Science Federation of Canada and those from the Canadian Federation for the Humanities, together with the report of the Healy Commission on Graduate Studies in the Humanities and Social Sciences, all add fresh impetus to the review and reconsideration of the council's programs currently underway.

In the transition period, the council will provide $27.6 million in 1979/80 for the support of university S&T activities in the humanities and social sciences, compared to $16.0 million in 1978/79. The $2.0 million additional funds made available under the special R&D initiatives of 1 June 1978 will be used mainly

- to initiate a research program into the new problems arising as a result of our rapidly aging population;
- to increase support for the *Dictionary of Canadian Biography / Dictionnaire biographique du Canada*;
- to establish a program for the maintenance and development of collections of national significance in Canadian university libraries.

Among the other government departments and agencies supporting scientific activities in the universities, the Department of National Health and Welfare will remain the largest funder, with estimated expenditures of $8.2 million in 1979/80. Most of this support will be provided through the National Health Research and Development Program, which exists to enable the department to acquire research-based information relevant to its statutory functions and responsibilities. The program assists research into all facets of the health sciences, with the exception of basic biomedical research undertaken for the purpose of adding to the store of knowledge of human biology.

Through the National Research Council the government will provide $9.5 million in 1979/80 for its continuing contribution for ancillary equipment and operating costs at TRIUMF, the medium energy proton accelerator and meson facility located at the University of British Columbia. Research projects using TRIUMF are funded through the Natural Sciences and Engineering Research Council and other non-federal sources.

Support of university research by the Department of Agriculture in 1979/80 is estimated at $5.1 million, of which $1.8 million will be in operating grants, and $3.3 million in contracts for research directly complementing departmental activities.

The Department of Energy, Mines and Resources estimates that 1979/80 S&T support to universities will total $2.5 million, $1.2 million from the Earth Science Services Program, $0.5 million from the Mineral Program and $0.8 million from the Energy Program.

The Department of the Environment will provide $3.4 million for university research in such areas as forestry, water, fisheries and oceans, and the atmosphere.

Research contracts and grants to universities by the Department of National Defence are expected to amount to $2.2 million in 1979/80.

The Department of Transport will continue its support of university research and research training in disciplines and areas of study of relevance to the transportation field. It estimates 1979/80 expenditures at $2.0 million, compared to $2.5 million in 1978/79.

Provinces

Federal-provincial interaction in science and technology arises in three ways: the federal government makes direct payments to provinces for various S&T activities, there are joint federal-provincial S&T programs and the federal government undertakes S&T activities in which the provinces have an interest. There are numerous federal-provincial coordinating committees concerned with special science areas. For example, the Canadian Agricultural Research Council meets regularly to coordinate agricultural research in Canada. The Coordinating Council of Resource and Environment Ministers deals with environmental matters which include S&T as a major component.

On a bilateral basis, there is the Canada-Ontario Forestry Research Advisory Council.

Departmental payments to provincial governments either directly or through joint programs are shown in Table 4.4.

The Department of Energy, Mines and Resources is the largest spender, with expenditures in 1979/80 of about $35 million on joint programs with the provinces. Payments to the Alberta/Canada Energy Resources Fund will increase from $10 million to $24 million in 1979/80. This fund is used for energy research and development projects, such as the

Table 4.4

Federal Science Expenditures in the Provincial Sector

	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**24.9**	**29.7**	**45.2**
Energy, Mines and Resources	12.2	13.4	35.1
Environment	3.3	6.2	5.6
National Health and Welfare	4.6	2.2	1.1
Regional Economic Expansion	1.5	1.4	1.0
Others	3.3	6.5	2.4

Coal Mining Research Centre at Devon, Alberta, which will undertake research primarily in the areas of coal mining and coal beneficiation. About $3.4 million will be contributed by the government in 1979/80 to the joint Canada-Saskatchewan program for the development of heavy oil recovery technology compared to $0.9 million in 1978/79. About $5.5 million will be contributed under federal-provincial agreements for the new program of development and demonstration of new technologies related to renewable and non-conventional sources of energy and energy conservation. About $1.6 million will also be contributed under the Mineral Development Agreement with Newfoundland.

The Department of the Environment will spend about $5.6 million in 1979/80 on joint ventures with the provinces. It will contribute $1.2 million, to be matched by participating provinces, for research concerned with ameliorating flood damage. There is shared-cost research ($1.2 million) under the Canada-Ontario Great Lakes Water Quality Agreement, and $1.5 million will be contributed to federal-provincial planning studies of river basins. The department will also pay $0.7 million to Quebec for hydrometric survey data.

Atomic Energy of Canada Limited's provincial cooperation occurs chiefly in its working relations with electric utilities, currently those in Ontario, Quebec and New Brunswick. Three reactors owned by AECL, of which two are prototypes, are operated by the Ontario and Quebec utilities under contract to the corporation. All three serve as test beds for development work ranging from fuel-related studies to the design and development of special instrumentation for nuclear reactors. AECL undertakes joint R&D programs in many areas with the utilities and with provincial research institutes.

The Department of Regional Economic Expansion will spend about $1.0 million in 1979/80 in support of such S&T activities as the development and adjustment of personnel resources in selected areas. Most of the S&T activities funded by the department are in the Atlantic provinces and Quebec. About $0.8 million is estimated for the 1979/80 contribution to the Newfoundland Oceans Research and Development Corporation, under a subsidiary agreement with Newfoundland for cold oceans research in the areas of fisheries and hydrocarbon exploration.

Foreign

This section considers the expenditures of various government departments outside the country. Foreign performers are utilized when a particular expertise is not available in Canada or when specific research facilities or research training are only available abroad.

Table 4.5 shows that there are eight major funders of the foreign sector. Two of these, the Canadian International Development Agency and the International Development Research Centre, are discussed in the Special Applications-Developing Nations section. Of the rest, the Medical Research Council's expenditures include fellowship awards held outside Canada and research grants to Canadian scientists visiting outside Canada. The Social Sciences and Humanities Research Council has the same type of expenditures in its support for

Table 4.5

Federal Science Expenditures in the Foreign Sector

	1977/78	1978/79	1979/80
		(millions of dollars)	
Total	**45.1**	**44.5**	**47.3**
Communications	—	0.3	1.0
Canadian International Development Agency	7.5	10.0	10.7
International Development Research Centre	23.2	22.2	23.8
National Defence	0.9	1.2	1.5
Medical Research Council	2.1	2.1	2.2
National Research Council	2.1	0.5	1.2
Natural Sciences and Engineering Research Council	2.1	1.9	2.1
Social Sciences and Humanities Research Council	3.4	2.6	2.6
Others	3.8	3.7	2.2

Canadian post-graduate students working for doctoral degrees. Most of these students are in the United States (approximately 52%) while others are working in the United Kingdom, France and other European countries.

The Natural Sciences and Engineering Research Council's foreign expenditures include research grants to scientists working abroad, post-doctoral research fellowships, post-graduate education support and an international exchange program which supports the costs of bringing foreign professors to Canada and sending Canadian scientists abroad.

The Department of National Defence's foreign expenditures are for contracts for work that cannot be performed in Canada. These contracts go to government agencies in both the United States and Great Britain and also to companies in these and other countries which have unique capabilities needed by the department, for example, in electronics, avionics or communications. The National Research Council's foreign expenditures are mainly for the Canada-France-Hawaii Telescope, a large optical telescope being built on an extinct volcano in Hawaii. Also, there is a contribution to the International Energy Authority and payments for affiliation in international organizations, for example, the International Council of Scientific Unions, the International Union of Pure and Applied Chemistry and the International Bureau of Weights and Measures.

The Department of Communications foreign expenditures result from a cooperative agreement between Canada and the European Space Agency (ESA), signed in December 1978, and taking effect in January 1979. It provides for Canadian participation in the General Studies program of the agency, and will give Canada the opportunity to participate in future applications programs where this is consistent with Canadian policies, and where industrial benefits, including the development of export opportunities, are likely to result. The expenditures by the government for participation in the European Space Agency will be partially offset by the value of contracts awarded to Canadian industry under the General Studies program.

5. Major Funders

Introduction

The government's expenditures on science activities in areas of national concern are discussed in the Special Applications section. These activities frequently cut across departmental mandates and represent the government's aggregated effort in these areas. This section is concerned with individual departmental budgets and in particular the science programs of the departments, their science objectives and the organization of their science activities. The structure of this section corresponds to the presentation of the Main Estimates, that is, by ministry, department or agency and, within those, by program. It gives a summary of expenditures in millions of dollars ($M) and person-years (PY) directed to science for the past, current and estimates years; additional data are to be found in the companion document "Federal Science Expenditures and Personnel, 1977/78-1979/80".

In most departments and agencies only a portion of a departmental budget is allocated to science activities, and this may fluctuate from year to year depending on the extent to which the departmental managers require scientific information to achieve their objectives. Within some departments science activities are focused in a separate program, such as the Research Program of the Department of Agriculture. Nevertheless, even in such departments, other programs may also conduct scientific activities; for example the Health of Animals Program of Agriculture carries out scientific activities in support of its more specific objectives. For comparison purposes both the scientific resources and the total resources (expenditures and person-years) for each program and each department are provided.

It is not feasible to present all departmental scientific and technological endeavours and for several departments much of the S&T activity has already been discussed in the Special Applications and Extramural Activities sections. Selected highlights or significant activities not discussed elsewhere in the report are presented for some departments and agencies.

Department of Agriculture

	Science Resources*						Total Resources*	
	1977/78		1978/79		1979/80		1979/80	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Administration	5.3	207	5.8	204	6.1	203	37.0	1,080
Research	104.4	3,728	118.1	3,781	126.0	3,673	126.0	3,673
Food Production and Marketing	1.1	8	1.2	8	1.2	8	421.7	2,327
Health of Animals	4.2	148	4.8	150	6.0	150	93.8	2,783
Canadian Grain Commission	3.0	84	3.1	95	3.2	93	27.3	857
Total	**117.9**	**4,175**	**133.0**	**4,238**	**142.6**	**4,127**	**705.8**	**10,720**

* In this and subsequent tables in this section data are given in millions of dollars ($M) and person years (PY).

The Department of Agriculture's expenditure on science will be $142.6 million, of which $126.0 million will be spent in the Research Program. The remaining $16.6 million will be spent in the programs of Administration, Production and Marketing and Health of Animals, and the Canadian Grain Commission.

The broad objective of the Department of Agriculture's science programs is, through the development of new knowledge and improved technology, to ensure the efficient production of an adequate and appropriate supply of food and other agricultural products, and to assist in maintaining a stable and profitable agricultural industry. The following paragraphs describe the ways in which the department is organized to achieve this objective.

The Research Branch is organized to solve agricultural problems in the many soil and climatic zones of Canada and is responsible for 47 research establishments located from coast to coast. Its program pertains to plant and animal production, protection and utilization, land classification and use, biosystematic studies and environmental quality. In the plant research program, forage crops are important and there is increased emphasis on solving problems of legume survival. The branch and the university sector are conducting research on production and utilization of oil-seed crops to keep Canada in a favourable competitive position and to provide rapeseed growers in northern areas with suitable varieties. Research in horticulture emphasizes breeding for resistance to disease, the use of new pest control techniques, and physiology and nutrition related to plant survival.

The increasing demand in Canada for animal products is continuing. It has been estimated that by 1985 the national beef herd will have to be increased by 43% over that of 1974 to meet the expected demand. Research Branch programs are focused on the production and selection of animals that are efficient in converting livestock feeds into high-quality animal products and on efficient animal management systems. In the meats utilization program, scientists are developing new grading standards, determining key factors that influence meat toughening during rigor, and improving methods of carcass handling.

The Food Production and Marketing Branch conducts research on the behaviour and interrelationships of economic and social variables affecting the agricultural industry.

Research on animal diseases is carried on by the Health of Animals Branch and is directed mainly at diseases that cause serious economic losses of livestock and poultry, and those that may be transmitted to people.

Department of Communications

	Science Resources						Total Resources	
	1977/78		1978/79		1979/80		1979/80	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Communications	30.3*	425	49.3*	425	40.2*	425	92.1	1,939

* Includes transfers from National Defence ($3.9 million in 1979/80).

The department's estimated 1979/80 science expenditures are $40.2 million, a decrease of 18% from 1978/79 forecast expenditures. Estimated science expenditures represent 46% of the total estimated departmental expenditures. The department spends $14.5 million extramurally, 88% in industry and 5% in universities with the balance going to other performers.

In 1978, the department announced three major increases in expenditures: the first, for the government's share of a rural field trial of a fibre optics telephone system in Elie, Manitoba, is an expenditure of up to $5 million, with a matching amount to be contributed by other organizations; the second, totalling $2.3 million, is for the development of the ANIK-C satellite; and the third,

totalling $18 million, is for the extension of the David Florida Laboratory. These expenditures began in 1978/79. On the other hand included in 1978/79 expenditures was $20.1 million representing the major portion of the cost for the provision of 14/12 GHz facilities on Telesat Canada's ANIK B satellite, launched in December 1978. Consequently 1979/80 expenditures on the ANIK B program will be approximately $17 million less than 1978/79 expenditures. Further details are given in the Special Application-Space section.

The department must invest heavily in science to achieve its objectives of fostering the orderly development and operation of communications for Canada in the domestic and international spheres. The bulk of the research is conducted under two activities: Telecommunications Research and Space Application. Science activities are also to be found in the National Telecommunications Development, Management of the Radio Frequency Spectrum and International Participation activities.

Under an agreement with the Department of National Defence, the department operates the Communications Radar Research Laboratory, which carries out basic research in radar and in microwave remote sensing as part of the study of radar surveillance from satellites.

Most of the department's intramural research is conducted at its Communications Research Centre in Ottawa. The centre manages the department's major space programs, and conducts research on radio propagation, the radio environment, fibre optics and electronics technology and systems.

Highlights of the department's activities in support of its mandate in space and communications are given in the Special Applications-Space and Communication sections.

Department of Energy, Mines and Resources

	Science Resources						Total Resources	
	1977/78		1978/79		1979/80		1979/80	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Administration	—	—	—	—	—	—	19.6	520
Energy	29.4	386	34.0	396	58.0	404	848.7	656
Minerals	19.8	611	21.9	610	22.0	588	22.6	617
Earth Science Services	69.2	1,425	73.7	1,392	75.8	1,385	94.0	2,088
Total	**118.4**	**2,422**	**129.7**	**2,398**	**155.8**	**2,377**	**984.9**	**3,881**

The department's total estimated expenditures for scientific activities in 1979/80 are $155.8 million. Distributed among three programs, these S&T expenditures will be 64% of total departmental expenditures, (exclusive of $740 million for oil import compensation). Extramural expenditures are estimated to be $60.9 million, with $20.1 million to industry, $2.5 million to universities and $35.1 million to provincial governments. The payments to industry represent a decrease of 3% from 1978/79.

The department's two main areas of responsibility are to stimulate the discovery, development, use and conservation of Canadian mineral and energy resources, and to provide the earth science information needed for effective use and demarcation of the country's land mass. The accomplishment of these tasks necessitates ongoing research and information-gathering in the fields of geology, surveys and mapping, earth physics, remote sensing, energy, and resource technology, as well as in mineral and energy economics and statistics, the results of which form the basis for planning and policy formulation in resource development. The relevant information is also made available to the private sector through departmental information units, joint industry-government programs, and the contracting out of studies and projects.

The objective of the Minerals Program is to ensure adequate supply and effective use of Canada's

mineral resources. Because of its important place in the economy, the mineral industry has a number of economic, social and policy implications, and research in the social sciences plays a significant role in dealing with these, particularly in the areas of international trade, frontier and regional development, and employment opportunities. Analysis and evaluation of the impact of changing patterns of mineral activities are required to develop strategies for ensuring maximum benefit from resource utilization. The Geological Survey of Canada supports the program by providing estimates of mineral resources and by developing new exploration techniques for transfer to industry. It is also engaged in continuing research into the improvement of methods of resource estimation.

The Canada Centre for Mineral and Energy Technology (CANMET) participates in inter-agency activities related to the disposal of hazardous wastes and contributes to standards and reference information on both the national and international scale. The results of accelerated efforts in R&D related to health, safety and environmental quality have already been widely applied.

In 1970, the department launched a major effort aimed at improving recovery rates from complex and problematic mineral deposits which occur widely throughout Canada. Success in this endeavour is expected to improve performance at some existing mines in New Brunswick and could lead to the economic exploitation of known but currently undeveloped deposits elsewhere in Canada. Research in the utilization of mineral-based materials in the manufacturing and transportation industries is aimed at providing a technological capability for economic diversification and further processing of minerals. Increased efficiency, and hence conservation, is being achieved through the application of improved and new technology developed at CANMET to fabrication processes, material substitution, and waste usage and recycling.

The objective of the Earth Science Services Program is to provide basic knowledge of Canada's geological, geophysical, and geographical make-up, including offshore areas. Such information is needed for delineation and assessment of Canada's mineral and energy resource base and for planning its development and the development of other kinds of land use.

The Geological Survey of Canada is a major contributor to this program, devoting almost all its resources to it. By means of an integrated program of geological and geochemical studies and surveys and airborne radiometric and magnetic surveys, information is provided on bedrock geology for use in identifying and appraising non-renewable resources including oil and gas, uranium, and metallic and non-metallic minerals. Information is provided on the overlying surficial materials to aid in assessing their effect on resource development and its feasibility and safety. Both kinds of information are used by private companies in planning resource exploration and development, as well as by the government agencies which plan and regulate development. Improvement of exploration techniques and transfer of these improved techniques to industry is an important part of the Geological Survey's program.

The Earth Physics Branch conducts a comprehensive program in solid earth geophysics. Ongoing activities include the determination of seismicity and seismic risk in all parts of Canada, delineation of the geomagnetic field of the earth and its variations and anomalies, delineation of the gravitational field of the earth including anomalies, delineation of the geothermal regime including prediction of permafrost and studies of crustal dynamics in Canada. These activities support policy-making bodies, regulatory agencies and industry in such areas as navigation, transportation, communications, surveying and geophysical prospecting, and provide data and information for research and development activities by the government and other sectors. Interdisciplinary studies on geothermal energy resources in Canada, earthquake prediction, the geological containment of radioactive wastes, and the origin and emplacement of mineral resources form a significant part of the work of the branch.

The Surveys and Mapping Branch will continue to discharge its responsibilities for national surveying and mapping services, and positional and land boundary survey services, meeting the growth in demand through improved technology and increased dependence on contracting out to the private sector. Examples of new technology include automated digitized terrain systems and the Inertial Survey System for secondary field surveys. Another example is the use of satellite Doppler techniques for primary geodetic surveys.

The role of the Canada Centre for Remote Sensing is also discussed in the Special Applications-Space section. Its activities include a project in which four aircraft are used to acquire data by remote sensing

for experimental users in Canada and to develop new sensors. Sensor developments include a laser fluorosensor for detecting oil spills. Several applications have been developed, such as the detection of heat loss from buildings and aerial hydrography for mapping water depth in shallow coastal areas. In support of Canada's satellite systems two receiving stations are operated at Prince Albert, Saskatchewan and Shoe Cove, Newfoundland (near St. John's). Data from the LANDSAT and NOAA satellites are received for such applications as ice mapping, crop information systems and forest management.

The Shoe Cove ground station also received data from the synthetic aperture radar on the NASA SEASAT satellite until the spacecraft became inoperative in late 1978. This project was in support of the department's role as the lead agency for the interdepartmental project SURSAT, which is assessing this means of providing surveillance of Canadian territory. Approximately 100 projects are being undertaken in cooperation with users of the satellite systems in Canada. The purpose of the project is to establish Canada's options for participation in an operational surveillance satellite system for the 1980s.

The objective of the department's Energy Program is to ensure the availability and to promote the effective use of energy resources for Canada, with due regard for other social and economic goals. The principal groups concerned with energy S&T are the Canada Centre for Mineral and Energy Technology, which conducts energy research in its laboratories and pilot plants; the Geological Survey of Canada, involved in studies of oil, gas and uranium resources; the Earth Physics Branch, studying geothermal potential, and the Office of Energy Research and Development, which provides coordination and facilitates improved management of the government's total energy R&D program.

A new Conservation and Renewable Energy Branch has been created, which is responsible for policy and program coordination in the areas of conservation and renewable sources of energy. Details of some of the department's energy activities are described in the Special Applications-Energy section. In addition to those activities, the department also carries out environmental and socio-economic impact assessments of resource exploration, development, production and transportation both in land and offshore regions.

Atomic Energy of Canada Limited

	Science Resources						Total Resources	
	1977/78		1978/79		1979/80		1979/80	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Nuclear Research and Utilization	77.2*	2,275	92.5*	2,324	85.3*	2,338	133.2	6,865

* Excludes transfers from the program to other departments ($2.0 million for 1979/80).

As part of the restraint in government spending the estimated science expenditures of Atomic Energy of Canada Ltd., will be 8% lower in 1979/80 than in 1978/79. In spite of this reduction, R&D on the safe immobilization and disposal of radioactive materials from the operation of CANDU reactors will be expanded a further $3.5 million to $13.4 million. The R&D on nuclear safeguards for CANDU reactors will be maintained at the planned level of $1.4 million, a slight drop from the $1.7 million forecast expenditure for 1978/79. To provide these additional resources, other R&D programs are being curtailed, certain capital projects deferred or stretched out, and more laboratory effort devoted to revenue-producing activities. S&T contracts to industry, including payments for the operation of demonstration power reactors, will be lower at $17.2 million than in 1978/79 ($19.6 million). S&T contracts to universities will increase to an estimated $1.2 million from the 1978/79 level of $0.8 million. Because of its status as a Crown corporation and the isolated location of its two main

laboratories, the company's expenditures include the full cost of maintenance of plant and experimental sites, including provision of municipal services and utilities, in contrast to most departmental budgets.

The overall objective of the company's R&D program is to develop the knowledge and technology base needed to maintain a nuclear generating system that meets the criteria of safety, economics and energy self-reliance. Most of the program activities support at least two of these criteria, often all three. Over half of the R&D resources provide technical support in meeting demands for increased efficiency, greater system reliability and increased safety requirements. The program, which spans the full range of technological activity from basic research to full-scale demonstration and technological support, is organized into six major activities: power reactor systems, nuclear fuel cycle, environmental protection and radioactive waste management, heavy water processes, radiation equipment and radionuclides, and underlying and advanced systems research. Planning and coordination of these activities is carried out by a company-wide committee, under which working parties coordinate specific projects at the company's several laboratory sites.

The Power Reactor Systems activity is concerned with R&D related to all aspects of the steam supply of nuclear generating stations except the fuel, i.e., the reactors, moderator, heat removal, control and ancillary systems.

The Nuclear Fuel Cycle activity is mainly concerned with fuel performance and with advanced fuel cycles. Computer models of fuel performance have been developed and improved upon over several years, based on theoretical considerations and reactor experiments to verify critical features of the models. These models have become essential aids in the design of larger reactors and more efficient fuel elements. The purpose of advanced fuel cycles is to multiply the amount of energy produced from a given quantity of uranium, thus insuring against scarcity and/or high cost of uranium.

Within the Environmental Protection and Radioactive Waste Management activity, a high priority has been assigned to the R&D required to demonstrate the safe disposal of radioactive materials from CANDU reactors. As mentioned above, increased resources are being directed to this task by reallocation from other R&D areas. The activity also includes the R&D on safeguard procedures for CANDU reactor operations and subsequent spent fuel operations. The third major task, protection of people and the environment, involves environmental and biological research relating to radioactive migration and radiation effects.

The Heavy Water Process activity carries out generic R&D related to the production of heavy water, investigating the physico-chemical factors that can lead to improved production efficiency. Given that plant investment is in the billion dollar range, increased efficiency significantly reduces heavy water costs and consequently nuclear power costs. Results to date have helped to reduce the need for new plants until the late 1980s.

The Radiation Equipment and Radionuclides activity is concerned with R&D which results in new and improved products for AECL's Radiochemical Company (formerly Commercial Products). This company was a pioneer, and is still a leader, in the development and sales of cancer therapy equipment and is one of the leading sellers of processed radioisotopes for medical and industrial uses.

The work in Underlying and Advanced Systems Research is conducted on three broad fronts: chemistry and materials science, physics and advanced systems research. An important criterion in selecting projects is the relevance of the research to the company's mission. The physics research group has achieved a world-wide reputation, which provides direct access to the work of other major nuclear research centres. Most aspects of nuclear system development require an understanding of phenomena in the fields of chemistry and materials science, for example, corrosion of materials, radiolysis and behaviour of fission products. The research objective is to explain observed conditions and to counteract or exploit them. Advanced systems research is concentrating on the spallation process, i.e., the production of neutrons by the bombardment of heavy-metal targets with intense streams of high-energy particles. Such a neutron production system could breed fissile materials for new sources of nuclear fuel, and hence provide an alternative to controlled fusion power whose feasibility has still to be demonstrated.

Department of the Environment

Program	Science Resources 1977/78 $M	1977/78 PY	1978/79 $M	1978/79 PY	1979/80 $M	1979/80 PY	Total Resources 1979/80 $M	Total Resources 1979/80 PY
Administration	1.2	36	1.2	36	1.2	36	24.3	783
Fisheries and Marine	102.3	2,525	97.8	2,425	93.8	2,325	290.5	4,967
Environmental Services	186.8	4,771	196.8	4,741	194.0	4,411	268.4	6,066
Environmental Management	87.4	2,082	89.8	2,069	89.4	1,885	—	—
Environmental Protection	7.3	159	9.3	160	5.9	162	—	—
Atmospheric Environment	92.2*	2,530	97.7*	2,512	98.8*	2,364	—	—
Total	**290.3**	**7,332**	**295.8**	**7,202**	**289.0**	**6,772**	**583.2**	**11,816**

* Excludes transfers to Transport ($8.2 million in 1979/80).

The department spends 48% of its total resources on S&T activities. In 1979/80, the S&T expenditures will be $289.0 million, virtually unchanged from 1978/79. Because of the department's major role in international negotiations, inter-provincial "refereeing", and industrial monitoring and control, most (86%) of its S&T program is performed in-house; 8% is contracted out to industry and 1% to universities.

The primary objective of the Department of the Environment is to preserve and enhance environmental quality, for the benefit of present and future generations of Canadians, to achieve the following goals:

- to safeguard man's health and property from harmful substances and environmental changes, whether natural or man-made;
- to foster resource productivity, through conservation and wise use of renewable resources, for sustained economic and social benefit; and
- to safeguard quality of life, based on development of society in harmony with its environment, permitting enjoyment of the environment and its constituent resources.

The Department of the Environment is responsible for leadership and coordination of all federal activities involving the environment, including specifically air, water, lands, forest and wildlife.

The Fisheries and Marine program is responsible for fisheries and oceanographic research related to fisheries management, hydrographic surveying and charting of navigable waters. The estimated S&T expenditures in 1979/80 amount to $93.8 million, of which $16.9 million will be spent extramurally.

Scientific programs within the Fisheries Management activity include resource and stock assessment and associated biological research, with particular emphasis on the fish stocks within Canada's new 200-mile fishing zone, fisheries resource enhancement and control of fish diseases, aquaculture, and fisheries habitat management.

The scientific objective of the Oceans and Aquatic Sciences activity is to provide, improve and apply knowledge of the physical and chemical characteristics of Canada's oceans and inland waters for the effective management and use of our marine resources while preserving and improving the quality of the environment. Science programs include oceanographic research, the collection of marine data from the ocean and the seabed, and the conduct of hydrographic and other types of survey of coastal, oceanic and inland waters.

A recently-proposed major offshore survey to be conducted jointly by Ocean and Aquatic Sciences and the Department of Energy, Mines and Resources is described as a highlight in the Special Applications-Ocean section.

The science programs of both Fisheries Management and Ocean and Aquatic Sciences are largely decentralized, with research establishments located on the east and west coasts and on two large inland lakes. More details are given in the Regional Expenditures section.

The primary objective of the Environmental Services program is to promote and undertake programs for the preservation and enhancement of environmental quality. It also contributes to the improvement of the management and sustainable economic utilization of Canada's forest, wildlife and inland water resources. To achieve this objective, the program is organized into three activities: the Environmental Management Service, the Environmental Protection Service and the Atmospheric Environment Service.

The scientific activities of the Environmental Management Service will involve expenditure of $89.4 million in 1979/80 in support of research on the quality and productivity of Canada's forests, inland waters, wildlife and lands. This includes taking a major part in environmental assessments concerned with protection of the environment against the possible impacts of proposed developments or construction projects. The service is formed of four scientific directorates — the Canadian Forestry Service, the Inland Waters Directorate, the Canadian Wildlife Service and the Lands Directorate — and a Policy and Program Development Directorate. The latter, in addition to policy and program responsibilities, plays a coordinating role for several integrated programs which involve the other directorates, such as environmental impact assessment and toxic substance research.

The Canadian Forestry Service is responsible for coordinating of programs to help the provinces and industry protect forests from fire, disease and insects, and for conducting research in forest products and in forest resource development.

The Inland Waters Directorate participates in national and international water management programs and conducts research on both the quantity and quality of inland waters. Major concerns include flood damage reduction, boundary water problems, river basin planning and the research programs of the National Hydrology Research Institute and the National Water Research Institute.

The Canadian Wildlife Service is responsible for supporting research and management for the conservation of migratory birds and for cooperating with the provinces on programs of wildlife research and management wildlife relating to endangered species, transboundary populations and other federal government interests.

The Lands Directorate uses computerized land information systems (the Canada Land Data System) and an ecological land classification and interpretation system in the development of land use and management plans. This knowledge base serves policy needs of government and meets important information requirements in land use planning and environmental impact assessment.

The Environmental Protection Service estimates an expenditure of $5.9 million on science activities in 1979/80, of which $2.5 million will be spent in industry. The service develops and enforces regulations that are used to protect the environment. The water pollution control program includes development and implementation of minimum effluent control requirements based on the best practicable technology. Under the Air Pollution Control Program, the service undertakes activities to control hazardous air pollutants, to develop new technology to contain pollutants and to detect and measure potential health hazards in ambient air. The service is also involved in limiting or preventing the entry of contaminants into the environment under its Contaminants Control Program, the development of capability to reduce significantly the effects of accidental or deliberate spills, including the development and demonstration of contaminant and clean-up technology, control technology demonstration projects at government facilities and resource and energy conservation technology.

The Atmospheric Environment Service will spend $98.8 million in 1979/80 for scientific activities. Its primary responsibilities are to provide data and information on past, present and future atmospheric, ice, air and sea conditions, and to conduct research in atmospheric processes, weather forecasting observing systems and air quality. Concerning the latter, the service also has a continuing program of measuring trace quantities of potential carcinogens in ambient air as well as carrying out national air quality field measurements in urban and rural areas, including laboratory

analyses of air samples. Widespread concern about drought and about possible effects of modern technology upon the upper layers of the atmosphere has led to the establishment of a National Climate Program within this service which will act as the government's lead agency for climate monitoring, prediction, modelling and application. In addition, the Atmospheric Environment Service has a significant program on ice forecasting and modelling to assist arctic transportation and development.

Canadian International Development Agency

	Science Resources						Total Resources	
	1977/78		1978/79		1979/80		1979/80	
Program	$M	PY	$M	PY	$M	PY	$M	PY
CIDA	25.3	51	30.9	56	30.8	56	655.0	1,016

The objective of the Canadian International Development Agency (CIDA) is to support the efforts of developing countries in fostering their economic growth and social evolution.

As can be seen from the table CIDA's substantial activities in science and technology are a small part of its total program (5%). Most of the scientific activities occur in CIDA's Multilateral Program which is concerned with giving aid to developing countries in concert with other agencies. For example, CIDA has provided core funding to the International Rice Research Institute and to the International Centre for Research in the Semi-Arid Tropics. Other multilateral and bilateral agencies have also provided funding to assist in setting up these and other similar international institutes.

Under its Bilateral Program the agency negotiates directly with individual developing nations to provide assistance. A case in point is where Canadian experts have helped the government of Kenya in its land use and sectoral planning through studies of the interaction of wildlife and livestock in the rangelands.

CIDA also has a program to aid non-governmental agencies, such as OXFAM, which are active in the developing countries and which have contacts at the grass-roots or village level. These direct contacts can help to implement programs in ways that would be difficult if not impossible for more bureaucratic agencies. One particular project of interest is in the Sahelian Zone in Niger. Titled "Green Carpet", the R&D project focuses on desert land reclamation and the use of solar energy.

International Development Research Centre

	Science Resources					
	1977/78		1978/79		1979/80	
Program	$M	PY	$M	PY	$M	PY
IDRC	34.5	344	36.9	355	36.9	345

The total expenditures of the International Development Research Centre are devoted to S&T activities. The IDRC was established by Parliament in 1970 to initiate, encourage, support and conduct research into the problems of the developing regions of the world and into the means for applying and

adapting scientific, technical and other knowledge to the economic and social advancement of those regions, and, in carrying out those objectives:

- to enlist the talents of natural and social scientists and technologists of Canada and other countries;
- to assist the developing regions to build up the research capabilities, the innovative skills and the institutions required to solve their problems;
- to encourage generally the coordination of international development research; and
- to foster cooperation in research on development problems between the developed and developing regions for their mutual benefit.

IDRC has many unique features. It is the first organization set up specifically to support research projects that are identified, designed, conducted and managed by developing country researchers in their own countries, in terms of their own priorities. Although it obtains funds by vote of the Parliament of Canada, and reports annually to Parliament, its operations are guided by an international and autonomous Board of Governors.

The centre, through its four program divisions — Agriculture, Food and Nutrition Sciences; Health Sciences; Information Sciences; and Social Sciences — supports research aimed at helping developing countries to find the solutions to some of their most pressing problems. It does not offer conventional technical assistance and capital grants for large-scale development programs. Instead, it offers direct grants to institutions or individuals which enable the recipients to secure the best available professional skills and to finance projects in the most effective way without regard to the source of the resources.

Projects submitted to IDRC for funding are initiated by the applicants and channelled through representatives of the program division concerned. Each project brought to the attention of the Director of the Program Division and submitted to the Board of Governors for final approval is considered in light of a number of factors: the need for and practicality of the research, the applicability of the research findings to as wide an area as possible, the use of local resources, and the potential for training local researchers and developing local research institutions through the project.

Research institutions conducting IDRC-supported projects have full responsibility for their administration and control. IDRC program representatives make regular visits to project sites to be of assistance should the need arise.

More information on the areas of research supported by IDRC can be found in the Special Applications-Developing Nations section.

Department of Industry, Trade and Commerce

	Science Resources						Total Resources	
	1977/78		1978/79		1979/80		1979/80	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Trade-Industrial	89.7*	165	63.7	157	86.6	176	322.1	2,413
Tourism	0.2	4	0.3	4	0.3	4	27.9	321
Grains and Oilseeds	2.9	2	2.2	3	2.0	3	82.3	45
Total	**92.8***	**171**	**66.2**	**164**	**88.9**	**183**	**432.3**	**2,779**

* Includes $16.4 million for payments under the Industrial Research and Development Incentives Act

S&T objectives of the Department of Industry, Trade and Commerce are to stimulate innovation and to promote the use of modern technology in Canadian industry. The department will spend approximately $88.9 million in 1979/80, an increase of $22.7 million from 1978/79.

Most of the department's S&T expenditures are through the Trade Industrial Program. One of the major activities in this program is the Enterprise Development Program, instituted in 1975 to replace several former programs of industrial incentives and assistance and to support the development or

introduction of new or improved products or processes that offer good prospects for profitable commercial exploitation. An additional $21 million has been earmarked for the Innovation Component of the new program, bringing the total expenditure on this S&T element to an estimated $47 million in 1979/80. The Defence Industry Productivity Program is another major industry support program which is intended to sustain the technological capability of the Canadian defence industry; estimated S&T expenditures in 1979/80 are $30.3 million compared to $33 million in 1978/79.

The Industry Energy Research and Development Program was introduced in 1978/79 to encourage and assist in the development of more energy efficient industrial processes. Expenditures are expected to be the same level as the current year, $1.5 million. Through the Technological Innovation Studies Program, the department also supports studies and awards scholarships in the uses and management of technological innovation. As part of the Special Initiatives for R&D announced in June 1978 a new program, Industrial Innovation Centres, has been instituted, in which separately-run centres on university campuses would provide assistance to inventors, innovators and entrepreneurs in the commercialization of new ideas, processes and products. It is expected that two or three start-up grants will be awarded during 1979/80.

Additional details of the incentive programs are given in the Extramural-Industry section of this report.

The Tourism Program of the department performs some in-house economic studies for tourism. The Grains and Oilseeds Program has been one of the supporting organizations in the development of a protein oil-seed plant at Saskatoon which was completed in June 1977 and is now being run by the P.O.S. Pilot Plant Corporation, an independent non-profit corporation.

Statistics Canada

	Science Resources					
	1977/78		1978/79		1979/80	
Program	$M	PY	$M	PY	$M	PY
Expenditures	130.0*	5,432	139.9*	5,109	127.7*	4,534

* Includes transfers from other departments ($2.1 million in 1979/80), formerly shown as revenues under the Revolving Fund.

Statistics Canada serves as the country's central statistical agency and its principal objective is to collect and publish statistics on the social and economic institutions and activities of Canadians for use in public and private research and decision making. It is also required to coordinate similar work carried out by other government departments, both federal and provincial.

Statistics Canada's entire budget is classified as a related science activity, that is, data collection, and this work is performed almost entirely intramurally. During 1979/80, Statistics Canada's estimated expenditures will amount to $127.7 million, which is a reduction of $12.2 million from 1978/79. This reduction is the net of allowances for salary and price increases and the agency's share ($13.4 million) in the broad-ranging program of budgetary reductions announced by the Minister of Finance and the President of the Treasury Board on 8 September 1978. In selecting areas of its program for cuts, Statistics Canada gave the highest priority for retention to those series which provide inputs to critical national economic aggregates.

Almost all indicators associated with the System of National Accounts will still be available in their customary format, as also will be the newly-revised Consumer Price Index and the statistics derived from the monthly Labour Force Survey. During 1979/80 Statistics Canada will continue to make available an extensive array of statistical products and services, and to furnish special analytical studies in a number of areas. 1979/80 will see the completion of the publications program of the 1976 Census, and customized dissemination activities from the 1971 and 1976 Census data bases and associated products will be a continuing activity.

Planning will proceed on the 1981 Census which is expected to collect data on an extensive range of information about the population such as sex, age, occupation, income and family composition. Basic demographic data will be collected from the total population and the other information will be drawn from a sample of one in every five Canadian households.

Continuing household surveys will examine income distribution for different types of recipient units and different kinds of income, and gather information indicative of levels of living, such as type of housing and characteristics of households. More specifically, special reports will be issued on the wealth holdings and indebtedness of Canadian families. The reports will contain an analysis of data collected in the Survey of Consumer Finances in 1977. These will be the first such data in 7 years, the last survey having been taken in 1970. A National Family Expenditure Survey conducted early in 1979 will be in the processing phase during 1979/80, and results will probably be available some time during the calendar year 1980.

During 1979/80, population projections derived from the 1976 Census will be used to continue the forecasts of enrolment at all levels of education. They will also be the basis of a study of trends in the educational attainment of Canada's population and labour force. One project will be a comprehensive study of the number of people likely to enter the labour force between now and 1986. Another will be a special study of the school-age groups in each province. In addition to the education-related projects, the long-term impact of population growth and structural shifts on the need for hospital space will be examined. Special attention will be given to the numerical and proportionate increase of elderly people.

A series of analytical monographs will also result from a survey of 1976 post-secondary graduates. Topics such as employment status and the relationship between education, occupation, job satisfaction and income will be examined. Particular attention will be paid to graduates with doctorates.

The development of a Mortality Data Base containing machine-readable abstracts of all deaths registered in Canada since 1950 will also be completed during 1979/80. This will be used to support medical follow-up studies designed to detect significant relationships between incidence of disease, particularly cancer, and occupation, environment, certain drugs, diet and exposure to chemicals.

A study will be carried out to examine the relationship between health and fluctuation in economic activity at the ecological level, i.e. relating to human beings and their environment.

Finally, a study will be carried out in cooperation with the Bureau of Epidemiology in the Department of National Health and Welfare to identify the socio-demographic correlates of mortality in Canadian metropolitan areas.

Department of National Defence

	Science Resources						Total Resources	
	1977/78		1978/79		1979/80		1979/80	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Defence Services	83.2*	2,142	88.8*	2,142	99.5*	2,142	4,590.8	116,809

* Excludes transfers to other departments ($9.9 million in 1979/80).

The Department of National Defence's estimated expenditures for scientific activities in 1979/80 are $99.5 million, an increase of $10.7 million from the previous year. Its S&T program is aimed at improving the operating capability of the armed forces by the effective application of science and technology to all departmental functions, ranging from strategic policy decisions through military operations to the maintenance of effective personnel and material resources. The analysis of new

technological developments and their impact on operations is an essential element in the timing and selection of equipment acquisitions. The department depends, in part, on the R&D activities of other government departments and private agencies, and on the sharing of S&T information with Canada's allies.

Its intramural R&D program contributes to the international sharing of S&T information and provides the knowledge base for the application of S&T to equipment acquisitions and operations. Conducted at six Defence Research Establishments at various locations across the country, the program comprises three groups: Human Protection and Performance, Sensors and Electromagnetics, and Ordnance and Vehicles.

Human Protection and Performance covers a spectrum of science ranging from the protection of the soldier in a variety of natural or artificial environments, to the performance of men at high altitudes or in ocean depths. The human-engineering of equipment is another research activity, involving studies of human perception, vision, and hearing, and of the effectiveness of man/machine systems.

Construction of the Deep Diving Facility at the Defence and Civil Institute of Environmental Medicine in Toronto has been completed and the facility is available for use by other government and civil agencies. The facility is currently capable of simulating depths to 1,700 metres and is man-rated to 760 metres. In addition to a research program on saturation diving, the facility will be used to study atmospheric diving systems, such as miniature submersibles and the development of manipulator arms.

In-house programs in sensors and electromagnetics include research in underwater acoustics, electronics, electro-optics, navigation, magnetics, and command and control systems. In addition, the Communications Research Centre of the Department of Communications carries out contracted and cooperative work on radar and communications.

As part of an interdepartmental project, and in cooperation with NASA, the department participated in the SEASAT-A surveillance satellite experiments until the satellite stopped functioning in late 1978. This was the first earth satellite to contain a synthetic aperture radar. The data from this radar, received at the ground station at Shoe Cove, Newfoundland, was processed by the Defence Research Establishment, Ottawa, using an optical correlator developed there. The resulting imagery was intended to assist in the assessment of this means of earth surveillance.

Ordnance and Vehicles activities include programs on ordnance, hydronautics, energy conversion and conservation, materials services, and mobility, countermobility and combat engineering technologies. In addition, there is an extramural program in aeronautics which supports research and design capabilities in Canadian industry.

Ordnance is the major in-house program, utilizing half the personnel resources used in this area. Activities related to the CRV7 rocket weapon have continued to receive emphasis. The Canadian Forces have accepted this improved 2.75-inch air-to-ground rocket for operational use on the CF-104 aircraft. Bristol Aerospace Limited is producing the rocket motor, using technology transferred from Defence Research Establishment Valcartier (DREV). During 1978/79, DREV work has centred on an improved warhead, launchers and a low-smoke version of the rocket motor. Considerable interest in the rocket has been expressed by a number of countries, particularly in Europe, and arrangements for off-shore sales/production are currently being explored.

The department is increasingly employing the social sciences in its research program. The Operational Research and Analysis Establishment provides expertise in operations research, the techniques of management science, social and economic analysis, strategic studies, forecasting and futures studies. At present the main areas of study are strategic analysis, in which an active topic is the study of methods of averting war by deterrence and arms control; socio-economic analysis, to evaluate the impact of military forces on the society in which they operate; and studies relating to the efficient management of the department's large resources of personnel and material. Although most of this work is carried out in-house, some specific studies are contracted out.

The Personnel Applied Research Unit is looking at the social relations of personnel within the Canadian Forces and of the forces with the community at large. It is also involved in motivational research, behavioural science, personnel selection and management development. In 1979/80, the unit will extend its work on training methodology to areas other than flying.

Department of National Health and Welfare

Program	Science Resources 1977/78 $M	1977/78 PY	1978/79 $M	1978/79 PY	1979/80 $M	1979/80 PY	Total Resources 1979/80 $M	1979/80 PY
Administration	8.8	148	6.7	151	5.1	111	23.0	664
Health and Social Services	28.5	151	28.2	93	18.8	63	5,714.0	541
Medical Services	0.5	22	0.1	3	0.1	3	172.7	3,750
Health Protection	24.2	859	24.7	856	22.5	770	61.3	1,870
Fitness and Amateur Sport	0.4	8	0.3	4	0.3	3	27.3	112
Income Security	0.4	17	0.5	19	0.5	17	8,095.9	2,816
Total	**62.7**	**1,205**	**60.6**	**1,126**	**47.3**	**967**	**14,094.2**	**9,753**

Prior to November 1976 the department operated under two deputy ministers, one for Health and one for Welfare. Since then a single deputy minister has been responsible for all health and welfare programs.

As a result of Established Programs Financing for health programs, the department is reorienting its role to emphasize the establishment and maintenance of national standards for health and social services, the preventive aspects of health and social well-being, and the provision of leadership and co-ordination vis-à-vis other government departments and other levels of government dealing with areas of concern to the physical, economic, and social well-being of Canadians.

The Non-Medical Use of Drugs Activity, formerly in the Health Protection Program, is being transferred to a new Health and Social Services Program, and its contributions element combined with the Family Planning grants.

As can be seen from the table, the major portion of the department's science expenditures occur in the Health Protection Program. The main aim of the program is to "reduce illness and untimely death of Canadians associated with hazards in the environment, both man-made and natural." To do this, it has five activities, three of which are concerned with the quality and hazards associated with food, drugs, and the environment, a fourth which is concerned with Laboratory Health Surveillance and the fifth provides the administration of the program.

The new Health and Social Services Program has six activities of which three, Health Promotion and Prevention, Health Care Services, and Social Services Development, have significant scientific expenditures.

The Health Promotion and Prevention activity will oversee the National Health R&D grants and contributions — $9.3 million in 1979/80 — and the contributions for innovative projects and research concerned with Non-Medical Use of Drugs — $2.1 million in 1979/80. A substantial amount of science will also be conducted in-house, estimated at $2.2 million for 1979/80.

Scientific expenditures in the Health Care Services activity occur mainly through three programs;

- family planning grants, an estimated $1.1 million in 1979/80;
- grants to Voluntary Health Organizations, $0.4 million; and
- the Health Resources Fund, $2.5 million for 1979/80.

The purpose of the Health Resources Fund has been to assist the construction of health research and teaching facilities. Due to budgetary restraints, the fund was terminated in 1978/79, approximately one year ahead of the scheduled termination date of 31 March 1980. No new commitments were made after September 1978.

Scientific expenditures in the Social Services Development Activity occur mainly through two

programs: grants to welfare organizations ($1.3 million) and social services development contributions ($3.5 million). Grants to voluntary health organizations and to welfare organizations include support for groups such as the Traffic Injury Research Foundation of Canada, the Canadian Public Health Association and the Canadian Council on Social Development. These grants are in the nature of core-funding and help to defray the operating costs of these groups.

Medical Research Council

	Science Resources					
	1977/78		1978/79		1979/80	
Program	$M	PY	$M	PY	$M	PY
Grants and Scholarships	56.7	—	63.0	—	68.7	—
Administration	1.2	39	1.4	40	1.4	40
Total	**57.9**	**39**	**64.4**	**40**	**70.1**	**40**

All of the Medical Research Council's expenditures are for S&T activities. The 1979/80 funding for grants and scholarships has been determined according to a long-term funding strategy, in which annual adjustments over the next 5 years will be determined by a formula based on the use of appropriate economic indicators. This funding strategy was approved by the government in late 1978, as part of the rationale for stable funding of its support of medical research so as to meet "core" research needs and to enable the council to provide leadership in the evaluation and coordination of medical research in Canada. The formula does not preclude consideration of additional funding in areas of national concern nor the future use of more appropriate indices for price and salary increases. Included in the estimates is the $3.0 million in additional funds for research in areas of national concern, part of the special R&D initiatives announced in June 1978.

The objective of the Medical Research Council is to help attain the quality and scale of research in the health sciences essential to the maintenance and improvement of health services. The council has articulated a number of sub-objectives:

- to expand the scientific and technological base for health care;
- to improve the application of scientific principles to health care;
- to ensure an adequate research base for education in the health sciences;
- to support the training of researchers in the health sciences; and
- to support research contributing to new knowledge in the health sciences.

The council's objective implies that the government should not assume sole responsibility for supporting health research in Canada. Indeed, there exists a long-standing partnership between the council and other federal, provincial and voluntary agencies. In cancer research, for example, the Medical Research Council, the National Cancer Institute, the Ontario Cancer Treatment and Research Foundation, and the National Health Research and Development Program of the Department of National Health and Welfare have cooperated for many years, under a formally-established Cancer Research Coordinating committee. One of the major activities of the committee has been the fostering of collaborative clinical trials in cancer therapy, of which four are currently underway.

Nearly 97% of the council's grants budget is used to support research, research training and related scientific activities in Canadian universities. This support is provided under a number of grant programs of which the three most important are the following:

- the Grants Program, which provides grants for research by individuals and groups;
- the Subject Research Development Grants, which provide support in areas of not only national

concern but also with the potential to respond to special initiatives; and

- the Development Grant program, whose purpose is to strengthen university research in health science in those regions where the level is considered inadequate to serve the needs of health care and professional education.

The remainder of the grants budget is used to support Canadians undertaking research training or specific research projects in other countries, with a small amount for the support of international scientific organizations in the health sciences.

In supporting research, the council strives to achieve both a balance and an effective integration between targeted or "applied" research and basic research leading to a better understanding of the fundamental biological processes in health and disease. Thus, no proposal for basic research goes unscrutinized by competent scientists who can assess the potential for clinical application of the results. Similarly, applied research proposals are carefully assessed for the validity of the basic methodology to be applied.

National Research Council

	Science Resources						Total Resources	
	1977/78		1978/79		1979/80		1979/80	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Scientific and Industrial Research	159.9*	2,803	195.3*	2,816	200.3*	2,919	202.6*	2,945
Scientific and Technical Information	12.7	270	14.9	272	13.6**	215	13.6	215
Total	**172.6**	**3,073**	**210.2**	**3,088**	**213.9**	**3,134**	**216.2**	**3,160**

* Includes transfers from other government departments ($2.7 million in 1979/80)

** The Technical Information Service ($2.6 million) is to be transferred to the Scientific and Industrial Research Program April 1979.

The Scientific and Industrial Research Program has estimated expenditures of $202.6 million for 1979/80, with nearly all (99%) of the program's total resources devoted to science and technology.

Research is conducted within all sectors of the scientific community in Canada, and the council's role is to develop and disseminate scientific knowledge in response to the current and future needs of government departments and agencies, Canadian industry, universities and provincial institutions. This comprehensive role is accomplished by a variety of means including direct assistance to external performers of research in the form of R&D contracts, provision of technical guidance and scientific information, the performance of both medium- and long-term research in the council laboratories, and assistance in the development of coordinated programs in conjunction with other performers of research and development.

The Scientific and Industrial Research Program is divided into seven activities: basic and exploratory research; research on long-term problems of national concern such as transportation, energy, food, building and construction; research in direct support of industrial innovation and development; research to provide technological support to social objectives; research and services related to standards; the management of national facilities as a service to industry, governments and universities; and the provision of administrative and special support services for all of the National Research Council.

Concurrent with its research programs aimed at providing solutions to the technological problems facing Canadian society, the council carries out a broad spectrum of investigations designed primarily to expand the knowledge base of science and to explore promising new applications. While a certain amount of this basic research, which represents

approximately 25 per cent of the overall laboratory research effort, is performed in all divisions to support other projects and to develop required expertise, the major part occurs in the fields of astrophysics and molecular biology.

Energy, food, shelter and transportation are some of the essential human needs of modern societies. With Canada's vast areas of land and water, rigorous climate and scattered population, the provision of these needs poses special problems that are engaging a considerable part of the council's research capabilities.

The National Research Council's work in the energy field is subject to the coordination and review of the Energy R&D Panel, and details of its energy activities will be found in the Special Applications-Energy section.

The council has identified approximately $10 million for research related to the various aspects of Canada's food industry during 1979/80. In addition to its own intramural programs, which range from basic studies of plant cell chemistry, through large-scale methods of milling and utilizing pea protein, to investigations of antibiotic poisoning of sheep, the council also supports food research in outside laboratories. This extramural research will account for approximately 35% of the total expenditure in 1979/80.

Funds totalling approximately $11.6 million will be used by the Division of Building Research for research on building and construction during fiscal year 1979/80. Of this amount, approximately 4% will be spent on research contracts to Canadian industrial research establishments. As a guide to the division's research program, the Canadian Committee on Building Research, comprising representatives from industry, the universities and the government, suggests areas of research need, and assists in coordinating research activities in the three performing sectors.

In recent years the council has given priority to policies and programs for advancing and assisting Canadian industrial R&D. Based on its particular and sometimes unique research resources, council staff have identified 10 activities as constituent elements of a comprehensive strategy. Foremost among these are two direct assistance programs, the Industrial Research Assistance Program (IRAP) and the Program of Industry/Laboratory Projects (PILP). These are described more fully in the Extramural-Industry section. These programs assist Canadian industry in the formation, development and exploitation of its own research capabilities. At the same time the council is also making known and accessible to industry its own material and human resources, and is conducting a substantial amount of intramural research of benefit and assistance in developing new capabilities in selected industrial sectors. While such research is carried out mainly in the engineering divisions, there are projects in all divisions which are of significance to Canadian industry in the fields of improved manufacturing techniques or novel product and process development, thereby qualifying for the support of an industrial partner under the Program of Industry/Laboratory Projects.

Research in support of social objectives may be grouped under three headings; health, public safety and environmental quality.

Several research divisions share the dual responsibilities of maintaining and improving a wide range of national standards. The research is concerned with such areas as electrical and engineering standards, involving such derived quantities as force or acceleration, and standards related to transportation, construction and safety, such as those embodied in the National Building Code and the National Fire Code (which are the textbooks of Canada's construction industry).

International comparison of primary national standards is an important facet of the standards activity. Such global participation, under the aegis of the *Bureau international des poids et mesures*, ensures a uniform, consistent realization of physical standards the world over. Also, the standards-related work at the National Research Council not only has wide-reaching importance outside the laboratory, but also provides a direct service, particularly in Canada's industrial sector. Annually, council physicists calibrate nearly all the cameras used for aerial survey photography in Canada and by Canadian companies working abroad.

National facilities for research provided and managed by the council include wind tunnels, optical and radio telescopes, marine engineering and ship laboratories, railway testing equipment, low temperature chambers, rocket and balloon launching ranges. A new venture will be an industrial materials research institute in the Province of Quebec—*l'Institut de génie des matériaux*—whose construction is scheduled to begin in 1979/80. In addition to those facilities directly operated and

managed by its staff, the council is supporting through contributions and overseeing the management of certain major scientific facilities operated by universities, such as TRIUMF, the nuclear physics facility at the University of British Columbia.

The Scientific and Technical Information Program, with its Canada Institute for Scientific and Technical Information, provides a wide range of information services to the government and private sectors, including access to printed material in the world's scientific literature and delivery of information from computerized data bases. The decrease in 1979/80 expenditures to $13.6 million from $14.9 million in 1978/79 reflects the transfer of the Technical Information Service to the Scientific and Industrial Research Program. Estimated expenditures for the Technical Information Service are $2.6 million for 1979/80. The service is discussed in the Extramural-Industry section.

Natural Sciences and Engineering Research Council

	Science Resources					
	1977/78		1978/79		1979/80	
Program	$M	PY	$M	PY	$M	PY
Scholarships and Grants in Aid of Research	97.9*	—	109.9*	—	118.6*	—
Administration	1.6	57	2.1	59	2.4	61
Total	**99.5**	**57**	**112.0**	**59**	**121.0**	**61**

* Includes funds from NATO ($0.2 million in 1979/80)

The estimated expenditures of $118.6 million in 1979/80 on scholarships and grants-in-aid of research include allowances for price and stipend increases, and a continuation of the $5 million additional funding provided in 1978/79 for research in areas of national concern, as part of the special R&D initiatives announced by the government in June 1978.

Formerly, the Grants and Scholarships Program was administered by the National Research Council. On 1 April 1978 its administration was assumed by the newly-formed Natural Sciences and Engineering Council. The objective of the program is to promote and support the development and maintenance of research in Canada and the provision of highly qualified personnel in the natural sciences and engineering. Concomitant sub-objectives are as follows:

- to support excellence in basic research in the natural sciences and engineering;
- to promote and support the development of research in selected fields of regional and national importance; and
- to assist in the provision and development of highly qualified personnel.

As with the Medical Research Council, nearly all of the council's grant budget — 95% — is used to support research and research training in Canadian universities. This university support is discussed more fully in the Extramural-University section. Of the remainder of the 1979/80 budget, an estimated $2.1 million will be spent in support of Canadians undertaking research or research training outside Canada, and an estimated $1.7 million will be spent for S&T support in Canadian non-profit institutions. The council also intends to provide $1.8 million for industrial fellowships. The council's program is organized into four activities which are described in the following paragraphs.

Peer Adjudicated Grants will have estimated expenditures of $87.9 million compared to $81.4 million in 1978/79. These are grants awarded to individuals on a competitive basis to assist the operating expenditures of research projects.

Developmental Grants will be awarded worth an estimated $16.1 million compared to $15.0 million in 1978/79 and $8.7 million in 1977/78. Most of the additional funds provided in 1977/78 and 1978/79 have been directed to this activity, which includes the Strategic Grants program, initiated in 1977. This program is intended to encourage research in areas

of national concern. For 1979/80 five areas have been specified: in addition to energy, environmental toxicology and oceans which were selected for 1977/78 and 1978/79, proposals in the areas of communication and agriculture/food are also being invited.

The Highly Qualified Manpower Training and Development activity will spend an estimated $13.0 million in 1979/80, compared to $12.1 million in 1978/79. The activity provides support mainly to post-graduate students and post-doctoral fellows through bursaries, scholarships and fellowships awarded in national competitions.

Expenditures on National and International Activities will increase slightly from $1.2 million in 1978/79 to $1.3 million in 1979/80. These funds are used to support both national and international conferences, the publication of Canadian learned journals and to assist Canadian scientific societies.

National Museums of Canada

	Science Resources					
	1977/78		1978/79		1979/80	
Program	$M	PY	$M	PY	$M	PY
National Museums of Canada	45.7	1,002	53.9	1,025	46.1	1,006

The National Museums of Canada is another of the federal government agencies and departments whose science budget constitutes 100% of the total program. By international convention museum services are classed as a related scientific activity. The National Museums estimate total expenditures of $46.1 million for 1979/80, down 14% from 1978/79. The majority of the agency's resources (82%) are allocated intramurally, with 15% being granted to museums and other organizations in Canada for their operations, special projects, purchase of equipment and construction of facilities.

The agency's objectives include the acquiring, classifying, preserving and exhibiting of both natural and man-made objects of cultural and scientific importance in an attractive and interesting way so as to stimulate, educate and inform the Canadian public. To achieve these objectives the agency's program is organized into four activities, corresponding to the following fields: fine arts, including Canadian and non-Canadian sculpture, paintings, and the like; natural sciences, including botany, zoology, paleontology and mineral sciences; human history, including archeology, ethnology, folk culture, and Canadian history; and science and technology, including industry and the physical sciences. A fifth activity, National Programmes, is the mechanism through which the agency cooperates with other museums in preserving collections, making inter-museum loans, and extending museum services directly to the public in areas not otherwise served.

Research plays an important role in the program of the National Museums of Canada. Research and interpretation of data are carried out on all the museums' collections of natural objects, man-made artifacts and works of art, including their nature, provenance and preservation, and the knowledge gained is disseminated through displays and by publication.

Social Sciences and Humanities Research Council

Program	Science Resources 1977/78 $M	PY	1978/79 $M	PY	1979/80 $M	PY
Grants & Scholarships	29.3	—	29.9**	—	32.3	—
Administration	3.9	97	4.2	98	3.7***	107
Total	**33.2***	**97**	**34.1**	**98**	**36.0**	**107**

* Prior to 1 April 1978, accounting and financial systems were different when the program was under the Canada Council.

** Includes transfer of $0.9 million from the Department of External Affairs.

*** Includes transfer of $0.1 million from the Department of External Affairs.

All of the expenditures of the Social Sciences and Humanities Research Council are devoted to S&T activities. The estimated expenditures of about $32.3 million for grants and scholarships include allowances for price and stipend increases, and a continuation of the $2.0 million additional funding made available in 1978/79 for research in areas of national concern, as part of the special R&D initiatives announced by the government in June 1978.

On 1 April 1978, the new Social Sciences and Humanities Research Council assumed the administration of the former Social Sciences and Humanities Research program of the Canada Council. The objective of the council is to promote and assist research and scholarship in social sciences and humanities. The council has enunciated several sub-objectives:

- to encourage excellence in research;
- to enhance the advancement of knowledge by assisting independent research;
- to promote research which would contribute to the fulfillment of national objectives;
- to encourage the diffusion of scholarly works; and
- to assist in the training of researchers.

Somewhat less of the council's grants budget — 85% — is used to support research and research training in universities in comparison to the Medical Research and Natural Science and Engineering Research councils. This university research support is discussed in the Extramural-University section. The remainder of the budget is about equally divided between payments to learned societies to promote scholarly exchanges (publications and editorial projects) and payments for the support of Canadians in research training abroad.

The council awards the following types of grants: grants to aid advanced research undertaken by career scholars; direct support for scholarly publications and for major editorial projects; grants for the development of research instruments; grants for the international exchanges of scholars; grants to scholarly organizations and learned societies; and scholarships for the development of research skills.

Transport Canada

Program	Science Resources 1977/78 $M	1977/78 PY	1978/79 $M	1978/79 PY	1979/80 $M	1979/80 PY	Total Resources 1979/80 $M	1979/80 PY
Administration	9.8	86	10.4	77	9.4	69	76.7	1,516
Marine Transportation	9.3*	9	10.3*	10	9.9*	9	285.8	6,440
Air Transportation	9.3**	47	10.6**	59	5.0**	58	452.1	10,236
Surface Transportation	11.5	25	15.3	26	5.7	24	580.8	284
Total	**40.0**	**167**	**46.6**	**172**	**30.1**	**160**	**1,395.4**	**18,476**

* Includes transfer from Department of the Environment ($6.0 million in 1979/80).

** Includes transfer from Department of the Environment ($2.2 million in 1979/80).

The S&T expenditures of Transport Canada comprise 2% of its total program. In 1979/80, the science spending of the department will be $30.1 million, down 35% from 1978/79. The major reasons for this decline are a change in accounting procedures for calculating transfers between the Air Transportation Program and the Department of Environment, the termination of urban transportation research in the Surface Transportation Program, and a general reduction in expenditures as a restraint measure. A significant portion of Transport's S&T program is contracted out with 39% of the program funds being spent in industry and 7% in the universities.

The general objective of the Department of Transport is to see to the development and operation of a safe and efficient national transportation system that contributes to the achievement of government objectives and to operate specific elements of this system.

The department supports this objective through the use of research and development as one means among many. The Transport Canada Research and Development Centre (TDC) in Montreal is the major R&D arm of the department, with a science budget of $7.0 million for 1979/80, 71% of which will be contracted out. In addition, the department operates the following intramural research and test establishments: the Air Traffic Services Simulation Centre, Hull; the Electronic Systems Development Laboratory, Ottawa; the Air Traffic Control Development Certification Centre, Ottawa; the Aviation Safety Engineering Facility, Ottawa; the Coast Guard Hydraulics Research Centre, Montreal; and vehicle-testing facilities in Ottawa and Blainville, Quebec. The budgets of these relatively small establishments total $4 million in 1979/80.

6. A Perspective on Science in Canada

The purpose of this section is to provide an international and historical context for Canada's scientific activities. It also discusses the implications of the new national target that by 1983 Gross Expenditures on R&D (GERD) should be 1.5% of Gross National Product (GNP). By international convention GERD is based on R&D in the Natural Sciences, excluding RSA in the Natural Sciences and both R&D and RSA in the Human Sciences. This restricted definition of GERD is used for the new national target. International comparisons can be useful for looking at trends but they must be treated with some caution as there are differences among countries in their concepts and definitions of R&D. Nor of course do expenditure data necessarily measure the effectiveness of national scientific efforts.

It must also be noted that the historical Canadian GERD data presented in this section are not comparable exactly with the other data in this report and the companion report *Federal Science Expenditures and Personnel, 1977/78 — 1979/80.* There are definitional and procedural differences between the sets of data. For example, the timing of the industrial survey by Statistics Canada would not yet reveal any acceleration in industrial R&D generated by recent tax incentives and other government initiatives.

International Comparisons

The most recent comprehensive data on science expenditures by other countries are available from the 1978 survey by the Organization for Economic Cooperation and Development (OECD), covering the period up to 1975. As shown in Table 6.1, the survey reveals a general stagnation of R&D spending when expressed in constant dollar values or as a share of Gross Domestic Product (GDP). (As a measure of economic activity GDP is very similar to the Gross National Product (GNP) commonly used in Canada). In the United States and Canada there has been a persistent decline.

Table 6.1

GERD/GDP Ratios, 1971 to 1975 (Selected OECD Countries)

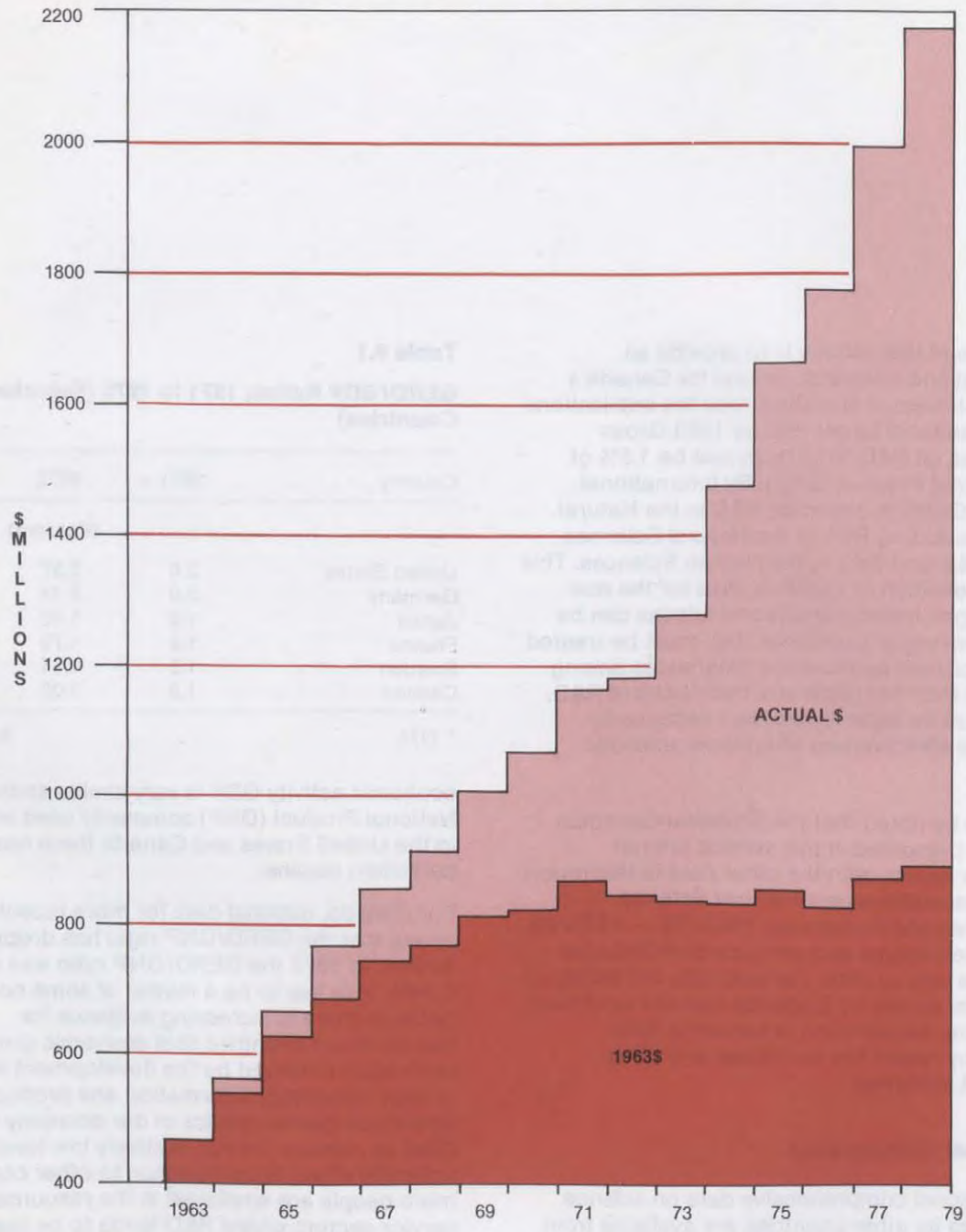
Country	1971	1973	1975
		(Percent)	
United States	2.6	2.37	2.35
Germany	2.0	2.14	2.16
Japan	1.6	1.90	2.00*
France	1.9	1.79	1.86
Sweden	1.5	1.51	1.59
Canada	1.2	1.02	1.00

* 1974

Source: OECD

For Canada, national data for more recent years reveal that the GERD/GNP ratio has dropped further. In 1978 the GERD/GNP ratio was only 0.94%. This has to be a matter of some concern because there is increasing evidence for industrialized countries that economic growth is markedly influenced by the development and export of high technology information and products. Structural characteristics of our economy have been cited as reasons for our relatively low level of scientific effort. In comparison to other countries more people are employed in the resource and service sectors where R&D tends to be lower; fewer are employed in manufacturing. Nor does Canada have the massive defence and space research programs that contribute significantly to the national science effort of a country such as the United States. Nevertheless Canada cannot afford to continue to lag so greatly in its scientific effort.

Figure 6.1
Canadian GERD (1963-1978)



Coupled with the low level of Canada's scientific effort is the low involvement of the business sector. As shown in Table 6.2, both as performer and funder of R&D the business sector in Canada lags by a significant margin those in other industrialized countries in the OECD.

Table 6.2

Business share of GERD (1975)

Country	Source of Funds	Performer
	(Percent)	
Canada	31	42
France	40	61
Japan	65	64
Germany	53	66
United States	43	68
Sweden	57	69

Source: OECD

Historical Trends

Following substantial expansion in the latter half of the 1960s, R&D spending in Canada during the 1970s has remained relatively constant in real terms, as it has in several other countries belonging to the OECD. This is shown in Figure 6.1 in which R&D expenditures are presented in both current dollars and constant dollars (computed using an implicit price index for Gross National Expenditure). It can be seen that current dollar expenditures have consistently increased. The rate of increase during the early seventies, however, did not keep pace with inflation. Expressed in constant dollars, the real effort has exceeded the peak of 1971 only in 1977 and 1978. Depending on the extent and rate of response to recent improvements in tax incentives for industrial R&D, GERD for 1978 may be revised upwards in future statistical reports.

More importantly, while science spending demonstrated little real growth, the economy was growing substantially, so that the proportion of our economic activity devoted to R&D expenditures has shown a steady decline since a peak in 1967, when the GERD/GNP ratio was 1.29%. The trend is shown in Figure 6.2.

Similarly, there is some indication that the proportion of our scientific effort performed and funded by the business sector is increasing, as shown in Table 6.3. The increased tax incentives and other government policies such as contracting out the government's scientific activities, are designed to encourage greater involvement of Canadian business in R&D and should reinforce this trend.

Table 6.3

Industrial Participation in Canadian GERD

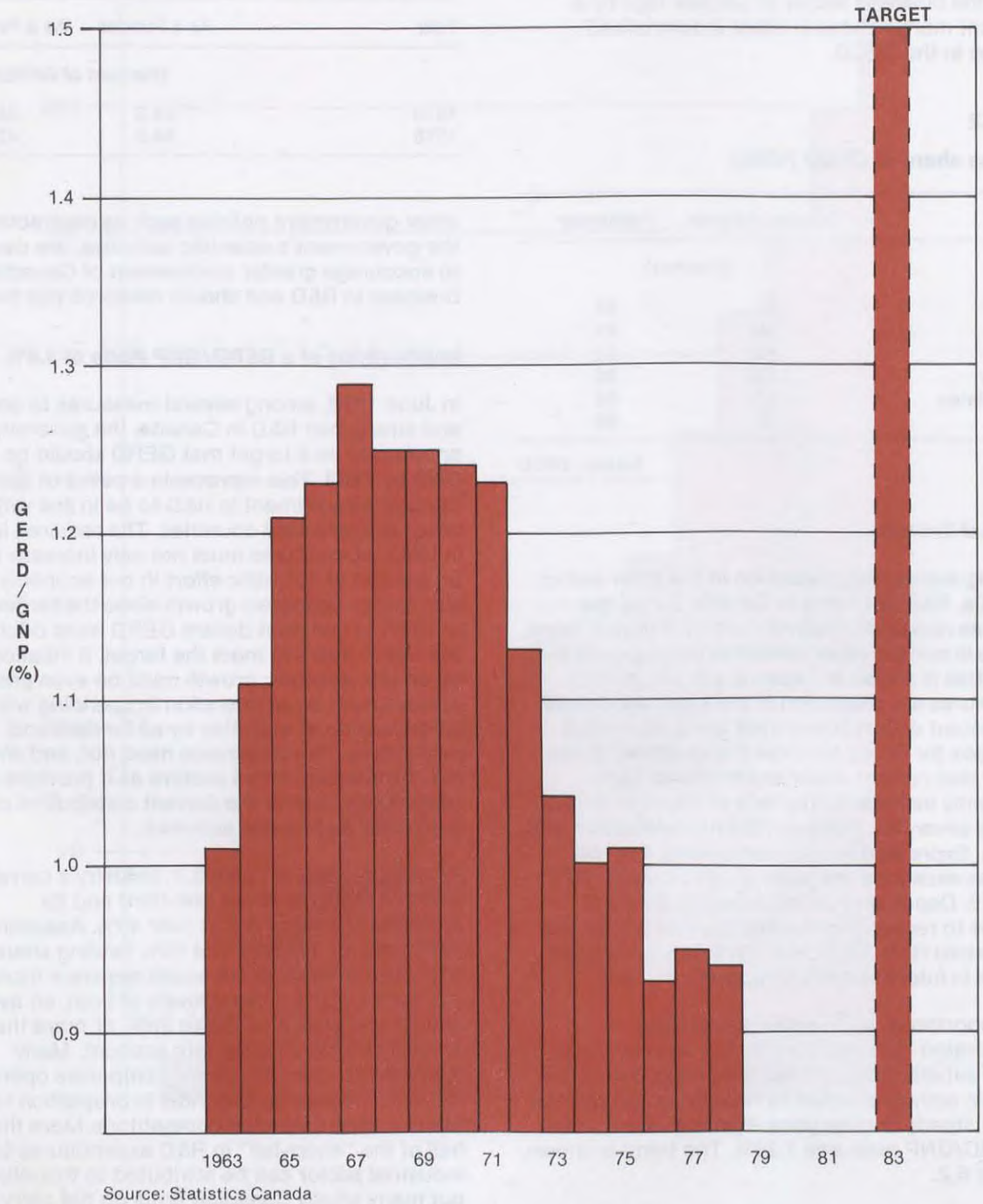
Year	As a Funder	As a Performer
	(Percent of GERD)	
1970	31.3	38.8
1978	34.0	42.6

Implications of a GERD/GNP Ratio of 1.5%

In June 1978, among several measures to encourage and strengthen R&D in Canada, the government announced as a target that GERD should be 1.5% of GNP by 1983. This represents a policy of raising Canada's investment in R&D to be in line with that of other industrialized countries. The required increase in R&D expenditures must not only increase the proportion of scientific effort in our economy but also match economic growth since the target is tied to GNP. In constant dollars GERD must double over the next 5 years to meet the target. If inflation is taken into account, growth must be even greater. To achieve such an acceleration in spending will require an expansion of activities by all funders and performers. This expansion need not, and should not, be identical for all sectors as it provides an opportunity to alter the current distribution of performer and funder activities.

As already seen in Table 6.3, industry's current share of GERD is about one-third and its performance share is just over 40%. Assuming a 1983 goal for industry of a 50% funding share and 65% performance share would require a tripling in real terms of the current levels of both, an average annual real growth of about 25%, or more than 30% annually taking inflation into account. Many subsidiaries of multinational companies operating in Canada conduct far less R&D in proportion to sales than do their Canadian competitors. More than one half of the "short-fall" in R&D expenditures by the industrial sector can be attributed to this situation, but many wholly Canadian firms do not carry out sufficient R&D to remain competitive in today's international markets. Clearly no component of Canadian industry can afford to be complacent about its investment in R&D.

Figure 6.2
Canadian GERD/ GNP Ratios



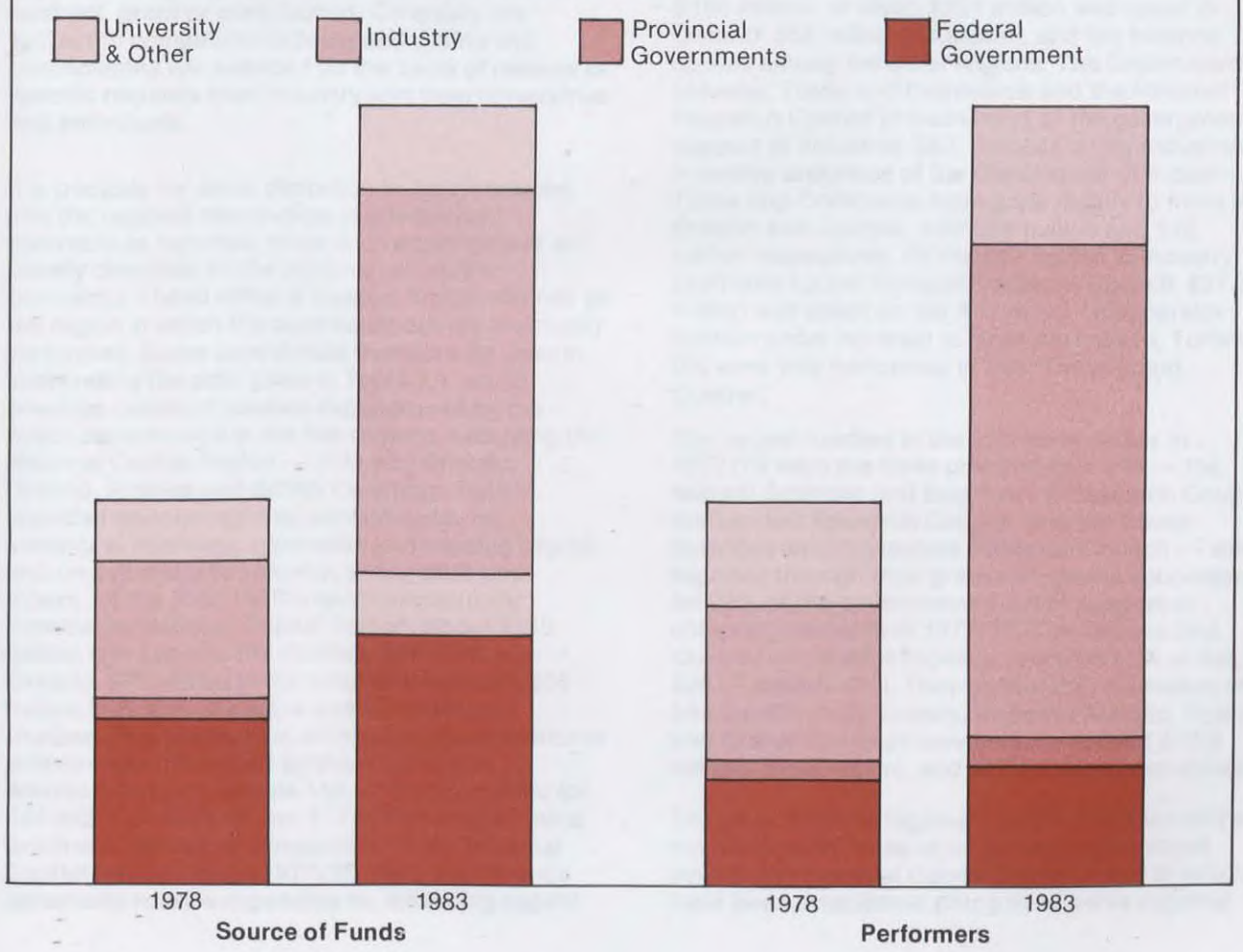
Source: Statistics Canada

Consistent with the above assumption about industry's share of GERD in 1983, the federal government's share of funding R&D would drop to about one-third, compared to its current share of over 40% (which makes it the largest funder). Its expenditures for R&D would not, however, decline. Rather they would have to grow annually by over 10% in real terms, or more than 15% in current dollar terms. In line with the government's current policies, such as restricting the size of the public service and contracting out its science requirements, most of the growth in its science expenditures would be in the form of contracts and grants for industrial R&D, and as a somewhat lower priority, support for university research. As a group the provincial governments currently spend proportionally much less on R&D than does the federal government. If the 1983 target is to be met, there must be substantial growth in funding and performance of R&D by the provincial sector.

In this scenario the university sector is assumed not to expand its own funding of R&D much over the next 5 years, faced as it is with declining enrolments, and considering that most of its funding comes from government. It was assumed that as a performer, however, the university sector would grow about 5% annually through receipt of some of the increases in government expenditures, in line with policies to channel research funds into national priority areas and to promote cooperation in R&D among industry, universities and government.

A pictorial comparison of sectoral shares of GERD in 1978 and 1983 under the above assumptions is shown in Figure 6.3.

Figure 6.3 Distribution of Canadian GERD (1978, 1983)



7. Special Topics

Regional Expenditures

This section provides an overview of the regional distribution of the government's S&T expenditures. Data are presented for 1977/78 only since it is not possible to predict with reasonable certainty which organization, group or individual will be awarded a contract, grant or contribution. Contracts are subject to competitive bidding and grants and contributions are awarded on the basis of reviews of specific requests from industry and from universities and individuals.

It is possible for some distortion to be introduced into the regional distribution of government contracts as reported, since such expenditures are usually classified by the region in which the contractor's head office is located, which may not be the region in which the contracted activity is actually performed. Some care should therefore be used in interpreting the data given in Table 7.1, which provides details of science expenditures by the major departments in the five regions, excluding the National Capital Region — Atlantic, Quebec, Ontario, Prairies and British Columbia. Data is provided on total regional expenditures, on intramural operating expenditures excluding capital, and on payments to industry, universities and others. Of the $381 million spent intramurally outside the National Capital Region, about $110 million was spent in the Prairies, $99 million in Ontario, $77 million in the Atlantic Provinces, $56 million in British Columbia and $39 million in Quebec. This distribution of intramural expenditures was strongly influenced by the laboratories of Atomic Energy of Canada Ltd. which accounted for $46 million in Ontario and $17 million in the Prairie provinces. By way of comparison, in the National Capital Region during 1977/78, the government's intramural science expenditures, excluding capital funds, totalled $588 million, and payments to industry were $23.2 million and to universities $8.1 million.

Regional expenditures in industry totalled about $192 million, of which $101 million was spent in Ontario, $55 million in Quebec, and the balance spread among the other regions. The Department of Industry, Trade and Commerce and the National Research Council provide most of the government's support of industrial S&T. Awards under industrial incentive programs of the Department of Industry, Trade and Commerce have gone mainly to firms in Ontario and Quebec, with $39 million and $30 million respectively. Of the $47 million in industry payments by the National Research Council, $27.7 million was spent on the Advanced Teleoperator System under contract to Spar Aerospace, Toronto; the work was performed in both Ontario and Quebec.

The largest funders in the university sector in 1977/78 were the three granting councils — the Natural Sciences and Engineering Research Council, the Medical Research Council, and the Social Sciences and Humanities Research Council — which together through their grants programs accounted for 78% of the government's direct support of university research in 1977/78. The Ontario and Quebec universities together received 63% of the $201.7 million total. They obtained $72.3 million and $54.9 million respectively, while the Atlantic, Prairie and British Columbia universities received $13.0 million, $34.5 million, and $27.0 million respectively.

The government's regional intramural expenditures mainly support those of its laboratories located outside the National Capital Region, most of which have been established primarily to serve regional

Table 7.1

Regional Science Expenditures 1977/78

Region	AGR	EMR	AECL	ENV	NRC	DND	ITC	MRC, NSERC, SSHRC	Other	TOTAL
					(millions of dollars)					
Grand Total	**61.2**	**32.0**	**78.2**	**189.2**	**68.8**	**48.0**	**78.5**	**159.2**	**111.2**	**826.2**
Atlantic	9.3	3.4	–	55.0	5.0	8.3	1.3	10.1	13.2	105.6
Quebec	6.9	2.1	9.6	15.1	5.2	14.4	30.4	42.1	31.6	157.5
Ontario	8.2	3.1	51.4	37.6	38.6	9.6	38.9	61.7	31.7	280.8
Prairies	29.3	20.8	17.2	38.7	8.9	12.2	3.5	28.0	20.7	179.3
B.C.	7.4	2.6	–	42.8	11.1	3.5	4.4	17.2	14.0	103.0
Intramural Total	**60.0**	**13.3**	**62.5**	**184.0**	**12.3**	**40.5**	**–**	**–**	**8.2**	**380.9**
Atlantic	9.2	2.5	–	54.1	3.0	7.9	–	–	0.7	77.4
Quebec	6.8	–	–	14.0	0.4	13.1	–	–	4.8	39.0
Ontario	8.2	0.6	45.5	37.0	1.0	4.8	–	–	1.7	98.9
Prairies	28.9	8.3	17.0	38.1	5.3	11.7	–	–	0.5	109.8
B.C.	7.0	1.9	–	40.8	2.6	3.0	–	–	0.5	55.6
Industry Total	**–**	**6.0**	**15.7**	**–**	**47.2**	**7.4**	**78.2**	**1.1**	**36.2**	**191.8**
Atlantic	–	0.8	–	–	1.7	0.4	1.2	–	5.0	9.1
Quebec	–	1.1	9.6	–	4.6	1.3	30.4	0.3	7.3	54.6
Ontario	–	2.2	5.8	–	37.0	4.8	38.9	0.6	11.8	101.0
Prairies	–	1.3	0.2	–	2.9	0.5	3.4	0.1	4.3	12.7
B.C.	–	0.7	–	–	1.2	0.5	4.4	0.1	7.7	14.5
University Total	**–**	**–**	**–**	**–**	**7.6**	**–**	**–**	**157.4**	**36.7**	**201.7**
Atlantic	–	–	–	–	0.1	–	–	10.0	2.9	13.0
Quebec	–	–	–	–	0.1	–	–	41.8	13.0	54.9
Ontario	–	–	–	–	0.3	–	–	60.6	11.4	72.3
Prairies	–	–	–	–	0.1	–	–	27.9	6.5	34.5
B.C.	–	–	–	–	7.1	–	–	17.1	2.8	27.0
Others Total	**1.1**	**12.7**	**–**	**5.2**	**1.6**	**0.1**	**0.3**	**0.6**	**30.1**	**51.7**
Atlantic	0.2	0.1	–	0.9	0.2	–	0.2	0.1	4.5	6.2
Quebec	0.1	1.0	–	1.2	0.1	–	–	0.1	6.5	9.0
Ontario	0.1	0.3	–	0.6	0.3	–	–	0.5	6.8	8.6
Prairies	0.4	11.2	-	0.6	0.7	–	0.1	–	9.3	22.3
B.C.	0.4	0.1	–	2.0	0.2	–	–	–	3.0	5.7

requirements. Some of the major R&D establishments are described below.

Atomic Energy of Canada Limited operates Canada's largest nuclear centre, the Chalk River Nuclear Laboratories (CRNL), at Chalk River, Ontario. The centre has five nuclear reactors and laboratories for engineering, metallurgy, physics, chemistry, biology and medicine. Facilities include two major research reactors, three auxiliary reactors, a tandem Van de Graaff accelerator and sophisticated analytical instrumentation. Research is carried out in such fields as nuclear physics, nuclear chemistry, radiobiology, reactor physics, radiation chemistry, environmental radioactivity and physics of solids and liquids. High priority is given at CRNL to applied research and development in support of the Canadian nuclear power program. The irradiation facilities in the NRX and NRU reactors have been used in the engineering testing of power reactor fuels and materials and in the investigation of their performance characteristics.

Atomic Energy of Canada Limited also operates a second nuclear research centre, the Whiteshell Nuclear Research Establishment, located at Pinawa, Man., 100 km northeast of Winnipeg, on the Winnipeg River. The establishment has the primary objective of developing economic nuclear power technology. The emphasis is on the development of metals, alloys and non-metallic materials for use in power reactors, and involves work in chemistry, chemical engineering, fuel development, metallurgy, engineering design and a wide spectrum of other disciplines.

The establishment has one engineering and materials test reactor which uses an organic liquid as the primary coolant and heavy water as the moderator. The only operating organic-cooled, heavy water-moderated reactor in the world, it has loop facilities incorporated in its pressure tube design for the testing of fuels, fuel cladding materials, heat transfer materials and nuclear power reactor systems and concepts developed in the laboratories.

The Department of Energy, Mines and Resources operates the Pacific and Atlantic Geoscience Centres at Patricia Bay, B.C., and Dartmouth, N.S. These centres perform geoscience studies and surveys of the coastal regions, the continental slope and the floor of Canada's oceans. The department also operates the Institute of Sedimentary and Petroleum Geology in Calgary which studies the sedimentary basins of western and arctic Canada. In Vancouver the Cordilleran and Pacific Margin division is concerned with the composition, structure and geological development of the Cordillera. The Western Research Laboratory, housed in the Alberta Research Council of Edmonton, performs research in carbonization, coal beneficiation and fine particle chemistry. In addition, small laboratories for mining research are located at Calgary and Elliott Lake.

Under the aegis of the Department of the Environment, the Canadian Forestry Service operates a number of research laboratories outside the National Capital Region. A national forestry institute located at Sault Ste Marie, Ont., specializes in work on the eradication, control and management of forest pests such as harmful insects, fungi and diseases. A second institute, at Petawawa, Ont., performs research on silviculture and tree genetics, forest fires, and forest management techniques and practices. In addition to these national institutes, there are six regional centres which carry out R&D designed to apply the general knowledge developed by universities and the national forestry institutes and to adapt it when necessary to the specific needs of local forest industries. These centres are located in Victoria, Edmonton, Sault Ste Marie, Quebec City, Fredericton and St. John's.

Another major network of federal environmental laboratories is concerned with fisheries and with water-related problems. The Department of the Environment operates three large institutions —the Bedford Institute of Oceanography at Dartmouth, N.S., the Institute of Ocean Sciences, at Patricia Bay, B.C. and the Canada Centre for Inland Waters, at Burlington, Ont. —housing hydrographers, marine scientists and engineers who study the aquatic environment found in Canada's lakes, rivers, coastal waters and oceans. These institutions, along with other smaller specialized laboratories in the various regions of Canada, perform research and related scientific activities in the areas of fisheries management, physical and chemical oceanography, aquaculture, hydrography, water quality monitoring and management, hydrology and hydraulics, and develop and demonstrate innovative and cost-effective technology for the control of water pollution. Their work is largely in support of the operational responsibilities of the Department of the Environment in the fields of environmental protection and management and fisheries management.

The Department of Agriculture operates 47 research establishments of varying size and degree of specialization, located from coast to coast. The research programs are aimed at alleviating current

and anticipated agricultural problems in the many soil and climatic zones of Canada. Each research station is specifically designed to serve the agricultural needs of the area in which it is located. Of special interest are the programs of the Beaverlodge Research Station, Alberta, working on northern agricultural problems; those of Summerland, B.C., and Kentville, N.S., on tree fruit research; and those at Swift Current Research Station, Sask. on dry land farming.

The Department of National Defence maintains five research establishments outside the National Capital Region. Those in Halifax and Esquimalt, Defence Research Establishments Atlantic and Pacific respectively, concentrate mainly on defence research oriented toward naval matters, including undersea warfare. The Defence Research Establishment Valcartier, near Quebec City, undertakes R&D projects mainly on armament, projectiles and explosives, although this centre is also credited with inventing the world's first atmospheric pressure gas laser. The establishment at Suffield, Alta., develops countermeasures against chemical and biological weaponry. The Defence and Civil Institute of Environmental Medicine, Toronto, conducts research on human perception and performance in adverse environments, and on the man-machine interface.

The National Research Council maintains a number of regional centres. The Atlantic and Prairie Regional Laboratories, at Halifax, N.S. and Saskatoon, Sask., carry out research and development programs in areas of local interest and importance, such as marine science and steel production in the east, and a major new thrust in fermentation technology in the west. The Division of Mechanical Engineering has a Vancouver laboratory which supports industries through research and development. The Division of Building Research and the Technical Information Service both operate a number of small offices scattered across the country where local businesses can have direct access to advice and information available on basic knowledge, techniques, guidelines, codes and standards. The Herzberg Institute of Astrophysics operates three major national facilities for astronomy: the Dominion Astrophysical Observatory in Victoria is the government's optical astronomy observatory, while the radio observatories at Penticton, B.C., and Lake Traverse, Ont., have achieved a reputation as world leaders in the field. The Space Research Facilities Branch operates the Churchill Research Range at Churchill, Man., as a national facility for experiments in space research. During 1979 it is planned to transfer most of this establishment to a new location at Gimli, Man. This new Space Research Facility will provide an improved balloon-launching capability as well as a headquarters for expeditions carrying out ground-based, rocket and balloon-borne space science programs.

In addition, the National Research Council plans to commence construction of two new research institutions in 1979/80. In St. John's, Nfld., a laboratory will be built for testing model ships and other marine structures in saline ice and open water tanks, while in Quebec, south of Montreal, work will begin on a materials research institute, *l'Institut de génie des matériaux*, NRC's first francophone research institute.

The Management of Federal Science Activities

The government's perception of problems and opportunities and its definition of national goals and priorities are reflected in the objectives set for federal departments and agencies. These objectives and priorities provide a framework for the development of programs, and for decisions on the resources to be allocated to achieve program purposes.

Several years ago the government recognized a need for new policies in science and technology. In February 1974, the Speech from the Throne described science policy as a basis for "the rational generation and acquisition of scientific knowledge and the planned use of science and technology in support of national goals."

In recognizing the need for science and technology to contribute to Canada's well-being, the government has given the Ministry of State for Science and Technology responsibility for advising on the most effective use of existing and proposed science resources to achieve departmental missions and for reporting how well the government's science activities comply with its objectives and policies in science and technology.

This responsibility for advice to the government on science programs and expenditures requires regular and close consultation with the Treasury Board Secretariat and with departments throughout the annual budget cycle. The ministry's Program Review and Assessment Division analyses, assesses and

provides advice on the science and technology components of both departmental Program Forecasts and Main Estimates, and of program submissions to Treasury Board. The advice is transmitted to the government through the Minister of State for Science and Technology, who is also a member of Treasury Board.

In addition to the advisory role just described, the ministry also collaborates closely with departments in the planning and implementation phases of science programs. The actual management of science programs is of course, the responsibility of the department or agency involved and in general, the allocation and utilization of resources are under the control of the managers responsible for program delivery. In certain areas, however, the government has assigned responsibility for leading, directing or coordinating major science or technology programs to a particular department or to a group of departments. The strategy adopted varies with the situation. A single department may be designated as the lead agency and be given the responsibility of coordinating or apportioning work among other departments or agencies of the government, in order to produce an integrated and coherent research and development program. This role is effected by interdepartmental committees or panels as coordinating bodies, as priority setting groups, or even as fund-allocating authorities.

The Ministry of State for Science and Technology is frequently included as a member of such committees, and provides for example, advice concerning the interpretation of government policies, or information which facilitates the coordination of science activities among departments.

A few examples of interdepartmental panels and committees concerned with science matters are those on Energy R&D, Space, and Transportation R&D. The following paragraphs describe in some detail the management structure that has been put in place for the government's energy R&D program. This includes an Interdepartmental Panel on Energy R&D, an Office of Energy Research and Development, several task coordinators, and an interlocking series of lead agencies at different levels of aggregation of projects and programs.

Following the OPEC oil embargo, an interdepartmental committee on energy research and development was established by the government in January 1974, charged with the provision of advice to the Minister of Energy, Mines and Resources in accordance with its defined objectives:

- to review federal energy R&D activities;
- to develop and implement a coordinated federal program on energy R&D;
- to advise Treasury Board on the allocation of funds for energy R&D;
- to coordinate energy R&D activities in the federal government, including the federal approach to major international and federal-provincial initiatives; and
- to provide for the exchange of information on energy policy and strategies which would affect the direction of federal energy R&D programs.

Currently the panel comprises nine permanent members, and 10 associate members, all at the assistant deputy minister or equivalent level.

The Office of Energy R&D in the Department of Energy, Mines and Resources is the secretariat to the panel and its committees and acts as a coordinating focus for federal energy R&D. The Director of the Office of Energy R&D acts as permanent secretary to the panel and as chairman of the Energy R&D Policy Advisory Committee.

The Office of Energy R&D has a full-time staff whose duties include control of quantitative and qualitative data on energy R&D activities; preparation of annual reviews of, and continued integration with, non-federal energy R&D activities; ongoing appraisal of long-term technical futures; and provision of an initial Canadian focus for systems analysis of energy policy with respect to its R&D implications.

In order to facilitate the panel's functions of review, coordination, budgetary advice and policy information exchange, the government's energy R&D has been classified under a system of tasks and programs. Each task is composed of a number of programs, and is coordinated by a task coordinator appointed from the agency with primary policy responsibility in that task. The task coordinator chairs a committee of program convenors, each of whom is responsible for the development and coordination of a program within that particular task.

The program convenor is usually an official of the department or agency responsible for most of the R&D in that program. He is responsible to the panel

for developing a coordinated program covering work within his own department and other departments, and for reporting on results. Responsibility for execution of the approved program rests with sub-program and project managers who are accountable to their respective departmental management for the achievement of their objectives.

Within the overall energy program, the Minister of Energy, Mines and Resources proposes to the Treasury Board the allocation of resources among departments, according to their individual mandates and spheres of capability. For example, under the Nuclear Power task, the National Research Council has been designated as the lead agency responsible for establishing a coordinated national program of research on controlled nuclear fusion.

An increasingly important aspect of resource allocation, both in S&T programs and in other areas, is the mechanism of the A-Base Review, which is a critical review of all existing and ongoing activities in terms of their relevance to departmental and governmental objectives, their effectiveness and their efficiency. As the need for expenditure restraint has intensified, the government has been requesting departments to reallocate existing resources to undertake new program initiatives. In several cases the process of reallocation has been formalized into a comprehensive, detailed review of the department's on-going activities, or A-Base, with each program component being subjected to critical scrutiny and each manager within the department being required to justify his expenditures directly to his deputy minister. On occasion representatives from the Treasury Board Secretariat and from the Ministry of State for Science and Technology have participated in such reviews, along with officials from the departments involved.

In some cases reviews have been conducted which cut across departmental lines. For example, two reviews of existing (A-Base) expenditures on energy R&D have been made (for the 1975/76 and 1976/77 fiscal years). The information so provided, together with current energy policy objectives, has been the basis on which the Panel on Energy R&D has recommended priorities for incremental new funding each year.

Among the benefits of such reviews are improved communication and understanding between senior management and middle managers, improved understanding by the managers of their own programs and an improved capability to respond to new government policy initiatives. The A-Base Reviews have some limitations, however, particularly in the case of science-oriented departments, in that the task force conducting the process may lack the technical expertise necessary for the proper evaluation of such activities as scientific research. In these cases the only persons who may be capable of reviewing the technical conduct of the work are the managers themselves. Nevertheless, non-experts can evaluate the management of the program on the basis of such evidence as clearly stated objectives, goals, projected schedules and milestones, and relevance to government objectives.

International Development and Canadian R&D

The United Nations Conference on Science and Technology for Development (UNCSTD), which will take place in Vienna in August 1979, is designed to bring about fundamental changes in the ways in which all countries, developed and developing, try to apply science and technology to the economic and social development of the Third World. Among the many tentative resolutions contained in the draft Program of Action to be discussed at the conference, the following three in particular reveal the implications for the planning and execution of R&D in the developed countries:

- R&D for the benefit of developing countries should be formally recognized as a national priority in developed countries;
- developed countries should allocate an increased share of their domestic R&D budgets to such activity;
- this R&D should, to the extent possible, be carried out within the developing world.

These proposals, and all of the others which will be discussed at the conference, are elements of the broader question about the evolution or creation of a "new international economic order". As conceived by Third World countries, this new order will be achieved only by the massive transfer of technology, resources and capital from the developed to the developing countries, by the introduction of revised terms of international trade, by a reform of the

international monetary system and by greatly increased aid. These topics are being negotiated in many international forums. The negotiations have, however, been affected by the economic difficulties experienced by the industrialized world in recent times.

The final phases of preparation for the conference itself lie ahead. Member countries of the United Nations are engaged in a series of preconference meetings to lay the groundwork for the decisions expected to emerge in Vienna. The goal is the definition of a realistic Program of Action with all countries resolving to improve or intensify their contributions to global development by the application of science and technology.

These early negotiations are likely to focus on a set of six "target areas" which the draft Program of Action characterises as follows:

Target Area I:

Sharing of knowledge and experience by all members of the international community;

Target Area II:

Increasing the capability for policy making in science and technology within the framework of development planning;

Target Area III:

Transfer of technology for the benefit of development;

Target Area IV:

Enhancing endogenous capabilities in a context of national self-reliance;

Target Area V:

Promoting collective self-reliance through cooperation among developing countries; and

Target Area VI:

Strengthening the role of the United Nations in the field of science and technology cooperation.

To quote from the draft Program of Action,

> "As far as science and technology are concerned, the New International Economic Order should ensure
>
> a) the cooperation of developed and developing countries in the establishment, strengthening and development of the scientific and technological infrastructure of developing countries;
>
> b) the significant expansion of the assistance of developed countries in direct support of the scientific and technological programmes of the developing countries, in accordance with feasible targets to be agreed upon;
>
> c) the substantial increase of the proportion of the research and development in developed countries devoted to the specific problems of primary interest to developing countries and to the creation of suitable indigenous technology, also in accordance with feasible targets to be agreed upon;
>
> d) the expansion of international co-operation on the basis of principles and regulations designed to adjust the scientific and technological relationships among states in a manner compatible with the special requirements and interests of developing countries, especially in the field of transfer of technology."

It is in this context that Canada is preparing for the conference. A major element in our preparation is the consideration of ways and means of enhancing the use of Canadian science and technology in our international development assistance program.

In creating the International Development Research Centre (IDRC) in 1971, Canadian policy, in a sense, anticipated by 8 years some of the principal thrusts to be discussed at the conference, since IDRC's main objective is to foster R&D for the developing countries, in the developing countries and, to the extent feasible, carried out by the scientists and technologists of the developing countries themselves. By 1975, as a consequence of the growth in IDRC's expenditures and other Canadian overseas development assistance, Canada and Sweden were the two OECD countries which devoted the largest share of their R&D budgets to international development; that year the figure stood at 2% of National Gross Expenditures on R&D. In 1979/80 IDRC's budget will reach $36.9 million, or 2% of the government's planned expenditures on R&D for that period.

Parallelling the activities of IDRC, the Canadian International Development Agency (CIDA) also funds S&T activities: its total science expenditures in 1979/80 are expected to be of the order of $30.8

million. In the past CIDA has made use of the scientific and technical competence of a variety of governmental, industrial and university-based Canadian institutions and has helped finance joint research activities involving scientific groups from Canada and Third World countries. More details on the current S&T programs of IDRC and CIDA, together with illustrative examples of typical projects, are provided in the Developing Nations section.

Among the preparations for UNCSTD is a detailed analysis of the prospects and problems of systematically expanding the involvement of the government's scientific and technological groups in collaborative research programs with Third World countries. Although this analysis is the most comprehensive single review being carried out specifically as an element of Canada's preparations for UNCSTD it is by no means the sole activity. Consultations are in progress with the provincial governments, with the professional and learned societies, with the non-governmental organizations concerned with international development, with the universities, and with business and labour. Organizations representing the S&T community are being consulted by the Royal Society of Canada and SCITEC under an agreement with the Ministry of State for Science and Technology. All these consultations share the same two primary objectives: to provide information to interested groups on global preparations for the conference and to receive from them reactions, comments, proposals or ideas which will contribute to the process of defining Canada's overall stance at the conference itself.

Three seminars, being planned respectively by the United Nations Association of Canada for February, and by *l'Association canadienne française pour l'avancement des sciences* and by IDRC for May, will provide further opportunities for widespread discussion of the issues involved in the conference agenda.

The one major element of Canada's preparations which is already complete is the submission to the Conference Secretariat of a "National Paper" dealing in a preliminary fashion with Canadian experience relevant to the themes of the conference and to the concerns of the developing world. It attempts to provide an outline of some Canadian experiments in applying science and technology to problems of development at home and abroad, and tries to reflect a sense of common interest in the global problems faced by the United Nations. To quote the preface of the National Paper,

> "Although a comparatively wealthy and technologically advanced country, much of Canada's past and contemporary situation makes us acutely aware of the challenges now faced by other developing nations. Our experience of foreign ownership of industry and resources, our global trade in basic commodities and raw materials, and our dependence on foreign markets for our manufactured goods have been fundamental forces in shaping and, to some extent, limiting our national S&T capacity. We have been net importers of capital, technology and skills. Our geographic station beside the world's largest economy has confronted us with chronic difficulties in maintaining an indigenous pool of skilled manpower, a high level of national expertise and training, and a viable component of innovative secondary industry. Successive Canadian governments have tried and are continuing to try to design institutions and mechanisms to enable S&T to be an effective part of the solutions to these crucial national problems."

Canada's experience in applying S&T to development is relevant to a United Nations conference in the late 1970s: firstly because our history of economic development is not remote, but recent; secondly because it is therefore a response to the contemporary economic and social problems of development; and thirdly because it is largely the story of a nation in search of a national indigenous competence in a modern world.