Ministry of State
Science and Technology
Canada

Ministère d'État
Sciences et Technologie
Canada

Federal Science Activities

1980/81

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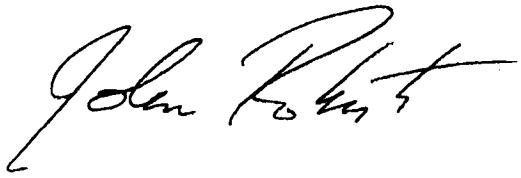
Foreword

This fourth annual publication reports on the scientific and technical activities to be funded by the government during the fiscal year 1980/81.

The 1980/81 Main Estimates presents the proposed total programs of departments and agencies. This report provides additional information on the government's expected activities in science and technology, using a descriptive narrative 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 an overview of the government's proposed activities in science and technology. More numerical data is available in the companion report "Federal Science Expenditures and Personnel, 1980/81".

This overview of the government's science programs is prepared by the Ministry of State for Science and Technology as part of its responsibility for the development of a science and technology policy and for the provision of advice to the government on the best use of science and technology. All departments and agencies which fund scientific and technological activities have cooperated in this task, and their assistance is gratefully acknowledged. Special thanks are due to the Treasury Board Secretariat and Statistics Canada; without their assistance, a complete report could not have been published at this time.



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1. Introduction

This report is a companion publication to the 1980/81 Main Estimates, and consequently departmental and agency programs are listed according to the format used in the Estimates. Agencies are grouped under the department of the Minister to whom they report or are responsible, for example Statistics Canada under the Treasury Board, 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 Related Scientific Activities (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 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, 1976/77 to 1980/81, indicating aggregate changes in expenditures. The second section, Special Applications, discusses science activities which although they may be 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.

2. Overview

The total government expenditures for science and technology are estimated to be $2,094 million in 1980/81, compared to forecast expenditures of $1,884 million in 1979/80, an increase of $210 million or 11%. The data on S & T expenditures for five years up to 1980/81 are given in Table 2.1.

Nearly half (47%) of the total increase in 1980/81 S & T expenditures is accounted for by three departments. The increase in S & T expenditures for the Department of Energy Mines and Resources is estimated at $24 million, of which $13 million is for energy S & T. The $30 million increase in the Department of Industry, Trade and Commerce includes $26 million increase in industry support programs. The $42 million increase in the budget of the Natural Sciences and Engineering Research Council was announced late in 1979.

A consideration of the two-year increase since 1978/79 shows that these three departments plus the National Research Council account for 60% of the $300 million increase in S & T expenditures. It should be noted that the two-year increase of $30.5 million for the National Research Council has occurred while the expenditures on a major space project, the Remote Manipulator System, have been decreasing markedly as it nears completion. Over the two-year period, Transport Canada has shown a significant decrease in S & T expenditures — $16.5 million — in large part due to the phasing-out of urban transportation research. The Department of National Health and Welfare has a two-year decrease of $4.2 million, although its estimated 1980/81 expenditures for S & T are increasing $5.6 million over 1979/80.

With respect to the 5-year pattern of S & T expenditures shown in Table 2.1, those in the Department of Communications show an increase which far outweighs that of any other department. The expenditures increased a factor of 2.5 by 1978/79 and over the five years a total of 272%, and the department's share of total governmental S & T expenditures increased from 1.1% in 1976/77 to 3.1% in 1980/81. Other departments and agencies showing an increase in their share of total S & T expenditures are: Agriculture, from 6.7% to 7.4%; Energy, Mines and Resources, from 6.0% to 8.0%; National Research Council, from 9.2% to 10.9%. Those showing decreases in their share of total S & T expenditures are: Atomic Energy of Canada Limited, from 6.3% to 4.6%; Statistics Canada, from 9.2% to 6.7%; Transport Canada, from 2.1% to 1.2%. The combined 1980/81 expenditures of Fisheries and Oceans with Environment (of which it was formerly a part), considered as a share of total S & T expenditures, shows a decrease from 17.1% in 1976/77 to 16.5% in 1980/81. The five-year pattern for the Department of Industry Trade and Commerce is complicated by the effect of replacing the Industrial Research and Development Incentives Act with tax incentives which are not classed as S & T expenditures. If payments under the act in 1976/77 and 1977/78 are included, there is a decrease from 7.3% to 5.0% in the department's share of S & T expenditures. If these payments are excluded on the premise that an equivalent support is provided by the tax incentives, then the remaining industrial S & T support program of the department shows an increase from 4.4% to 5% in its share of the total S & T expenditures since 1976/77.

Data on departmental and agency personnel engaged in S & T activities are shown in Table 2.2. Consistent with the policies of restraint in the growth of the Public Service and the contracting out of S & T activities there has been a steady decline in S & T person-years from 1976/77 to 1979/80, with a marginal increase estimated for 1980/81. The overall total decrease over the five years is 8%. Major decreases have been experienced by: Statistics Canada, 31%; National Health and Welfare, 12%; Transport Canada, 9.5%;

Table 2.1

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

Department	1976/77	1977/78	1978/79	1979/80	1980/81
			(millions of dollars)		
Total Science	**1,577.9**	**1,673.0**	**1,809.0**	**1,883.8**	**2,093.9**
Total Major Funders	1,424.3	1,511.5	1,661.2	1,719.9	1,922.5
Agriculture	106.5	117.9	127.2	142.0	155.7
Communications	17.8	30.3	61.9	65.0	66.3
Energy, Mines & Resources	95.4	118.4	124.5	143.7	167.8
Atomic Energy of Canada Ltd.	99.6	77.2	92.0	91.3	96.5
Environment	269.3	290.3	206.4	215.4	229.8
External Affairs					
Canadian International Development Agency	22.6	25.3	35.6	37.8	38.7
International Development Research Centre	32.4	34.5	36.7	35.7	40.0
Fisheries and Oceans	*	*	122.5	112.7	116.4
Industry, Trade & Commerce	115.2**	92.8**	61.4	74.8	104.8
National Defence	74.4	83.2	83.3	93.4	104.0
National Health & Welfare	49.5	62.7	58.2	48.4	54.0
Medical Research Council	51.9	57.9	64.2	70.1	80.0
Science & Technology					
National Research Council	145.3	172.6	197.2	211.2	227.7
Natural Sciences and Engineering Research Council	94.3	99.5	111.9	121.1	163.0
Secretary of State					
National Library	—	—	13.1	14.7	17.2
National Museums of Canada	42.2	45.7	55.1	51.2	52.5
Social Sciences and Humanities Research Council	29.2	33.2	34.6	36.6	42.6
Transport Canada	33.3	40.0	42.1	27.1	25.6
Treasury Board					
Statistics Canada	145.4	130.0	133.3	127.7	139.9
Others	153.6	161.5	147.8	163.9	171.4

* The Department of Fisheries and Oceans was established as a separate department in 1979; Expenditure data prior to 1978/79 are included in those of the Department of the Environment.

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

National Defence, 8.2%. On the other hand increases in person years have occurred in Atomic Energy of Canada Limited, 6.5% and the National Research Council, 2.5%. The major increase shown for the Department of Communications must be treated with reserve: part of it may be due to a statistical redefinition related to administrative support staff and which has not yet been reflected in the historical data series.

The government's expenditures on S & T according to performer sector are shown in Table 2.3. As a proportion of total science spending, expenditures on intramural S & T, after peaking in 1978/79, will decline in 1980/81 to their lowest point in the five-year period. Conversely extramural expenditures will show an increase of $95 million between 1979/80 and 1980/81: $23 million in industry, $64 million in universities and $9 million in the provincial sector. Over the five-year period S & T payments to industry, exclusive of payments under the Industrial Research and Development Incentives Act, have kept pace with the total extramural increases (37%) while S & T payments to university have increased markedly more — 63%. Even more marked is the increase in payments to provinces — 132% since separate data was first collected in 1977/78.

Expenditure data on R & D and RSA in the Natural Sciences are presented in Table 2.4. Total

Table 2.2

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

Department	1976/77	1977/78	1978/79	1979/80	1980/81
			(person-years)		
Total Science	**34,496**	**34,726**	**34,035**	**33,035**	**33,100**
Total Major Funders	31,188	30,409	30,581	29,518	29,644
Agriculture	4,186	4,176	4,168	4,105	4,091
Communications	422	425	635	640	646
Energy, Mines & Resources	2,434	2,422	2,458	2,421	2,415
Atomic Energy of Canada Ltd.	2,321	2,275	2,363	2,343	2,473
Environment	7,177	7,332	4,989	4,665	4,645
External Affairs					
Canadian International Development Agency	51	51	56	56	56
International Development Research Centre	331	344	217	237	230
Fisheries and Oceans	*	*	2,423	2,325	2,325
Industry, Trade & Commerce	183	171	170	281	349
National Defence	2,126	2,142	1,909	1,916	1,952
National Health & Welfare	1,104	1,205	1,099	966	971
Medical Research Council	39	39	40	40	39
Science & Technology					
National Research Council	3,055	3,073	3,083	3,105	3,131
Natural Sciences and Engineering Research Council	48	57	59	61	75
Secretary of State					
National Library	—	—	494	500	500
National Museums of Canada	997	1,002	1,026	1,014	1,006
Social Sciences and Humanities Research Council	96	97	98	107	105
Transport	221	166	183	202	200
Treasury Board					
Statistics Canada	6,397	5,432	5,111	4,534	4,435
Others	4,308	4,317	3,627	3,517	3,456

* The Department of Fisheries and Oceans was established as a separate department on 2 April 1979; data prior to 1978/79 are included in those of the Department of the Environment.

expenditures in Natural Sciences are estimated to be $1,647 million for 1980/81, of which 75% is for R & D. The estimated R & D expenditures are $155 million or 14% higher than those forecast for 1979/80. The overall increase since 1976/77 is 45%. The intramural share rose from 1976/77 to 1978/79 and has since declined to a value slightly below that in 1976/77. With respect to the five-year behaviour of the industry share, the replacement of the Industry Research and Development Incentives Act with other tax incentives not reported as expenditures is a complicating factor. At least its share has remained at about the same level as for the last year of payments under the act (1977/78). The university share has shown an overall increase over the five years.

The estimated RSA expenditures in the Natural Sciences for 1980/81 are $405 million, a 21% increase over the five years, and 6% over 1979/80, compared to 14% for R & D, reflecting the greater emphasis being placed on R & D. The intramural share has increased marginally over the five years, while the industry share has dropped five percentage points and the other performing sectors have together increased about three percentage points.

Expenditure data on R & D and RSA in the Human Sciences are provided in Table 2.5. The 1980/81 estimated expenditures are $447 million, a 7.7% increase over 1979/80 and 15.5% since 1976/77. The expenditures on Human Sciences will account for

Table 2.3

Federal Expenditures on Scientific Activity by Performer

Performer	1976/77		1977/78		1978/79		1979/80		1980/81	
	(millions of dollars and (%))									
Total	**1,577.9**	**(100)**	**1,673.0**	**(100)**	**1,809.0**	**(100)**	**1,883.8**	**(100)**	**2,093.9**	**(100)**
Intramural	1,010.5	(64)	1,070.0	(64)	1,188.3	(66)	1,200.8	(64)	1,316.3	(63)
Extramural	567.4	(36)	603.0	(36)	620.8	(34)	683.0	(36)	777.7	(37)
Industry	268.2*	(17)	262.2*	(16)	254.3	(14)	281.1	(15)	303.9	(15)
University	197.6	(13)	223.8	(13)	244.9	(14)	258.9	(14)	322.4	(15)
Private Non-Profit	21.9	(1)	23.4	(1)	27.4	(1)	25.4	(1)	23.1	(1)
Provincial & Municipal Governments	32.7**	(2)	24.9	(1)	29.6	(2)	48.4	(2)	57.8	(3)
Other Canadian			23.5	(1)	17.6	(1)	20.5	(1)	17.4	(1)
Foreign	47.1	(3)	45.1	(3)	47.0	(3)	48.7	(3)	53.1	(2)

* Includes payments under the Industrial Research and Development Incentives Act (IRDIA) program; 1976/77 $45.9 million, 1977/78 $16.4 million.

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

21% of the government's total S & T expenditures in 1980/81, compared to 24.5% in 1976/77. In contrast to the Natural Sciences, expenditures for RSA account for 77% of the total for Human Sciences and the share of RSA performed intramurally in 1980/81 is slightly higher than it was in 1976/77. 47% of the intramural effort in RSA is conducted by Statistics Canada, with estimated 1980/81 expenditures of $140 million. On the other hand more than half of the R & D in Human Sciences is carried out extramurally, and the university share of this extramural work has increased steadily and substantially from 41% in 1976/77 to 57% in 1980/81.

During 1979 a major innovation in the resource allocation process was introduced, known as the (budgetary) envelope system. In this system all of the government's expenditures — departmental and agency budgets, fiscal transfer payments, public debt, Parliamentary operations — were grouped into a series of envelopes for which expenditure ceilings were established. Resource allocation decisions were then made within each envelope. From the point of view of S & T resource allocation the relevant envelopes are: Economic Development, Social Development, External Affairs, Defence, Justice and Legal, Services to Government.

S & T expenditures by major funding departments and agencies, classified by budgetary envelope, are shown in Table 2.6 for the three years, 1978/79 through 1980/81. The estimated increases over 1979/80 are: Economic Development, 12.5%; Social Development, 9.8%; External Affairs and Defence, 9.1%; Justice and Legal, 6.2%; Services to Government, 7.7%. The above-average increase for the Economic Development envelope reflects the emphasis that has been placed on economic development initiatives in the past two years.

Table 2.4

R&D & RSA Expenditures—Natural Sciences

	1976/77		1977/78		1978/79		1979/80		1980/81	
	(millions of dollars and (%))									
Total Natural Sciences	**1,190.8**		**1,277.9**		**1,397.8**		**1,468.5**		**1,646.8**	
R&D Expenditures (Total)	**855.5**	**(100)**	**918.0**	**(100)**	**1,011.2**	**(100)**	**1,087.4**	**(100)**	**1,242.0**	**(100)**
Intramural	460.8	(54)	506.4	(55)	583.4	(58)	592.6	(54)	658.5	(53)
Extramural (Total)	394.8	(46)	411.6	(45)	427.8	(42)	494.9	(46)	583.6	(47)
Industry	198.4*	(23)	186.4*	(20)	181.8*	(18)	214.7	(20)	238.1	(19)
University	148.5	(17)	171.1	(19)	190.3	(19)	203.3	(19)	252.7	(20)
Private Non-Profit	8.7	(1)	7.2	(1)	8.3	(1)	8.0	(1)	8.7	(1)
Provincial & Municipal Governments	10.5**	(1)	11.9	(1)	13.8	(1)	32.6	(3)	44.1	(4)
Other Canadian			6.4	(1)	4.3	(–)	4.8	(–)	5.3	(–)
Foreign	28.3	(3)	26.6	(3)	29.3	(3)	31.5	(3)	34.7	(3)
RSA Expenditures (Total)	**335.2**	**(100)**	**359.8**	**(100)**	**386.6**	**(100)**	**381.1**	**(100)**	**404.8**	**(100)**
Intramural	256.4	(76)	273.6	(76)	296.1	(77)	294.0	(77)	316.6	(78)
Extramural	78.9	(24)	86.3	(24)	90.4	(23)	87.0	(23)	88.2	(22)
Industry	55.4	(17)	56.6	(16)	58.0	(15)	50.0	(13)	49.8	(12)
University	12.4	(4)	13.3	(4)	13.7	(4)	14.2	(4)	21.0	(5)
Private Non-Profit	1.5	(–)	2.2	(1)	2.5	(1)	2.6	(1)	2.8	(1)
Provincial & Municipal Governments	6.8**	(2)	5.1	(1)	7.5	(2)	9.3	(2)	6.6	(2)
Other Canadian			7.2	(2)	6.3	(2)	8.3	(2)	4.7	(1)
Foreign	2.8	(1)	2.0	(1)	2.4	(1)	2.6	(1)	3.3	(1)

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

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

Table 2.5

R&D & RSA Expenditures—Human Sciences

	1976/77		1977/78		1978/79		1979/80		1980/81	
	(millions of dollars and (%))									
Total Human Sciences	**387.2**		**395.1**		**411.3**		**415.3**		**447.2**	
R&D Expenditures (Total)	**107.6**	**(100)**	**101.0**	**(100)**	**100.3**	**(100)**	**100.1**	**(100)**	**103.1**	**(100)**
Intramural	55.9	(52)	47.6	(47)	42.2	(42)	42.4	(42)	45.3	(44)
Extramural (Total)	51.7	(48)	53.3	(53)	58.1	(58)	57.7	(58)	57.8	(56)
Industry	6.6	(6)	5.7	(6)	4.9	(5)	6.6	(7)	4.9	(5)
University	21.4	(20)	21.6	(21)	26.0	(26)	27.5	(27)	32.9	(32)
Others	23.7	(22)	26.0	(26)	27.2	(27)	23.6	(24)	20.0	(19)
RSA Expenditures (Total)	**279.6**	**(100)**	**294.1**	**(100)**	**311.1**	**(100)**	**315.2**	**(100)**	**344.1**	**(100)**
Intramural	237.5	(85)	242.4	(82)	266.6	(86)	271.8	(86)	295.9	(86)
Extramural (Total)	42.1	(15)	51.7	(18)	44.5	(14)	43.4	(14)	48.2	(14)
Industry	7.8	(3)	11.6	(4)	9.6	(3)	9.8	(3)	11.2	(3)
University	15.3	(5)	17.8	(6)	14.9	(5)	14.0	(4)	15.8	(5)
Others	19.0	(7)	22.4	(8)	20.0	(6)	19.6	(7)	21.2	(6)

Table 2.6

Federal Expenditures on the Natural and Human Sciences by Budgetary Envelope

Departments	1978/79	1979/80	1980/81
		(millions of dollars)	
Total science	**1,809.0**	**1,883.8**	**2,093.9**
Total—Economic Development	**1,029.9**	**1,087.7**	**1,223.9**
Agriculture	127.2	142.0	155.7
Communications	61.9	65.0	66.3
Employment and Immigration	10.0	10.2	9.8
Energy, Mines and Resources	124.5	143.7	167.8
Atomic Energy of Canada Ltd.	92.0	91.3	96.5
Environment—Canadian Forestry Service	29.8	34.0	33.8
Fisheries and Oceans	122.5	112.7	116.4
Industry, Trade and Commerce	61.4	74.8	104.8
Science and Technology			
National Research Council	197.2	211.2	227.7
Natural Sciences & Engineering Research Council	111.9	121.1	163.0
Supply and Services	12.4	15.3	16.1
Transport	42.1	27.1	25.6
Others	37.0	39.3	41.5
Total—Social Development	**436.8**	**442.6**	**486.1**
Environment (except Canadian Forestry Service)	176.6	181.4	196.1
National Health and Welfare	58.2	48.4	54.0
Medical Research Council	64.2	70.1	80.0
Secretary of State			
National Library	13.1	14.7	17.2
National Museums of Canada	55.1	51.2	52.5
Social Sciences & Humanities Research Council	34.6	36.6	42.6
Others	35.0	40.2	43.7
Total—External Affairs and Defence	**160.5**	**172.2**	**187.9**
External Affairs			
Canadian International Development Agency	35.6	37.8	38.7
International Development Research Centre	36.7	35.7	40.0
National Defence	83.3	93.4	104.0
Others	4.9	5.3	5.2
Total—Justice and Legal	**7.2**	**9.7**	**10.3**
Total—Services to Government	**174.7**	**171.6**	**184.8**
Treasury Board	10.5	11.7	11.8
Statistics Canada	133.3	127.7	139.9
Others	30.9	32.2	33.1

Figure 2.1
Federal S&T Activities by Performer

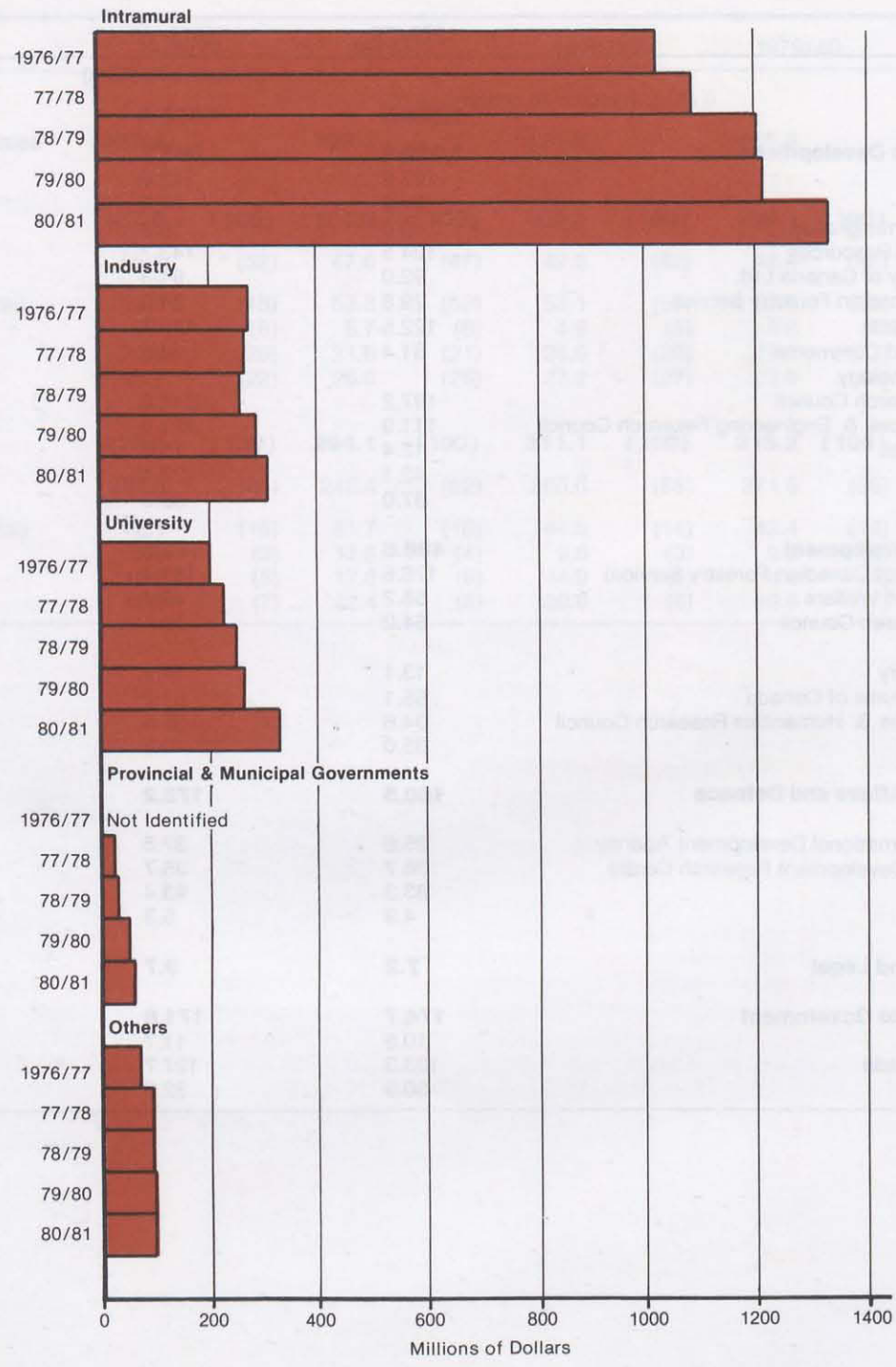


Figure 2.2
Federal Expenditures in Natural Sciences

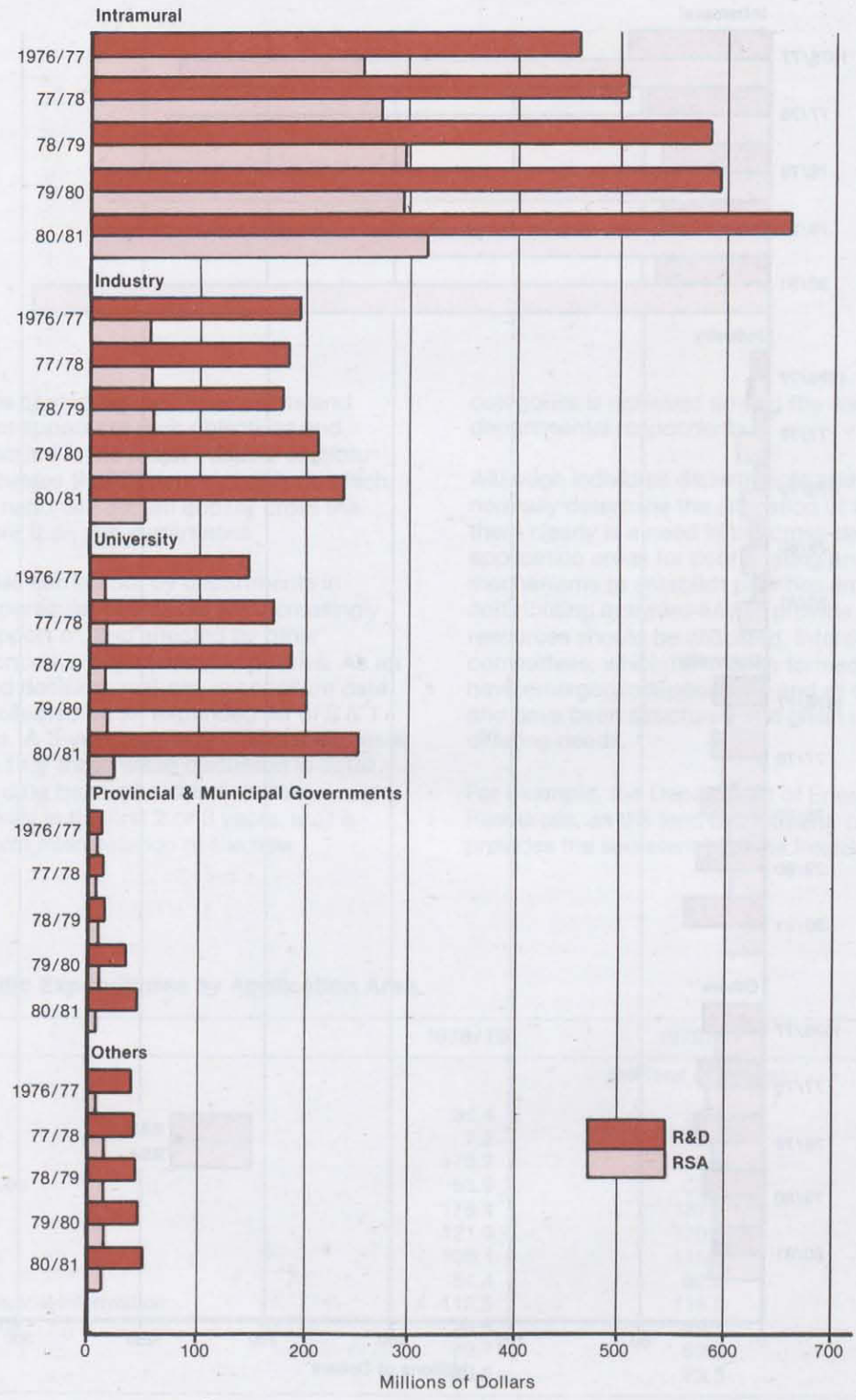
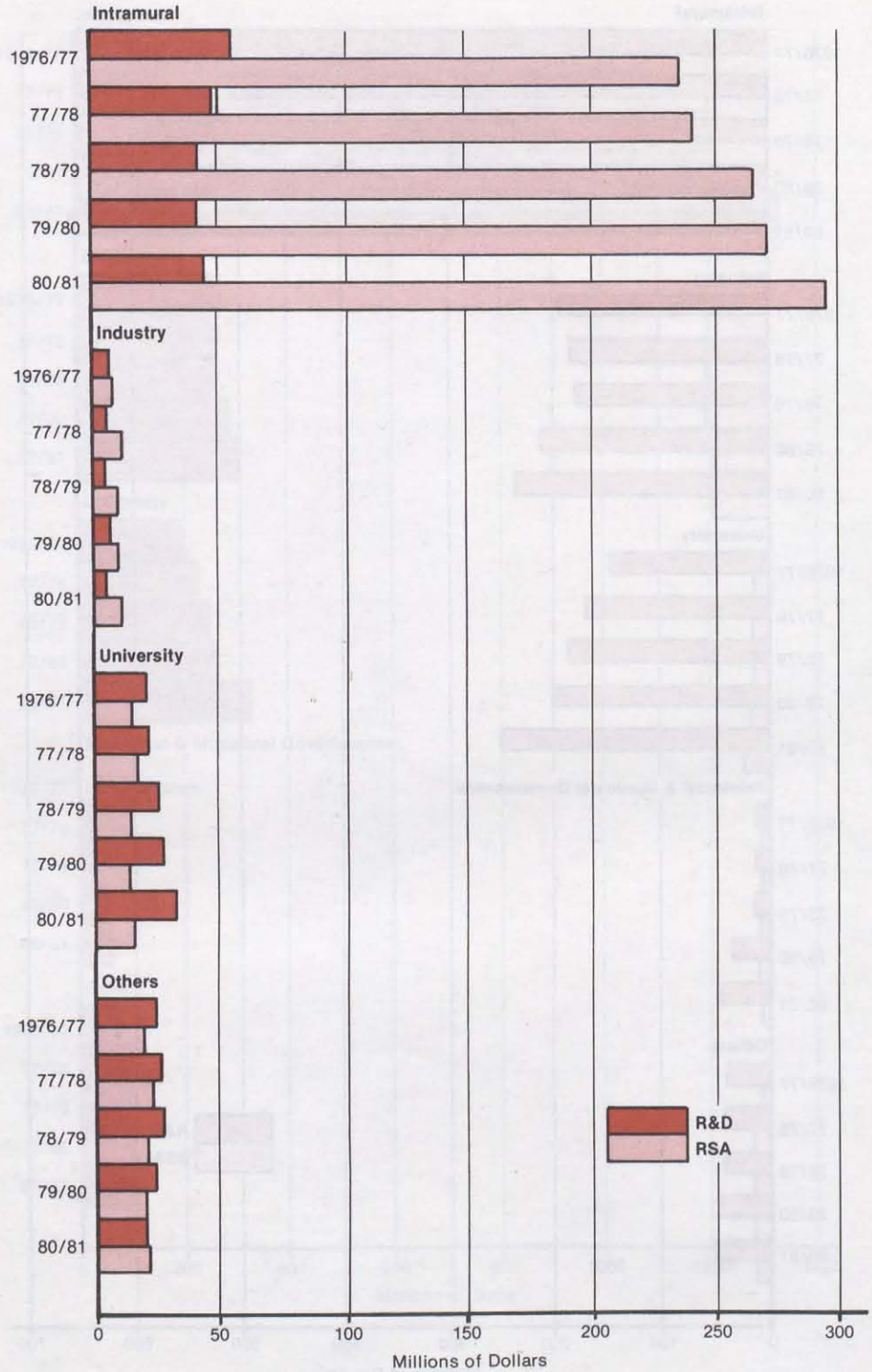


Figure 2.3
Federal Expenditures in Human Sciences



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

Table 3.1

Federal Scientific Expenditures by Application Area

Application Area	1978/79	1979/80	1980/81
		(millions of dollars)	
Communications	31.4	36.5	39.4
Domestic Security	7.2	8.4	9.2
Energy	178.2	210.0	235.6
Environmental Issues	53.9	57.4	58.7
Food	178.4	187.1	203.0
Health	121.0	120.2	135.8
Natural Resources	106.1	115.0	120.6
Oceans	54.4	52.2	53.4
Scientific and Technical Information	112.5	118.8	131.0
Social Development	28.5	28.1	28.2
Space	79.7	62.9	54.8
Transportation	89.8	73.3	73.7

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 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 an integrated program for approval 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

New technologies such as lasers, fibre optics, micro-computers, large scale integration and videodiscs are the ingredients of what has come to be known as the "Information Revolution". These ingredients make it possible to provide nearly universal access to a myriad of new computer-based information services, whose number and variety are limited only by our imagination. The basis of such access will be a well developed communications system. The orderly development of Canadian communications is the responsibility of the Department of Communications. Consequently, as may be seen in table 3:2, the predominant majority of the government's expenditures occur in this department. The other agencies playing a role in communications science are the National Research Council and the Canadian Broadcasting Corporation.

The impact of the Information Revolution is being compared to that of the industrial revolution. Just as that revolution multiplied man's physical strength, so the information revolution will multiply his intellectual capacity. The communication and application of information in many different forms makes us human. Consequently quantum jumps in our ability to handle it are likely to be marked by fundamental changes in human society. The Organization for Economic Coordination and Development has stated that "Out of this universal ability of 'information power', there will flow special changes and opportunities for human development that promise to make the next four decades among the most critical mankind has ever faced".

The most striking aspect of these new electronic information systems and services is the speed with which they have developed. Even ten years ago they were still dreams for the future. Now, however, in a myriad of different forms, combined computer-communications systems are spinning a web of services around the globe.

In the light of these factors, the Department of Communications has established the objective of "channeling the communications revolution to the benefit of Canada and Canadians" as its highest overall priority and under this umbrella has identified the subsidiary objective of developing appropriate policies, plans and programs for:

- Achieving the most rapid feasible expansion of services and systems without prejudice to other social priorities;

Table 3.2

Federal Science Expenditures in Communications

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**31.4**	**36.5**	**39.4**
Communications	21.1	23.8	26.7
National Research Council	3.6	2.8	3.1
Canadian Broadcasting Corporation	3.1	3.3	3.5
Others	3.6	6.6	6.1

- Ensuring equitable distribution of services to all social and regional groups;
- Ensuring adequate Canadian control and ownership;
- Protection of right of access;
- Protection of privacy;
- Protection of freedom of speech.

Videotex is a generic name for systems which permit a residential or business subscriber to use a suitably modified television set to access information stored in a central computer data bank, or to cause information to be transmitted to the computer or to another terminal. Information transmission can be via a telephone line, a cable system, optical fibre or radio transmission. The development of a Canadian Videotex system called TELIDON was first announced in August, 1978. Its development arose out of some generic applied research, which began in 1974 at the Communications Research Centre of the department.

To promote the exploitation of TELIDON, the department has instituted an on-going program of field trial subsidization, assistance towards the development of production prototypes of the necessary range of equipment, and coordination, standardization and related activities. A Consultative Committee has been formed, comprising representatives of information suppliers, carriers, cable TV companies and broadcasters, manufacturers, labour and civil groups, to help guide Telidon development and to give early warning of possible problems.

Product development in the Canadian electronics industry is proceeding at a rapid pace. Bell Canada is undertaking a $10 million field trial of TELIDON which will involve over 1,000 terminals with about 100,000 "pages" of accessible information. Other field trials of TELIDON are underway or planned by Alberta Government Telephone, Manitoba Telephone System, the Ontario Educational Communications Authority and Telecable Videotron.

A key element of the exploitation strategy is to maximize Canadian content delivered to Canadian homes via TELIDON by encouraging the rapid growth of Canadian commercial information sources. At the same time, to broaden the potential market for TELIDON, the department is pursuing the international adoption of TELIDON communications protocols via international standards meetings.

In recent years, automation (in the form of free standing text editing and automatic word processors) has been making rapid inroads into the office environment. At the same time, new data communications services have led to the creation of computer communications networks which permit wide-spread access to data processing and information services of all kinds. These two technologies, data communications and automatic word processing, are now being combined to make possible automated offices, or "offices-of-the-future", involving electronic office-to-office communications, information storage and retrieval, and sophisticated information management tools. As a result, it is expected that there will be large-scale office automation in the immediate future. Canada, with a leading position in both the data communications and word processing industries, has an excellent opportunity to play a major role in office automation.

Under the leadership of the department, a joint government-industry program has been initiated to establish Canadian industrial leadership in certain communications-related aspects of the office-of-the-future through the development of nationally manufactured equipment to implement Canadian network services. The first phase, a market survey, was completed in November, 1979, with a report by Canadian National-Canadian Pacific Telecommunications, which indicated a market potential for office communications in the order of $5-20 billion over the next fifteen years. The immediate target is to extend word processing technology to complement and strenthen the existing range of TELEX services provided to some 40,000 Canadian subscribers.

On the industry side, the initial strategy was to build a vertically-integrated industrial structure around one company, but the current strategy is to develop an adequate capital base for growth through direct involvement of several Canadian companies in a consortium of equipment and service suppliers. On the government side several departments are involved. For example, the industrial aid programs of the Department of Industry, Trade and Commerce will be able to assist in the development of Canadian hardware and software products and in the establishment of Canadian manufacturing capability. The Department of Communications' specific role in the program is the development of a "systems" capability, in which a range of compatible products operating in a network environment can solve office communications problems for both domestic and foreign users. The objectives of the department's activities in this program are:

- to ensure operating compatibility of Canadian products in both national and international network environments;

- to foster the development of a suitable industrial infrastructure in the office communication systems field;

- to plan and manage field trials of Canadian-made products and services in order to accelerate development, optimize performance and demonstrate Canadian capabilities.

The efficient exploitation of the radio frequency spectrum is a statutory responsibility of the federal government, i.e., the Department of Communications. To discharge this responsibility effectively, research is required on the propagation of radio waves, natural and man-made sources of unwanted radio emissions or interference, and the development of techniques for more extensive use of the available spectral regions. Since 1969 the effort has increasingly been devoted to increasing the efficiency of spectrum utilization in the face of growing congestion and complete exhaustion of available space in the most favourable bands.

The projects that comprise this program are relatively small and respond only to the most critical issues identified by the department or industry. While the research results have considerable impact on the performance and efficiency of the nation's communications systems and their development, this impact is seldom visible to the public at large. Much of the program involves joint activities with Canadian industry and universities. At present the department is supporting spectrum research projects at Nova Scotia Technical College, Laval University, McGill University, the University of Western Ontario, University of Manitoba and the University of British Columbia. On the industrial side, there are cooperative programs with several telephone carriers for the study of propagation problems associated with the new, high-capacity 8GHz digital relay systems which are being installed across Canada. In these projects the department is providing both equipment and expertise to assist in the evaluation of system performance.

A substantial proportion of the research resources are dedicated to work in support of policy and regulatory priorities. An extensive study of electromagnetic propagation in the Great Lakes area was initiated to provide technical data required for policy development and planning for broadcasting and land mobile services. Considerable research effort has also been deployed in developing the automated spectrum management system, mainly for determining spectrum usage and for spectrum surveillance.

In addition to addressing research problems of departmental and national concern the program has also provided extensive input to the work of the International Telecommunications Union. Much of this has appeared in the recommendations and reports of the International Radio Consultative Committee or in the deliberations of World Administrative Radio Conferences.

Mobile radio systems serving users on land, air and water operate on frequencies assigned by the department under the Radio Act. The department has a number of activities in progress, ranging from planning for a satellite to serve air and marine and some land mobile users to development of mobile digital radio systems. The most interesting activity is planning for the eventual development of a national, universally accessible mobile radiotelephone service. The current service provides access from mobile stations (e.g. car or truck) via a radio link and the "mobile operator" to the public telephone network but the price is too high for it to be a universal service. Additionally, in some parts of the country (Alberta, British Columbia, Toronto) the service is heavily used and congestion prevents expansion of the service.

A major departmental project, leading to the eventual development of integrated mobile radio systems, is being conducted under contract with Westech Ltd., a consortium recently established by Alberta Government Telephones. Westech is to design a mobile radiotelephone system aimed initially at meeting Alberta's needs. The system will be fully integrated with the general telephone network to provide universal toll-quality, mobile telephony.

The next phase of the development will involve a broader program of research and development, leading to the development of a fully automatic system integrated to the telephone network, and a field trial to evaluate its performance. The total cost of the program is estimated at $6 million over four years. Approximately one half of this total cost will be shared with industry while the other half, relating to system options and the generation of specific information of interest to the department will be funded by the government.

The Rural Communications Program and the Communications Network Research activities of the sector were recently combined into one program currently known as the Communications Networks R & D program. The rural program started in 1976, and by April 1980 it will have spent, exclusive of field trials, close to $2 million in contracts and incurred a total in-house effort of approximately 30 person-years. The prime objectives of this program are:

- to provide the engineering and economic framework for the development of Federal policies on rural communications;

- to foster federal-provincial cooperation in the improvement of rural services;
- to stimulate Canadian product design for rural communications;
- to create a coherent domestic market base for equipment to be used in improving rural services.

Canada is ranked as having one of the best telecommunications services in the world. This is really only true for our major cities; Canadians in rural areas endure a lesser quality of communications services due to lack of market incentives for suppliers of the services and to the use of outdated technologies. With the rapid development of satellite systems, fibre optics, etc., a major purpose of the program is to evaluate current technologies and encourage developments which bring the quality of rural communications closer to that of our urban systems. A number of activities are jointly carried out with universities for technical studies, Canadian industry for hardware and system development, and provincial government agencies and carriers for field trials. Current activities will advance previous work on rural communications toward joint industrial field trials and implementation such as the Elie field trial and the Rural Interface Device programs.

In the network R & D area, Canada has been in the forefront in network development. The department's participation in international bodies such as the International Telegram and Telephone Consultative Committee and the International Standards Organization are included in the Network R & D program, to ensure that Canadian interests in communications services, network and equipment standards are adequately protected. In order to deal with standardization issues at the national and international level, priority is given to the study of digital networks and network protocols.

Domestic Security

The application area, domestic security, aggregates scientific activities related to the protection of the life and property of the citizens of Canada. In practice, these activities are mainly concerned with improving the effectiveness and fairness of the criminal justice system, aiding in the reduction of the social and economic costs of crime and the criminal justice system and increasing public understanding and support for crime prevention and control efforts. As shown in table 3:3, only three departments and agencies report science activities in support of domestic security, although it is known that the Royal Canadian Mounted Police is actively engaged in human and natural science activities both for its own requirements and to provide support for other police forces in Canada.

One of the responsibilities of the Department of Justice is to overview both public policy and legal policy issues at the federal and provincial levels. The public, Parliament and various priority-setting reviews have stressed the need to identify and remedy deficiencies and anomalies in the law and the legal system. Within the department much of the requisite work falls to the Policy Planning and Development Branch; one of its objectives is "to promote the development of laws and a legal system that are sensitive and responsive to the needs of the citizens and are more intelligible and accessible to the public". In support of this objective, the following kinds of activities are involved:

- development of a decision-making framework and background analyses for developing departmental objectives and policies;

Table 3.3

Federal Science Expenditures for Domestic Security

Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**7.2**	**8.4**	**9.2**
Justice	2.6	3.4	3.9
Law Reform Commission	2.3	2.4	2.8
Solicitor General	2.3	2.6	2.5

- perceptive evaluation of emerging issues concerning the law and legal system that can be expected to require policy responses;

- the identification of research needs and the promotion of a research capacity as an aid to: (i) law reform; (ii) the identification of anomalies and inconsistency in the law; and (iii) the evaluation of the operation of the legal system;

- background studies on policy issues to expose, question and clarify basic assumptions that underly policy concerns;

- recommendations to senior officials of the department and the government regarding legal and empirical studies which should be conducted;

- integration of program objectives, output measures and evaluation mechanisms into new policy initiatives and ongoing program commitments;

- the collection and development of statistics required for the development and evaluation of legal policies, programmes and experimental projects.

Although a wide range of projects are carried out, they may be grouped into three main categories. The first is policy-directed research, which is intended to provide a valid and reliable base of social and legal information for the development of policy options in such areas as: family violence; sexual offences against adults and children; drugs and crime; human experimentation; consanguinity and affinity; sentencing; the jury; homicide and assault; arrest and seizure; the general part of the criminal law; discovery; Unified Family Courts; administrative law; the Federal Court; commissions of enquiry and judicial review; and representations in the public interest.

The second category of projects is concerned with policy development and coordination. The projects arise from a wide variety of sources, with varying time frames and priorities. Some examples are: child abduction and abuse; courts policing; criminal justice policy; the federal role in law enforcement and prosecution.

The third category is concerned with assessment of proposals from the Law Reform Commission dealing with: sexual offences; mental disorder; diversion, evidence; marriage; divorce and maintenance; criminal responsibility; contempt; the jury; homicide and assault; arrest and seizure; the general part of the criminal law; discovery; Unified Family Courts; administrative law; the Federal Court; commissions of enquiry and judicial review; and representations in the public interest.

All of the expenditures of the Law Reform Commission of Canada are classed as Human Sciences. Its objective is to study and keep under review on a continuing and systematic basis the statutes and other laws of Canada with a view to making recommendations for their improvement, modernization and reform. The commission's Criminal Law Project is a major research activity which divides itself naturally into substantive criminal law and criminal procedure. This same division in the law itself has been suggested by both the judiciary and the bar associations, i.e., that there be a substantive Criminal Code and a separate statute, The Code of Criminal Procedure. The objective of the commission is not necessarily the production of a "new" criminal code but to conduct a fundamental review based on deliberate and careful research. Another concern of the commission is the importance of statistical record-keeping in legal matters by the government.

Under the Administrative Law Project the commission engages in a variety of activities: preparation of papers and participation in conferences; discussions with and advice to regulatory agencies concerning such matters as disclosure of information and confidentiality, regulations and sanctions; cooperation and information exchange with both federal and provincial agencies, bar associations, law faculties and international law associations. In particular, examination of representative kinds of independent administrative agencies is underway, and has resulted in a recent working paper which assessed the scope of reforms for such agencies.

Research activities within the Ministry of the Solicitor General are concentrated in the Research Division, whose overall objective is to develop and communicate valid generalizable knowledge and information about crime, criminal behaviour, the operation of the criminal justice system and related public concerns.

The research program is divided into four general areas: prevention of crime and victim assistance; research related to criminal justice policy; police research; and corrections research. Most of the research is performed extramurally under contract with universities and private consultants. Some research is contracted to other government agencies, such as Statistics Canada. The division's policy is to develop its research program in close consultation with the eventual clients for the information. Because of the time required to generate new knowledge, and the difficulty of administrators to be able to anticipate problems, the division has initiated activities which will help to forecast trends in crime and criminal justice and the kinds of new information needed.

Some examples of the division's larger research projects are the following. A major victimization survey was conducted in Vancouver at the end of 1979, and the data are being analyzed. The survey technique was developed by the division to collect data on: the frequency and distribution of selected crimes; the impact of these crimes on victims; the factors associated with the risk of being victimized; selected indicators of the function of the criminal justice system. The survey techniques were developed and tested in two methodological studies, one in Edmonton and the other in Hamilton. A contract has been awarded for a three-year project to evaluate the Gun Control legislation, by collecting information on the effect on firearms incidents and on the criminal justice system. A research project is underway to evaluate the Dakota-Ojibway Tribal Council Policing Program on six reserves in Manitoba. Two research contracts have been let relating to the effects of imprisonment; both are in the developmental phase. One will look at the effects of various lengths of imprisonment, the other at how prisoners cope with imprisonment. A systematic analysis of recent literature is underway to identify trends and research findings with respect to correctional goals and effective programs to meet these goals.

In the Fall of 1977, the Research Division began a new publication program, and fourteen reports have been published. In addition a reference centre has been developed to ensure the identification, coordination and communication of research findings and other information. The division has also developed a publication series which provides key information on topical issues to policy makers in a concise, readable form.

Finally, the Research Division has established a program of matched contributions to university criminology centres with the following objectives:

- the development of competent research teams in the major regions of Canada, to undertake contract research to meet specific needs of government and non-governmental organizations interested in criminal justice matters;
- the performance of long-term, perhaps multi-disciplinary, research in general areas of concern;
- the training and development of qualified researchers and others in the criminal justice system who need to know about and be able to use research results;
- the facilitation of research coordination and dissemination of results, regionally, provincially and nationally.

The focus of research activities at each university centre through to 1981 is: at Toronto, discretion in the criminal justice process; at Montreal, individual and collective violence and economic crime; at Ottawa, criminalization, decriminalization and diversion; at Regina, native persons vis-à-vis the criminal justice process; and at Simon Fraser, fitness to stand trial and rural native delinquency.

Although most of its research needs are provided by the Ministry of the Solicitor General, the Royal Canadian Mounted Police is actively engaged in some internal science activities. Its internal projects deal with such topics as: police response to disfunctional families; child abuse and domestic violence; white collar and computer crime; crime prevention techniques (e.g., improved environmental design, public education, patrols, media); gun control; police-community relations; standards of policing; training, personnel development and management.

A 1976 resolution by the Canadian Association of Chiefs of Police requested that the Royal Canadian Mounted Police and the National Research Council jointly submit a proposal for government support in the development of police equipment. An interdepartmental study group was convened, which subsequently recommended that the Royal Canadian Mounted Police assume lead agency responsibility for determining and securing the budgetary resources for R & D required to support the Canadian police community's needs for police equipment, with advice from the Association, while the role of the National Research Council should be to provide technical expertise and carry out R & D for the program. A statement of intention to this effect has been signed by the agencies. Major projects under this program relate to: Airborne lead content in firing ranges; Riot helmet face shields; Improved tear gas and methods of dispersal; Use of laser in fingerprint detection; Explosive handling equipment (bomb suits).

Energy

A recently-stated government objective is the attainment of Canadian self-sufficiency in energy by 1990, or more exactly self-sufficiency in liquid fuels. There are three avenues to this self-sufficiency:

- Conservation, particularly of liquid fuels
- Development of new domestic sources of liquid fuels
- Substitution of liquid fuels by other energy forms

These three routes complement and support each other and each requires comparable attention. The role of energy R & D is to provide technical options for each route. Nevertheless, for the majority of the government's energy R & D programs now underway, significant implementation will only begin some ten or more years hence. Moreover, self sufficiency, once achieved, is not immutable but is a moving target since the availability of energy resources continues to change. Consequently new technological options must continue to be sought. R & D on new technologies started now will not confirm or otherwise the viability of these options until the end of the century and beyond.

Self-sufficiency must not be restricted solely to the supply of energy per se but should also include the means of supply. To rely on the purchase or importation of technology from other countries is not in the interest of Canada's industrial and economic future. Given that Canada is economically a relatively small country, we can achieve this kind of self-sufficiency only in a few selected areas. Those areas where a domestic base exists, or a domestic capability is practicable, should receive priority attention. Priority should also be attached to developing the special solutions needed to exploit those domestic sources with unique characteristics, e.g., oil sands, Arctic gas and oil. We cannot expect others to develop the technology for these unique sources.

In addition to the two kinds of self-sufficiency, another objective of the national energy R & D policy should be the development of a resilient energy system, which uses a variety of fuels and energy sources. Singular or unique solutions should be avoided. The establishment of R & D priorities should not result in concentrating on one technology or technical solution, or on only one of the three routes to self-sufficiency in energy supply.

Other important policy objectives relate to the environmental consequences and the geographical diversity of Canadian energy technologies. In particular with respect to our unique energy resources, the development of technologies with minimum environmental impact is a responsibility which Canadian R & D policy must meet. Because of the size of the country and the uneven distribution of energy resources, the pattern of self- sufficiency and resiliency will vary significantly from region to region. This must be taken into account in both the national and provincial programs of energy R & D.

With respect to the national program of energy R & D there are three performers: the private sector, the provincial governments and the federal government. Where possible, energy R & D should be the responsibility of the private sector, in response to market forces. This can be expected in industries where the cash flow is sufficient to support R & D activities. The development of natural energy resources should be the responsibility of the provinces, if they are able. The federal government's direct participation in energy R & D programs will arise under the following conditions:

- where the risk is very high or over a protracted period, so that the expected return is well below the norm for the private sector, e.g., fusion power, advanced solar technologies;
- where Canadian industry is currently too weak or fragmented to support significant R & D programs, e.g., coal;
- where the return to society is greater than the return to an industry or industrial firm. In some cases leadership or example may be needed to stimulate changes from current practice, e.g., the use of wood as a fuel in the forest industry, the development of the solar heating industry;
- where in the national or regional interest, the development of an energy resource is beyond the capability of one or more provinces.

From the 1976/77 fiscal year on, most of the government's energy R & D activities have been monitored and coordinated by the interdepartmental Panel on Energy R & D, and all new resources for the activities under its purview have been based on its recommendations. Other energy-related S & T supported by the government, and outside the panel's responsibilities, involve such aspects as environmental impact, resource assessments, socio-economic studies and major demonstration projects. The requirement for new management mechanisms is emerging as success is achieved in the R & D stages, leading to the need, in some cases, of embarking upon large-scale and

expensive demonstration projects. With one or two exceptions, there is little experience in government departments with the management of large-scale scientific/engineering projects. There is also a lack in Canada of a large technical and industrial base which can respond to this requirement. The replacement of the short term, piece-meal contracts currently used with continuing 5- to 10-year agreements with selected organizations for the performance and management of a whole program, from research through development to demonstration, could be an important mechanism for developing the required Canadian technical and industrial expertise.

Since the inception of coordinated budgeting for energy R & D in 1976/77, the level of incremental or new funding has increased each year, reaching a total of $38 million for 1979/80 over the base level of resources in 1976/77. Within this incremental funding priority has been given to S & T concerned with energy conservation ($9.3 million) and renewable sources of energy ($15.5 million). The total resources for energy S & T under the direction of the panel will reach an estimated $158.8 million in 1980/81, exclusive of allowances for price and salary increases. As shown in table 3.4 the S & T activities directed by the panel are organized into five tasks, plus the coordination and review activity centered in the Office of Energy R & D in the Department of Energy, Mines and Resources.

In the Conservation task, analysis and assessment studies have identified several specific opportunities with considerable potential for energy savings, principally in buildings, the food supply system and industrial and municipal wastes management. In the building field, heating and air conditioning accounts for some 35% of secondary energy demand. Past work has led to a proposed semi-prescriptive building code emphasizing energy conservation in new buildings. The new code would optimize within a given design, but not dictate the design. It appears, however, that more radical building design might further increase energy savings by a factor of two or three. Planning by the National Research Council and the Department of Energy, Mines and Resources is underway for a high priority major RD & D (research, development and demonstration) program which is structured to match the disaggregated nature of the building industry and which will take into account both the retrofit and new construction markets.

Increased attention to the complete food supply system has shown that both the cost and availability of energy are major elements in the government's food strategy. Additional personnel resources in the Department of Agriculture are being reallocated to this aspect, particularly in food processing. Existing resources will support energy R & D, not only in food processing but also in livestock structures, crop drying and greenhouse operations.

The largest program in the Conservation task is concerned with energy conservation in the transportation sector ($2.6 million). Working relationships have been established with industry and with U.S. agencies in many areas. Two examples of cooperative efforts are:

- in conjunction with a Canadian company, the development, design and testing of an engine cooling system which provides significant fuel economy and compatability with new automobile designs
- a comprehensive 3 year plan for developing the technology for energy efficient small aircraft and

Table 3.4

Expenditures Under the Federal Energy R&D Panel

Tasks	1978/79*	1979/80*	1980/81*
		(millions of dollars)	
Total	**150.8**	**158.0**	**158.8**
Energy Conservation	12.5	12.5	12.1
Fossil Fuels	11.4	12.6	12.2
Nuclear Energy	105.8	106.4	105.9
Renewable Energy Resources	14.5	19.4	20.8
Transportation and Transmission	6.1	6.3	6.3
Coordination and Review	0.5	0.8	1.5

* Allowances for price and salary increases are not included.

power plants, which will strengthen an existing Canadian industry.

Work to date has revealed significant variations in fuel economy performance of different automobile engine tehnologies in Canadian cold weather conditions. Since Canada will mainly import automobile technologies developed elsewhere, high priority will be assigned to augmenting research on the optimization and testing of these technologies for high fuel economy under Canadian conditions and environmental standards.

The Department of the Environment is conducting a successful R & D program in industrial and municipal wastes management for conservation and energy recovery. Profitable projects have been established for the recovery of used oil and ferrous and non-ferrous scrap; the reuse of waste paper; and the processing of used tires into rubber/asphalt compounds, through close collaboration with municipal agencies and industry. The cost-shared industrial support program for "Development and Demonstration of Resource Energy and Conservation Technologies" (DDRECT program) is proving to be a successful vehicle for encouraging industrial participation in this area.

There will also be some increases for S & T: to complete the development by CANMET* staff of a retrofit oil burner kit for domestic furnaces which can save up to 20% in fuel; to investigate new concepts of hydrogen storage and photoelectrolysis related to off-peak utilization of electricity; and to explore consumer attitudes to energy conservation.

Within the Fossil Fuels task, incremental funding has accelerated the development by CANMET of a successful hydrocracking process for heavy oils, as found in the Cold Lake and Lloydminster fields, and Athabaska oil sands and Venezuela bitumens. The construction of a pilot plant, or even a commercial plant is under consideration. Utilization of heavy oil resources would make a major contribution to oil self-sufficiency. If commercialization proceeds, the current S & T resources in this area, estimated at $3.2 million in 1980/81 would be committed to its support for at least three years.

The task also includes a coal combustion program with 1980/81 estimated funding of $2.2 million, whose objective is to demonstrate the technical and economic benefits of substituting coal for oil in heat and electricity generation, particularly in Maritime industries and utilities. The substitution of coal for oil could be a key option in the self-sufficiency strategy. Another approach is the development of technology for using coal-in-oil mixtures. The beneficiation of coal appears to be able to increase the percentage of coal in the mixture to commercially-acceptable levels. Funding will be provided to the National Research Council to support a pilot plant demonstration of the spherical agglomeration of coal.

A further approach being pursued is the development of atmospheric and pressurized fluidized-bed combustion technology. A program of sequential demonstrations of atmospheric fluidized-bed combustion is being supported by contract and intramural R & D. The engineering phase for the wholly federal-funded demonstration at the Summerside Canada Forces Base will be completed and the procurement and construction phase will begin during 1980/81, with a funding requirement of $1.5 million. A larger demonstration at Chatham, N.B., and demonstration projects for pressurized fluidized-bed combustion, on a shared-cost basis with the provinces and the utilities, are under consideration. A new materials support program is being established in CANMET within existing resources, to develop in-house expertise and to support a Canadian boiler manufacturing capability.

The possible substitution of coal for oil will depend on the solution of significant environmental and economic problems in coal production and utilization. Accordingly, the task includes an R & D program which spans the range of coal supply activities from locating deposits through extraction (mining) to product upgrading (coal preparation). R & D in coal preparation shows considerable promise: higher recovery, cleaner coal, lower costs, leading to more economical transportation, easier cleaning of combustion products, and potentially more efficient and economical conversion processes.

Expenditures in the Nuclear task, as a proportion of the government's expenditures on energy R & D, have dropped from 75% in 1975/76 to 67% in 1979/80. Within the task, R & D by Atomic Energy of Canada Limited to provide technological support to the CANDU nuclear system accounts for most of the expenditures - more than 93%. Other programs in the task are fusion research, R & D concerned with the uranium fuel resource base and R & D in support of regulatory activities. With the exception of increased resources in 1977/78 and 1978/79 for R & D on reactor wastes storage and disposal, R & D funding for the agency has decreased somewhat over the past few

*CANMET — Canadian Centre for Mineral and Energy Technology, Department of Energy, Mines and Resources.

years. Nevertheless, the use of fission power technology for the production of electricity and other energy forms is an existing and major avenue to oil substitution for Canada, for which there is in place a Canadian technological and industrial capability and a long-term Canadian-based reactor fuel supply. The composition of the agency's R & D program is described in the Major Funders section.

The current level of resources directed to fusion research ($2.9 million) are mainly devoted to an on-going, in-house program in the National Research Council, investigating the interaction of intense laser radiation on matter. It is considered unlikely that the current level of fusion research in Canada can provide a credible contribution to the international fusion activity, which is seen as necessary to provide an adequate awareness of international efforts.

The task also includes an R & D program ($3.9 million) concerned with the uranium resource base, the exploitation of which must take into account both the maintenance of a secure supply for Canadian needs and an export potential of up to $1.5 billion annually from 1982 on. A strong export position reinforces our ability to implement our policy on the non-proliferation of nuclear weapons. It is in the national interest to maintain our technical leadership in the discovery, mining and refining of uranium. Expenditures by the Atomic Energy Control Board for contract research related to its regulatory mandate are reported in this task, but the Panel on Energy R & D exercises no influence in the nature or extent of this funding.

As mentioned above, the Renewable Energy Resources task is one of the priority areas for incremental funding. Measures announced in 1978 to encourage the development of renewable energy resources included phased increases for R & D directed to developing technologies for obtaining energy from forest biomass. Consequently, funding will be increased to $3.2 million in 1980/81 from $1.4 million in 1979/80, for the ENFOR contract program established with the forest industry. This program is showing considerable success and it is expected that by 1985 there will be insufficient mill wastes to meet the potential for biomass energy, so that R & D is being directed to harvesting techniques and technology. On the conversion side, current R & D emphasis is on the production of synthesis gas. The technology for producing methanol from synthesis gas is well established. Research is also underway on the direct liquefaction of wood, using hydrogenation processes, to produce a heavy oil. This oil could be substituted for No. 6 residual oil and chemical upgrading could convert it to diesel fuel and/or gasoline. With respect to other biomass energy sources — farm, animal and food processing wastes — fundamental biochemical research and the development of conversion systems for Canadian farms will receive some increased attention. A thin-film process which results in a five-fold increase in the rate of methanol production in anaerobic digestion has been developed by the National Research Council and a successful demonstration has been conducted by Canada Packers.

Other measures introduced in 1978 are aimed at the establishment of a Canadian industrial capability in solar energy. The National Research Council was given lead agency responsibility for the S & T required to support the PUSH (Purchase and Use of Solar Heating) program and PASEM (Program of Assistance to Solar Energy Manufacturers). The S & T objectives are:

- to develop components and systems;
- to provide test facilities, methods, standards and analytical techniques for continuing use by industry; and
- to support the industrial development of prototype systems for eventual mass production.

In the solar heating field, the council's approach is to provide assistance and guidance in response to initiatives from the private sector.

The testing and confirmation of new technologies has turned out to be a lengthy process: one to two years after concept formulation are required to design, contract and construct a system, followed by up to three years of trials and monitoring and up to a year for final analysis. Experience to date suggests that passive solar technology can be cost effective and consequently is receiving R & D priority, and that solar hot water is more economic than solar space heating. The cost effectiveness of active solar systems appears to be several years away, and will require a major cost decrease in conversion systems. The council has underway long-term research in photovoltaic devices for the direct production of electricity from solar radiation. In accordance with the cash flow schedule for the program, solar S & T resources will drop $0.5 million to a level of $10.9 million in 1980/81.

Both demonstration projects and basic research on the technology and resource potential of wind-generated energy are in progress. 1980/81 resources are estimated to be $1.4 million. The main technological focus has been on the vertical axis wind turbine, chiefly at the 50-kilowatt level. Several 50-kw.

units, coupled to the electrical grid, are in operation or planned under cost-sharing arrangements with provincial utilities. A joint venture between the National Research Council and Hydro Quebec to construct a megawatt-scale prototype on a 50/50 cost sharing basis is being considered.

With respect to possible geothermal sources of energy, a number of test drillings are underway or planned, mainly in British Columbia, where a demonstration of electrical generation is likely within three years. The hole drilled on the campus of the University of Regina has yielded sufficiently good temperatures and flowrates of hot water to justify drilling the second hole and proceeding with the demonstration of geothermal space heating.

The task on Transportation and Transmission (of energy) is divided into two programs: the transportation of oil, gas and coal; and the transmission of electricity. With respect to northern/Arctic transportation emphasis is shifting from ice studies to other technological aspects of moving oil and gas from the north. The government's work in Arctic vessel technology is primarily in support of regulations. The technological feasibility of northern transportation of oil and gas will require very large, powerful ships capable of year-round operation in ice-covered waters. The transmission program consists of electrical research at the National Research Council and government support for a wide range of S & T projects in industry and the utilities, which are coordinated and managed by the Canadian Electrical Association. Useful results from industry and utility activities have been obtained in such areas as: environmental effects of electrical transmission; thermal generation and coal utilization; load control, micro-processor applications, distribution automation; residential use of electricity including heat pumps; long range electricity demand forecasting; storm prediction; low grade heat and biomass utilization.

Details of the government's total expenditures for energy S & T, by department and agency are given in Table 3.5. While not included in the table, a portion of defence R & D supported by the Department of National Defence is considered to be energy related, and is estimated to be $1.2 million in 1980/81, 25% of which is contracted-out.

Table 3.5

Federal Science Expenditures on Energy

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**173.5**	**204.2**	**230.0**
Energy, Mines and Resources	44.8	65.5	79.7
Earth Science Services Program	11.8	10.6	12.0
Energy Program	33.0	54.9	67.7
Atomic Energy of Canada Ltd.	85.1	83.5	88.8
Environment (Total)	0.4	4.9	5.1
Canadian Forestry Service	—	4.2	4.4
Fisheries and Oceans	7.9	7.5	7.8
Industry, Trade and Commerce	1.7	1.1	1.5
National Research Council	21.9	28.9	31.8
Natural Sciences and Engineering Research Council	4.0	3.8	4.9
Public Works	0.4	1.1	2.0
Transport	3.5	3.5	3.7
Others	3.8	4.4	4.7

Environmental Issues

This section deals with various components of environmental sciences, including the atmosphere, water, land and wildlife. Departmental and agency expenditures for all aspects of environmental science are shown in Table 3.6. Research on environmental issues is necessary to develop policies, regulations and guidelines that will ensure that the availability and productivity of our renewable resource base will be maintained for future generations. It also helps to develop, in advance, the information base required to formulate environmentally-sound industrial development plans. It should be noted that the expenditures related to water as a resource and those to water as an environmental issue have been aggregated and discussed here, because of the difficulty in distinguishing environmental research from research for resource management.

Air

In 1980/81 the government's expenditure on air-related environmental issues will amount to $3.7 million, about 6% of the total shown in table 3.6. The Environmental Protection activity of the Department of Environment has a number of on-going scientific activities related to the control of air pollution. This includes the monitoring and collection of ambient air data on the most common contaminants through an extensive surveillance network which covers all major urban centres in Canada. Special air monitoring surveys are also carried out to provide information on specific problem areas. Another on-going activity is the assessment of proposals for the development and demonstration of new air pollution control technology.

Air pollution research is concerned with improving process and control technologies for industries that emit air pollutants, documenting the economic, technical and social impacts of different levels of controls on various industrial emission sectors and understanding the nature of the environmental impacts, the mechanisms of pollution transport and the associated atmospheric chemistry.

The Atmospheric Environment activity estimates an expenditure of $2.4 million on air-related environmental issues. The Long-Range Transport of Air Pollutants Program has been developed to examine the environmental consequences of greater use of coal. Short-term studies include development of models and scenarios for projected future damage, and surveys of historical data to obtain qualitative indications of the rate of deterioration in the past. Over the longer term the environmental impact of the transport of air pollutants and acid rain resulting from sulfur and nitrogen oxides will be elucidated, and a monitoring system will be put into place to assess the effectiveness of various control strategies.

The Department of Health and Welfare will collaborate with the Department of the Environment to study the potentially harmful effects of acid rain on human health.

Water

The government's S & T expenditures on water-related environmental issues and resource management will amount to $38.4 million. The largest spender will be

Table 3.6

Federal Science Expenditures on Environmental Issues

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**53.9**	**57.4**	**58.7**
Energy, Mines and Resources	2.4	2.5	2.9
Environment (Total)	41.8	42.9	42.2
Atmospheric Environment Service	2.3	2.3	2.4
Environmental Management Service	29.3	31.6	30.4
Environmental Protection Service	9.0	7.9	8.1
Fisheries and Oceans	2.5	2.2	2.4
National Research Council	3.2	3.8	4.2
Natural Sciences and Engineering Research Council	2.4	2.7	3.6
Others	1.6	3.3	3.4

Environmental Management activity of the Department of Environment, with estimated expenditures of $33.4 million.

Potential water shortages on the Prairies arising from urban population increases, energy development, new industrial activity, and continuing agricultural activity, are being studied. The capacity of the area to augment its water supply will be limited by increasing resistance to diversion schemes on environmental grounds. Research is focussed on new systems for demand management and using weather modification techniques to augment rain.

Studies in the Water Quality Program are carried out in support of the Toxic Substances Program. These studies will include ground water contamination, acid rain on Canadian lakes, lake renovation methods, water quality modelling, and pathways analysis and fate of pollutants. Research priorities in the area of Water Pollution Control include the development of small scale sewage treatment systems, the automation of larger treatment systems, new methods of waste recycling, and waste water treatment systems for cold climates. Development of appropriate oil spill control technologies for the Arctic and other offshore areas of Canada is also receiving priority.

As part of its active research and advisory program, the Department of National Health and Welfare has prepared a comprehensive re-evaluation of the guidelines for Canadian Drinking Water Quality. The analytical surveys on the physical and chemical contaminants of drinking water are being carried out to evaluate the toxicological significance of these factors.

Land

In 1980/81 the government's S & T expenditures on environmental issues related to land are estimated to be $6.2 million. Of this amount, $2.6 million will be funded through the Department of Energy, Mines and Resources, principally in studying the environmental impact of mining and energy development.

The Environmental Management activity of the Department of Environment will spend a total of $2.2 million on land-related issues. Research will continue on ecological land classification methodology and the applications of remote sensing. Analysis of the large volume of Canadian Land Inventory data on land capability and land use will continue under the Canada Geographic Information System. The most urgent problem in land resources centres around the rapid conversion of agricultural land to industrial use. The social and economic problems associated with the loss of agricultural land are being studied using computerized land inventories and numerical modelling of physical, environmental, social and economic phenomena.

Other

The Environmental Management activity of the Department of Environment will spend $11.0 million on other environmental issues including those which involve wildlife. A pilot study for a ten-year banding program on lesser snow geese in the eastern Arctic is jointly funded by the U.S. Fish and Wildlife Service, the Mississippi and Central Flyway Water Fowl Councils and the Canadian Wildlife Service. Assessment of the possible effects of various kinds of development on wildlife and wildlife habitat is being continued. The most notable of these activities are along the proposed pipeline routes and in the area of oil sands development in Alberta.

The National Research Council will spend $4.2 million on various environmental issues, mainly on biological research on waste and pest management. It also provides coordination of scientific activities through its Associate Committee on Scientific Criteria for Environmental Quality.

Food

Food science is a term used to encompass those science and technology 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. It embraces both the agriculture and fishery sectors. These S & T activities serve an industry whose gross output is about $20 billion, or about 9% of Canada's economic activity. Canada traditionally enjoys a surplus position in agricultural trade, which has an important positive effect on the trade picture. Against the background of recent concerns about exports of non-renewable resources, exports of agricultural, forestry, and fishery products may assume a greater role. To maintain Canada's export position in food, research and development is concerned with helping

to limit cost increases and to enhance productivity. In agriculture, for example, there is little potential for an increase in Canadian croplands. Also, the Canadian climate is generally unfavourable to agricultural production in comparison to that of other major food-producing areas. Consequently much of the increased production will have to come from technology improvements and better management practices. As shown in Table 3.7, expenditures by the Department of Agriculture predominate in the government's support of food science, consistent with the major role of agriculture in Canada's food production. Nevertheless, the contribution of the fishery sector is significant and S & T expenditures by the Department of Fisheries and Oceans is an important component of this support.

Canada produces about 3% of the total world grain production or about 11% of the grain that enters world markets. Cereal crops are vital to the Canadian economy with a total farm value estimated over 5 billion. Although the yields of grain crops in Canada are not as great as in parts of the world with more rainfall and a longer season, our varieties and climate ensure that Canada produces some of the highest quality bread wheats in the world. Cereals are also used extensively as animal feeds. Corn is king of the feed grains in Ontario and in most of the rest of Eastern Canada.

Over the years, several new varieties of wheat, barley and corn have been licensed and distributed. The varieties of grain crops have undergone steady improvements as a result of research in the Department of Agriculture. Canada's grain crop would soon deteriorate if it were not so capably protected by the efforts of science. Wheat varieties developed by Agriculture Canada occupy more than 90% of the production area in Canada.

Reduction of losses by insects attacking agricultural crops has largely depended on the application of chemical insecticides. The department's research is currently directed toward developing pest management systems that rely less on chemical insecticides and make more use of biological control methods and cultural practices. In these integrated pest control programs, specific insecticides are applied in minimum quantities and only when necessary. In the fruit-growing areas of interior British Columbia and Southern Ontario, the quantities of chemical insecticides currently in use are less than half those used prior to 1970.

Breeding of new varieties resistant to pests and diseases is an important part of the plant breeding program in Canada. For example, red raspberry cultivars are selected in British Columbia to resist post harvest fruit rot, particularly because of the ineffectiveness of known chemicals in controlling the organism. Progress is also made in incorporating genes associated with resistance to a specific pathogen into cultivars of several crops to improve their disease resistance. A similar approach to improving insect resistance is also under development.

The Canadian food strategy is to increase production and market research and to assure technology transfer so as to provide assistance to producers in adopting new products or technology and in responding more quickly to changed market circumstances. The quantity and quality of food available to consumers depend upon a chain of connecting services that comprise the food system. A number of improvements

Table 3.7

Federal Expenditures for Food Science

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**178.4**	**187.1**	**203.1**
Agriculture (Total)	118.8	126.1	139.2
Research Branch	105.4	112.5	123.9
Fisheries and Oceans	35.9	34.4	34.1
National Health and Welfare	3.9	4.4	5.0
National Research Council	9.6	10.5	11.4
Natural Sciences and Engineering Research Council	—	1.8	3.6
Statistics Canada	5.3	5.0	5.5
Others	4.9	4.9	4.3

are being made in this system, through the Processing, Distribution and Retailing contract program, which is managed by an interdepartmental board, chaired by the Department of Agriculture. The program aims at the development of: new or improved food products and ingredients; more efficient processing, storage and distribution methods; methods of energy conservation; better maintenance of food quality, or enhancement by fortification or other processing; and improved food safety.

To maintain its position as the world's number one exporter of fish, the government has embarked upon a number of major marketing initiatives. Within the Department of Fisheries and Ocean, activities related to the East Coast fishing industry are funded under the Atlantic Fisheries Development program; the 1980/81 expenditures are estimated to be $16.9 million. The current research emphasis is the elucidation of factors influencing the size and distribution of fish stocks, such as: variations in stocks due to natural forces and various exploitation levels; the effect on stocks of other species from exploitation of a particular species in the same ecosystem. The objective is to establish a maximum sustainable catch of particular species. On the West Coast the department is investigating ways of strengthening the stocks of Pacific salmon. In addition to construction of hatcheries under the Salmon Enhancement Program, there were stream improvement measures, community activities and lake fertilization and prototype production facilities which together are expected to boost production by more than two million fish.

The department continues its efforts to protect fish habitats that support Canadian commercial and recreational fisheries by assessing fish stocks contaminated by PCBs, Mirex, pesticides and mercury and designing controls to protect fish under the Pest Control Products Act and the Environmental Contaminants Act. Ecological work continues relating to stream rehabilitation, atmospheric transport of pollutants and acidification of freshwater lakes. As required, the department assesses the environmental impact of proposals likely to harm fish habitats, such as the Fundy tidal power development and exploratory drilling of oil and gas on the continental shelf. Other research is being conducted in aquaculture technology, fish health and fish genetics. Aquaculture is already established as a cottage industry in the Western region, with some 3,500 farmers participating. Further technology development is directed to improved genetic stocks of fish and to improved production efficiency.

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. The activities include studies on the harmful effects of chemicals intentionally involved in the food supply, such as agricultural chemicals and food additives. The latter include emulsifiers, antioxidants and colours. Special attention has been focussed on the relationship, if any, between food additives and hyperactivity in children and the possible contributions of additives, pesticides and food contaminants to the incidence of cancer.

A major activity is establishing limits for the presence of bacteria in foods, for example, salmonella in poultry. The department, in consultation with the provinces and relevant trade associations, is working to attain uniform national standards for safe temperatures to be used in the holding, transport, storage and sale of certain perishable foods, thus reducing the incidence of food-borne disease and improving the quality of such products.

The department monitors the food supply for contaminants, both those resulting from human activities and those occurring naturally. It assesses data collected by food inspectors, develops analytical methods, and continually reviews the use of chemicals and the presence of bacteria in food. It also encourages industry to acquire more highly trained, technically qualified people and to develop more effective educational programs in the area of good manufacturing practices.

With respect to nutrition, the department develops regulations on the addition of nutrients to improve the nutritional quality of food. Research activities include metabolic studies and analytical method development, both of which involve work on macronutrients such as proteins and carbohydrates, and on minerals, vitamins and fibre. The department will continue to implement the recommendations of the Expert Committee on Diet and Cardiovascular Disease through activities with professionals and the public. Education, information and advisory services are provided to provincial and federal governments, consumers and the food industry, in an effort to reduce the incidence of nutrition-related diseases such as cardiovascular disease, dental caries and obesity. Nutrition education for children is being given particular attention. Consumer education and resource materials in support of the department's initiatives in food and nutrition are provided as an outcome of the food strategy meetings.

The department also works toward ensuring that food safety and nutritional considerations are taken into full account in policies and programs affecting all elements of the food system. It also contributes significantly to

the food activities of the World Health Organization's Codex Alimentarius, the Food and Agriculture Organization and the Association of Official Analytical Chemists.

The food and agricultural science activities of the National Research Council range from basic research on nitrogen fixation, genetic improvement of plants and insect control to such practical applications as improvements in food preservation. Its Prairie Regional Laboratory in Saskatoon conducts research serving the prairie region as a whole, whereas the research in its Ottawa and Halifax laboratories deals mostly with food processing and environmental quality.

Health

As stated in previous editions of this publication, federal scientific activities relating to health have the ultimate goal of improving the general health of Canadians. Intermediate goals were identified as:

- adding to the store of knowledge of basic human biology and behaviour;
- determining the deleterious effects of various factors in the natural and man-made environments on mental and physical health;
- identifying links between the living habits of individuals and the state of both their mental and physical health;
- applying knowledge of human biology and human behaviour to improving personal health care;
- finding ways to influence individual Canadians to take more responsibility for their own physical and mental health and reduce the risks they incur when they continue to indulge in potentially harmful living habits;
- reducing the cost and improving the accessibility and effectiveness of the health care system.

The government's expenditures in health science are shown in Table 3.8.

Various federal departments and agencies share in meeting these goals, through the scientific activities they support. Sharing the goal of adding to the store of knowledge of basic human biology and behaviour are the Medical Research Council, the Social Sciences and Humanities Research Council, and the Department of Health and Welfare. Most research supported by the Medical Research Council is aimed at advancing knowledge of the functions of the human body, in both health and disease, through the bio-medical sciences such as biochemistry, genetics, pathology, pharmacology and physiology. Some research, however, is also directed toward evaluating the effectiveness of new treatments and interventions in various disease states through clinical trials and, through multidisciplinary team efforts, toward developing applications in specific areas where the state of knowledge is already sufficiently

Table 3.8

Federal Science Expenditures on Health Science

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**125.7**	**126.0**	**141.4**
Energy, Mines and Resources	0.9	0.9	1.3
Atomic Energy of Canada Ltd.	6.9	7.7	7.7
National Health and Welfare (Total)	42.0	34.3	38.2
Health and Social Services Program	21.1	13.9	16.8
Health Protection Program	20.8	20.3	21.3
Medical Research Council	64.2	70.1	80.0
National Research Council	7.3	8.6	9.4
Statistics Canada	3.9	3.7	4.0
Others	0.5	0.7	0.8

well-advanced. Specific areas where new emphasis is being sought are perinatal disorders and geriatric health and the general area of toxicology.

The Social Sciences and Humanities Research Council supports research in health-relevant fields such as education, psychology and sociology. Adding to the store of knowledge about how humans learn, what induces self-injurious and anti-social behaviour, and what economic and social forces influence, for example, the use of home care or mental health services, is potentially valuable for improving the life habits of individuals and designing and instituting or modifying health care systems. Applied research in fields related to health, building on basic knowledge in the health, administrative and social sciences, is supported and carried out by the Department of National Health and Welfare (see also the description under "Major funders").

Several federal departments support research and other scientific activities that are related to the identification of health hazards in the natural and man-made environments and to their elimination or control. The Department of Labour, together with the Department of National Health and Welfare and the Canadian Labour Congress, supports a Centre for Occupational Health and Safety that, in turn, supports research on health hazards in the workplace. The departments of Transport and National Health and Welfare co-fund a Civil Aviation Medical Unit, which undertakes studies directed to the determination, prevention and elimination of human factors in air accidents.

The Department of National Health and Welfare acts as health advisor to the Department of the Environment for the Clean Air Act and is jointly responsible with it for implementing the Environmental Contaminants Act. It will spend over $5 million on an environmental health program encompassing the development of regulations and guidelines, as well as research and advice on the physical and chemical contamination of air, drinking water, and indoor and outdoor environments. For example, in collaboration with other agencies, there are plans to study the potentially harmful effects of acid precipitation from oxides of sulfur and nitrogen on human health.

The department has prepared a comprehensive re-evaluation of the Guidelines for Canadian Drinking Water Quality and has an active research and advisory program. Analytical surveys on the physical and chemical contaminants of drinking water are to be carried out and the toxicological significance of these factors evaluated. Scientific studies and advice are provided under the Great Lakes Water Quality Agreement and to international agencies including the World Health Organization and the North Atlantic Treaty Organization.

Not unimportant is the contribution of the Natural Sciences and Engineering Research Council to the advancement of basic biological, physical and chemical knowledge, knowledge of animal behaviour, and the development of engineering principles. Such knowledge underlies many advances in the understanding of human biology and behaviour and the bioengineering of new medical devices and technology.

Atomic Energy of Canada Limited conducts scientific activities related to health, primarily to reduce exposure to radioactive emissions, but also related to the production of radioactive isotopes used in the diagnosis and treatment of disease and in basic research on disease processes. The Department of National Health and Welfare provides advice on radiological health to the Atomic Energy Control Board and an occupational radiation dosimetry service for over 70,000 workers throughout Canada on a regular basis. Each worker's exposure history is maintained in a national records system which is used by federal and provincial agencies for regulatory control. The system is also used to obtain statistical information on health risks. There is a program of routine monitoring of air, water and food for environmental radioactivity. Radioactivity monitoring is also carried out in specific areas of the nuclear industry and in homes where there is a high natural background radiation.

The Department of Agriculture supports extensive investigations on the use and environmental effects of pesticides, fertilizers and other agricultural chemicals, while the Department of National Health and Welfare assesses the potential health hazard of these chemicals, establishes safe levels and monitors their presence in food, air and water. Work supported by the Department of Fisheries contributes to the understanding of the role of such agents. Other health hazards in the natural environment include a myriad of biological agents — viruses, bacteria, fungi, parasites, allergens and other toxic biological agents. Epidemiological studies of induced ill health are undertaken both intramurally and extramurally by the Department of National Health and Welfare, while studies of the natural occurrence of such disease agents, their life cycles, chemical makeup, propagation, vectors and vector control are supported not only by the department but also by the Natural Sciences and Engineering Research Council and the Department of Agriculture.

Included in the research program of the Centre for Occupational Health and Safety mentioned above is the investigation of factors affecting the mental health of workers. The Health Services and Promotion Branch of the Department of National Health and Welfare, through its National Health Research and Development Program, also encourages extramural research on the social, cultural and economic factors that affect health. Research designed to yield an understanding of and to suggest strategies for the modification of such habits as smoking, drug and alcohol abuse and improper eating is encouraged and supported by the Medical Services branch, and the Health Services and Promotion Branch. Translating the results of such investigations into educational programs designed to improve individual attitudes and life habits as they affect physical and mental health is also part of the work of the Medical Services Branch, particularly in the Indian and Northern Health Program, as well as of the Health Promotion Directorate. Research on social and cultural factors that lead to anti-social or self-destructive behaviour is supported through contracts by the Solicitor General's Department and investigations of factors affecting the health of native people is encouraged both by the Department of Indian Affairs and Northern Development and the Department of National Health and Welfare.

The Canada Health Survey, carried out jointly by the Department of National Health and Welfare and Statistics Canada, is unique in the range of health-related data which has been collected. Although economic restraint has forced indefinite suspension of what was to have been an annual survey, the data already collected will provide information on health status, on risk of exposure to hazards to health, and on use of the health care system. A report will be published in mid-1980 which will contain aggregated data and some basic analyses.

The health care system includes not only the training of and provision of services by health professionals but also the provision of ancilliary services such as diagnostic laboratories, the manufacture and marketing of medications and medical devices, and the provision of both active treatment and longer-term care facilities and services. A major contributor in these areas of health sciences is the National Research Council, which has work underway on the development of medical devices and prostheses, vaccines and computerized programs for medical education. With respect to medical devices and prostheses, the council's Rehabilitation Technology Unit, located in the Sunnybrook Medical Centre, Toronto, is dedicated to the development of aids for the disabled. For example, a mouth-operated typing aid, called Target, for use by quadriplegics has recently been developed and is expected to be commercially available early in 1980.

A practical method for localized cooling of the injured section of a spinal cord has been developed after many years of collaborative effort by the council, the Montreal Neurological Institute and Queen's University. Early clinical trials have shown encouraging results in minimizing permanent spinal cord damage by cooling the injured site during the first few hours after injury. The cooling reduces the swelling caused by reduced blood flow, the effects of hemorrhaging in the spinal cord, and other destructive processes which cause irreversible damage after a few hours. Extensive clinical trials are underway in Canada and the United States.

The Department of Communications is developing electronic means for delivering medical services to remote areas of Canada (telemedicine). Other research on the factors affecting the delivery and utilization of health care services is supported by the Department of National Health and Welfare. Some is carried out by its Medical Services Branch in connection with its responsibility for providing health services to registered Indians on reserves and Crown Lands, to residents of the Northwest and Yukon Territories, to quarantined immigrants, public servants and Canadians in foreign posts, and during emergencies.

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

Canada has one of the major forests of the world. The forests and their products account for the employment of 11% of the labour force, constitute the largest component of export earnings and are second only to

food in total value of shipments. In addition the forests support an abundant wild life, influence our climate, provide major recreational and tourist attractions and are a potential source of considerable quantities of energy.

In recent years, the annual timber cut has begun to exceed the annual growth and it is estimated that currently, the area of inadequate regrowth is increasing at about 200,000 hectares (2000 km^2) annually. In the coming years, it will be necessary not only to stem this trend but also to increase the annual harvest significantly to meet expected increases in the demand for forest products.

As shown in table 3.9, almost all the government's expenditures in forestry S & T are made by the Canadian Forestry Service, Department of the Environment. Expenditures for 1980/81 are expected to be some $32.0 million, devoted to R & D on the forests themselves, rather than on forest products. With the privatization of the Forest Products Laboratories in 1979, virtually all the R & D on forest products — wood products, pulp and paper — is now performed by the industrial sector, including the research institutes. The government's support to this R & D is expected to be $4.6 million in 1980/81.

The S & T activities of the Canadian Forestry Service (CFS) are devoted to promoting proper management of the forests and in the future will stress the enhancement of their productivity both by improving growth and minimizing losses. The annual cut of the Canadian forests amounts to about 1 million hectares (10,000 km^2) or about 0.5 percent of the total available for industrial wood production. Each year, however, about the same area is destroyed or damaged by fire and a much larger area is attacked by pests and diseases. The extent of the present spruce budworm infestation is about 50 million hectares (500,000 km^2) of forest. The current method of control by insecticide spraying must be repeated regularly and is suspected by some of being a health hazard. Various ways of overcoming these problems include increasing the rate of reforestation by improving planting machines and breeding better trees that are resistant to diseases and pests and/or grow faster. Environmentally benign methods of controlling pests and diseases include biological methods using bacteria, hormones and viruses specific to budworm or other organisms. Improved methods of firefighting, involving both equipment and management techniques are being developed.

Remote sensing techniques appear potentially useful in forestry studies, and should be particularly useful for locating and following the progress of fires. Much of the required development of equipment for retrieval, storage and processing of the output of satellite-borne sensors is done under contract by industry. At present experiments on combining satellite data with other aspects of fire control are being conducted in Quebec, Ontario and British Columbia.

A major consideration on planning forestry R & D is its long term nature. Trees require 50 years or more to mature, so that payoff from R & D does not come quickly. Thus the whole history of forestry R & D in Canada has existed for little more than one growth period.

Within the industry, the increasing need to use stands of smaller diameter or poorer quality has resulted in the development of new machines or equipment to maintain the quality of products in spite of decreasing quality of feedstock. For example, what was formerly waste material is being used in such products as chip or particle boards. Machinery is being developed to minimize production of sawdust. In addition, wood waste and poorer quality forest stands not presently used are potentially a major renewable source of energy through combustion or conversion to other fuels. In future special plantations of rapidly-growing trees may also be feasible or necessary. This possibility is discussed under Energy in this section.

Table 3.9

Federal Science Expenditures for Forestry Resources

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**32.3**	**32.1**	**32.0**
Environment (Total)	30.3	30.2	29.9
Canadian Forestry Service	29.8	29.8	29.4
Others	2.0	1.9	2.1

Mineral Resources

Exploitation of Canada's mineral resources is an important factor in our economic prosperity; in 1978 mineral processing and products contributed about $26 billion or 10% of Gross National Product. 42.5% was export business.

Table 3.10 shows that essentially all 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. Within the department, the Earth Science Services program collects and disseminates a wide range of geoscience information about the Canadian landmass and continental shelf.

Most of the R & D in mineral technology is carried out by the Canada Centre for Mineral and Energy Technology (CANMET). It performs, contracts and coordinates research on the mining, extraction and utilization of minerals and metals. It also has an important responsibility for providing technological information as a basis for government policy and planning to aid industry, government agencies, educational institutions and the general public throughout Canada.

The centre's mineral research program is concerned with non-energy minerals and metals. The 1980/81 program will see continuation of research on mining technology, including health and safety; on processes to improve existing metallurgical operations and develop marginal resources; and on materials development and metals processing.

In mining technology research, open-pit mining techniques outlined in the centre's recently-completed Pit Slope Manual are being communicated to industry through a technology transfer program. Scientists are also writing guidelines for underground mining of wide, steeply-dipping ore bodies below 1000 m. Important concerns of mineral research are environmental protection and the health and safety of workers. Topics embrace land reclamation, safe disposal of mine and nuclear wastes, control of particulate emissions and radiation exposure. To address the acid rain problem, an expanding program of research on SO_2 capture in smelters is underway. Details of environmental and health-related R & D activities are given under those headings in this section. Resource conservation is the motive for work on by-product recovery in ore processing and on recycling of primary mineral wastes and metallic scrap. A major project, begun in 1976, is designed to improve recoveries from complex zinc-lead-copper sulphide deposits such as those under development in New Brunswick and also known to occur in Ontario and the Yukon. Domestic non-bauxite sources of alumina are also being investigated.

The centre 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 use diversification in metals and alloys through research on mechanical, corrosion and abrasion resistance and welding. Of particular concern is the integrity of materials, such as pipeline steels, for use in Arctic environments. Metals processing is being studied to develop better materials for use in rail, automobile and marine transportation systems, to improve casting and fabrication techniques, and to reduce plant energy use.

Attempts by the centre to increase technology transfer under the Cooperative Projects with Industry program have been restricted by the need for expenditure restraint. A small number of projects have been initiated but there is a significant list of candidates which are considered to be eligible under the program.

Table 3.10

Federal Science Expenditures for Mineral Resources

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**39.7**	**37.1**	**42.0**
Energy, Mines and Resources	39.2	36.8	41.6
Earth Science Services Program	22.5	20.6	23.9
Minerals Program	16.7	16.2	17.7
Others	0.6	0.4	0.4

Although the Earth Science Services Program comprises nine component activities, only the Geological survey is discussed here, because practically all 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; currently 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

Canada has a longer coastline than any other country. Its continental shelf covers an area larger than the land area of most other countries. In addition, most of Canada's coastline lies in the Arctic or Sub-Arctic and most of the oceans surrounding it are either ice-covered or ice-laden for at least part of each year. The importance of oceans to Canada has been recognized for some time and an oceans policy was formulated in 1973 and expanded in 1975. Canada declared an extension of fisheries jurisdiction to 200 miles on January 1, 1977. This further increased the importance of all ocean-related research. The objectives of Canada's ocean policy are:

- to stimulate the development and effective participation of Canadian industry in the exploitation of offshore resources,
- to place special emphasis on a wide range of marine science and technology: in resource management; in ocean engineering; on weather, ocean currents and ice movement forecasting,
- to achieve world recognized excellence in operating on and below ice-covered waters,
- to attain an equal or superior status to other countries or large multi-national corporations in developing and maintaining a current information base about its renewable and non-renewable offshore resources.

Offshore natural resource potentials are rapidly gaining importance. Canada's exploration is carried out mainly in search of oil and natural gas. The time may not be far off when serious consideration will be given to non-hydrocarbon resources produced from the seabed. The large scale offshore exploration activity necessitates a whole series of other activities, namely transportation, charting of marine routes, surveillance and environmental protection measures. Table 3.11 shows departmental and agency expenditures in ocean S & T.

The Panel on Ocean Management was established in 1976, comprising senior officials of government agencies with involvement and responsibilities in Canada's ocean area. One of its first tasks was to define the management functions and future support system requirements. Main areas of responsibility have been identified as follows: renewable resources; non-renewable resources; protection of the marine environment; development and control of navigation; defence; and international concerns.

In April 1979 the Department of Fisheries and Oceans was formally created from the former Fisheries and Marine Service of the Department of Environment to reflect the greater emphasis placed on ocean-based resources. The major activities of the Fisheries area of the new department are discussed in the Food application area. The Oceans and Aquatic Sciences activity in the department, as the major spender in oceans S & T, is concerned with scientific activities related to preserving and enhancing the quality of fresh and marine waters and to contributing to the effective use of these resources. Oceans and Aquatic Sciences conducts research in physical, chemical and biological

Table 3.11

Federal Expenditures for Oceans Science

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**54.4**	**52.2**	**53.4**
Energy, Mines and Resources	3.7	4.4	4.9
Environment			
Atmospheric Environment Service	8.6	8.4	8.4
Fisheries and Oceans	33.3	30.9	31.2
National Research Council	3.3	3.7	3.9
Natural Sciences and Engineering Research Council	1.2	1.7	2.8
Others	4.3	3.1	2.2

oceanography and limnology, and is responsible for hydrographic surveys, charting and various related publications.

As an example of the scientific activities in the department, Fisheries Management and Ocean and Aquatic Sciences are collaborating in a detailed study of the biological and oceanographic parameters of the waters at the Flemish Cap. This is a relatively shallow spot in the North Atlantic, off Newfoundland, about 500 km east of the Grand Banks. Known for hundreds of years as a productive area, the Flemish Cap is now the subject of a multi-year, comprehensive and intensive study, with many different disciplines being brought to bear in the study of the factors that determine its marine ecology.

Canada participates in a variety of international programs. It supports the Intergovernmental Oceanographic Commission which is affiliated with the United Nations. Ocean and Aquatic Sciences of the Department of Fisheries and Oceans is supplying buoys for a weather monitoring projet organized by the World Meteorological Organization and the Intergovernmental Commission. As part of the Integrated Global Ocean System, Canada regularly transmits and receives data on sea surface, temperature, salinity and ocean currents through the World Ocean Data Centre in Washington.

The Earth Sciences Service Program of the Department of Energy, Mines and Resources carries out research and field surveys in the coastal areas and on the continental shelf. This activity has recently increased in importance because of the increased activity in offshore exploration. The Canada Centre for Remote Sensing (in the Department of Energy, Mines and Resources) aids the development of effective information and management systems for Canada's ocean resources by developing and demonstrating systems, methods and instruments to acquire, disseminate and analyse remote sensing data obtained from aircraft and satellites.

The government's recognition of the importance of oceans is indicated by its inclusion as a subject area in the strategic grants program of the Natural Sciences and Engineering Research Council. The recently announced major increase in funding for the council also increased significantly the available grants in the ocean field from $1.7 million in 1979/80 to $2.8 million in 1980/81.

In addition to the expenditures shown in Table 3.11, the Department of National Defence will spend a total of $3.9 million on ocean-related S & T in 1980/81, with 19% 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.

The National Research Council expects to spend $3.9 million in 1980/81 on oceans S & T. Some of this activity is in the form of joint projects with other departments and industry, some of which are discussed below. A major new initiative for the council in this field is the establishment of the Arctic Vessel and Marine Research Institute on the grounds of Memorial University, St. John's, Nfld. Construction is expected to begin in 1980, with scheduled completion for 1983/84.

There are numerous examples available to illustrate significant oceans-related technology development which has taken place recently. The success of the Canadian Ocean Data Systems (CODS) program has

been described in the preceding issue of this report. With scientific and technical assistance from the National Research Council and funding support from the council and the Department of the Environment, Hermes Electronics of Dartmouth, N.S., has developed an ocean data buoy system which is internationally competitive. Although the CODS program is officially complete, Hermes Electronics is continuing to develop the buoy system so that it could be used to replace the PAPA weatherships. In connection with this development Oceans and Aquatic Sciences and the National Research Council are sponsoring a research program as part of their CORE technology development. The combined funding is $250,000.

Another interesting Canadian high technology project, which illustrates the benefits of government and industry R & D cooperation, is known as SEABED. This project, initiated in 1975, is designed to develop new methodology for geological mapping of the seabed and the first 200 metres of the underlying strata. It is an engineering and scientific partnership between industry and government with an annual funding of $450,000 and an expected duration of five years. The project involves Huntec (70) Ltd. of Toronto; the Atlantic Geosciences Centre and the Atlantic Oceanographic Laboratories of the Bedford Institute of Oceanography; the National Research Council; the Defence Research Establishment-Atlantic and Memorial University. The Geological Surveys branch of the Department of Energy, Mines and Resources, is the lead agency in this project. The project was inspired through the design and development of a Deep-Tow High Resolution Seismic System (DTS) developed by Huntec in 1974.

The DTS system, as the primary data acquisition tool, has steadily evolved throughout the lifetime of the project. A resolution of the order of a few centimetres on the sea floor is already attainable. Processing techniques have been developed to provide on-line measurements of the acoustical reflectivity of the seabed and current research involves a study of the subsurface reflectivity and other acoustic properties.

Under the project the government of Canada has operated the DTS system for approximately 2800 hours representing 28,000 line kilometers of profiles since 1975. It should be noted that commercial systems are operating in the North Sea. The SEABED project has resulted in a rich harvest of new ideas and a unique combination of advanced Canadian high technological capabilities which can provide the basis for an entirely new family of instrument systems for imaging and probing beneath the sea floor. To exploit these new opportunities and to realize the full benefits of such research will require new mission-defined programs beyond 1981. For the past twenty years scientists from the Physics Division of the National Research Council have collaborated with the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, and other governmental institutions and Canadian high technology companies to develop a wide range of sophisticated oceanographic instruments.

Their collaborative effort culminated in the development of a unique Canadian system for rapid, ocean-related data gathering. The system is nicknamed BATFISH and it is a versatile oceanography research vehicle which carries sophisticated equipment to gather data about temperature, the salt content of sea water, and the concentration of microscopic plankton. The system is based on the use of specialized sensors mounted on a versatile towed body developed at the Bedford Institute and now manufactured under licence by Guildline Instruments, Smiths Falls, Ont. The BATFISH can "fly" from the surface to a depth of 300 metres, diving and rising in a sawtooth pattern at a set rate. The continuous measurements replace the traditional method of stopping a ship to make the necessary tests.

Extensive offshore resources exploration has a significant impact on the marine environment. Offshore Labrador Biological Studies (OLABS) is an industry/community/government program designed to assist in the environmental assessment of oil and gas developments off the coast of Labrador. It is designed to complement the environmental studies already undertaken by industry and government in the region and to fill major gaps in our knowledge of marine and coastal biota. OLABS has been planned as a three-year program of studies funded by industry, to cost some $2.5 million. It was originally conceived within the larger Eastern Arctic Marine Environmental Studies Program (EAMES). The management committee of the OLABS Program consists of representatives from the Department of Energy, Mines and Resources, the Labrador Resources Advisory Council, the offshore exploration industry, the Canadian Wildlife Service, the departments of Fisheries and Oceans and Indian Affairs and Northern Development, and the Province of Newfoundland. The OLABS program includes studies on fish and the fisheries, zoobenthos, sea birds, marine mammals and plankton.

The Canadian Hydrographic Service is engaged in a large number of R & D and technology transfer programs. The following examples illustrate this activity. Two of the most difficult technical problems

faced by the service are (i) the detection of underwater pingos in the Beaufort Sea, which pose a significant threat to deep draft shipping and (ii) expediting the surveys of inshore waters, the most tedious of all tasks. Using funding provided by the Interdepartmental Panel on Energy R & D, contracts have been awarded to study the complex accoustical paths in the highly stratified Beaufort Sea and the reflectivity characteristics of the pingos which have an ice core.

Philip A. Lapp Ltd. was awarded a contract, using Unsolicited Proposal Funds, to manage the aerial hydrography project and transfer this technology to industry. This is a joint thrust by the Canadian Hydrographic Service and the Canada Centre for Remote Sensing. A DC-3 aircraft is equipped with an air survey camera and a laser profiler to measure both the height of the aircraft and depth of the water, and an inertial guidance system is used to determine and record the position and altitude of the aircraft. This will enable the preparation of accurate maps of the shoreline and shallow water areas. Four companies are now involved in the processing of the results from the first test flights in the Thousand Islands area.

Two other projects have been transferred to industry for exploitation. The first is an electrically-actuated spike transducer which can be fitted outside a helicopter or a tracked vehicle for sounding through the ice. Its use more than doubled the rate of data collection in 1979. The second is HY-NAV, the commercial version of NAVBOX which was designed and developed within the Canadian Hydrographic Service. Commercial exploitation by D.G. Instruments Ltd. is being supported using funds from the Cooperative Projects with Industry program. The equipment enables a survey platform to be navigated along any pre-chosen line using the signals from any electronic positioning system. Once a reliable recorder has been developed, it will also be used as a data logger to record the depth, position and time of every sounding.

Huntec Ltd. have been awarded a contract using Unsolicited Proposal Funds to evaluate the possibility of obtaining continuous ice profiles by aerial surveying. This uses a parametric transducer design, an innovative technique where acoustic signals of two different frequencies are mixed to obtain a strong signal at the difference frequency. Huntec has also developed a body-motion compensator that promises a dramatic improvement in the side scan sonars. This is one technique for obtaining a superior total coverage of the sea floor, information which is essential for deep draft ships in channels where there is very little bottom clearance. The Canadian Hydrographic Service has now built up considerable expertise in calibrating Loran-C, the electronic aid to navigation adopted for use in Canadian coastal waters and the Great Lakes. Abrupt, and potentially dangerous, changes occur where the signals cross from land to water, or where the signals cross complex terrain involving different lengths of land and water. It is intended to extend these studies into the Arctic where a third variable is introduced, the variation in snow and ice cover.

As well as seeking additional funds for the front-end costs involved in contracting out hydrographic surveys, the Hydrographic Service has also requested additional resources for a major five-year program to survey the routes that will be used by tankers to move oil from the Beaufort Sea or liquid natural gas from the Queen Elizabeth Islands. Funds are also being sought for a contract to carry out offshore multiparameter surveys in the Davis Strait and off the Scotian Shelf. The transfer of this technology to industry would enable it to compete for contracts of this type abroad.

Scientific & Technical Information

Canada's scientific and technical information (STI) services are an essential element catalyzing both the efficient conduct of R & D and its effective application in the solution of problems, in the exploiting of opportunities and in the production of goods and services.

The supplying of scientific and technical information (STI) to users in Canada is made difficult by such factors as a small population distributed over large distances, a pluralistic society with two official languages, multiple levels of government, and the need for an industrialized country to maintain coverage of virtually all fields of S & T while itself producing only a small percentage of the world's output. No matter what exact definition may be chosen for STI, it is clear that maintenance of an adequate and up-to-date knowledge data base must be an important part of Canadian science and technology. Within the federal government alone, $131.0 million will be spent on scientific information services in 1980/81 out of a total budget of $2094 million for scientific activities of all

Table 3.12

Federal Expenditures for Scientific and Technical Information

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**112.5**	**118.8**	**131.0**
Consumer and Corporate Affairs	8.1	8.3	8.7
Energy, Mines and Resources	5.0	5.5	6.0
Environment (Total)	13.5	14.1	14.9
Atmospheric Environment Service	3.6	4.4	4.6
Environment Management Service	7.5	7.4	7.4
International Development Research Centre	3.1	3.3	4.0
National Library	12.8	14.7	17.1
National Research Council (Total)	15.0	18.6	21.5
Scientific and Industrial Research Program	1.6	4.9	5.5
Scientific and Technical Information Program	14.4	13.7	16.0
Public Archives	7.9	8.6	9.7
Social Sciences and Humanities Research Council	3.3	4.1	4.8
Statistics Canada	9.8	9.2	10.1
Others	34.0	32.4	34.2

kinds. For the most part these STI activities are elements of broader programs, contributing to such activities as training of highly qualified manpower, regulatory functions, resource management, defence, and support of industrial technology, as well as scientific research in general. In developing mechanisms for the collection and delivery of STI in Canada, the emphasis has been placed on practical tools and services rather than on information policies. The importance is recognized of interdependency and cooperation, both domestic and external.

Because Canada is largely dependent on knowledge published elsewhere, we are accustomed to drawing on the world's S & T literature through science libraries and related systems and services. Foremost among these resources is the Canada Institute for Scientific and Technical Information (CISTI), which holds our largest collection of STI. CISTI is part of the National Research Council, which operates the federal government's largest multi-disciplinary R & D laboratories. It carries primary responsibility for providing national STI services and related support, and has been specifically charged with building up a national network of STI services. (General bibliographic matters of national scope are the particular responsibiliy of the National Library of Canada).

The institute's strengths in the natural sciences and engineering are complemented by other federal collections of national stature such as those of the National Library in the social sciences and humanities, of the Geological Survey of Canada, and others. The Department of Agriculture has a network of over 20 branch libraries located across the country, at the hub of which is the headquarters library in Ottawa. There is also a well established cooperating network of university libraries across the country. Many scientific and special libraries in Canada have grown up over the years in response to institutional needs, and there is typically a great degree of cooperation and interdependence in matters such as interlibrary loans.

Examples of other S & T information services include those based on specialized data collections, such as the National Index to Sources of Geoscience Data, of the Department of Energy, Mines and Resources, or the Water Resources Document Reference Centre operated by the Department of the Environment.

Increasing use is being made in Canada of various computerized information systems that are available commercially, through companies such as Informart and QL Systems in Canada, both providing rapid and effective on-line bibliographic search services. CISTI itself has pioneered the development of a number of innovations in systems and services for bibliographic search and retrieval in order to meet broad national needs. A prime example is CAN/OLE (Canadian ON-LINE ENQUIRY SYSTEM), now widely used in Canada and well-known internationally. At present over nine million citations from 15 data-bases can be

accessed, in either French or English, through some 525 communications terminals across the country. CAN/OLE is not only a bibliographic search system but also provides a document location index tool as well as national directory of subject expertise.

The National Research Council also operates a Technical Information Service (TIS), which operates rather like an agricultural extension service, but is oriented to the needs of small and medium manufacturing businesses with few or no technical staff or resources of their own. Through a network of field offices, many operated in conjunction with provincial organizations, the Technical Information Service provides technical information to help solve their manufacturing problems, and to improve productivity, to identify opportunities resulting from technological developments, and to promote the use of research results in industry. With more than three decades of operating experience, TIS has become a model for similar schemes in a number of other countries.

Social Development

Science activities in the social development field within the federal government provide information for policy decisions over a wide range of areas: education, labour, manpower training and employment, population control, housing, consumer safety and health standards, community development, and social welfare. Consequently, several departments and agencies are involved in such activities, as shown in Table 3.13. Some of the goals of the policy initiatives are: improving welfare services; providing training for a more capable and flexible work force; increasing employment and improving the standard of living; measuring the implication of new technologies with respect to the economic security and safety standards of the work force; studying the growth of urban communities and their impact on transportation and housing.

Research in economics, sociology, education, demography, anthropology and other social disciplines has made a significant contribution toward the analysis of issues facing Canadian society. For example problems linked to unemployment among youth and skilled manpower have been extensively studied. Nevertheless additional disciplinary research is needed to diminish social tensions and their consequences.

Within the Department of Labour, the Research and Development Division serves as the planning center for researching, advising and recommending programs and policies relating to conditions of work. During the year, the division was engaged in research related to sick leave and handicapped workers, a survey of the hours of work and time-budgets in Canada, and in the preparation of papers dealing with problems of elderly workers for meetings of the International Labour Organization and the Organization for Economic Cooperation and Development (OECD).

The department's Employment Relations Branch has been developing policies and programs directed toward improving labour-management relations and

Table 3.13

Federal Science Expenditures on Social Development

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**28.5**	**28.1**	**28.2**
Employment and Immigration	2.3	1.9	1.9
Labour	3.3	3.2	3.8
National Health and Welfare (Total)	11.9	9.5	10.6
Administration Program	6.7	5.3	6.4
Health and Social Services Program	4.9	3.9	3.8
National Research Council	2.6	3.4	3.4
Statistics Canada	3.4	3.2	3.5
Others	5.0	6.8	5.0

the quality of working life (QWL). Since its establishment, the branch has been actively engaged in promoting conditions within which successful applications might be undertaken to improve QWL, with emphasis being placed on the restructuring of organization and employee control systems, the redesign of jobs and the improvement of the work environment. Development work undertaken during the year has continued:

- to increase public awareness of the QWL approach to organizational change and its potential for improving employee satisfaction and organization effectiveness;
- to develop a Canadian network of QWL consultants, managerial practitioners and union officials having specialized knowledge in the principles and techniques associated with QWL;
- to support and conduct QWL conferences, seminars, workshops, work change projects and research studies.

A major vehicle for S & T in social development in the Department of National Health and Welfare is the National Welfare Grants program. Its objective is to promote improvements in welfare services and self-help activities:

- by providing financial assistance, consultation, information and advice to governmental and non-governmental welfare agencies, including citizen organizations, to enable them to carry-out short-term research and demonstration projects and other S & T activities, and
- by providing financial assistance to individuals for advanced studies in social work.

Research activities funded by the program are directed towards the aged, single parent families, family life, unmarried mothers and the handicapped. Support is also given to on-going research in the areas of social policies, child welfare, the service delivery systems, family violence and breakdown, industrial social work, social gerontology and welfare manpower. New demonstration projects have focused on models of human resources development and residential treatment for abusive families. There are on-going projects in support of community corporations for economic and social development, which enable low-income groups to find alternatives to dependency on social assistance. In addition to sustaining grants to national voluntary agencies to assist with core operational costs, project grants are provided to a number of voluntary agencies for related science activities. For example, studies have been conducted:

- in family resources and comprehensive community services for developmentally handicapped children and adults;
- in trends in foster care and adoption services and home help services;
- of a developmental model of services, technical aids and information service systems for the physically handicapped.

The National Research Council is engaged in a variety of research projects that have a significant social or cultural object in many areas of Canadian life, particularly public safety, consumer protection, and education and training. Among other things, the council has assumed responsibility for the Rehabilitation Technology Unit located at Sunnybrook Hospital, Toronto. The council supports a continuing program of work on improved aircraft safety and technical aspects of air accident investigation. A viable and cost-effective computer-aided learning system for Canadian users has progressed to the final stage of technical development.

Science activities in support of social development within the Citizenship Program of the Secretary of State Department range from research into second-language learning disabilities to development of automatic translation systems and to survey design and data collection concerning a variety of cultural topics. The Language Programs branch has been developing an automatic system for translating weather forecast reports and a more efficient, computerized system was put into operation on an experimental basis in March, 1979, in cooperation with the University of Montreal. The Research and Statistics Directorate is cooperating with Statistics Canada in developing a joint national Cultural Statistics program. Examples of recent major science projects are:

- a major survey of cultural activities and performing arts in eighteen Canadian communities;
- analyses of the data from a national readership survey conducted by Statistics Canada;
- evaluation of the impact of the 100 Percent Capital Cost Allowance on the Canadian feature film industry.

The department's Policy Planning and Priorities Directorate participates in such science activities as

questionnaire design for surveying the usefulness of the Canadian Ethnic Press Review, the establishment of a research data base for the Migrating Native Peoples' Program, and questionnaire design for a survey of organizations involved in multicultural studies.

Space

This application area embraces two distinct kinds of scientific activity: space technology, i.e., the development of satellite systems for various applications including space research; and space research, such as upper atmosphere research, planetary research, cosmology and research in astronomy. Since 1969 the government's activities in space technology have been coordinated by an Interdepartmental Committee for Space. Beginning in 1978, the committee now prepares an annual integrated submission for all space technology activities. Departmental and agency proposals are reviewed and, where possible, ranked in terms of relative priority and their relations to the achievement of national goals.

As seen in Table 3.14, the government's expenditures in space science declined from $80 million in 1978/79 to $55 million in 1980/81, partly as a consequence of major projects nearing completion and partly due to the deferral of a number of new projects so as to smoothe the work load in the Canadian space industry. Since most of the current major projects are expected to be completed by the end of 1980/81, maintenance of an adequate industry load requires the initiation of new projects. An overall five-year plan has been developed by the Interdepartmental Committee for Space from individual departmental proposals. Elements of the plan are discussed later.

The major objectives of Canada's space policy are:

- that space activities serve national goals;
- that a viable, competitive space industry in Canada be developed and maintained;
- that there be underlying research and development both to contribute to the knowledge of the fundamental properties of space and to assess the potential applications of satellite systems.

The utilization of space technology in the achievement of national goals occurs through activities proposed and budgeted by departments and agencies in accordance with their established mandates. In support of the objective of achieving a competitive Canadian space industry, there is a deliberate policy of moving the performance of the government requirements for space science into industry and a purchasing policy which favours Canadian supply in satellite system deployment, with the exception of launching capability. Canada will continue to procure its launch vehicle requirements from other nations. It is an element of our space policy that Canada seek opportunities for cooperation and participation in the space programs of countries with launch facilities.

The policy recognizes that Canada's ability to use space science will be improved significantly by supporting underlying research into the nature of space, the search for potential applications, and technology programs which develop industrial capability to meet future requirements for operational satellite systems. Our use of space science will also be strengthened by participating in international activities for the use and regulation of activities in space,

Table 3.14

Federal Science Expenditures on Space Science and Satellite Technology

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**79.7**	**62.9**	**54.8**
Communications	40.7	41.2	39.6
Environment	1.7	1.9	2.2
National Research Council	36.9	19.3	12.5
Others	0.4	0.5	0.5

negotiating agreements for continuing access to science, technology and required facilities, and maintaining knowledge of foreign space activities, in order to respond quickly at the national level to opportunities and threats to national sovereignty. From the very inception of its space program, Canada has pursued a policy of international cooperation through agreements negotiated with the U.S. and, in some cases other countries as well, for all its major projects, e.g., Alouette, ISIS, HERMES, RMS, LANDSAT. This approach has been very successful in reducing the costs of the program, in forging international scientific and technology links that provide Canada with technology not otherwise available and in creating opportunities and economic benefits for our industry.

Since satellite technology is particularly suited to the solution of some distinctly Canadian problems deriving from our severe climate, vast land and coastal area, and scattered population, Canada has been involved in satellite development for two decades. It was the third nation to have its own domestically-developed satellite in orbit. Our satellite development activities aim to improve and develop communication systems, weather forecasting and surveillance of land and ocean areas, to support search-and-rescue missions and to support space-related scientific research.

In 1977 the Government of Canada determined that a priority objective of the national space program should be to demonstrate at the earliest possible time the capability of Canadian industry to compete as prime contractor for communications satellites. This policy was reaffirmed in 1979, and in support of the policy, the David Florida Laboratory of the Communications Research Centre, Department of Communications, is being expanded to provide Canadian companies with an increased integration and test capability for future Canadian and international satellite programs. Initially, facilities will be available for the Anik-C-3 satellite being built for Telesat Canada. The fully expanded facilities will be available for Telesat's Anik-D program. The extension will include modifications to the present buildings, to provide an increased area for satellite integration, a 25-ft by 40-ft thermal vacuum chamber, an upgraded vibration facility, testing equipment for the satellite systems, as well as upgraded data acquisition, radio frequency range, and alignment capabilities. The completed facility is expected to be available by January, 1981.

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 U.S. National Aeronautics and Space Administration (NASA) 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 ionospheric 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 redesigned as a highly sophisticated communications technology satellite to explore the use of the 14/12 GHz band for the provision of new communication services. Launched in 1976, and named HERMES it was until recently the world's most powerful communications satellite. Since 1973, operational communications systems have been using the Anik-A series of satellites.

Canada has not restricted its satellite useage to tele-communications but has a highly diversified satellite program. During the past decade an increasing number of agencies have used satellite systems to supply operational services. The departments of National Defence and Transport are investigating satellite systems for search-and-rescue notification. The Department of Communications is sponsoring satellite field trials for direct-to-home broadcasting and the delivery of tele-health and tele-educational services to remote areas. In addition, it is studying a multipurpose satellite, MUSAT, for use in mobile communications services. The Canada Centre for Remote Sensing (Department of Energy, Mines & Resources) is receiving and processing data from LANDSAT and TIROS-N/NOAA Satellites for application in agriculture, forestry, water resources, ice reconnaissance and oil and mineral exploration. The Department of Environment operates a network for reception and distribution of data from GEOS and TIROS-N/NOAA satellites. These data are used operationally in preparing forecasts of weather and ice conditions. Discussion of the uses of two of these non-communications type satellites follows.

The U.S. LANDSAT system gives information about the earth's surface, which is being found to be increasingly valuable for crop inventory, forest and wildlife management, water resource management, land use mapping, ice reconnaisance, and mineral and petroleum exploration. LANDSAT-1 was launched in July 1972 and was followed by LANDSAT-2 in January, 1975 and LANDSAT-3 in March, 1978. Canada has participated in this program by providing Canadian earth stations for the reception of LANDSAT

data. LANDSAT-D, which is expected to be launched by NASA in 1981, will provide better color and spatial resolution (30 instead of 80 metres) and, consequently, more detail and an improved identification capability but will require that the Canadian earth stations at Prince Albert, Sask. and Shoe Cove, Nfld. be extensively modified.

SURSAT was established in 1977, as an interdepartmental project, to determine the feasibility of using satellites to assist in meeting surveillance needs for the period 1980-2000 over the 200-mile coastal zone. These needs include daily all-weather monitoring of sea ice, wind and sea state, ocean pollution, ships, oil rigs and navigational aids. The project included participation in the U.S. SEASAT-A experiment, a complementary research and development program, and consultation with potential international partners regarding a joint operational system.

Developed within the SURSAT program, a technique called Synthetic Aperture Radar (SAR) is of particular interest to Canada, since it affords an all-weather 24-hour capability for surveillance and has proven its effectiveness for monitoring ice and sea conditions. It has also demonstrated reasonable capability for monitoring shipping. McDonald, Dettwiler Associates of Vancouver has developed a unique capability in the computer processing of SAR data. Since 1963, Canada has acquired cloud pictures and other data from U.S. satellites, using our own earth stations. The meteorological services of the U.S., Canada and other members of the World Meteorological Organization operate data acquisition, communications, and processing networks to provide a truly global system for meteorological information. R & D activities are undertaken and coordinated both to meet national needs and to advance the global capability.

As seen in the accompanying table, the Department of Communications is the largest funder of space science and technology. In addition to programs directly in support of its mandate, the department also provides technology support to other departments, including the Department of National Defence, in meeting Canadian needs in the design, development and construction of Canadian satellite systems. The department is providing project management and technical expertise for SARSAT, a joint Canada-France-U.S. search-and-rescue satellite. Other current R & D projects include the development of a global positioning system and support to the Canada Centre for Remote Sensing for work on the surveillance satellite project. There is also indirect support to other departments through the Secretariat of the Interdepartmental Committee on Space.

Within the department, advanced planning has been completed for the multi-use satellite, MUSAT, which is being developed to meet existing and projected mobile communications and other needs for government operations in the northern and coastal areas of Canada.

In its technology development program the department identifies and develops satellite and communications systems technology necessary to meet Canada's needs in space telecommunications. Most projects are carried out in cooperation with Canadian industry or universities under the department's industrial contract fund and other contracts from the department's operating budget. Projects in this program include the development of earth terminals and satellite technology (transponders, antennas and component development) for super high frequency communications, and spacecraft power systems technology, including battery management on spacecraft. The control of spacecraft attitudes is also being investigated, in particular satellite and antenna control and pointing. The department is also using Telesat's Anik-B satellite to determine the viability of new telecommunications services by means of pre-operational projects. The aim of these projects is to develop expertise in user institutions to better utilize the 12-14 gigaherz satellite technology. Approved pilot projects include community communications, tele-education, tele-health, and public service communications.

The department is deeply involved in the support program for the development of the Anik-C and -D series of satellites. The support includes the extension of the David Florida Laboratory to provide integration and test capability, as mentioned above. The department will act as a design authority for the Anik-C-3 integration and test contract. It will provide specific technical support to the prime contractor in the areas of reliability and integration and test for the Anik-C-3 and -D programs and will support the Anik-D procurement activities.

In the foreign sphere, an Agreement of Cooperation between Canada and the European Space Agency (ESA) came into force on the 1st of January, 1979. It provides for contributions to ESA's general studies program and fixed common costs. Canadian companies registered interest with ESA in meetings held in February, 1979. Contracts have been awarded in general studies and basic technology to Canadian industry. Participation in ESA's L-SAT, a communications platform development and demonstration, and the Preparatory European Remote-sensing Satellite Program has recently been approved.

The department maintains an industrial contract fund to foster the growth of Canadian industrial capability for the design, development and manufacture of satellite sub-systems and components. 50% of the contracts are for satellite work and 50% are for earth terminal-related work. The program has reinforced the bilateral exchange of technology between the department and industry, and has established closer contacts between industry and departmental scientists.

The other broad category of the government's space activities, space research, is conducted entirely within the National Research Council. Canada's last scientific satellite, ISIS II, was launched in 1971. A new cooperative space science program has been negotiated with NASA and approved by the government. Its objectives are:

- to sustain and improve Canadian research competence in the space sciences;
- to provide a significant fraction of new knowledge needed by Canada to base decisions on the future use of space;
- to train young scientists and engineers in a variety of space disciplines of interest to Canada and to share with NASA the generation of new knowledge.

The program will consist of three separate contributions to the Shuttle/Spacelab missions: ground-based observational facilities in support of a NASA study of the origins of plasma in the Earth's neighbourhood; the processing and storage of data from both ground-based and satellite observations; and a mechanism for funding future Canadian responses to NASA's "Announcements of Opportunity". The 6-year program is expected to cost about $34.5 million (1980 dollars) and Parliamentary approval will be sought for 1980/81 funds of $4.53 million.

Most of the large satellite projects of recent years, such as the Remote Manipulator and the HERMES and Anik-B satellites, have been or are in the process of being completed. To fulfill the national space mandate and to maintain continuity in space activities new R & D projects are required. New projects are also required at this time to maintain international contacts and to develop cooperation. Other countries, notably the U.S. and the European Economic Community, are going through a similar stage in the development of their own programs and are looking for partners in cooperative ventures. The Interdepartmental Committee for Space has combined individual departmental plans into an overall Five-Year Plan for proposed new space activities, including a planning envelope for major projects that may be proposed by departments in later years. In addition the Department of National Defence is actively considering additional R & D projects, starting in 1981/82, which are directed towards the military application of satellite systems. Fifteen new projects have been proposed for 1980/81, most of which can be categorized as R & D-intensive. Four categories of R & D projects have been proposed:

Remote Sensing

- Technical studies prerequisite to a Canadian radar development program,
- A Canadian radar development program (subject to the above prerequisite),
- Utilization of new meteorological satellites,
- A joint Canada/USA meteorological satellite research program.

Space Science

- A joint NRC/NASA Space Science Program

Communications

- Engineering definition studies prerequisite to a multipurpose satellite system (MUSAT),
- Planning studies for a direct satellite broadcasting system (DBS),
- Extension of the ANIK-B experimental program.

Industry Support

- . An increase of DOC's technology development program,
- . Industry support in its bid for the NATO-IV satellite contract
- . Support of new international initiatives.

Transportation

Combined effects of demography, physiography, climate and resource distribution have been responsible for the evolution of the extensive and diverse transportation systems within Canada. Transport Canada has responsibility for the efficiency and safety of these systems, and for the operation of specific elements within them. Technical research and development is one of the means by which recognized deficiencies and inefficiencies can be rectified. A major consideration in the resolution of transportation requirements is the current state of existing systems and the major capital expenses involved in new systems. Consequently upgrading and incremental improvements by application of modern technical advances is a major objective of the research activity. To fulfil its role the department requires up-to-date expertise which can recognize and assess the potential of technical advancements for incremental improvements to mature, highly-developed tranportation systems, and at the same time can assist and encourage the introduction of new concepts and designs when modification of existing systems is considered uneconomical or insufficient to meet requirements. Among the related scientific activities data gathering is important for the accurate assessment of existing transportation capabilities, for the prediction of future requirements and for the establishment of the optimum methods for achieving goals.

Because transportation is involved in many of the activities and responsibilities of the federal government, transportation- related science and technology is also conducted by other departments, as shown in Table 3.15. The coordination of activities and delegation of specific responsibilities of these departments is carried out by the Interdepartmental Panel of Transport Research and Development, which is chaired by the Assistant Deputy Minister for Strategic Planning, Transport Canada. Special emphasis is given to problems of particular importance to Canadian transportation and to the adaption of known techniques to satisfy Canadian conditions.

In the Department of Energy, Mines and Resources, the Earth Sciences Program is involved in the construction requirements and routing of land transport systems. Transportation applications in the Minerals and Energy programs are found in the need for developing fabrication techniques and structural materials with characteristics suited to the many needs of transportation such as: lighter weight materials and alloys for vehicles, rail and wheel materials with improved wear characteristics and materials specifically suited to the rigours of the arctic environment.

The Department of Fisheries & Oceans provides marine data services; in particular the charting of inland and ocean waters is required for marine navigation. Related science activities in meteorology, seastate and ice forecasting are carried out by the Atmospheric Environmental Service (Department of the Environment) and provide essential support for the air and marine transport modes. Environmental information is valuable in establishing requirements for systems and components, particularly with respect to recent endeavours to extend transportation in northern regions.

Table 3.15

Federal Science Expenditures on Transportation

Department/Agency	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**89.8**	**73.3**	**73.7**
Energy, Mines and Resources	2.3	1.9	2.5
Fisheries and Oceans	25.2	23.1	23.9
National Research Council	15.9	18.0	19.1
Transport Canada (Total)	38.6	23.6	21.9
Air Transportation Program	10.9	5.8	6.6
Marine Transportation Program	10.6	9.5	10.8
Surface Transportation Program	12.7	3.8	0.5
Canadian Transport Commission	3.6	2.7	2.7
Statistics Canada	2.9	2.7	3.0
Others	1.3	1.3	0.6

The National Research Council is a major contributor to research and development in all aspects of transportation engineering through its maintenance of national facilities and the interaction of diversified scientific personnel. A highly developed expertise has been built up in scale modelling techniques and associated equipment such as wind and water tunnels, towing tanks and topographical models, which provides great economy in the testing, evaluating and design of various transport system components. A new major test facility is the full scale curved track simulator which allows the testing of rail cars. Methods to enable the safe usage of rail cars at increased speeds and wheel loadings without excessive rail and wheel deterioration are being investigated. Studies of air cushion vehicles have shown them to have characteristics and applications especially suited to some of Canada's off-road surface transportation needs. This expertise in air cushion vehicle technology has been instrumental in the development of an air cushion platform which, when attached to the bow of existing vessels, has shown a high improvement in ice-breaking capabilities.

Present day transportation systems rely on the availability of cheap portable fuel in the form of oil. A dominant motivation for current transportation-related research is the predicted scarcity and increased cost of natural oil fuels. In the face of decreasing conventional oil supplies more efficient usage is necessary, while alternative oil sources and/or energy forms are developed. Methods of optimizing those parameters affecting current vehicle fuel consumption are being studied and tested while diverse alternative types of fuel and propulsion units are being explored.

One of the alternative oil sources for Canada is being developed in the Arctic islands. Exploitation of these resources, however, will depend on the development of efficient safe and economic movement of this oil and gas to southern Canadian markets. Transportation via the favoured marine mode requires extensive development of transportation capabilities under extreme climatic conditions and through hazardous ice-covered and ice-infested waters. The energy situation gives added incentive to on-going research into arctic shipping requirements which were instigated in order to fulfill a federal role of establishing Canadian sovereignty in the Arctic.

The majority of Transport Canada's S & T activity for 1980/81 will be of an on-going nature. Involved in the marine mode, are the updating of navigational aids, improvements to the handling capacity of the St. Lawrence Seaway, increased effectiveness of icebreaking, and investigations related to transportation in ice-covered waters. In the air mode incorporation of new developments into air traffic control methods and navigational aids, and in surface transport work on those aggregated projects recommended by the Rail Advisory Committee will be continued.

Two major new proposals from this latter package will be the development of an advanced technology diesel locomotive and a high speed ballast undercutter. Locomotives currently in use were essentially developed over 25 years ago and new technologies are now available which would allow increased efficiency and reduced fuel consumption to such an extent that redesign and production of a new generation of locomotives is justified. The handling capacity and safety of rail systems as determined by weight and speed limitations is dependent on the maintenance of high quality track conditions. The labour cost and time of such maintenance will be reduced considerably by the proposed high speed ballast undercutter. These two projects are being conducted in industry under the cost shared industrial support program of Industry, Trade and Commerce.

The Department of National Defence cooperates with Transport Canada by providing some facilities and technical support to the Road Safety Unit at the Defence and Civil Institute of Environmental Medicine in Toronto and by conducting anthropometric and human engineering studies related to vehicles. In addition to vehicle mobility studies at the Defence Research Establishment in Suffield, Alberta, a number of other defence projects can be considered as transportation- related. These cover such diverse fields as search-and-rescue (because of the implications for transportation safety), ship reliability studies, marine propulsion and vehicle batteries. Approximately $15.8 million of its S & T expenditures in 1980/81 will be related to transportation, of which 71% will be performed extramurally.

In recent years there has been a growing concern both in Canada and throughout the world over the problems of urban transportation. Alternatives to existing urban transportation systems with improved economy of operation, increased handling capacities, environmental and aesthetic acceptability and positive contribution to present day energy concerns are being pursued. While the construction, operation and maintenance of urban transportation in Canada is primarily the responsibility of local and provincial governments, the federal government is involved through its concern for the urban transport equipment manufacturing industry. Development of improved urban transit systems not only satisfies a domestic need but has potential as a profitable export industry.

The urban transport industry is fragmented in that it is supplied by elements of many industries. To coordinate these activities in Ontario the Urban Transport Development Corporation was formed by the Government of Ontario and the Transit Development Centre was set up in Kingston as a nucleus for technology development activities. A prototype intermediate- capacity urban transport system has been developed and it is now proposed that a fully operational passenger-carrying demonstration be built in the Hamilton Wentworth municipality. Such projects are considered vital to establish credibility in international markets. Possible funding schedules involving the municipality, the Government of Ontario and the Government of Canada are under consideration. To eliminate needless diversity in Canadian efforts the activities of other Canadian urban transportation enterprises may also be incorporated.

The proposed intermediate capacity system features trains travelling on exclusive rights of way either above, below or at street level and has a capacity of up to 20,000 persons per hour. This lies between the range for current bus or streetcar systems and that of subway systems, but with significantly lower costs than the latter. All aspects of currently operating systems and components have been individually assessed, modernized and tested before integration into a highly sophisticated prototype system. Some specific features included are: instead of wheel propulsion, the system uses linear induction motors driving and braking on an aluminum strip between the rails, steel wheels with an innovative steerable axle system to reduce squeal and wear on curves, ready adaption to various degrees of automation from manual to fully automatic, when the trains are electronically linked to allow safe operation at closely spaced intervals. Flexibility of design and development of new body welding techniques will allow the system to be readily adapted to specialized uses and will provide economy in fulfilling small order requirements.

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. The government's extramural expenditures by performing sector are shown in Table 4.1.

Since 1978 the government has pursued a policy of strengthening the R & D capacity of the country, primarily in the extramural sectors and particularly in industry, with a target of increasing Gross Expenditures on R & D (GERD) to be closer to that of other industrialized countries. Earlier initiatives in support of increased GERD included: increased tax incentives; improved procurement policies; enhanced technology transfer from government laboratories to industry; improved interfaces among government, industry and university laboratories; science and technology employment initiatives; and further enhancement of university research in areas of national concerns.

The magnitude of the increase in Canadian R & D being sought implies a major increase not only in the supply of highly qualified manpower but also in the knowledge base, i.e., basic research. This in turn implies a strengthening of the university research system. Accordingly, the estimates show substantial increases in the 1980/81 budgets of the three granting councils: $42 million, or nearly 35% increase for the Natural Sciences and Engineering Research Council, $10 million, or 14% increase for the Medical Research Council and $6 million, or 16% increase for the Social Sciences and Humanities Research Council.

Table 4.1

Federal Extramural Science Expenditures

	1978/79		1979/80		1980/81	
	(millions of dollars and (%))					
Total	**620.7**	**(100)**	**683.0**	**(100)**	**777.7**	**(100)**
% of Total S&T	*34%*		*36%*		*37%*	
Industry	254.3	(41)	281.1	(41)	303.9	(39)
University	244.9	(39)	258.9	(38)	322.4	(41)
Canadian Non-Profit Institutions	27.4	(4)	25.4	(4)	23.1	(3)
Provincial and Municipal Governments	29.6	(5)	48.4	(7)	57.8	(7)
Foreign	47.0	(8)	48.7	(7)	53.1	(7)
Others	17.6	(3)	20.5	(3)	17.4	(2)

Concerning the use of government procurement to encourage R & D in Canada, a new procurement policy has been put into force whose objective is to obtain significant socio-economic benefits from government procurement. One of the sub-objectives is to concentrate initially on industrial benefits, particularly in the electronic and other high technology sectors. In addition to fostering the development of high technology industries, the policy is expected to assist in improving export potential, stimulating new product innovation and improving production technology. In particular the policy permits, under certain conditions, the payment of extra costs or a premium for "buying Canadian". Among the criteria to be met for choosing a procurement where extra costs are involved are:

- there are good prospects for commercial viability;
- the benefits justify the extra costs;
- the benefits would not be realized without government assistance;
- the procurement will contribute to the exploitation of a strategic opportunity.

Other initiatives in the procurement area include the establishment of a federal-provincial working group on Cooperation in Procurement Policy. A number of case studies are underway including one which examines the effects of procurement policy on industrial R & D efforts. The Department of Energy, Mines and Resources established an Advisory Committee on Industrial Benefits which, with provincial input, has been reviewing major capital projects in the energy development field with the objective of obtaining maximum Canadian industrial participation. The Cold Lake and Alsands projects have been the subject of recent and on-going negotiation with respect to Canadian managerial content.

In concert with the increased emphasis on technology transfer, Canadian Patents and Development Limited has seen a considerable increase in the past year in the licensing of "know-how", i.e., unpatentable or unpatented technology. The trend shows no signs of abating. In its more traditional patenting and patent licensing activities, the agency expects that some of the most important scientific advances of the 1970's will be licensed in 1980/81, particularly in the fields of genetic engineering and energy. 1979/80 royalty income is expected to be in excess of $1 million.

The agency continued its funding of the Inventors Assistance Program at the University of Waterloo. By means of a simple registration and disclosure and payment of a $50 fee, an inventor may obtain a feasibility and marketability assessment, on a confidential basis, from a select group of professionals, drawn from the university staff and elsewhere. From its inception in April, 1976 to September, 1979, there have been over 1,700 enquiries, 517 inventions were evaluated and 160 were considered to have commercial potential.

Other measures in this area included an expansion of the National Research Council's successful Program of Industry/Laboratory Projects (PILP) and the establishment of a similar program, Cooperative Projects with Industry (COPI), for other departments. Because of the need for expenditure restraint, funds for COPI have remained at the initial level of $2.1 million, shared equally by the departments of Agriculture, Communications, Energy, Mines and Resources, Environment and Fisheries and Oceans.

Implementation of the policy to strengthen government/industry/ university interfaces is proceeding. Construction will begin in 1980 on the facilities for the Arctic Vessel and Marine Research Institute at Memorial University, St. John's, Nfld. Priority is being given to the recruitment of staff for the National Research Council's new *Institut de génie des matériaux* on the South Shore near Montreal. An expanded program on fermentation technology has been established as a collaborative venture between the Prairie Regional Laboratory of the National Research Council and the Saskatchewan Research Council.

Within the Canadian science system, it is in the universities that our capacity to undertake basic research has been developed and is located. The need for new knowledge cannot fully be met without investment in university research. This research is also the principal means of training research manpower in Canada. As a consequence the universities are the very core of the Canadian science effort.

Since Canada undertakes about 3% of the world annual expenditures on R & D, our first science priority must be to maintain access to the other 97%. To draw from this pool we must contribute visibly to it, which implies the need to maintain excellence and a healthy capacity in most disciplines. We cannot, however, rely on imported knowledge to understand our own society and cultures, nor to achieve international leadership in selected areas of science and technology. In these areas Canada must develop specialized and enhanced capabilities.

There are convincing arguments that a proportion of research must be unconstrained so as to provide for the unexpected breakthroughs and to respond to the

emergence of new priorities and problems. If all research were to be orchestrated on the basis of today's prediction of tomorrow's priorities, there would be a serious impairment in the ability to respond to the unexpected. Ten years ago, for example, few would have predicted the resulting consequences for science activities of declaring a 200-mile ocean limit for Canada. Nor were there many who could foresee the future role of satellite-based communication systems in Canada arising from the launching of the Alouette satellite to conduct ionospheric research. Yet that research initiative has led to a Canadian industrial capability in aerospace.

Although science generally progresses by fortuitous discovery, i.e., as a random walk, there are numerous examples that science can be concerted and directed when there is an enunciated objective. For example, in the six year period of World War II, science and technology provided: computers, radar, jet engines, rockets, antibiotics, vaccines, surgical techniques and nuclear bombs. The innovation process was accelerated by several orders of magnitude. The argument that science is best left to itself is simply untenable today. Much basic science can be conducted and exploited within a context of national priorities, provided the underlying research capacity is in good health.

Based on these perceptions of the role of university research in utilizing science and technology in pursuit of national goals, the government has identified three main objectives for its support of university research:

- to support fundamental research in order to advance knowledge, and to provide the infrastructure necessary to support concerted programs and to maintain flexibility to adapt to changing demands,
- to institute concerted research programs in support of identified scientific goals within national priorities established through the political process,
- to support and develop research-trained manpower to participate in fundamental research and concerted programs and to contribute to the economy in the usual ways.

In this context the key difference between *fundamental research* and *concerted research programs* is the way in which the research is defined and managed. Fundamental research arises solely from an investigator's personal interest, whereas in concerted research the investigator is asked to contribute to the attainment of some more-or-less broadly defined objective, i.e., there is a presumed "customer" for the latter. In both cases the investigator is free to design his own program and to contribute in an optimum manner. Both categories can contain elements of basic and applied research. Concerted programs will likely involve varying mixtures of basic and applied research, depending on the state of knowledge and the scale and type of effort required to reach an implementation decision. Concerted programs are more likely to be interdisciplinary than is fundamental research.

In line with its revised rationale for federal support of university research, the government decided that some revision and strengthening of the operations of its three main research grants programs was needed. On April 1, 1978 the Natural Sciences and Engineering Research Council and the Social Sciences and Humanities Research Council were formed to assume responsibility for the university research granting programs operated, respectively, by the National Research Council and Canada Council. The mandate of the Medical Research Council was also extended to include research in health care. At the same time an Inter-Council Coordinating Committee was established to provide to the Minister of State for Science and Technology an overview of the councils' activities and advice on the allocation of funds. Within the general aims stated above, a more specific set of objectives was developed for the restructured councils:

- to support and foster excellence in research,
- to provide a base of advanced knowledge through encouragement of curiosity-oriented research,
- to encourage research which would contribute to national objectives,
- to encourage interdisciplinary research,
- to ensure regional balance in scientific capability,
- to assist in the focus and concentration of research activities and facilities,
- to maintain a basic capacity for research training.

In responding to the new policy for federal funding of university research, the Ministry of State for Science and Technology, in close cooperation with the Inter-Council Coordinating Committee, evaluated the state of the university research system and identified the key problems to be addressed if university research is to make its proper contribution[1]. These were summarized as follows:

[1] MOSST Background Papers "7. Federal Funding of University Research: Major Issues" and "8. A Rationale for Federal Funding of University Research", both November, 1979.

- the maintenance and strengthening of the universities' capacity to carry out research both as a corrective to the weakening that occurred in the 1970's and as part of the objective to raise the national R & D effort;
- an assured level of funding so that the necessary long-term plans and commitments can be made;
- a growing proportion of university research effort directed to concerted programs in areas of national concern;
- replacement of equipment and facilities;
- a contribution by the Federal government towards resolving problems in the research system arising from the decline in enrolment;
- increased research-trained manpower to conduct the expansion of R & D effort called for in the national R & D target;
- improved transfer of knowledge and expertise to other sectors, especially industry;
- more research concentration and specialization by regions, based to the extent possible on comparative regional advantages and integrated with regional requirements;
- more thorough consultation with provincial authorities.

In response to the revised objectives and the problems facing the university research system, the three granting councils have each developed five-year plans for strengthening and reorienting their support of university research. The emphasis given to a particular factor has varied from council to council because of differing circumstances for their clientele but there are certain common elements in all three plans. First and foremost are proposals for increased support for the direct costs of research so as to maintain and strengthen the level and quality of university research, which is perceived to have been relatively neglected in the last few years. Considerable importance has been given to a long-term funding commitment by the government. This is considered essential for the success of the councils' programs because of the long time-frame involved in planning and conducting research, in training research manpower and in providing buildings and equipment. Considerable stress has also been placed on continuing and expanding support for curiosity-oriented research. Nevertheless, substantial increases in funds have been proposed for research in areas of national concern. Details of specific program proposals for each council are discussed in the Major Funders section.

Industry

The government's direct support of industry S & T activities is estimated to reach $303.9 million, an increase of 8% over forecast expenditures of $281.1 million in 1979/80, and 19.5% increase compared to 1978/79 expenditures. A major portion of the increase occurs in the industry support programs of the Department of Industry, Trade and Commerce, which is the largest funder of S & T activities in industry. Increases of $20.4 million to $60.7 million in 1980/81 for the Innovation component of the Enterprise Development Program and $10 million for assistance to the electronics industry will more than offset a decrease of $4.6 million to $26.7 million in 1980/81 for the S & T portion of the Defence Industry Program. There is also an estimated increase of $0.5 million to $1.5 million total for the Industrial Energy R & D program.

The next largest funder of industrial S & T activities is the National Research Council, at an estimated level for 1980/81 of $42.0 million, down $9.6 million from 1979/80 and $16.2 million from 1978/79. The decrease is due to the decreasing cash flow for the contract for the development of the Advanced Teleoperator System as it nears completion: expenditures for this contract in 1980/81 are estimated at $3.6 million compared to $11.1 million in 1979/80 and $28.5 million in 1978/79. Better than 98% of the council's industrial funding is for R & D, approximately equally divided between contracts ($19.5 million) and grants and contributions ($21.7 million). Included under the contract mechanism is the Program for Industry/Laboratory Projects (PILP), and under the grants mechanism the Industrial Research Assistance Program (IRAP), both of which are further discussed below.

Other major funders of industrial S & T are the Department of National Defence with 1980/81 estimated expenditures of $28.8 million, the

Department of Energy, Mines and Resources with $16.0 million, the Canadian International Development Agency with $24.0 million and the Department of Communications with $19.5 million. The industrial funding by the Department of National Defence is almost 100% in the form of R & D contracts and represents about 85% of its extramural spending which in turn represents about one-third of its S & T expenditures. Of the $1.5 million or 10% increase over 1979/80 in industrial S & T expenditures by the Department of Energy, Mines and Resources, $0.4 million occurs in the Energy Program, mostly in the form of contributions to stimulate the forest industry to greater use of forest biomass as a substitute source of energy. All of the industry S & T funding by the Canadian International Development Agency, up $1.4 million from 1979/80, is for RSA, such as feasibility studies concerned with agricultural, industrial and commercial development projects in Third World countries.

Table 4.2

Federal Science Expenditures in Industry

	1978/79	1979/80	1980/81
		(millions of dollars)	
Total Payments to Industry	**254.3**	**281.1**	**303.9**
R&D Grants and Contracts (Total)	**186.7**	**221.3**	**242.9**
Mission-oriented R & D Contracts (Total)	95.4	100.0	100.6
Communications	3.9	3.9	6.0
Energy, Mines and Resources	6.1	6.8	7.2
Atomic Energy of Canada Limited	7.1	8.1	8.7
Environment	3.9	9.5	9.7
Fisheries and Oceans	5.0	2.9	3.0
National Defence	17.6	26.5	28.7
National Research Council (excluding PILP)	31.6	16.1	9.9
Supply and Services (Unsolicited Proposals)	10.2	11.8	12.0
Transport	7.1	5.5	4.7
Others	2.9	8.9	10.7
Technology Transfer R & D contracts (Total)	8.1	10.5	11.7
National Research Council (PILP)	6.0	8.4	9.6
Cooperative Projects with Industry (COPI)	2.1	2.1	2.1
Agriculture	—	0.4	0.4
Communications	—	0.4	0.4
Energy, Mines and Resources	—	0.4	0.4
Environment	—	0.4	0.4
Fisheries and Oceans	—	0.4	0.4
National Research Council	2.1	—	—
R & D Grants & Contributions (Total)	83.2	110.8	130.6
Communications	4.5	13.3	12.2
Energy, Mines and Resources	2.0	2.5	2.1
Industry, Trade and Commerce	54.3	64.4	90.2
National Research Council	20.6	26.4	21.7
Natural Sciences and Engineering Research Council (Industrial Research Fellowships)	1.6	1.6	1.8
Others	0.2	2.6	2.6
RSA Grants & Contracts (Total)	**67.6**	**59.8**	**61.0**
Energy, Mines and Resources	9.2	4.7	6.3
Atomic Energy of Canada Limited	11.6	13.5	9.5
Environment	2.6	1.8	1.9
Fisheries and Oceans	1.9	2.0	2.0
Canadian International Development Agency	21.3	22.6	24.0
Transport	9.9	3.3	3.0
Others	11.1	11.9	14.3

The estimated 1980/81 funding of industrial S & T by the Department of Communications shows an increase of $1.0 million over 1979/80 expenditures, which at $18.4 million, were $9.5 million higher than those in 1978/79. A major portion of the two-year increase relates to contributions to TELESAT Canada for the development of the ANIK C-3 and ANIK-D satellites, as well as contributions and contracts to assist industry in the exploitation of TELIDON, a departmentally-developed videotex system. This latter assistance covers such activities as field trials, development of production prototypes, equipment standardization and related activities. Field trails are underway or planned by such organizations as Bell Canada, Alberta Government Telephone and the Manitoba Telephone System.

Contractual links between government departments and Canadian industry are administered 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. This fund provides interim financing 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 1979/80 this fund will have provided a total of $56.4 million. For 1979/80 forecast expenditures are $11.8 million in support of mission- oriented R & D and $1.3 million for RSA in industry.

Although many of the R & D contracts in support of departmental missions implicitly aid in technology transfer, the government decided in 1978 that there should be a renewed emphasis given to the policy that technology transfer should be an explicit objective of all its laboratories. The intention is to encourage all government laboratories to identify at an early stage research that may be of possible industrial interest, and to plan for the successful transfer to, and exploitation by, industry of the results of the research.

There have been some significant technology transfers from government laboratories over the years: the development of a sizeable nuclear industry has been fostered by Atomic Energy of Canada Limited; significant technological advances in Canadian farming have occurred as the results of efforts by the Department of Agriculture; the industrial exploitation of visual and interactive displays of computer-based information is currently being fostered by the Department of Communications, and the Department of Energy, Mines and Resources has made a major contribution to the technology of open-pit mining by developing a pit-slope manual in cooperation with industry. One of the explicit and successful programs of technology transfer is the Program for Industry/Laboratory Projects (PILP), established by the National Research Council in 1975. The concept underlying PILP is that government laboratory projects are contracted out to industry for further stages of development. This fosters closer cooperation between government scientists and those working in industrial R & D and it helps to further the development of industrial R & D in Canada. Moreover, projects whose development has occurred in industry are more likely to progress to the manufacturing and marketing stage than those developed entirely in government laboratories. Successful PILP projects include extraction of oil from tar sands; vertical-axis wind turbines for electrical power generation; a snow-and ice-free railroad switch; and reduction of hydrogen levels in steels. The 1980/81 estimated PILP funding is $9.6 million, up $1.2 million from 1979/80 and $3.6 million from 1978/79.

In 1978/79 additional funds of $2.1 million were provided to extend the PILP concept to worth-while projects proposed by other departments, designated the Cooperative Projects with Industry (COPI) program. These projects were administered by the PILP program office for that year. Their administration and requisite funding were transferred to the respective departments in the following year. Examples of these projects are: a modified skim milk drying process; an integrated radio telephone system; side-scan sonars; and synthetic aperture radar.

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 principle 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 1980/81 are $20.9 million compared to $19.7 million in 1979/80, and $18.0 million in 1978/79. The National Research Council estimates that a further $3.2 million will be spent in 1980/81 in other grants and contributions to industry, including $1.8 million for research fellowships.

The Enterprise Development Program is a multi-purpose 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 S & T expenditures under the program for 1980/81 are $50.8 million, an increase of $20.4 million over 1979/80, which itself showed an increase of $21.5 million over 1978/79. In addition, there is a proposed increase in assistance to the electronics industry in 1980/81 of $10 million. S & T expenditures under the Defence Industry Program are estimated to drop $4.6 million to $26.7 million in 1980/81. This program assists 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 1980/81 will be $1.5 million, compared to forecast expenditures of $1.0 million in 1979/80.

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; twelve 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; four industrial research associations have been established to date. The annual budget for the three programs in 1980/81 will be $1.4 million, unchanged from last year. 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 25 centres and institutes established in the past 12 years, 17 are now self-supporting.

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 was increased by $0.4 million in 1978/79 and a further $0.4 million in 1979/80 to provide financial support for the use of senior students in science and engineering in providing industrial assistance under supervision of university professors. Total estimated expenditures, in 1980/81, for the service are $2.8 million.

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 1980/81 are estimated to be $322.4 million, a 24.5% increase from 1979/80. Further details are given in Table 4.3.

Of the total direct payments to universities 89% is for R & D; the remainder is for RSA. Most (79%) 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 most of the total support. Approximately 30% of the direct funds for scientific activities in the universities and affiliated institutions, however, are provided by other departments and agencies, which also provide approximately half of the indirect costs of these activities through Established Program transfers to the provinces for post-secondary education and for hospital and medical care.

The amount spent by the government on R & D contracts in the university sector is estimated to increase by 5% in 1980/81 ($17.4 million), compared to a 43% increase in 1979/80. Another significant avenue of R & D support is research fellowships to individuals, estimated to be $12.3 million in 1980/81 compared to $9.3 million in 1979/80. Of the expenditures on RSA, 80% ($29.6 million) 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 $152.6 million, by the Natural Sciences and Engineering Research Council (NSERC) to individuals and institutions in the university sector, are projected in 1980/81, compared to $113.3 million in 1979/80, and $105.0 million in 1978/79. Reflecting the new policy of increased support for research in areas of national concern and interdisciplinary research, and for balancing regional research capability, a significant portion of the additional funds for program expansion in the past 3 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 13.7% ($16.2 million) in 1979/80 and is expected to be 15.5% in 1980/81 ($24.6 million). Of particular interest within this activity, the Strategic Grants Program will increase to $17.8 million in 1980/81 in comparison to the $2.4 million

Table 4.3

Federal Science Expenditures in Universities

	1978/79	1979/80	1980/81
		(millions of dollars)	
Total Payments to Universities	**244.9**	**258.9**	**322.4**
R&D (Total)	**216.3**	**230.7**	**285.6**
R & D Grants (Totals)	196.9	204.7	255.9
Medical Research Council	57.1	61.6	70.8
Natural Sciences and Engineering Research Council	96.6	103.9	136.3
Social Sciences and Humanities Research Council	13.7	14.6	17.3
National Health and Welfare	12.6	8.6	10.9
National Research Council	8.7	9.5	13.5
Others	8.2	6.5	7.1
R & D Contracts	11.6	16.6	17.4
Research Fellowships	7.8	9.3	12.3
RSA (Total)	**28.6**	**28.2**	**36.8**
Total Education Support	21.0	21.7	29.6
Medical Research Council	1.5	1.7	1.9
Natural Sciences and Engineering Research Council	7.7	8.3	14.9
Social Sciences and Humanities Research Council	7.5	7.3	8.1
Others	4.3	4.4	4.7
Other RSA	7.6	6.5	7.2

awarded in its first competition in 1977/78. Areas identified for support under the Strategic Grants program are energy, environmental toxicology, oceans, agriculture/food and communications.

Awards under the Peer Adjudicated Grants Activity are expected to total $110.1 million in 1980/81, compared to $88.5 million in 1979/80. These grants-in-aid of research are provided through a national competition to university researchers (as individuals or in groups) as a contribution to research operating expenses and the purchase of ancillary equipment. The Highly Qualified Manpower Training and Development Activity will see an increase in 1980/81 to $19.8 million, compared to $12.6 million in 1979/80, for scholarships and fellowships awarded under national competitions to post-graduate students and post-doctoral fellows in science and engineering, for studies and research in Canada and abroad, and to senior researchers in universities and in industry.

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 $75.6 million in 1980/81, compared to $66.0 million in 1979/80. 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).

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 with 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 $5.4 million for research related to cancer, $1.1 million to diabetes and allied disorders, $4.4 million for cardiovascular disease and $2.0 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 less than 1% ($0.5 million) of the 1980/81 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 ten 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 1980/81 expenditures will be spent on this program.

An important complement to the Medical Research Council's support of university science in the health field is the National Health Research and Development Program of the Department of National Health and Welfare, which accounts for over 80% of the department's expenditures on university science. During the past five years, it has been instrumental in expanding and upgrading research in the health care field, including social, preventive and community medicine and dentistry, nursing, occupational health, public health, health care administration and other allied areas. The program is now being re-oriented toward research in areas of particular interest to the department. By agreement with the Medical Research Council the re-orientation is designed to minimize undesirable duplication and overlap between programs of the two agencies while ensuring that every health-related proposal will be considered by one or the other.

The Social Sciences and Humanities Research Council will provide $33.4 million in 1980/81 for support of university S & T activities in the humanities and social sciences, compared to $28.2 million in 1979/80. This represents about 85% of its total grants budget. The council's 5-year plan, which is now under consideration, proposes four major program thrusts for the first half of the 1980's: to maintain and expand its

core activity of support for independent research; to expand support for research on themes of national importance; to make a major effort to improve communication of research results to researchers, decision-makers and the interested public; and to improve the quality and extent of basic research facilities and instruments.

The fellowship and scholarship programs, administered by the Fellowships Division, comprise the largest expenditure category in the council's budget: 44% in 1978/79 for the support of over 1,700 Canadian students and career scholars. These programs include Special Scholarships, the Queen's Fellowships, Doctoral Fellowships, and Leave and Postdoctoral Fellowships.

The Research Grants program supports advanced research in the social sciences and humanities. Grants totalled some $8.3 million for 522 projects in 1978/79. Fields of research covered a broad range, including social history, psychology of child behaviour, linguistic and cultural development, folklore collection, archaeological excavation, and biographical, economic, management and political studies. Following are some typical projects: at the University of Toronto, an historical study of the movement of refugees into Canada from 1933 to 1948; an intellectual history by a University of Saskatchewan scholar of anti-Catholic thought in Canada at the end of the 19th century; excavations by a University of Calgary archaeologist of a site in southern Alberta which has yielded human skeletal remains dating back more than 4,000 years; the recording of Acadian folklore for the Centre of Acadian Studies at the University of Moncton.

The Negotiated Grants program offers support to large-scale research and editorial projects undertaken at eligible institutions — usually universities — by groups of scholars over a period of years. These awards are of two types: Program Grants and Grants for Major Editorial Projects. In 1978/79, $5.4 million was awarded to new and continuing projects. Among the seventeen current projects are Dalhousie University's examination of employment in low-wage work settings in the Maritime Provinces and its role in the development of the region, the University of British Columbia's investigation of economic policy and natural resource use, and McGill University's project on air space activities, which includes an examination of emerging international law. Among the Council's nine Major Editorial projects are the *Dictionary of Canadian Biography/Dictionnaire biographique du Canada* being prepared and published jointly by the University of Toronto Press and Les Presses de l'Université Laval, and the critical edition of the collected papers of Louis Riel being undertaken by scholars at the University of Alberta.

The first grants under a new $1.6 million program of grants for research in areas of national concern were made in 1979/80. Population aging and the strengthening of university research resources were chosen as areas for support. Offered are grants for research projects, workshops and research centres in institutions of higher learning, postdoctoral fellowships and re-orientation grants for full-time university scholars who wish to focus their research on aspects of the topic concerned, and for university research libraries to strengthen specialized collections.

Through the National Research Council the government will provide $13.5 million in 1980/81 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 1980/81 is estimated at $3.7 million, of which $1.4 million will be in operating grants, and $2.3 million in contracts for research directly complementing departmental activities.

The Department of Energy, Mines and Resources estimates that in 1980/81 S & T support to universities will total $2.9 million, $1.2 million from the Earth Science Services Program, $0.6 million from the Mineral Program and $1.1 million from the Energy Program.

The Department of the Environment will provide $2.7 million for university research in such areas as forestry, water and the atmosphere.

Research contracts and grants to universities by the Department of National Defence are expected to amount to $3.1 million in 1980/81, compared to $2.8 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 1980/81 expenditures at $1.0 million, unchanged from 1979/80.

The University Research Program in the Department of Communications has been supporting applied

research in Canadian universities since 1971. The objectives are to complement the departmental research activities and to develop a cadre of competent university researchers upon whom the department can call on for assistance. The areas of research are defined by a University Research Advisory Board, in response to requirements expressed by the department. The main criterion in assessing contract proposals and awarding contracts is the probable impact in meeting departmental objectives. Although available funds are less than $1 million per year, the program reaches all Canadian universities and contributes to the development of expertise in both the socio-economic and technological aspects of telecommunications.

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 for example, the Canada-Ontario Forestry Research Advisory Council.

Early in 1979, the Ministry of State for Science and Technology initiated bilateral consultations with each of the provinces to identify goals and priorities for industrial R & D in which federal/provincial cooperation could be beneficial. The consultations have included consideration of the economic development goals of the provinces, the essential role of R & D in the realization of medium and long-term goals, and the development of regional specialization in science capability within a framework of national priorities. It is expected that the consultations will be completed during 1980, leading to new federal/provincial initiatives.

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 estimated expenditures in 1980/81 of about $43.4 million on joint programs with the provinces. Payments to the Alberta/ Canada Energy Resources Fund will remain at $24 million in 1980/81. This fund is used for energy research and development projects, such as the Coal Mining Research Centre at Devon, Alberta, which is conducting research primarily in the areas of coal mining and coal beneficiation. About $2.5 million will be contributed by the government in 1980/81 to the joint Canada-Saskatchewan program for the development of heavy oil recovery technology. The federal share of federal/provincial agreements to demonstrate conservation technologies is estimated to be $15.3 million in 1980/81.

Table 4.4

Federal Science Expenditures in the Provincial Sector

	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**29.6**	**48.4**	**57.8**
Energy, Mines and Resources	13.6	33.9	43.4
Environment	4.7	5.8	4.4
National Health and Welfare	2.2	1.1	1.6
Regional Economic Expansion	1.9	1.9	0.7
National Museums	4.9	4.6	4.8
Others	2.3	1.1	2.9

The Department of the Environment will spend about $4.4 million in 1980/81 on joint ventures with the provinces. There is $1.2 million for shared-cost science activities under the Canada-Ontario Great Lakes Water Quality Agreement. The department will pay $0.7 million to Quebec for hydrometric survey data and will contribute $1.2 million, to be matched by participating provinces, for studies concerned with ameliorating flood damage.

The provincial S & T payments by the National Museums of Canada — an estimated $4.8 million in 1980/81 — provide support for regional and provincial museums and are entirely classed as the related scientific activity, museum services. The increase to $2.0 million in provincial S & T payments in 1980/81 by the Department of Agriculture relates to a single-year contribution to the construction of a provincial agricultural research facility at St. John's, Newfoundland. Practically all of the estimated $1.6 million in provincial payments by the Department of National Health and Welfare in 1980/81 are for the guaranteed income demonstration with the Province of Manitoba. The Department of Regional Economic Expansion will spend about $0.7 million in 1980/81 in support of S & T including programs of research on the development and adjustment of manpower resources in selected areas and for development services to industry. Most of the S & T activities funded by the department are in the Atlantic provinces and Quebec.

Foreign

This section considers the expenditures of various government departments outside the country. In general, 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. Exceptions to these general reasons are found in the International Development Research Centre and the Canadian International Development Agency, whose foreign S & T expenditures far outweigh those of the rest of the government, as shown in table 4.5. For these two agencies the use of foreign performers is not incidental but a direct consequence of their mandate to aid developing countries, both with tangible, material assistance and with assistance in establishing the means for self-development. The hallmark of the operations of the International Development Research Centre, in particular, has been to assist developing countries in establishing research and development activities which are planned, managed and conducted by their own researchers in terms of their own priorities.

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

Table 4.5

Federal Science Expenditures in the Foreign Sector

	1978/79	1979/80	1980/81
		(millions of dollars)	
Total	**47.0**	**48.7**	**53.1**
Communications	0.3	1.0	1.5
Canadian International Development Agency	10.6	10.6	9.6
International Development Research Centre	25.0	24.0	26.3
National Defence	1.2	1.4	1.8
Medical Research Council	2.0	2.5	2.8
National Research Council	0.7	1.2	1.9
Natural Sciences and Engineering Research Council	2.2	2.6	3.3
Social Sciences and Humanities Research Council	2.8	2.6	2.9
Others	2.8	2.8	3.0

likely to result. Specifically the department will be participating in the development and preparation of L-SAT, a large-platform communications satellite. Approval has also been obtained for the Department of Energy, Mines and Resources to participate in the development of PERSSP, a remote-sensing satellite.

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 e.g. in electronics, avionics and communications.

The Medical Research Council's foreign 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 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 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, such as the International Council of Scientific Unions, the International Union of Pure and Applied Chemistry and the International Bureau of Weights and Measures.

5. Major Funders

Introduction

The government's expenditures on science activities in areas of national concern are discussed in the Special Application 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 objective 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, 1980/81".

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 focussed 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 Parks Canada program in Environment 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*	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Administration	5.5	197	5.8	192	6.6	192	41.1	1,063
Research	113.9	3,725	128.4	3,673	140.4	3,659	140.4	3,659
Marketing	—	—	—	—	—	—	304.2	274
Food Production and Inspection	4.9	151	4.7	148	5.2	148	236.0	4,696
Canadian Grain Commission	3.0	95	3.2	92	3.5	92	26.4	840
Total	**127.3**	**4,168**	**142.0**	**4,105**	**155.7**	**4,091**	**748.1**	**10,532**

* 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 expenditures on science will be $155.7 million, of which $140.4 will be spent by the Research Branch. The broad objective of the department's science program is, through the development of new knowledge and improved technology, to ensure the efficient production of an adequate supply of food and agricultural products of the desired form and quality, and to assist in maintaining an efficient, stable, and profitable agricultural industry in Canada.

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. The programs of the branch concern all facets of agricultural endeavour pertaining to improved plant and animal production, food, protection against pests, land classification and environmental quality. Due to the ever-increasing public interest in food production, the branch has increased its research on energy, food processing, food safety, and the nutritional quality of food. New types of agricultural foods are investigated and expansion of collaborative research effort with industry is encouraged.

Research on animal diseases is conducted by the Animal Pathology Division of the Food Production and Inspection Branch. Research programs are directed mainly at diseases causing serious economic losses to livestock, and at those transmissible to man. The division develops diagnostic reagents used in the branch's disease control programs. Tests are developed to certify livestock, embryos, semen, and meats in support of export trade, and to protect the consumers.

Economic and social research on most aspects of the agriculture-food system, relevant to policy development and evaluation, is carried on by the Policy, Planning and Economics Branch within the Administration Program.

The Grain Research Laboratory of the Canadian Grain Commission conducts research to measure factors which determine end-use quality of cereal grains and oil seeds. It determines quality levels in each new crop and monitors domestic movement and oversees shipments on a continuing basis.

Department of Communications

	Science Resources						Total Resources	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Communications	61.9	635	65.0	640	66.3	646	110.7	1,911

The department's estimated science expenditures for 1980/81 are $66.3 million, compared to 1979/80 forecast expenditures of $65.0. The science expenditures represent 62% of the total estimates for the department. $20.2 million of the science activities will be performed extramurally, 88% in industry and 4% in universities with the balance by other performers. The department must invest heavily in science to achieve its objectives of fostering the orderly development and operation of communications for Canada in 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

Program	Science Resources 1978/79 $M	1978/79 PY	1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	Total Resources 1980/81 $M	1980/81 PY
Administration	—	—	—	—	—	—	17.0	505
Energy	34.3*	407	57.4*	450	70.8*	470	126.6**	676
Minerals	19.8	576	19.8	554	21.6	534	23.8	563
Earth Science Services	70.5	1,475	66.5	1,417	75.4	1,411	101.2	2,018
Total	**124.5**	**2,458**	**143.7**	**2,421**	**167.8**	**2,415**	**268.6**	**3,762**

* Includes transfers from other departments ($0.3 million in 1980/81)

** Excludes Oil Import Compensation ($2,600.5 million in 1980/81)

The department's total estimated expenditures for scientific activities in 1980/81 are $167.8 million. Distributed among three programs, these S & T expenditures will be 62% of total departmental expenditures, exclusive of expenditures for oil import compensation. Extramural expenditures are estimated to be $65.3 million, $16.0 million to industry, $2.9 million to universities and $43.4 million to provincial governments. The payments to industry represent an increase of 10% from 1979/80, those to provinces an increase of 28%.

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 development, and employment opportunities. Analysis and evaluation of the impact of changing patterns of mineral activities are required to develop strategies for ensuring maximum benefits from resource utilization. The mineral research program includes resource determination and technology development. Mining studies focus on mine design and health and safety. Research on mineral processing emphasizes improving established processes for better environmental control, and developing new techniques to use low-grade and complex ores and waste materials. Mineral-based materials are studied to improve their fabrication methods and serviceability. The Geological Survey of Canada supports the program by providing estimates of mineral resources and the development of new exploration techniques for transfer to industry. Research is also continuing on the improvement of methods of resource estimation.

Within the Minerals Program the Canada Centre for Mineral and Energy Technology (CANMET) is a technology research and development organization which performs, contracts and coordinates research on the assessment, recovery and use of the nation's mineral and energy resources. Energy research at CANMET is concerned mainly with fossil and nuclear fuels, from assessment to end-use. The work addresses the department's self-sufficiency objective through technology to conserve resources, to use low-grade feedstocks such as coals, oil sands, and heavy oils, and to develop alternative energy resources such as uranium and biomass. Through contract research, joint projects and information and technology, private sector involvement in CANMET research is essential and diverse. An increasing

amount of research is being contracted out, particularly in new technologies such as coal conversion. The emphasis is on applied research to meet immediate and long-term national and regional needs. The department periodically reviews the R & D activities of CANMET internally and externally. These reviews assist CANMET in streamlining and updating its work to contribute more effectively to national energy and mineral resource goals as well as to industrial needs.

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 much of its resources to it. Through an integrated program of geological, geophysical and geochemical mapping the survey is progressively expanding and updating knowledge of the geological framework for the whole of Canada, including offshore areas, for use in identifying and appraising non-renewable resources including oil and gas, coal, uranium, and metallic and non-metallic minerals. Maps and other information are also provided on surface and near surface materials, landscape features, and geomorphic processes particularly in relation to engineering, land use, and environmental aspects of resource development. In this regard the survey contributes to the interagency program of investigations into geological containment of high-level radioactive wastes. The information provided by the Geological Survey is used by government in planning and regulating resource development and by private companies in resource exploration and exploitation. Improvement of exploration technology and transfer of technology to industry is an important part of the 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 gravity field of the earth including anomalies, delineation of the geothermal regime including prediction of permafrost and studies of crustal dynamics in Canada. New techniques include the use of satellite data in magnetic and geodynamic studies. 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 by government and other sectors. Interdisciplinary studies on geothermal energy resources in Canada, earthquake prediction, the geological containment of radioactive wastes, the origin and emplacement of the Arctic Ocean Basin, the adjacent Arctic Archipelago and the Canadian Cordillera including offshore regions form a significant part of the work of the branch.

The Surveys and Mapping Branch is responding to continually increasing demands for national positional data and mapping services through advanced technology and increased contracting activity to compensate for the long-term policy of staff attrition. New data-gathering techniques such as inertial survey systems, Doppler satellite surveying and satellite earth sensing systems are being employed and continually improved. Concurrent with these scientific and technological activities is the effort to automate the mapping and position data systems, so that terrain data can be made available in both digital and graphic form in order to satisfy the needs of government, industry and the general public.

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 TIROS, LANDSAT and NOAA satellites are received for such applications as ice mapping, crop information systems and forest management.

The department is the lead agency for the interdepartmental project SURSAT, which is assessing a satellite system for providing surveillance of Canadian territory. Approximately 100 projects have been undertaken in cooperation with prospective 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 departmental 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. The Conservation and Renewable Energy Branch has been consolidated with the Electrical, Coal, Uranium and Nuclear Group to facilitate policy coordination among the non-petroleum energy options.

Details of some of the department's energy activities are described in the Special Applications-Energy section. In addition to those activities coming under the coordination of the Panel on Energy R & D, the department also conducts 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	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Nuclear Research and Utilization	92.0*	2,363	91.3*	2,343	96.5*	2,473	144.9	3,371

* Excludes transfers from the program to other departments ($2.2 million for 1980/81).

Science expenditures by Atomic Energy of Canada Limited are estimated to be $96.5 million in 1980/81, an increase of 5.7% over 1979/80 forecast expenditures. By reallocation of existing resources, expenditures for R & D on the safe immobilization and disposal of radioactive materials from the operation of CANDU reactors will be increased to $16 million in 1980/81, compared to $13.4 million in 1979/80. Increased effort within existing resources will also be directed to developing new applications of reactor technology which could substitute for oil or improve the production of oil.

In 1979/80 Atomic Energy of Canada Limited was reorganized into a series of subsidiary companies and a corporate office. With the exception of $2 million for the Radiochemical Company (formerly Commercial Products) and $5.5 million for the operation of Gentilly I reactor, all of the reported expenditures for science and technology are managed by the Research Company. The mission of the Research Company is to carry out basic and applied R & D for peaceful purposes in the field of atomic energy for the benefit of Canada. The results of its R & D programs form the technological base for the engineering, chemical and radiochemical companies of AECL and for other components of the Canadian nuclear industry. Five major objectives have been defined:

- to provide the basic scientific understanding essential to all technological advance in nuclear energy and related fields;
- to secure the nuclear option, through research and development on power-reactor systems, heavy-water production processes, radioactive-waste management, health and environmental effects of radiation, and safeguards;
- to develop new applications for nuclear energy, to help Canada resolve its major energy problem, a shortage of oil;
- to ensure a continuing supply of nuclear fuel for many centuries;
- to transfer nuclear technology to Canadian industry where it will be put to use for the benefit of Canadians.

Many of the company's R & D programs contribute to several of these objectives while all contribute to technology transfer. The strength of the Research Company's R & D programs depends strongly on the operation of major research facilities, such as reactors, and the provision of services, including public information, many of which are unique to the operation of nuclear facilities in isolated areas.

These R & D programs are coordinated through an R & D program committee chaired by the Executive Vice-President, Research Company. Membership includes the site heads of the Chalk River Nuclear Laboratories (CRNL) and the Whiteshell Nuclear Research Establishment (WNRE), representatives of the other AECL operating companies, and key technical staff of the Research Company. Not a decision-making body, the program committee recommends programs to the President and Board of Directors, and then coordinates the programs which are approved.

With the reorganization of the company, there has also been some realignment of R & D program areas. The R & D activities are subdivided into six major program activities:

- Power Reactor Systems,
- Advanced Fuel Cycles,
- Environmental Protection and Radioactive Waste Management,
- Heavy Water Processes,
- Underlying and Advanced Systems Research, and
- New Applications.

Each program is coordinated through a steering committee chaired by a senior line manager. The program is subdivided into more specific work areas, each of which is also coordinated by a line manager. The R & D program committee normally meets every second month for a formal review of the programs.

The Power Reactor Systems activity is concerned with R & D related to all aspects of the steam supply of nuclear generating stations: the reactors, moderator, fuel performance, heat removal, control and ancillary systems. Today the technology is often consolidated into computer programs which allow the designer, operator, manufacturer and regulatory agency to predict the behaviour of CANDU-PHW (Pressurised Heavy Water) reactors and their components over a wide-range of normal-operating and postulated-accident conditions. These computer programs must be theoretically sound, experimentally verified and subjected to rigorous peer review.

The objective of the Advanced Fuel Cycles activity is to conduct research and assessment studies necessary to understand the technical and economic feasibility and the implications of the development and implementation of fuel cycle alternatives. The use of thorium in conjunction with enriched uranium or with plutonium produced in current fuel cycles could lead to a nearly self-sufficient fuel cycle and one that could be used in the current design of CANDU reactors. Such a cycle promises a secure supply of low-cost energy for centuries. Experimental work is being carried out at the laboratory level, mainly to verify the feasibility of the self-sufficient thorium cycle.

Work in the Environmental Protection and Radioactive Waste Management activity has been greatly expanded in the past two years — an increase of $6 million since 1978/79 to $16 million in 1980/81. The goals are: to prove that reactor wastes and spent nuclear fuel and nuclear fuel wastes can be disposed of safely, and to develop methodology which can be used to assess the environmental and health effects of nuclear and other waste products (pathways analysis). The steering committee for this area also coordinates the development of safeguards against non-peaceful uses of CANDU technology.

The technology being developed for wastes arising from reactor operation (excluding used fuel) involves converting the wastes to a stable, leach-resistant form of bitumen. For the used fuel and fuel wastes, technology is being developed for: safe and economical storage of the spent fuel until reprocessed or disposed of; immobilization of the spent fuel as is, or if the spent fuel is processed, immobilization of the wastes in a leach-resistant matrix; and safely and economically isolating the immobilized wastes from the biosphere for their hazardous life time. Work on interim storage is concentrated on dry-storage techniques as a feasible alternative to water-filled bays. Two options for immobilizing unprocessed fuel are being developed: a simple system that would provide immobilization for 300 to 500 years, and as a backup, an advanced system which would immobilize the fuel for a much longer period of time. The immobilization of separated waste in glass or other ceramics has been studied by several countries including Canada over many years. Current efforts are directed to the effects of temperature, water and radiation on the glasses or ceramics that may be used. The Canadian approach to disposal is concentrating on the possible use of stable geological formations, called plutons, found in abundance in the Canadian shield. The geophysical, geochemical and hydrogeological properties of various types of pluton are being determined in a program of test drilling at various sites in Ontario.

Work in the Heavy Water Processes activity concentrates on providing science and technology, frequently in the form of computer programs, which allow designers and operators to predict the

performance of the GS process over a wider range of plant conditions. The improved predictive capability has increased production and lowered costs. The recently developed Hydrogen-Water Exchange processes are being investigated for use in heavy-water upgrading and for forritium removal.

The objective of Underlying and Advanced Systems Research activity is to help maintain and revitalize all the company's science and technology activities. The Research Company has long-term programs in basic research aimed at increased scientific understanding in such areas as the fundamental physics of radioactive and non-radioactive matter; the properties of materials; the chemistry involved in fuel development, waste management and nuclear systems; and advanced systems for the production of energy. Current effort in advanced systems research is aimed at: keeping electronuclear fuel breeding open as a long-term option; assessing long-term nuclear alternatives to fission power, particularly fusion; and developing shorter-term benefits from the associated technology.

Both the accelerator breeder and the fusion breeder are possible avenues to electronuclear fuel breeding. Both involve the production of neutrons which are absorbed in a uranium or thorium blanket to produce heat and fissile materials (fuel) for fission reactors. The heat generated would be used to produce electricity. At this time the technology for the accelerator breeder is considered to be significantly easier to develop than that for the fusion breeder. With respect to shorter-term benefits from the associated technology, a new accelerator—the turn-around LINAC—is under prototype development as a cancer therapy machine.

Within the New Applications activity, increased effort will be devoted to developing new applications of nuclear reactor technology which could substitute for oil, such as hydrogen by electrolysis, and coal gasification or conversion into oil, or which could improve the production of oil, such as for the Alberta tar sands. Other possible applications are the use of reactors as direct heat sources for industrial processes, and the use of inherently-safe, small reactors for space heating, as well as the use of waste heat from power reactors in greenhouses and fish hatcheries.

Department of the Environment

	Science Resources						Total Resources	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Administration	1.7	45	1.4	38	1.8	44	26.2	699
Environmental Services	196.0	4,775	204.3	4,453	217.4	4,426	298.9	5,689
Atmospheric Environment	97.6*	160	100.5*	162	114.5*	162	—	—
Environmental Protection	9.0	2,495	7.9	2,364	8.1	2,333	—	—
Environmental Management	59.5	1,174	62.0	1,149	61.0	1,148	—	—
Canadian Forestry Service	29.8	946	34.0	778	33.8	783	—	—
Parks Canada	8.8	170	9.7	174	10.6	175	225.0	5,175
Total	**206.4**	**4,989**	**215.4**	**4,665**	**229.8**	**4,645**	**550.1**	**11,563**

* Excludes transfers to Transport Canada ($7.9 million in 1980/81).

The department's total estimated expenditures for scientific activities in 1980/81 are $229.8 million, 42% of total departmental expenditures. As shown in the table the majority of these expenditures will occur in the Environmental Management and Atmospheric Environment Service activities within the Environmental Services Program.

The main objective of the Environmental Services Program is to promote and undertake programs to protect and enhance the quality of the environment, as well as programs designed to improve the management and sustained economic utilization of the forest, wildlife and inland water resources of the nation. With better understanding of the relationship between resources, energy, technology and population, emphasis is being placed on anticipating problems stemming from the impact of human activities on the environment. The Environmental Management activity is concerned with the management of renewable resources and overall environmental quality and conducts research activities under the four broad areas of inland waters, lands, forestry and wildlife. These activities will involve an estimated expenditure of $61.0 million in 1980/81.

The Inland Waters Directorate is emphasizing the restoration and protection of water quality to protect water users through the application of national effluent regulations and guidelines to control pollution discharges at source and through the control of nutrients and chemical substances which can become dispersed in the environment. The Water Quantity Survey Program continues to measure streamflow, water level and sediment transport in Canadian waters. Studies of subsurface water quality at the National Hydrology Research Institute are focusing on factors important to disposal of high-level radioactive materials at depths of about 1000 metres. Included in the studies is research on the physical and chemical factors controlling subsurface movement of contaminants.

The Lands Directorate promotes the effective and environmentally-sound use of Canada's land resource. It supports and participates in land-related programs including: preparation of inventories of land characteristics, capabilities and use; formulation of land use alternatives; and promotion of ecologically-sound land-use planning. Research continues on ecological methods for land classification and the refinement of vegetation classification. The largest of the directorate's mapping programs is the Canada Land Inventory. More than 1,000 maps have been published to date illustrating land capabilities in the settled areas of Canada.

The Canadian Forestry Service promotes effective management of Canada's forest resources. A full-scale program is underway to develop forest biomass as an energy source, in particular to use mill and forest waste as raw material in the production of methanol (see also Special Applications-Energy Section).

The Canadian Wildlife Service is responsible for the protection and management of migratory birds through development of regulations, habitat management and research. With the provinces and other wildlife agencies, the service undertakes cooperative programs of research management and interpretation related to other forms of wildlife of national interest.

The Environmental Protection activity develops and enforces regulations to implement federal laws protecting the environment. This service estimates an expenditure of $8.1 million on science activities in 1980/81. It acts as a focal point on environmental protection matters with departments and agencies of the federal government and as a point of contact for the public. An important activity of the service is promoting the control of the disposal and destruction of hazardous wastes. The service is also placing increased emphasis on the determination of the potential environmental impact of energy proposals with a view to ensuring that potential problems are recognized and a balanced perspective is maintained between environmental concerns and energy initiatives. The service is continuing the development of standard reference methods for measurement and analysis related to the control of toxic substances in the atmosphere.

The Atmospheric Environment activity will spend $114.5 million in 1980/81 for scientific activities. The majority of these expenditures will result from related scientific activities such as data collection and weather forecasting. Research is conducted into the causes of natural and man-made climatic variations and into their socio-economic impacts. This information is used, along with the weather forecasts, in the provision of advisory services for many operations within sectors such as agriculture, forestry, transportation as well as resource and energy planning. The weather forecast production system is supported by a research program that involves the development of improved numerical prediction models for atmospheric and sea states and ice movements for Arctic and offshore oil and gas exploration, and techniques for the broader application of remote sensing in measuring present atmospheric and ice cover conditions.

Some of the other major areas of research involve the evaluation of the potential of weather modification to enhance rainfall, the development of models to predict the movements of air pollution, the understanding of the causes and impacts of acid rain, the assessment of wind and solar energy, the measurement and understanding of air-borne contaminants and the improved understanding of the effects of freons on the ozone layer of the stratosphere.

Canada is an active member of the World Meteorological Organization, and its science activities are supportive of international needs as well as the country's own domestic needs. Special contributions are being made to the Global Atmospheric Research Program and the World Climate Program.

Canadian International Development Agency

	Science Resources						Total Resources	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
CIDA	35.6	56	37.8	56	38.7	56	702.3	996

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. 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						Total Resources	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
IDRC	36.7	217	35.7	237	40.0	230	43.8	338

Nearly all the expenditures of the International Development Research Centre are devoted to S & T activities. The centre 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. In carrying out those objectives it:

- enlists the talents of natural and social scientists and technologists of Canada and other countries;
- assists the developing regions to build up the research capabilities, the innovative skills and the institutions required to solve their problems;

- encourages generally the coordination of international development research; and
- fosters cooperation in research on development problems between the developed and developing regions for their mutual benefit.

The centre was the first organization set up specifically to support research projects which 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 Parliamentary vote 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 to be used.

Projects submitted to the centre 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 these projects have full responsibility for their administration and control. Program representatives make regular visits to project sites and can provide assistance should the need arise.

Department of Fisheries and Oceans

	Science Resources						Total Resources	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Fisheries Management and Development	122.5	2,423	112.7	2,325	116.4	2,325	339.1	5,272

The Department of Fisheries and Oceans was created by an Act of Parliament in April 1979. The new department has taken over responsibilities for fisheries, oceanographic research related to fisheries management, hydrographic surveys and charting of navigable waters. The estimated S & T expenditures in 1980/81 will amount to $116.4 million of which $9.3 million will be spent extramurally.

The Fisheries Management and Development area of the department is organized into two distinct responsibility areas. The first of these is Fisheries Economic Development and Marketing, which is responsible for fisheries marketing, export development and industrial policy development. In addition to a mainly economic and policy development task, industry technological development, policy research data development and economic research will also be pursued. The second responsibility area covers fisheries management and research programs which are organized into two main regional groups. Activities in and for Newfoundland, the Maritimes and Quebec are grouped under Atlantic Fisheries Management and Research while those for Ontario, Western Canada and the Pacific Region compose the Pacific and Freshwater Fisheries Management and Research program. Both of these groups will be responsible in their respective areas for:

- biological and biochemical research and quantitative resource surveys, including development of science policy;
- resource enhancement and aquaculture;
- resource allocation for optimum social and economic resource utilization;
- supply management of the resource;

- development of harvesting technology;
- fishing fleet development and development of policies and plans for fleet deployment;
- provision of statistical data and analysis on catches, fishing effort, prices, costs and incomes;
- collaboration with Ocean and Aquatic Sciences, other federal departments and agencies, universities, industrial and fishermen's organizations, provincial governments, international commissions and the industry and governments of other countries.

The general objectives of the Oceans and Aquatic Science activity are:

- To conduct, on a national basis, research programs in physical, chemical and biological oceanography and limnology with the aims of: gaining a better understanding of the marine and freshwater environments; utilizing the information to define and help solve real and potential problems; responding to national concerns; and providing information and advice as a service.
- To support, through these programs, the management of marine and freshwater resources; the enhancement and protection of marine and freshwater environmental quality; and the safe, orderly, and efficient conduct of shipping in Canadian waters and in those areas of open ocean of direct interest to Canada.
- To contribute to the national capability in fisheries and marine science, through the development and transfer of ocean technology, the management of contracts pertaining thereto, the provision of direct financial aid to qualified university research projects (subvention program), and the implementation of a national fisheries and marine information and publications policy.
- To ensure that adequate hydrographic data, charts, and publications are available as and when required to meet the needs of navigation in all Canadian waters, including the re-surveying of all areas where existing surveys do not meet today's requirements.

Department of Industry, Trade and Commerce

	Science Resources						Total Resources	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Trade-Industrial	59.2	163	72.6	274	103.1	343	349.3	2,450
Tourism	0.3	4	0.3	4	0.3	4	30.1	302
Grains and Oilseeds	1.9	3	1.8	3	1.4	2	110.2	44
Total	**61.4**	**170**	**74.8**	**281**	**104.8**	**349**	**489.6**	**2,796**

The 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.

Most of the department's S & T expenditures are made through the Trade-Industrial program. It is estimated that in total the Trade-Industrial Program will spend approximately $103.1 million S & T in 1980/81, an increase of $30.5 million over 1979/80.

One of the major activities in this program is the Enterprise Development Program, instituted in 1977 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. In 1979/80 an additional $21.5 million was earmarked for the innovation component of the new program, bringing the total expenditure on the S & T element of the program in that year to a forecasted $30.4 million. It is estimated that these expenditures will increase to nearly $61 million in 1980/81, including $10 million in assistance to the electronics industry under a special component of the program.

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 for 1980/81 are $26.7 million compared to $31.3 million in 1979/80.

The Industry Energy Research and Development Program was introduced in 1978/79 to encourage and assist Canadian industry to undertake Research and Development of new and improved processes and equipment that will reduce energy consumption. Expenditures for 1979/80 are forecasted to be $1.0 million, and estimated at $1.5 million in 1980/81. Through the Technological Innovation Studies Program, the department also supports studies and awards scholarships in the uses and management of technological innovation.

Other programs of the department support studies of technological innovation and provide assistance for industrial research institutes, Centres of Advanced Technology and industrial research associations. Funding of these activities has remained unchanged over the past four years. In 1979 financial assistance was also provided for the start-up phase of two Industrial Innovation Centres which will provide assistance to inventors, entrepreneurs and small business in the commercialization of new ideas, processes and products.

Additional details of these 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 is now being run by the P.O.S. Pilot Plant Corporation, an independent non-profit corporation.

Department of National Defence

	Science Resources						Total Resources	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Defence Services	83.3*	1,909	93.4*	1,916	104.0*	1,952	5,283.0	116,434

* Excludes transfers to other departments ($7.2 million in 1980/81).

The Department of National Defence's estimated expenditures for scientific activities in 1980/81 are $104.0 million. 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. Research in the physical sciences is conducted at six Defence Research Establishments at various locations across the country and 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, anthropometry, physical fitness, vision, and hearing, and the effectiveness of man/machine systems.

The department's Defence and Civil Institute of Environmental Medicine has designed garmentry to protect aircrew against the loss of cabin pressure when operating at very high altitudes and also to enable operation at such altitudes without the use of full pressure suits.

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. These activities are in a growth phase and, as a result, are commanding an increasing share of the total R & D resources. On the Search and Rescue Satellite project (SARSAT), the Department of National Defence is the lead department for Canada. The first launch of SARSAT equipment is scheduled for 1982. Canadian participation with the U.S. Air Force in the NAVSTAR Global Positioning Satellite project is continuing. Trials of the transportable satellite ground terminal on the Headquarters/Lahr link have continued and development of a shipboard terminal for satellite communications is underway.

Ordnance and Vehicles activities include R & D 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 a high proportion of the personnel resources. The Canadian Forces have accepted an improved 2.75-inch CRV-7 air-to-ground rocket developed 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 1979/80, DREV work continued 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. DREV has supported the development by Canadian industry of a Gun Alignment and Control System and the MILIPAC Artillery Computer, Spinning Tubular Projectile practice rounds of various calibres and an indoor TOW weapon simulator.

The department is increasingly employing the social sciences in its research program. The Operational Research and Analysis Establishment (ORAE) 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. ORAE has been involved in support of maritime operations in developing computer models to be used in the Canadian Patrol Frigate program for evaluating ship performance when equipped with contractor-proposed system components. 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.

Department of National Health and Welfare

	Science Resources						Total Resources	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Administration	6.7	152	5.3	111	6.4	111	24.1	598
Health and Social Services	26.0	84	17.9	51	20.6	55	6,128.5	547
Medical Services	0.1	3	0.1	3	0.1	3	199.6	3,763
Health Protection	24.8	841	24.6	784	26.3	785	67.8	1,875
Income Security	0.5	19	0.5	17	0.5	17	9,124.1	2,864
Total	**58.2**	**1,099**	**48.4**	**966**	**54.0**	**971**	**15,544.1**	**9,647**

The scientific activities of the department support its primary missions of promoting and preserving the health and social welfare of Canadians. The department exercises leadership in the health and social welfare fields by developing and enforcing national standards of quality and safety in foods, drugs and medical devices, by identifying and developing ways to reduce or eliminate physical, chemical and biological threats to health, by finding ways to improve individuals' awareness and concern for factors that affect their health and social well-being, and by encouraging the experimental development of new or improved systems for delivering health and social services.

The accompanying table shows the departmental resources that are devoted to scientific activities. It should be noted that the programs shown in the table conform to the display in the Main Estimates and not necessarily to the actual organization of the department. Thus the science resources attributed to the Administration program are almost entirely those of the Policy, Planning and Information Branch, which serves as a support to the line branches. About one third of these resources is devoted to such studies as: the effects of smoking and hazardous drinking on mortality; the current status of occupational health in Canada; retirement in Canada; the changing dependence of women. Another third of the resources is devoted to the development of information systems and the collection of data for long-range health and welfare planning, and the remaining third is devoted to economic and feasibility studies of possible options for public programs of income support and social security. Most of these scientific activities are in the human sciences and are conducted intramurally.

In contrast, most of the scientific activities that are supported in the Health and Social Services program are carried out extramurally. The science resources reported for this program include those disbursed through the National Health Research and Development Program, the Health Promotion and Health Services directorates of the Health Services and Promotion Branch, and the National Welfare Grants disbursed by the Social Services Program Branch, as well as various studies performed under contract. The National Health Research and Development Program accounts for approximately half the science resources in this program. It supports studies, research, demonstration projects, and special health care projects and provides fellowships for research training and support for a limited number of career scientists, all in areas of enquiry related to the department's responsibilities in the health field. Scientific activities are supported from separate budgets for health promotion and family planning. Some health promotion program objectives which require a significant research input are: keeping young people from becoming smokers, helping smokers to quit smoking, assessing risks in individual lifestyles, educating people to eat nutritiously, and developing services for alcoholics and drug abusers.

In the social services field, the National Welfare Grants program supports studies, research, demonstrations, welfare manpower development and utilization activities and fellowships. About half the research supported by the Welfare Grants is carried out in universities, while most of the demonstration projects take place in social service agencies. An estimated thousand researchers, assistants and technical personnel are supported by the extramural funding programs of the Health and Social Services program. About three-quarters of the scientific resources are directed to activities classified as human sciences.

The Health Protection program is identical with the branch of the same name which contains five main divisions: the Food, Drugs, and Environmental Health directorates, the Laboratory Centre for Disease Control, and the Directorate for Field Operations. Practically all of the branch's science activities are classified as in the natural sciences and most are performed intramurally. The Field Operations Directorate maintains 23 field offices and 5 regional laboratories across Canada. Inspectors collect many kinds of samples which are analysed in regional or headquarters laboratories. The results are used by the directorate to determine compliance with regulations affecting the manufacture of foods and drugs and the control of environmental hazards and by the Food, Drugs and Environmental Health directorates to monitor regulated factors. The data are subsequently used by these directorates to determine program priorities and to develop realistic regulations.

The Food Directorate, devoting 238 person-years to scientific activities, is responsible for ensuring the nutritional quality of foods and their freedom from microbial, chemical and other contaminants. The directorate conducts research on the toxicity and effect on nutritional quality of additives and both chemical and microbial contaminants in foods. It develops and standardizes analytical methods for use on foods by the regional laboratories and assesses data generated by the Field Operations Directorate, which devotes 288 person-years to food monitoring and surveillance. The Food Directorate is also responsible for the development of a variety of regulations governing both nutritional quality of foods and the safety of chemicals used in their production,

processing and distribution. This involves review and assessment of the scientific documentation accompanying numerous submissions from manufacturers seeking permission to use new pesticides or additives, or supporting claims for the nutritional content of new foods.

The Drugs Directorate devotes 436 person-years to scientific activities. The directorate is responsible for ensuring the safety and efficacy of human and veterinary drugs which are manufactured or offered for sale in Canada, as well as for the safety of cosmetics. New drug submissions and applications for proprietary medicines are evaluated for safety and efficacy, as well as for manufacturing and labelling aspects. The directorate also licenses vaccines and other biological drugs for manufacture and sale. Surveillance programs are carried out to assess the safety, efficacy, pharmaceutical quality, advertising and manner of use of marketed drugs. The Field Operations Directorate devotes 54 person-years to data gathering activities in support of these surveillance programs. The Drugs Directorate also carries out programs to control the misuse and abuse of drugs, particularly psychoactive ones, and to provide information on the quality and the wise use of drugs to health professionals and to the general public. The directorate maintains the Drug Research Laboratories to support its drugs and cosmetics programs, by carrying out investigations in the fields of toxicology (carcinogenicity, mutagenicity, allergenicity, etc.) and pharmaceutical chemistry and by developing analytical methods.

The Environmental Health Directorate identifies, assesses and takes steps to reduce health hazards associated with the physical, chemical and technological components of natural and man-made environments. Its main program areas are directed toward the control of chemical hazards associated with consumer products, drinking water, pesticides and other contaminants of natural and man-made environments; radiation exposures associated with nuclear installations and the diagnosis and treatment of disease in occupational settings; and the quality and effectiveness of medical devices.

The Laboratory Centre for Disease Control provides bacteriological, virological, medical biochemical and epidemiological services to a wide variety of federal, provincial and municipal health agencies. It has three laboratory programs, offering internal and external reference and diagnostic services to provincial and hospital laboratories and providing standardized diagnostic reagents for their use. The centre is participating in the development of a National Program of Quality Assurance in Laboratory Medicine, in cooperation with the health professions, public health laboratories and clinical laboratories. Research on the role of immunoglobulins in allergy conditions and on the factors governing disease causation in population groups is integrated with disease surveillance and laboratory epidemiology.

The Medical Services Program is the largest program of the department, in terms of the proportion of total resources spent on direct services. Laboratory and investigative activities carried out in support of services in the Civil Aviation Medicine, Occupational Health and Environmental Contaminants components of the program have not been identified as science resources; the science resources shown in the table are those associated with the Northern Medical Research Unit, which carries out nutrition surveillance studies in the Northwest Territories and investigates diseases and environmental contaminants of northern wild life which may affect the health of northern residents.

Scientific activities supported in the Income Security program are all in the human sciences; they consist of the development of population and cost projections, the development and analysis of beneficiary surveys, program statistical data bases, and micro and macro socio-economic studies of the impact of existing programs and of proposed changes to them.

Medical Research Council

	Science Resources					
	1978/79		1979/80		1980/81	
Program	$M	PY	$M	PY	$M	PY
Grants and Scholarships	63.0	—	68.7	—	78.4	—
Administration	1.2	40	1.4	40	1.6	39
Total	**64.2**	**40**	**70.1**	**40**	**80.0**	**39**

All of the Medical Research Council's expenditures are for S & T activities. The estimates for 1980/81, at $80.0 million, include an additional $3.0 million for the grants activity over and above the funding increase determined in acccordance with the previously approved long-term funding strategy.

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. The growth of various non-profit agencies supporting elements of Canadian medical research has allowed the council to develop its primary role as a supporter of fundamental research and training of health science researchers. The council also collaborates with other funding agencies to develop concerted thrust areas as shown in its predicted continuation and expansion of cardiovascular research and perinatology.

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	
	1978/79		1979/80		1980/81		1980/81	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Scientific and Industrial Research	182.7*	2,815	197.5*	2,888	211.6*	2,913	213.4*	2,913
Scientific and Technical Information	14.4	268	13.7**	217	16.1	218	16.1	212
Total	**197.2**	**3,083**	**211.3**	**3,105**	**227.7**	**3,131**	**229.5**	**3,125**

* Includes the net of transfers from and to other government departments ($0.4 million in 1980/81)

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

The Scientific and Industrial Research Program has estimated expenditures of $211.6 million for 1980/81, 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.

With Canada's vast areas of land and water, rigorous climate and scattered population, the provision of energy, food, shelter and transportation poses special problems that are engaging a considerable part of the council's research capabilities.

In the energy field the council's activities are subject to the coordination and review of the Energy R & D Panel. Details of its energy activities will be found in the Special Applications-Energy section.

The council has identified approximately $11.4 million for research related to the various aspects of Canada's food industry during 1980/81. 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 41% of the total expenditure in 1980/81.

Funds totalling approximately $12.8 million will be used by the Division of Building Research for research on building and construction during fiscal year 1980/81. Of this amount, approximately 5% 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 ten 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. The council also operates a Technical Information Service to provide advice and interpret scientific information for small and medium-sized Canadian industry. 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 and rocket and balloon launching ranges. In addition to those facilities directly operated and managed by its staff, the council through contributions is supporting 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 council's activities in this area are also discussed in the Special Applications section — Scientific and Technical Information.

Natural Sciences and Engineering Research Council

	Science Resources					
	1978/79		1979/80		1980/81	
Program	$M	PY	$M	PY	$M	PY
Scholarships and Grants-in-Aid of Research	109.9*	—	118.7*	—	159.3*	—
Administration	2.0	59	2.4	61	3.7	75
Total	**111.9**	**59**	**121.1**	**61**	**163.0**	**75**

* Includes funds from NATO ($0.3 million in 1980/81)

The estimated expenditures of $159.3 million in 1980/81 on the program of scholarships and grants-in-aid of research are $40.6 million or 34% higher than forecast expenditures in 1979/80.

The objective of the program is to promote and support the development and maintenance of research in the natural sciences and engineering and to ensure the provision of highly qualified personnel in these areas. Concomitant sub-objectives are as follows:

- to support excellence in research for the creation of new knowledge 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, and a high priority is given to fundamental research for which the university environment is considered to be most suitable.

This university support is discussed more fully in the Extramural-University section. Of the remainder of the 1980/81 budget, an estimated $3.1 million will be spent in support of Canadians undertaking research or research training outside Canada, and an estimated $1.5 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 $110.1 million compared to $88.5 million in 1979/80. These are grants awarded to individuals on a competitive basis to assist in defraying operating expenses of research projects. Developmental Grants will be awarded up to an estimated $24.6 million compared to $16.2 million in 1979/80. A substantial increase in funding will be made to research in areas of national concern through the Strategic Grants program which is included under this activity—from $10.8 million in 1979/80 to $17.8 million in 1980/81. An encouraging response and an improved quality of research proposals has been observed since the introduction of the Strategic Grants Program in 1977. Although the percentage of funding assigned to this program will remain relatively low, studies show that researchers supported through peer-adjudicated grants are also carrying out research in areas of national concern. Areas identified for support through strategic grants are energy, environmental toxicology, oceans, communications and agriculture/food. There will also be increases in the Program of Project Research Applicable to Industry (PRAI), which comes under the development grants activity as well.

Expenditures for the Highly Qualified Manpower Training and Development activity will be an estimated $19.8 million in 1980/81, compared to $12.6 million in 1979/80. This activity provides support mainly to postgraduate students and postdoctoral fellows through bursaries, scholarships and fellowships awarded in national competitions. Highly qualified manpower programs will be expanded to increase the proportion of the awards that will be tenable in industry. This expansion is directly related to achieving the national goal of increased R & D by encouraging the training of highly qualified manpower particularly at the university industry interface.

NSERC has proposed a system of research fellowships for temporary, non-tenured faculty research positions. This program is intended to expand career opportunities for a select number of very promising researchers in the natural sciences and engineering.

The sub-objectives of this program are:

- to assist in maintaining the level of the university research and development effort in Canada;
- to assist in maintaining an adequate supply of promising and highly qualified researchers in Canadian universities to help meet the demand for new faculty appointments which is expected to expand rapidly in the early 1990's when the retirement rate of the existing research force increases significantly and when student enrolments start to increase again.

In addition, both this program and the corresponding NSERC program of Industrial Research Fellowships (to be introduced in the fall of 1980) will hopefully encourage closer interaction between researchers in the universities and in industry and mobility between these two sectors.

The council will contribute $20,000 per year towards the salary and fringe benefits of the research Fellow, in addition to providing a research grant. Universities will complete the remuneration if required, provide the Fellow with space and basic facilities and defray the indirect costs of research.

A special program to provide additional funds for the refurbishment of university equipment and facilities has been proposed by the council, and a task force is currently investigating the basis for distribution of the new equipment. This program may lead to a more rational funding of university research equipment.

Expenditures on National and International Activities will increase from $1.2 million in 1979/80 to $1.6 million in 1980/81. These funds are used to support both national and international conferences, the publication of Canadian scientific journals and to assist Canadian scientific societies.

The National Library of Canada

Program	Science Resources					
	1978/79		1979/80		1980/81	
	$M	PY	$M	PY	$M	PY
Program Expenditures	13.1	494	14.7	500	17.2	500

The total budget of the National Library constitutes "related scientific activities" in the human sciences, that is, information services, and this activity is performed intramurally. The estimated expenditures for 1980/81 are $17.2 million, an increase of $2.5 million from the previous year.

The objective of the National Library program is to facilitate the use of the library resources of the country by the government and the people of Canada by:

- maintaining a centralized bank of bibliographic information in all fields for reference and research purposes;
- co-ordinating the resources of the National Library, which are primarily in the fields of the social sciences, the arts and the humanities, with those of other research libraries.

To achieve this objective the agency's program is organized into five activities which are Administration, Library Systems Centre, Collections Development, Cataloguing and Public Services.

The Administration activity includes the central management responsibilities of the library, public relations and Federal Libraries Liaison activities including the Council of Federal Libraries. Also included in this activity is policy development, planning and liaison in the area of networking and co-operative projects both national and international. A special working group, the National Library Network Project, was created in 79/80 to design, promote and monitor the implementation of a nation-wide bibliographic network.

The Library Systems Centre provides computerized systems services to the National Library, to other federal libraries and to a developing Canadian library network. The centre is responsible for the maintenance, enlargement and further development of the automated on-line library data base management system called DOBIS (Dortmunder Bibliothekssystem). This computerized system is now used by the National Library, the Library of Parliament and the Canada Institute for Scientific and Technical Information in a network mode and other federal government libraries have begun to join this system.

The Collections Development activity administers the Book Deposit regulations of the National Library Act, the selection and acquisition by purchase, exchange or gift of library materials and controls the preservation of library materials. Also included in this activity are the surveying of library resources of Canada and the re-distribution of surplus library material through the administration of the Canadian Book Exchange Centre as well as the microfilming and sale of copies of Canadian theses.

The Cataloguing activity is responsible for the compilation and publication of the National Bibliography "*Canadiana*" as well as the organization of the resources of the library by the compilation of a catalogue which describes National Library holdings by subject classification and bibliographic analysis. Also administered in this area are bibliographic standards and the listing of Canadian theses.

The Public Services activity provides reference services to other libraries and to the Canadian public and compiles and publishes bibliographies for reference purposes. This activity is also responsible for the compilation and maintenance of the Canadian Union Catalogue (the national book resources index), the multicultural activities, automated selective dissemination of information, documentation of current developments in library and information science and has the custody of the resources of the library and the organization of the library's uncatalogued material.

National Museums of Canada

Program	Science Resources 1978/79 $M	1978/79 PY	1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY
Program Expenditures	55.1	1,026	51.2	1,014	52.5	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. Museum services are classed as a related scientific activity. The National Museums estimate total expenditures of $52.5 million for 1980/81, up 2.5% from 1979/80. The majority of the agency's resources (78%) are allocated intramurally, with 22% 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 1978/79 $M	1978/79 PY	1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY
Grants & Scholarships	31.3*	—	33.1*	—	38.7*	—
Administration	3.3	98	3.6	107	3.9	105
Total	**34.6**	**98**	**36.6**	**107**	**42.6**	**105**

* Includes transfers from the Department of External Affairs ($0.9 million in 1980/81)

All of the expenditures of the Social Sciences and Humanities Research Council are devoted to S & T activities. It is estimated that the council's expenditures in 1980/81 will be $42.6 million, an increase of $6.0 million over forecast expenditures for 1979/80.

The objective of the council is to promote and assist excellence in research and scholarship in the social sciences and humanities. The council

- supports such independent research as in the judgement of scholars will best advance knowledge
- encourages research on subjects considered by the council to be of national importance
- facilitates the dissemination and exchange of research results
- assists in and advises on maintaining and developing the national capacity for research.

In comparison to the Medical Research Council and the Natural Sciences and Engineering Research Council, somewhat less of this council's budget — 78% — is used to support research and research training in universities, through various programs of scholarships, fellowships and research grants. These are discussed in the Extramural-University section. The scholarship and fellowship programs, administered by the Fellowships Division, represent the largest share of council expenditures — nearly 44% in 1978/79. The council also provides assistance to the scholarly community through a series of consultative groups composed of specialists in various fields, which examine and report on issues of current scholarly interest and suggest guidelines or subjects for future research.

Within its Research Grants Program the council's first priority is the support of fundamental research. It will assign, however, a substantial increase in funding to areas of national concern which have been identified through organized workshops. First grants were made in 1979/80 under a new $1.0 million program of grants for research in areas of national concern. Continuing programs will be maintained for research on population aging, and for strengthening university research resources, in particular special library collections. The council is also in the process of reassessing the social sciences research potential in Canada with the aim of making greater use of the capacity available.

The Negotiated Grants Program offers support to large-scale research and editorial projects undertaken at eligible institutions — usually universities — by groups of scholars over a period of years. Two types of awards are available: Program Grants and Grants for Major Editorial Projects.

The Research Communications Division subsidizes learned journals in the social sciences and humanities, publication of scholarly manuscripts, and travel to scholarly conferences in Canada. Grants of over $1 million are being awarded to a total of 85 learned journals. Among scholarly conferences and seminars supported in the past have been the major conference on Ukrainian history at the University of Alberta, the first Colloque International des Acadiens in Moncton, and a Laval University seminar on the analysis of public policies in Canada and in Quebec. In 1978/79 for example, 105 such conferences and seminars were supported for a total of $304,186. Support for Canadian learned societies comprises assistance (totalling $942,440 in 1978/79) to attend annual meetings of these societies and administrative support. This form of assistance in both instances is provided through block grants to the Social Science Federation of Canada and the Canadian Federation for the Humanities. Grants are also provided to these bodies for the publication of scholarly manuscripts ($847,612 in 1978/79).

The council's Office of International Relations provides grants to enable scholars to participate in scholarly exchange at important meetings held outside Canada, and for scholars who hold high executive office or key ad hoc positions in international scholarly organizations to travel to management and policy meetings. Grants for international collaborative research are for a) small seminars, workshops or colloquia organized jointly by Canadian and foreign scholars to plan, coordinate or evaluate cooperation on specific research topics, and b) consultations between Canadian and foreign scholars on joint or parallel research projects.

The Council promotes and administers international scholarly exchanges through special exchange programs. It has concluded international agreements for exchanges of scholars with research institutes and academies in France, Japan, the Soviet Union and Hungary. Grants for such exchanges totalled $178,229 in 1978/79. The council also administers academic exchange programs for the Department of External Affairs with 1978/79 expenditures of $1.5 million.

Transport Canada

Program	Science Resources 1978/79 $M	1978/79 PY	1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	Total Resources 1980/81 $M	1980/81 PY
Administration	7.8	53	8.0	56	7.6	54	84.9	1,492
Marine Transportation	10.6	20	9.5	28	10.8	27	335.8	6,352
Air Transportation	10.9	108	5.8	116	6.6	117	500.7	10,038
Surface Transportation	12.7	2	3.8	2	0.5	2	782.3	302
Total	**42.1**	**183**	**27.1**	**202**	**25.6**	**200**	**1,703.7**	**18,184**

By comparison with its total resources of $1704 million for 1980/81 the expenditures of Transport Canada on science and technology will be relatively small, comprising 1.5% or $25.6 million. This low ratio reflects the major expenditures required for the upkeep, operation and expansion of existing mature transportation networks, mainly through the application of standard techniques and acquisition of standardized components.

Transport Canada interfaces with the transportation networks both through its support services and regulation of all Canadian transportation and through the operation of certain elements of the transportation network. Within the department the Transport Canada Research and Development Centre has the responsibility of providing research and development capabilities to assist in operational, regulatory, planning and evaluation activities. This includes the modification and improvement of existing systems together with assessment of advanced systems for future deployment and integration into the existing transportation networks.

Four modal advisory boards have been created to facilitate interaction with industry: the Rail Advisory Committee, the Marine Advisory Board, the Highway Advisory Board, and the Aeronautics Advisory Board. These boards are composed of members predominantly drawn from industry together with representation from the federal government and other Canadian organizations with transportation interests. They formulate research and development programs and recommend projects within the designated transportation modes. Projects proposed by the boards are undertaken on a shared-cost basis between government and industry. The boards are in the process of organizing except for the previously established Rail Advisory Committee which has already submitted program proposals for the next five years. The proposed program concentrates on those areas in which it is judged that maximum impact can be made in increasing economy, efficiency and safety of the Canadian railway systems.

The intramural research and test facilities of Transport Canada are relatively small establishments with budgets totalling about $3 million in 1980/81, consequently most of the R & D is contracted out and much of the subsequent testing and evaluation is carried out using the government-operated elements of the national transport systems.

The largest single grouping of new projects being initiated in 1980/81 are associated with updating air navigation and traffic control by deployment of recent advances in computing and microprocessing techniques.

Statistics Canada

Program	Science Resources					
	1978/79		1979/80		1980/81	
	$M	PY	$M	PY	$M	PY
Program Expenditures	133.3	5,111	127.7	4,534	139.9	4,435

As Canada's central statistical agency, Statistics Canada collects and publishes a wide range of information on Canadian social and economic institutions and activities for use in research and decision making. Statistics Canada is also responsible for coordinating and monitoring the data collection activities of other federal and provincial government departments.

The agency's entire budget is classified as a related science activity — data collection. Collection activities in respect to households, farms and institutions are mostly located in the Social Statistics Field. Those for reporting units in the commercial non-agricultural sector make up the Economic Statistics Field. Responsibility for the dissemination of data is centralized in the Marketing Field and overall bureau planning strategy and statistical coordination is the concern of the Policy, Planning and Evaluation Branch.

The Economic Statistics Field produces, analyses and publishes a broad range of production-oriented statistics by particular industry, as well as cross-cutting statistics on prices, employment and payrolls, external trade, capital investment, business finance and so on. In addition, the complete macro-economic framework known as the Canadian System of National Accounts is compiled by this field from the primary statistics just mentioned. An extensive planning process and resource re-allocation to high priority programs has helped to minimize the impact of budgetary constraints. Most vital national economic aggregates have been maintained although the discontinuance of a number of surveys and the streamlining of others was necessitated. Commitment to improved service to users, reduction of response burden and enhanced program efficiency will continue.

The Social Statistics Field is responsible for the quinquennial censuses of population and housing, provides detailed national and small area data, provides a comprehensive base for analytic studies and a program of inter-censal population estimates and projections. A program of regular sample surveys of households is carried out, providing current information on labour force characteristics, income distributions, family expenditures and household facilities and equipment. In addition, special household surveys on a wide variety of topics of current interest are conducted on behalf of other agencies. Data on public finance, health, justice, education, science, culture and agriculture are also collected both through direct surveys and through exploitation of administrative data files. As in the Economic Statistics Field, use of the latter means is receiving greater emphasis as a way of reducing the need for direct data collection.

Analytic and research studies in both methodological and subject-matter areas are being carried out to enhance the quality and efficiency with which data are collected and to provide data users with a better understanding of the uses and interpretation of the statistical product. One of the areas under development of considerable public interest is the examination of cancer mortality due to occupational and environmental hazards which may involve exposure to carcinogenic substances. Projects are sponsored by corporations, labour unions and private non-profit institutions, as well as by government departments and agencies. One study on occupational cancer involves a 10% sample of the Canadian labour force. Smaller projects are based on selected occupations, such as uranium or nickel mining, or specific drugs (e.g., isoniazid) and procedures (e.g., multiple fluoroscopies).

Budget reductions during the past fiscal year, combined with those of earlier years, have had the effect of reducing both the amount and the quality of the statistical output of the Social Statistics Field, and in some cases have effected timeliness. Substantial reductions in the resources available for the Census program have curtailed planned output from the 1976 Census, and have affected significantly the scope of development work on the 1981 Census. The cancellation of the Canada Health Survey at the end of 1978/79 was a major reduction in the field's program. The survey will not be repeated but the available data are now being processed on the health status of a random sample of 11,000 families, and a significant body of unique data will result.