Ministry of State
Science and Technology
Canada

Ministère d'État
Sciences et Technologie
Canada

Federal Science Activities

1981/82

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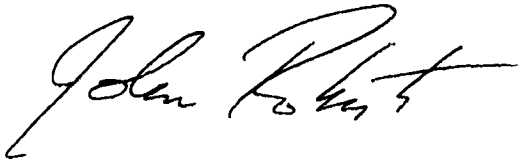
Foreword

This fifth annual publication reports on the scientific and technical activities to be funded by the government during the fiscal year 1981/82.

The 1981/82 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 both descriptive narrative and 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 government officials and the public, with an overview of the government's proposed activities in science and technology. Related numerical data are available in a companion report "Federal Science Expenditures and Personnel, 1981/82".

This overview of the government's science programs is prepared by the Ministry of State for Science and Technology in connection with its responsibility for the development of 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 1981/82 Main Estimates. In presenting its Main Estimates to Parliament the government spells out the objectives of its departments and agencies and lists its expenditure proposals in terms of the budgetary programs designed to achieve those objectives. The Main Estimates present program expenditures in terms of Standard Objects of Expenditures common to all the departments of government. In contrast, this publication highlights only that part of the expenditures proposed in Main Estimates which will be applied to scientific activities. The object is to assist parliamentarians, managers, scientists and the public generally to obtain a better appreciation of the scope and purposes of the governments' participation in the funding or the performance of scientific and technological activities.* Much effort by many people and organizations goes into the preparation of this report. In the interests of making the publication as useful as possible, readers are invited to forward comments and suggestions for improvements to the Ministry of State for Science and Technology.

The government funds activities in science and technology (S & T) which are performed either in its own establishments (intramurally) or are performed (extramurally) in other sectors of the economy, e.g., University, Industry, Provincial. S & T activities are funded or undertaken to assist departments and agencies to attain their individual objectives, or in pursuit of some cross-departmental objective of government such as encouragement of economic development or to encourage research which would contribute to national objectives.

There are some 60 departments and agencies reporting scientific expenditures undertaken within a total of over 100 budgetary programs, each with its particular goals and objectives. Against this background one can perceive some major roles which the government plays in its support of research and development (R & D). Thus the government's role in funding or performing R & D can be said to act in support of industry, in support of university research, or to support the attainment of some specific departmental mission, e.g., to ensure the safety and efficacy of human and veterinary drugs in Canada.

Within the present publication, departmental and agency programs are listed according to the format used in the Estimates. Agencies are grouped within the portfolio of the Minister to whom they report or are responsible, for example Statistics Canada under the Department of Supply and Services, the Medical Research Council under the Department of National Health and Welfare.

The Overview section which follows this Introduction highlights overall trends in expenditures, emphasizing 1981/82 expenditure changes, in comparison with the current year 1980/81. A five year expenditure perspective is also provided. Following the Overview, the Special Applications section draws attention to science activities in broad areas of national concern, in which expenditures may be shared by a number of federal departments or agencies.

Next comes a section entitled Extramural Activities dealing with scientific activities funded by the federal government but carried out by other sectors (including industry, universities, other levels of government, or in other countries.)

A Major Funders section follows, which highlights the organization and expenditures of the scientific and technological programs and activities of those departments and agencies which have the largest science expenditures, or whose activities are exclusively scientific and technological. The publication continues with

* For explanations of terminology used in the collection of science expenditure data, please refer to Appendix I.

the Perspectives section which provides a historical view of Canada's expenditures on scientific activities, compares them to those of other members of the Organization for Economic Cooperation and Development, and discusses the future impacts of the government's R & D target. The Regional section discusses the regional distribution of federal science expenditures and highlights some leading federal regional establishments. The publication concludes with an article on a Special Topic of interest—a description of the Regional Laboratories of the National Research Council of Canada.

2. Overview

In its recent announcement of a planning framework for R & D in Canada, the government has reaffirmed the policy of increasing Canada's performance of research and development to a level approaching that of the more industrialized nations belonging to the Organization for Economic Cooperation and Development. The year 1985 has been set as the date for having Gross Expenditures on Research & Development (GERD) reach 1.5% of Gross National Product (GNP). Within this target the federal government's share of GERD would be 0.5% of GNP or one third of the total, while the target for industry funding of R & D would be 0.75% of GNP or one half of the country's GERD. The balance of 0.25% of GNP would be funded by the provincial governments, universities and other sources.

As indicated by the expenditure trends discussed below, the government has, this past year and in the coming year, already begun to increase the funding for R & D required to meet its share of the target. Clearly, however, the target cannot be achieved solely by direct government expenditures; other initiatives by the government may be required to encourage industry to increase its R & D investment.

As shown in Table 2.1 the expenditures on R & D in the natural sciences provided for in the 1981/82 Main Estimates will reach $1,495 million, an increase of nearly $197 million or 15% over 1980/81 forecast expenditures and a 35% increase over 1979/80 expenditures. From 1979/80 to 1980/81, the rate of increase (24%) in extramural performance of the R & D was nearly double that for intramural R & D (13%), with the rate of increase in the university sector slightly higher than that in the industry sector. From 1980/81 to 1981/82, the rate at which expenditures have increased in the intramural and industry sectors corresponds to the overall rate of increase in R & D expenditures; the rate of increase for expenditures for performance in the provincial and municipal sector (33%) is significantly higher, while that for university sector performance is somewhat lower at about 8%. The estimated expenditures in 1981/82 for Related Scientific Activities, at $486 million, are 12% higher than in 1980/81, which in turn were 10% higher than in 1979/80. Over the two years there has been a higher rate of increase in the proportion of RSA performed extramurally with a marked rate of increase (30%) in the university sector performance.

With respect to expenditure trends in human science activities, shown in Table 2.2, the 1981/82 estimated expenditures for R & D and RSA combined will be about $567 million, an increase of 27% from 1980/81 and a 43% increase from 1979/80. Related science activities predominate in the human sciences and comprise more than 75% of the total; this is in contrast to the situation in the natural sciences. The forecast expenditures on RSA in human sciences for 1980/81 are 16% higher than in 1979/80, and the 1981/82 estimated expenditures of $460 million show a further increase of 30%. Most of this latter increase is accounted for by the estimated cost of the next Decennial Census, to be conducted by Statistics Canada in 1981. This also accounts for the overall 33% increase for 1981/82 in intramural expenditures for RSA. The share of the government's requirements for RSA which is performed by industry and universities has remained reasonably constant over this period. In contrast, expenditures for human science R & D increased slightly in 1980/81 after a 10% decrease in 1979/80 and show an increase of 14% to $107 million for 1981/82. This strenghtening of R & D in human sciences has occurred only in the intramural and university sectors, which show slightly better than a 25% increase since 1978/79.

Driven mainly by increased support for R & D in the natural sciences, government expenditures for all science activities are estimated to increase in 1981/82 to $2,548 million, an increase of $369 million or 17%

Table 2.1

R&D & RSA Expenditures—Natural Sciences

	1977/78		1978/79		1979/80		1980/81		1981/82	
	(millions of dollars and (%))									
Total Natural Sciences	**1,277.9**		**1,397.8**		**1,494.5**		**1,732.5**		**1,980.7**	
R&D Expenditures (Total)	**918.0**	**(100)**	**1,011.2**	**(100)**	**1,100.3**	**(100)**	**1,297.8**	**(100)**	**1,495.1**	**(100)**
Intramural	506.4	(55)	583.4	(58)	587.8	(53)	664.6	(51)	772.5	(51)
Extramural (Total)	411.6	(45)	427.8	(42)	512.5	(47)	633.2	(49)	722.6	(49)
Industry	186.4*	(20)	181.8	(18)	213.4	(19)	260.5	(20)	303.4	(20)
University	171.1	(19)	190.3	(19)	200.6	(18)	253.6	(20)	274.3	(19)
Private Non-Profit	7.2	(1)	8.3	(1)	8.9	(1)	10.7	(1)	12.0	(1)
Provincial & Municipal Governments	11.9	(1)	13.8	(1)	53.8	(5)	68.1	(5)	90.8	(6)
Other Canadian	6.4	(1)	4.3	(–)	4.3	(–)	4.4	(–)	4.3	(–)
Foreign	26.6	(3)	29.3	(3)	31.7	(3)	35.9	(3)	37.7	(3)
RSA Expenditures (Total)	**359.8**	**(100)**	**386.6**	**(100)**	**394.2**	**(100)**	**434.7**	**(100)**	**485.7**	**(100)**
Intramural	273.6	(76)	296.1	(77)	313.4	(79)	341.2	(78)	376.6	(78)
Extramural	86.3	(24)	90.4	(23)	80.8	(21)	93.5	(22)	109.1	(22)
Industry	56.6	(16)	58.0	(15)	45.8	(12)	51.7	(12)	58.1	(12)
University	13.3	(4)	13.7	(4)	15.0	(4)	19.7	(5)	25.4	(5)
Private Non-Profit	2.2	(1)	2.5	(1)	2.6	(1)	3.3	(1)	3.1	(1)
Provincial & Municipal Governments	5.1	(1)	7.5	(2)	7.4	(2)	8.9	(2)	13.1	(3)
Other Canadian	7.2	(2)	6.3	(2)	7.2	(2)	6.2	(1)	4.9	(1)
Foreign	2.0	(1)	2.4	(1)	2.8	(1)	3.6	(1)	4.5	(1)

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

over the current year, which in turn increased by $288 million or 15% over 1979/80 expenditures. Expenditure data by performer sector for total science activities are given in Table 2.3 for the 5-year period, 1977/78 to 1981/82. Expressed as a proportion of the total science expenditures, intramural performance peaked in 1978/79, declined in 1979/80 and remains at about the same level in 1980/81 and in 1981/82. The proportions performed by the industry and university sectors have remained comparatively stable since 1978/79.

Over the five-year period S & T payments to industry have increased 52%, those to university 57%, compared to a 56% increase in total extramural payments. On the other hand, payments to the provincial and municipal governments (mainly provincial) show a remarkable 3.5-fold increase over the five years, with a 230% jump from 1978/79 to 1979/80 and increases of 22% for 1980/81 and 33% for 1981/82. The increases arise mainly from payments under the Canada-Alberta Heritage Fund agreement, the Canada-Saskatchewan heavy oil agreement and the program of joint federal-provincial projects in energy conservation and renewable energy resources.

Expenditure data for the major funding departments and agencies for the period 1977/78 to 1981/82 are given in Table 2.4. With respect to the expenditure changes from 1980/81 to 1981/82, those in the departments of Energy, Mines and Resources and Industry, Trade and Commerce and in the National Research Council account for about 44% of the total increase of $339 million. The above, taken together

Table 2.2

R&D & RSA Expenditures—Human Sciences

	1977/78		1978/79		1979/80		1980/81		1981/82	
	(millions of dollars and (%))									
Total Human Sciences	**395.1**		**411.3**		**397.3**		**446.9**		**567.4**	
R&D Expenditures (Total)	**101.0**	**(100)**	**100.3**	**(100)**	**90.7**	**(100)**	**93.7**	**(100)**	**107.1**	**(100)**
Intramural	47.6	(47)	42.2	(42)	36.4	(40)	39.4	(42)	46.2	(43)
Extramural (Total)	53.3	(53)	58.1	(58)	54.3	(60)	54.3	(50)	60.9	(57)
Industry	5.7	(6)	4.9	(5)	4.7	(5)	3.7	(4)	4.9	(5)
University	21.6	(21)	26.0	(26)	26.9	(30)	30.6	(33)	34.0	(32)
Others	26.0	(26)	27.2	(27)	22.8	(25)	20.1	(21)	22.0	(20)
RSA Expenditures (Total)	**294.1**	**(100)**	**311.1**	**(100)**	**306.6**	**(100)**	**353.2**	**(100)**	**460.3**	**(100)**
Intramural	242.4	(82)	266.6	(86)	264.7	(86)	306.4	(87)	406.4	(86)
Extramural (Total)	51.7	(18)	44.5	(14)	41.8	(14)	46.9	(13)	54.0	(12)
Industry	11.6	(4)	9.6	(3)	9.6	(3)	12.1	(3)	13.9	(3)
University	17.8	(6)	14.9	(5)	13.6	(4)	15.9	(5)	17.6	(4)
Others	22.4	(8)	20.0	(6)	18.6	(7)	18.9	(5)	22.5	(5)

Table 2.3

Federal Expenditures on Scientific Activity by Performer

Performer	1977/78		1978/79		1979/80		1980/81		1981/82	
	(millions of dollars and (%))									
Total	**1,673.0**	**(100)**	**1,809.0**	**(100)**	**1,891.8**	**(100)**	**2,179.3**	**(100)**	**2,548.1**	**(100)**
Intramural	1,070.0	(64)	1,188.3	(66)	1,202.2	(64)	1,351.5	(62)	1,601.7	(63)
Extramural	603.0	(36)	620.8	(34)	689.6	(36)	827.8	(38)	946.4	(37)
Industry	262.2*	(16)	254.3	(14)	273.4	(14)	327.9	(15)	380.4	(15)
University	223.8	(13)	244.9	(14)	256.1	(14)	319.8	(15)	351.2	(14)
Private Non-Profit	23.4	(1)	27.4	(1)	25.7	(1)	26.2	(1)	28.4	(1)
Provincial & Municipal Governments	24.9	(1)	29.6	(2)	68.8	(4)	84.1	(4)	111.7	(4)
Other Canadian	23.5	(1)	17.6	(1)	16.1	(1)	16.3	(1)	15.5	(1)
Foreign	45.1	(3)	47.0	(3)	49.5	(3)	53.5	(2)	59.2	(2)

* Includes payments under the Industrial Research and Development Incentives Act (IRDIA): $16.4 million.

Table 2.4

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

Department	1977/78	1978/79	1979/80	1980/81	1981/82
			(millions of dollars)		
Total Science	**1,673.0**	**1,809.0**	**1,891.8**	**2,179.3**	**2,548.1**
Total Major Funders	1,511.5	1,661.2	1,734.2	2,002.7	2,347.7
Agriculture	117.9	127.2	143.9	152.9	170.1
Communications	31.0	62.5	59.2	71.6	57.5
National Library	—	13.1	14.7	17.2	21.6
National Museums of Canada	45.7	55.1	50.1	53.3	56.1
Social Sciences and Humanities Research Council	33.2	34.6	36.6	42.6	45.6
Energy, Mines & Resources	118.4	124.5	162.7	200.2	275.7
Atomic Energy of Canada Ltd.	77.2	92.0	88.9	98.6	111.5
Environment	290.3	206.4	220.1	249.1	286.8
External Affairs					
Canadian International Development Agency	25.3	35.6	37.4	37.1	41.5
International Development Research Centre	34.5	36.7	36.5	39.0	45.4
Fisheries and Oceans	*	122.5	112.7	116.4	119.8
Industry, Trade & Commerce	92.8**	61.4	83.5	99.9	127.1
National Defence	83.2	83.3	87.1	98.5	110.2
National Health & Welfare	62.7	58.2	58.0	66.2	74.1
Medical Research Council	57.9	64.2	70.1	82.0	88.6
Science & Technology					
National Research Council	172.6	197.2	201.4	237.4	274.1
Natural Sciences and Engineering Research Council	99.5	111.9	121.4	163.2	182.0
Supply and Services					
Statistics Canada	130.0	133.3	122.2	148.3	230.0
Transport Canada	40.0	42.1	27.7	29.2	30.0
Minor Funders	161.5	147.8	157.6	176.6	200.4

* 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: $16.4 million.

with Statistics Canada's increased expenditures for the Decennial Census, account for 65% of the overall increase. Most of the major funding departments and agencies show increased science expenditures slightly exceeding the rate of inflation, using the Implicit Price Index based on Gross National Expenditures. Exceptions are the Department of Communications, Department of Fisheries and Oceans, Medical Research Council, National Museums of Canada, the Social Sciences and Humanities Research Council and Transport Canada. If one considers the two-year changes since 1979/80, however, increases for the Medical Research Council and the Social Sciences and Humanities Research Council exceed the amount necessary to compensate for inflation; the Department of Agriculture and the Canadian International Development Agency join the group whose increases in expenditures did not keep pace with inflation. It should be noted that a significant portion of the expenditures of the Department of Communications is associated with major space projects and this results in marked year-to-year expenditure fluctuations, as existing projects are completed and new ones started.

A review of the 5-year expenditure trends shows an average increase of 55% for the major funders. The Department of Energy, Mines and Resources leads the list with a 133% increase, followed by the Department of Communications (87%), the Natural Sciences and Engineering Research Council (84%), Statistics Canada (77%), the Department of Industry, Trade and Commerce (60%), the National Library (65% since

Table 2.5

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

Department	1977/78	1978/79	1979/80	1980/81	1981/82
			(person-years)		
Total Science	**34,726**	**34,035**	**33,124**	**33,524**	**34,699**
Total Major Funders	30,417	30,590	29,723	30,195	31,318
Agriculture	4,176	4,168	4,057	4,053	4,075
Communications	433	644	649	671	651
National Library	—	494	500	500	517
National Museums of Canada	1,002	1,026	1,013	1,006	975
Social Sciences and Humanities Research Council	97	98	105	105	105
Energy, Mines & Resources	2,422	2,458	2,403	2,392	2,441
Atomic Energy of Canada Ltd.	2,275	2,363	2,322	2,372	2,427
Environment	7,332	4,989	4,921	4,913	4,935
External Affairs					
Canadian International Development Agency	51	56	56	56	57
International Development Research Centre	344	217	217	227	238
Fisheries and Oceans	*	2,423	2,122	2,143	2,211
Industry, Trade & Commerce	171	170	275	344	344
National Defence	2,142	1,909	1,895	1,934	1,935
National Health & Welfare	1,205	1,099	1,186	1,380	1,416
Medical Research Council	39	40	40	39	39
Science & Technology					
National Research Council	3,073	3,083	3,160	3,125	3,172
Natural Sciences and Engineering Research Council	57	59	61	75	81
Supply and Services					
Statistics Canada	5,432	5,111	4,534	4,619	5,489
Transport	166	183	207	241	210
Minor Funders	4,309	3,618	3,401	3,329	3,381

* 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.

1978/79), the Canadian International Development Agency (64%), the National Research Council (59%), and the Medical Research Council (53%). The remaining major-funding departments and agencies are below the average. The 5-year average increase for all the minor-funding departments and agencies is 23%.

Data on personnel engaged in S & T activities in the federal government are shown in Table 2.5. As a consequence of the government's efforts to restrain growth of the Public Service coupled with the policy of contracting-out S & T activities, there has been a decline in total S & T personnel from 1977/78 to 1979/80, with marginal increases in 1980/81 (2%) and 1981/82 (3%). A similar pattern is observed for the group of major funders of S & T activities while the decline for the minor funders persisted through 1980/81. In looking at trends, it should be noted that the 1981/82 data could be considered to be anomalous due to the temporary personnel increase within Statistics Canada, made necessary by the impending 1981 Decennial Census. If this temporary increase is excluded, the total S & T personnel increased less than 0.5% in 1981/82 and over the 5-year period declined about 3%. Similarly, the S & T personnel for the group of major funders also increased less than 0.5% over 1980/81 but over the five-year period has nearly recovered to the 1977/78 level, with an overall decline of less than 0.5%. The decline in S & T personnel in the minor funders group over the 5-year period has been nearly 22%. Among noteable departmental exceptions to this overall decline in S & T personnel are Energy, Mines and Resources, Atomic Energy of Canada Limited, National Health and Welfare, and the National Research Council.

Table 2.6

Federal Expenditures on the Natural and Human Sciences by Cabinet Committee

Departments	1978/1979	1979/80	1980/81	1981/82
		(millions of dollars)		
Total science	**1,809.0**	**1,891.8**	**2,179.3**	**2,548.1**
Total—Economic Development	**1,019.9**	**1,088.5**	**1,273.0**	**1,469.9**
Agriculture	127.2	143.9	152.9	170.1
Communications	61.9	58.6	70.9	56.8
Energy, Mines and Resources	124.5	162.7	200.2	275.7
Atomic Energy of Canada Ltd.	92.0	88.9	98.6	111.5
Environment—Canadian Forestry Service	29.8	39.8	50.3	58.3
Fisheries and Oceans	122.5	112.7	116.4	119.8
Industry, Trade and Commerce	61.4	83.5	99.9	127.1
Science and Technology				
National Research Council	197.2	201.4	237.4	274.1
Natural Sciences & Engineering Research Council	111.9	121.0	163.2	182.0
Supply and Services (Unsolicited Proposals)	12.4	14.9	15.0	15.1
Transport	42.1	27.7	29.2	30.0
Others	37.0	33.4	39.0	49.4
Total—Social Development	**454.0**	**473.0**	**531.2**	**593.9**
Communications				
National Library	13.1	14.7	17.2	21.6
National Museums of Canada	55.1	50.1	53.3	56.1
Social Sciences & Humanities Research Council	34.6	36.6	42.6	45.6
Employment and Immigration	10.0	16.0	17.3	18.4
Environment (except Canadian Forestry Service)	176.6	180.3	198.8	228.5
National Health and Welfare	58.2	58.0	66.2	74.1
Medical Research Council	64.2	70.1	82.0	88.6
Others	42.2	47.2	53.8	61.0
Total—External Affairs and Defence	**160.5**	**166.1**	**180.2**	**203.4**
External Affairs				
Canadian International Development Agency	35.6	37.4	37.1	41.5
International Development Research Centre	36.7	36.5	39.0	45.4
National Defence	83.3	87.1	98.5	110.2
Others	4.9	5.0	5.5	6.2
Total—Services to Government	**174.7**	**163.7**	**194.3**	**279.8**
Supply and Services				
Statistics Canada	133.3	122.2	148.3	230.0
Treasury Board	10.5	10.0	11.8	12.9
Others	30.9	31.5	34.2	36.9

Under the new policy and expenditure management system, responsibility for resource allocation decisions is exercised by policy sub-committees of the Cabinet. With respect to S & T resource allocation, the relevant policy areas are Economic Development, Social Development (including Justice), External Affairs and Defence and Services to Government. S & T expenditures by major funding departments and agencies, classified by these policy areas are shown in Table 2.6 for the four years, 1978/79 to 1981/82. The estimated increases over 1980/81 are: Economic Development, 15.5%, Social Development, 12%, External Affairs and Defence, 13%, and Services to Government, 44% (includes expenditures for the 1981 Decennial Census).

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3. Special Applications

Introduction

Scientific activities are carried out by departments not only to support the attainment of their particular objectives, but also in support of broader governmental concerns, objectives and policies. Accordingly, expenditure data for a set of cross-departmental S & T application areas have been collected for several years now, to assist in policy development and in related decisions. Table 3.1 summarizes expenditure data for the application areas discussed in this section. Descriptions of the kinds of S & T activities being funded by the government are largely confined to this present section. The section on Major Funders primarily describes how departments and agencies are organized to conduct their S & T activities.

Readers may care to note that the data provided in all the tables in the section are concerned only with the foremost or *primary* application areas. For example, the primary application of the S & T expenditures of the Department of National Defence lies in *national security*. Nevertheless, it is clear that portions of the expenditures contribute simultaneously to advances in the areas of communications, science, transportation, oceans, space technology, and so forth. Similarly, the S & T expenditures by the Canadian International Development Agency are made primarily in support of the *developing nations* application area. Nevertheless many projects contribute to advances in other application areas also. Some significant activities with such *secondary applications* are noted in the text and the relevant expenditures data are provided as footnotes in the tables.

Table 3.1

Federal Scientific Expenditures by Application Area

Application Area	1979/80	1980/81	1981/82
		(millions of dollars)	
Communications	33.3	38.7	37.9
Domestic Security	7.7	8.7	10.7
Energy	223.5	277.9	358.2
Environmental Issues	52.9	56.0	63.5
Food	184.1	201.2	221.6
Health	139.7	158.8	178.3
National Security*	92.4	105.6	117.4
Natural Resources	113.9	120.2	138.4
Oceans	54.6	56.2	63.0
Scientific and Technical Information	117.1	132.0	159.6
Social Development	30.3	37.3	42.5
Space	57.8	65.7	55.6
Transportation	72.5	77.1	81.0

* 1981/82 expenditures in this area by the Department of National Defence also contribute directly to advancement in other areas, as follows: Communications, $3.0 million; Energy, $1.2 million; Health, $5.3 million; Oceans, $3.6 million; Space, $3.9 million; Transportation $11.8 million.

Communications

Since orderly development of Canadian communications is the responsibility of the Department of Communications, the majority of the government's expenditures related to this topic occur in this department, as shown in Table 3.2. As a specific subject area within its Strategic Grants program, the Natural Sciences and Engineering Research Council has allotted $3.2 million for communications research in 1981/82. Other agencies playing a role in communications science are the National Research Council, the Canada Post Office, the Department of Supply and Services (Unsolicited Proposals) and the Canadian Radio-Television and Telecommunications Commission. The Department of National Defence, as part of its defence-related scientific activities, will also spend $3.0 million in 1981/82 on communications S & T.

Canada's vast size and thinly-spread population has made a large communication system an integral part of the nation. Even though Canada has one of the most advanced communications systems in the world, the search for better and less costly means of transmission continues. Canada is a leader in the development of reliable, efficient, high frequency sources and amplifiers, as well as carrier systems employing wire, multiconductor cable, coaxial cable, fibre optics and radio transmissions. The development of space technology in the 1960s revealed additional possibilities for long distance telecommunications. Satellites are proving to be economically practicable repeater stations, and they are also proving to be a feasible means of providing reliable low cost communications throughout Canada, and especially to far northern communities.

The world seems to be on the threshold of a revolution in information and communications technology. Such technology is fueled by microelectronics and makes possible such things as the mobile computer terminals now in use in various vehicle fleets. Such terminals, recently developed in industry in conjunction with the Department of Communications, is finding applications in courier services, police and fire departments. Another example is the feasibility of accessing huge computer data bases by means of home television sets. Such advances, coupled with others, such as the use of ever-higher radio frequencies and fibre optics, enabling more information to be transmitted each second, have caused communications to be an area of increasing importance to Canada and other developed nations. In this regard, discussed below is the Telidon system, recently developed by the Department of Communications, which is expected to be the focus of a major Canadian thrust over the next five years. Telidon takes the form of an interactive TV system allowing users to retrieve information stored in a computer data-base by means of a keyboard and a modified TV set. Information may be in textual, graphic or photographic form. The technology has been designed to permit data to be retrieved "off-air" from regular or special TV broadcasts, from central computers via phone lines, coaxial cables or fibre optics cables and to permit user-to-user communication for homes and offices in applications such as electronic mail, electronic banking and teleconferencing. It has also been designed so as to be immune to component obsolescence resulting from such things as improvements in television receivers, in transmission media and in data-base and storage techniques.

Since the department announced the development of Telidon in August 1978, significant advances have taken place both in development of the technology

Table 3.2

Federal Science Expenditures in Communications

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**33.3**	**38.7**	**37.9**
Communications	22.0	29.4	26.6
National Research Council	3.1	3.2	3.6
Natural Sciences and Engineering Research Council	1.0	2.2	3.2
Supply and Services (Unsolicited Proposals)	2.4	2.3	2.3
Others	4.8	1.7	2.3

* Directly-related expenditures by other departments and agencies in 1981/82: National Defence, $3.0 million; Canadian International Development Agency, $9.2 million.

and in its demonstration. The first use of Telidon to receive signals off-air was announced on February 1, 1980. In this trial, 35 "pages" of Telidon text and graphics are being continuously broadcast by TV Ontario. The coded information is contained in the portion of the transmitted TV signal which appears as a horizontal black line just outside the normal picture. Accordingly, no phone lines or cable connections are required for this *Teletext* mode of operation. In contrast, *Videotex* is the generic name for systems which use telephone lines and/ or cables to enable the user to interact directly with the computer storing the data. A number of trials of this mode of Telidon use were initiated in 1979.

Subsequently, Telidon was selected for the first United States consumer trial of teletext, conducted at Station WETA in Washington, D.C., starting late 1980. A second foreign sale was made to the Presidential Central Office of Statistics and Informatics of Venezuela. Here, Telidon is to be used in the videotext mode to provide government information to "store-front" locations.

Two Canadian videotext pilot projects using Telidon were announced recently: the Manitoba Telephone System's Project IDA and the installation of Telidon in several government service bureaus as well as in a number of public places across Canada early in 1981, for use in responding to the inquiries by citizens about government information. Project IDA is a pilot study in which 100 homes in South Headingly, Manitoba, are being provided with advanced communications services such as videotex, fire and buglar alarm services, remote metering and medic alert services. The department is supplying about 40 Telidon terminals for this project.

In December 1980, Telidon technology was officially ratified as one of the world standards for videotex by the agency of the United Nations responsible for setting worldwide telecommunication standards. This achieved one of the prime objectives of the government, which was to ensure that Telidon could be marketed around the world.

Complementing activities related to the development of Telidon is a federal contribution of $1.2 million towards development of what could be Canada's most sophisticated multi-service two-way cable TV system. The prime mover behind the four-year, $4.5 million program is Télécable Videotron, a major cable TV firm in the Montreal area. With government backing, and along with a number of other participants, the firm will develop a pilot system capable of providing new services such as videotex, fire, burglar or medical alarm-monitoring and home video games. A major component of the project is a 250-terminal field trial of Telidon. A key thrust 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.

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 Office Communications Systems 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 government has reserved $12.5 million for direct support of this program. Details of this program are discussed in the Extramural-Industry section.

On the industry side, the 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 are available to assist in the development of Canadian hardware and software products and in the establishment of Canadian manufacturing capability. The Department of Communication's 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 Communications Systems Research program includes projects for the extension of advanced information services to rural areas, small remote communities, ships and aircraft. A major experiment will be inaugurated this year in the rural communities of Elie and St. Eustache, near Winnipeg. A total of 150 homes will be provided with single-party telephone and cable-television service by means of a fibre optic distribution system. The purpose is to explore the feasibility of using such systems cost-effectively in rural areas. A further phase, also expected to be inaugurated this year, will provide some interactive services and Telidon data bases oriented to a rural population. Total cost of this project will be $9.6 million shared between government and industry. A further significant technological initiative to which the government has contributed is the Rural Interface Device, which enhances multi-party lines with most of the advantages of single-party lines at low cost.

Modern systems technology is being applied to bring by short wave radio reliable high quality telephony and data services to ships, aircraft and small remote communities too small to be able to afford direct satellite service. This development will provide direct access to information processing services.

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.

The Communications Systems Research program also includes communications system research for the Department of National Defence, such as advanced work in communications networks for tactical and strategic applications, based mainly on radio systems.

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. A substantial portion 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, water and in the air 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.

Domestic Security

The application area, domestic security, is concerned with scientific activities related to the protection of the lives and property of the citizens of Canada. Expenditures for these activities are shown in Table 3.3. 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 of the criminal justice system and increasing public understanding and support for crime prevention and control efforts.

The constitution creates a division of responsibilities in the administration of justice between the provinces and the federal government. In this regard, the Department of Justice has as one of its responsibilities the review of administrative 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;
- 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 is 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; family law; 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.

Table 3.3

Federal Science Expenditures for Domestic Security

Agency	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**7.7**	**8.7**	**10.7**
Justice	2.8	3.2	4.2
Law Reform Commission	2.3	2.6	3.3
Solicitor General	2.5	2.7	2.8
Others	—	0.1	0.4

The third category differs to some extent from the first two in that the projects emanate from outside the department. They arise from reports rendered by the Law Reform Commission of Canada. The subjects cover numerous topics: 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 criminal law, discovery, Unified Family Courts, administrative law, the Federal Courts, commissions of enquiry and judicial review, and representations in the public interest.

In particular the Evaluation and Statistics Unit in the department undertakes social science research in support of justice policies and departmental resource allocation. This research includes evaluation of ongoing programs, evaluation of existing legislation policy, evaluation of proposed programs and policies, and exploratory research in anticipation of new policy directions. At present, the following justice programs, which are cost-shared with the provinces, are being evaluated: the legal aid program, the native courtworker program, and compensations to victims of violent crime. These evaluations are performed on a cyclical basis across the country and involve detailed studies of policy, administrative structure, social impact, and legislative implications.

In addition, work is underway in support of future policies in the area of family law, including the evaluation of experimental unified family courts, the evaluation of various projects concerning pre-trial disclosure or evidence, the evaluation of various projects concerned with experimental diversion from the criminal justice system, the evaluation of various experiments in public legal education, the evaluation of innovations in sentencing, and the evaluation of innovative approaches to the provision of legal services. Each of these projects involves studies of existing procedures which have the promise of providing new directions for policy for the justice system as a whole or studies which have been designed to answer specific questions relating to issues soon to be addressed within the justice system. While the research is applied, in the sense that its objective is to answer specific policy questions, it is based upon general theories of public administration, jurisprudence, and sociology and it draws upon the methodologies common in the human sciences generally. The department does not, as a rule, support any research the genesis of which is a theoretical question, but encourages applied research which is informed by a full recognition of the fundamental theoretical issues at stake. Unsolicited proposals are considered but the majority of the work performed is contracted out after specific information needs have been articulated with the department. Research organizations and academic institutions interested in the social impact of justice policy however, are invited to make their interest known to the department.

All of the activities of the Law Reform Commission of Canada are classified as human sciences. The objective of the commission, as defined by the Law Reform Commission Act is "... to study and keep under review on a continuing and systematic basis the statutes and other laws comprising the laws of Canada with a view to making recommendations for their improvement and reform ...".

Under the administration law project the commission prepares for, and participates in, conferences and discussions with regulatory agencies concerning such subjects as confidentiality and release of information, regulations and sanctions, and liaison among federal and provincial agencies, law faculties and international law associations. A subject of particular interest now under examination is the application of sanctions by various administrative agencies whose practices appear to differ widely.

Another project, Protection of Life, deals with such matters as criteria for determination of death, behaviour modification, cessation of treatment and the concept of a person in law. The nature of this research and the sources of expertise are somewhat different from those otherwise concerned with criminal law but ultimately, the findings will be combined with other recommendations for reform in criminal law.

Within the Ministry of the Solicitor General, scientific and related activities in the human sciences are concentrated within three divisions of the Programs Branch—Research, Statistics and Planning and Liaison. The program of the Research Division is designed to respond to policy and program issues in criminal justice. Research is carried out to assist in policy and program development and to evaluate new legislation and programs. Because the divison's work is closely integrated with policy development and evaluation, specific projects are designed in close consultation with the primary users of the information. Most of the research is performed extramurally under contract with universities and private consultants. The activities of the Research Division are divided among four general areas: prevention of crime and victim assistance; research related to criminal justice policy; police research; and corrections research.

The Causes and Prevention Research section is responsible for studies dealing with the planning and

evaluation of crime prevention and victim assistance policies and programs. Examples of these studies include the evaluation of Canada's new gun control laws, studies on family violence, evaluations of police programs to assist victims, and a victimization survey.

Criminal Justice Policy Research focusses on the evaluation of the forthcoming legislation on young offenders, public attitudes, community participation, and expectations and satisfaction vis-à-vis police services. The section also carries out research relating to such fundamental issues as sentencing effectiveness and decision making in the criminal justice system, as well as studies relating to the effectiveness, efficiency, and equity of new policy initiatives such as diversion and community-based sentencing alternatives.

The research activities of the Police Research section are directed toward the development of police policy and practices which would increase the efficiency, effectiveness, and public acceptability of police services. Within this framework individual projects are being undertaken in areas such as native policing, police officer and public safety, women in policing, police productivity, police accountability, traffic law enforcement, and crisis intervention.

The Corrections Research section is concentrating its activities on the policy and program issues related to correctional effectiveness, conditional release, prison violence, and long-term imprisonment. The section is also studying the determinants of penitentiary populations, and carrying out a major historical study of the Canadian Corrections Service.

The Statistics Division provides specific statistics or analytical reports in response to ministry needs, such as the provision of a quantitative base for proposed revisions to the Cannabis and Young Offenders Legislation. It also provides specialist services in the fields of statistical methodology, computer technology and information systems development. The division's other major objective is to promote an environment of liaison and co-operation within the national criminal justice statistics community. To this end, the division has contributed to the work of federal-provincial committees whose main purpose has been the planning and implementation of a new national justice statistics agency.

The objectives of the Planning and Liaison Division include:

- ensuring that relevant, high quality criminal justice research, statistics, and other empirical findings and knowledge are understood and disseminated to federal, provincial and municipal departments and agencies, the private sector, the research community and the general public, who are working in or concerned about crime and the criminal justice system. This is done through two programs: a multifaceted publications program; and a program of workshops, seminars and courses.
- encouraging, through the ministry's CRIMDOC Centre, the timely exchange of information and providing library reference and referral services to its clients within the ministry, as well as to other users in Canada and abroad.

Scientific activities carried out by the Royal Canadian Mounted Police embrace both R & D and related scientific activities in the human sciences. Though much of the R & D is conducted internally, a significant portion of its research requirements is obtained with the assistance of the Research Division of the Ministry of the Solicitor General. The scientific activities are concerned with all aspects of police work including: policing standards; family dynamics e.g., crisis intervention, child abuse, interspousal violence, sexual assault, etc.; vandalism; subliminal advertising; crime prevention through environmental design; senior citizen/victimization programs; commercial crime e.g., fraud, computer crime; traffic law enforcement; police productivity e.g., shift scheduling; native policing; police management e.g., training and personnel development; police-community relations; gun control; electronic and specialized equipment used for law enforcement e.g., voice identification, polygraphs, surveillance equipment, computers; forensic sciences e.g., toxicology, alcohol, drugs, document examination, hair & fibre chemistry, serology, radiography, firearms; fingerprints; physical, data processing and technical security; explosive disposal technology.

In 1979, the Force assumed the lead agency role for a program of Science and Technology in Support of Law Enforcement, with responsibility for financing, contracting and monitoring of all work carried out under the program, from project definition through to final output. The S & T requirements under the program are based on needs identified in an annual submission from the Operational Research Committee of the Canadian Association of Chiefs of Police. Some examples of such projects are: development of a Canadian-made bomb suit, development of a protective headgear information package, saliva monitoring for drugs, more effective tear gas and improved methods of tear gas dispersal and specialized imaging systems.

Energy

Canada's current energy problem is a shortage of easily accessible oil; it is well endowed with other sources of energy. As reflected in the National Energy Plan, announced in November, 1980, Canadian research effort must be directed towards the priorities of:

- substitution for oil
- improving efficiency of energy use
- developing new energy sources

Substitution for oil is of critical importance and is being attacked on two fronts: the development of alternatives to gasoline for transportation and the substitution of oil by other fuels, notably coal and uranium, for heating and industrial processes.

Significantly increased resources for energy R & D were included in the National Energy Plan: $260 million for the period 1980 to 1983 has been reserved to expand the core program of energy R & D for which the Interdepartmental Panel on Energy R & D has been providing programming recommendations since 1975. Other R & D support in the plan includes $4 million over the next four years for special support coal R & D in the Atlantic provinces, as well as $50 million over the period 1980 to 1983 to carry the technical risk involved in the introduction of new coal utilization technologies, especially fluidized bed combustion, with the possible further provision of $100 million during 1984 and 1985.

The chief candidates for gasoline alternatives are the alcohols - methanol and ethanol—and compressed natural gas (CNG). A study of the relative merits of the two alcohols as gasoline extenders in the form of "gasohol" mixtures is underway. Technical problems that may arise from the use of gasohol in existing car engines, especially in winter driving conditions, are being identified. Engine modifications to accommodate higher proportions of alcohol in the mixture are also being tested. In the case of CNG, only minor engine modifications appear to be required. The main obstacles to be overcome are consumer acceptance of the increased fuel volume and the perceived hazards of compressed gas tanks in accident situations. Funding is being provided for testing CNG in fleets of commercial vehicles and the results will be carefully monitored. Safety tests will be carried out on vehicle prototypes.

Both coal and uranium can be used to produce electricity and/or heat and increased emphasis is being devoted to developing efficient and convenient means of implementing the substitution of these fuels for oil. There is a growing realization that Canada could lose an opportunity for self-sufficiency not possible in many other countries if it responded to a shortage of oil by conserving electricity.

The potential for savings from increased efficiency of energy use is very great. One of the most promising areas is in the design of energy-efficient buildings. Monitoring continues on the prototype houses constructed in past years. The emphasis in future will be to analyse the data and evolve optimal design configurations incorporating improved construction standards, better insulation, and passive solar heating concepts such as thermally efficient windows and shutters. In existing buildings the main emphasis is on retrofit improvements to oil and gas furnaces that can provide energy savings of at least 20 percent.

The priority on "new energy sources" will lead to increased funding of some of the renewable or "inexhaustible" energy technologies. The first projects to receive this added impetus were nuclear fusion and wind energy. Federal funding is being provided in the amount of $18.7 million over several years, to support the construction of an experimental fusion device, called a Tokamak, at Varennes, Quebec. The project, which is to be funded equally through the National Research Council and Hydro Québec, will provide a tool for exploring certain characteristics of the magnetic confinement approach to fusion. It will complement fusion research, based on the alternative inertial confinement concept, that is already being carried out by the National Research Council in Ottawa. In wind power, Canada's vertical axis, "eggbeater" design will undergo an important scale-up step. The $20 million Aeolus project will be capable of generating a maximum 3.8 megawatts of electricity. It will be built by Canadian industry under contract to Hydro-Québec, which will share equally with the National Research Council both in its financing and in the provision of technical support for its development and evaluation. This huge wind turbine will be over 100 metres high and will supply power directly into the Hydro Québec electrical grid.

Because the process of planning and programming the additional energy S & T activities among the several departments and agencies was not complete when the Main Estimates were prepared, the additional funds for energy R & D in 1981/82 under the plan have been included in the expenditures of the Department of Energy, Mines and Resources in Table 3.4. For the

Table 3.4

Federal Science Expenditures on Energy

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**223.5**	**277.9**	**358.2**
Energy, Mines and Resources	86.8	119.2	183.0
Mineral and Earth Science Services Program	26.3	29.2	31.9
Energy Program	60.5	90.0	151.1
Atomic Energy of Canada Ltd.	81.7	93.2	103.1
Environment (Total)	5.1	5.4	7.2
Canadian Forestry Service	4.2	4.4	6.2
Fisheries and Oceans	7.5	7.8	8.3
Industry, Trade and Commerce	1.6	1.5	1.5
National Research Council	26.8	30.5	34.6
Natural Sciences and Engineering Research Council	3.8	6.0	6.2
Public Works	2.7	5.3	4.6
Transport	3.7	4.8	4.9
Others	2.9	3.3	4.8

* Directly-related expenditures by other departments and agencies in 1981/82: National Defence, $1.2 million.

same reason, 1981/82 expenditure data are not provided for each of the five tasks under which the core program is organized, and the discussion of the activities within these tasks is generally limited to an overview.

Conservation

In addition to the activities described above for increasing energy efficiency in buildings, another major thrust relates to making better use of heat rejected in primary applications because it is not in the right form or right place at the right time for convenient use. Considerable R & D is being directed to devices, processes and equipment configurations that make use of waste heat in industrial processes. For example, experiments are underway to demonstrate the use of reject heat from electrical generating stations to heat greenhouses, fish hatcheries and other buildings.

Although strictly speaking not an efficiency improvement in energy use as such, another avenue being pursued under the Conservation task is to increase the utilization of the country's electrical generating capacity. In response to electricity demand, generating stations frequently do not run at full capacity, but there have not been convenient and cost effective means of "storing" electricity. A variety of different "energy storage" systems are under investigation of which the most promising is the production of hydrogen by electrolysis. Hydrogen is potentially an alternative transportation fuel and considerable effort is underway to develop the necessary technology for safe storage, transportation and handling of hydrogen.

Fossil Fuels

Research is being carried out to prepare the way for a full-scale demonstration program on fluidized-bed combustion technology. Detailed design concepts are being evaluated and commissioning of the first prototype unit is expected in 1982. In such systems, low-grade fuels can be utilized, such as coal with high sulphur content, wood wastes or garbage. Limestone added to the bed reacts with sulphur dioxide to form sulphates that remain in the bed, thus reducing atmospheric sulphur dioxide emissions by up to 90 percent.

Oil is currently separated from the oil-sands by a hot water process which is inefficient when the sands have a high clay content because of the formation of a clay emulsion. The National Research Council has developed a new process, spherical agglomeration, which overcomes emulsion formation. A pilot plant test has been completed and scale-up to a 100 tons-per-day demonstration plant is planned. Federal funding is also contributing to the development of a cold water separation process and a feasibility study for a full-scale plant has been completed.

A hydrocracking process, developed by the Canada Centre for Mineral and Energy Technology, produces

10-15 percent higher distillate yields from tar-sands bitumen than the conventional coking process. The new process is being further developed with the expectation of early commercialization. In recent work progress was made in increasing the degree of desulphurization and in achieving higher yields at lower pressures.

Nuclear Energy

As stated in the National Energy Plan, the success of the CANDU reactor has resulted from the government's investment in energy R & D in past years. While the plan involves new priorities, as mentioned above, support for nuclear R & D will continue, both to maintain the necessary technological base for the CANDU system, and to pursue potential applications of nuclear power in providing new energy sources and improving the production of existing sources.

Most of Canada's nuclear research is carried on by Atomic Energy of Canada Limited which has a large, comprehensive program. Most of its work is aimed at securing the highly successful CANDU reactor option for Canada, and this objective is pursued with research in a number of areas. In addition to underlying research, which is essential for the basic scientific understanding of all nuclear technology, work is devoted to radioactive waste management, to ensuring a continuing supply of nuclear fuel for many centuries and increasingly, to finding ways in which nuclear energy can help solve Canada's major energy problem, a shortage of cheap oil.

The Canadian approach to the safe permanent disposal of radioactive material from irradiated CANDU fuel is to *immobilize* the material in a water-resistant matrix and *dispose* of it deep in a stable hard rock formation in the Canadian Shield. The R & D program includes laboratory scale work on *immobilization* of both used fuel and separated wastes. Work on used fuel immobilization is focussed on the design of high-integrity containers with a life of some 300 to 500 years. With this containment, isolation of the vast majority of radioactive fission products for the duration of their hazadous lives would be guaranteed. For separated fuel waste, the reference concept is immobilization in borosilicate glasses, but attention is also being given to matrix materials. To obtain the necessary geotechnical understanding for the disposal program extensive drilling is being carried out in several different rock formations. There is also a requirement to conduct experiments on a scale and in an environment which can only be achieved underground in a typical hard rock formation. To meet this requirement an Underground Research Laboratory is being developed in the Lac du Bonnet batholith near AECL's Whiteshell Nuclear Research Establishment at Pinawa, Manitoba. The Waste Management R & D program is now well established and significant progress is being made.

Using the once-through natural-uranium fuel cycle in present CANDU reactors it is possible to recover only about 1% of the energy potentially available from the uranium. However, advanced fuel cycles using thorium, in conjunction with either plutonium produced in current reactors, or enriched uranium, will permit that energy recovery to be increased manyfold. In the long term these advanced fuel cycles would make the cost of nuclear energy less sensitive to variations in the prices of uranium and thorium, hence making feasible the use of low-grade ores and promising a secure supply of low-cost energy for centuries. Experimental work is being carried out at the laboratory level within AECL, concentrating on verification of the feasibility of the self-sufficient thorium fuel cycle. The use of the thorium fuel cycle in CANDU reactors would avoid the need to develop another reactor, the fast breeder.

The oil-shortage problem is being attacked on two fronts: the substitution of nuclear energy for oil and the potential use of nuclear energy in extracting oil from the Alberta tar sands. Substitution studies include a hybrid oil/electric heating experiment in the town of Deep River, the development of a mini-reactor for district heating and assessments of the direct use of heat from the Bruce reactors for industrial processes. Large amounts of energy, particularly in the form of high-pressure steam, are required for the production of oil from the tar sands and the role of nuclear reactors, which could provide this energy on a competitive basis, is being studied.

Renewable Energy

A large number of renewable energy sources are being studied and only a few can be mentioned. Development of active solar space heating systems is proceeding but it is now clear that a number of major innovations will be required to achieve a cost-effective product. The most promising components for improvement are storage systems, solar collector and collector mountings. In contrast, domestic hot water systems are expected to become commercially viable within a few years given modest R & D investment.

The National Research Council has evolved a promising new technique—the fixed film reactor—for anaerobic digestion of biomass media such as municipal sewage. The process involves bacterial action on a

fixed support such as clay tile. It produces a greater volume of methane per tank volume as compared with a homogeneous reactor. It is possible that the methane could be produced economically. Scale-up tests are proceeding and various feedstocks are being examined.

A proposal is under consideration for the development of a system to convert cellulosic materials to ethanol fuel. An economic process for the first step conversion of the cellulose to sugar may involve extensive research on the bio-engineering of new organisms, using such techniques as gene-splicing. Improvements are also needed in the subsequent fermentation and alcohol recovery steps. The proposed approach involves developing a reference design for pilot plants and the construction of a series of process development units to optimize the performance of the system. If successful, the ethanol produced could be used in gasohol mixtures.

In non-conventional hydraulic energy, the National Research Council is examining the feasibility of vertical axis watermills. Based on the same principles as the vertical axis wind turbines, these watermills may be used in low head river flows or in ocean tidal currents. An advantage is that expensive dams would not have to be constructed.

Geothermal energy, the heat available below the surface of the earth, is being studied by the Earth Physics Branch of the Department of Energy, Mines and Resources. A joint federal-provincial study of the geothermal resource at Meager Mountain, B.C., has shown sufficient promise that B.C. Hydro is going ahead with a 50-megawatt steam-to-electrical energy generating station. Other areas under study are the sedimentary basins of the prairies and the structures of the Atlantic provinces.

Recent experience in Alaska shows that research is necessary on the stability of permafrost surrounding pipelines. The government is increasing its research program in this area to gain a better understanding of the structural changes in permafrost in the neighbourhood of hot pipelines. Oil and gas production in the Arctic and off the east coast of Newfoundland will require the development of innovative transport systems. Although the projects are largely in the private sector, federal R & D is required to provide information for the development of regulation, safety and navigation standards. The federal program involves R & D projects on ice movements, the ecological impacts of oil spills and design standards of Arctic ships.

Environmental Issues

This section deals with scientific activities related to environmental issues such as acid rain and air pollution, toxic substances, pollution control, weather and climate services and other environmental issues. 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.

Departmental and agency expenditures on environmental S & T are shown in Table 3.5. Those of the Department of the Environment far exceed the others and the following discussion consequently concentrates on its S & T activities. The environmental S & T conducted by the Department of Energy, Mines and Resources ($3.5 million) is mainly concerned with investigating the impact of energy development and mining activites. The $4.8 million being spent in 1981/82 by the National Research Council in this area is directed principally to biological research on waste and pest management. The Natural Sciences and Engineering Research Council has allocated $3.3 million for research on environmental toxicology under its Strategic Grants program. With an estimated expenditure of $2.6 million, the Department of Fisheries and Oceans will, in addition to S & T concerned with atmospheric transportation of pollutants and acidification of freshwater lakes (acid rain), continue its ecological studies on stream rehabilitation.

Acid Rain and Air Pollution

A decade ago, higher smokestacks were still being promoted as the answer to local air pollution problems. As a result of this dilution and dispersion, the pollutants were transported over long distances through the atmosphere and chemically transformed in the process—now known as Long-Range Transport of Air-

Table 3.5

Federal Science Expenditures on Environmental Issues

Department/Agency	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**52.9**	**56.0**	**63.5**
Energy, Mines and Resources	2.6	2.9	3.5
Environment (Total)	38.4	40.1	46.2
Atmospheric Environment Service	2.6	2.3	2.6
Environmental Conservation Service	26.9	27.4	33.1
Environmental Protection Service	7.1	8.1	8.2
Fisheries and Oceans	2.2	2.4	2.6
National Research Council	3.8	3.9	4.8
Natural Sciences and Engineering Research Council	2.7	3.6	3.3
Others	3.2	3.2	3.2

borne Pollutants (LRTAP). Acid precipitation, a mixture of sulfate and nitrate compounds with rain or snow, is a serious international consequence of this phenomenon. Thousands of lakes are affected by acid rain, the result of pollution from large industrial areas, and many of these can no longer sustain normal aquatic life. Another concern is the impact of acid rain on terrestrial ecosystems, forests in particular.

In response to this emerging environmental crisis the government announced in the Fall of 1980, a significant expansion of the science activities related to acid rain which were already underway in the departments of the Environment, Fisheries and Oceans and National Health and Welfare. Four-year increases of $10.0 million for Environment, $12.4 million for Fisheries and Oceans and $3.7 million for National Health and Welfare will bring the government's science expenditures on this problem to about $41 million over the four-year period.

Within the Department of the Environment, the Atmospheric Environment Service's much expanded effort in the long-range transport of air pollutants and acid rain will contribute to the development of a bilateral agreement with the United States to deal with the problem. The work has three major components. Firstly, an extensive network of stations will monitor the current amounts and trends in the chemical constituents of the air and precipitation. Secondly, computer techniques will be used to model the pathways through the atmosphere of the main sulphur and nitrogen acidic compounds in the atmosphere. These models will allow the deposition of acid materials on a sensitive receptor to be quantitatively related back to the emission source regions. The third component is research on the physical and chemical processes of air pollution transport, transformation and deposition to support and improve the modelling capabilities.

The Environmental Conservation Service undertakes activities related to the development of a capability to predict impacts of airborne pollutants on aquatic and terrestrial ecosystems, and the monitoring of changes and trends of these impacts. Socio-economic studies related to the long range transport of airborne pollutants are also included. Examples of these activities are eco-district mapping according to the sensitivity to acid rain, studies of the sensitivity of land to acid precipitation in the area of Turkey Lakes in the Algoma District of Ontario, group studies to investigate the role of ground water systems in buffering acidity and providing a delayed response to acid rain fallout and studies of water chemistry and the effects of acid rain on waterfowl and fish.

The Canadian Forestry Service's program in acid rain and air pollution focuses upon Canada east of the Manitoba/Ontario boundary and smaller areas in Alberta and Manitoba. The threat of reduced forest productivity and degraded forest ecosystems is the prime concern. This could be caused by the direct action of precipitation upon vegetation tissues or indirectly through forest-soil impoverishment. The program aims to quantify the degree of injury being brought about by the different components of acid rain and to indicate abatement levels necessary to preserve environmental values.

New resources are permitting greatly expanded field and laboratory studies. Three major catchment studies have been initiated, in collaboration with other agen-

cies, in representative forest and soil types encompassing the zones of medium to heavy acid precipitation in eastern Canada. A variety of investigations, ranging from tree foliage through the vegetation/soil complex to soil leachates, will show how deposited pollutants stress the forest system.

Toxic Substances

Over 50,000 chemicals are currently in commercial use in North America and this number is growing rapidly. Many of these chemicals are released into the environment in quantities and ways which contaminate our land, water, air, flora and fauna, and thus directly or indirectly endanger human health. The persistent and toxic nature of some of these chemicals, even at low level of exposure, may have profound negative effects on human health and on the structure and functioning of ecosystems.

The Department of the Environment has developed a set of principles and policies to manage chemical contamination in Canada in a comprehensive and cohesive way and has established a Toxic Chemicals Management Centre. Through this centre, the department's Environmental Protection Service plays a significant role in preventing or limiting the negative impacts on the natural environment and also in minimizing the involuntary risks to the health of Canadians arising from the use of toxic chemicals.

The Environmental Conservation Service conducts research and monitoring activities dealing with concentrations, transportation, sedimentation and precipitation of toxic substances and their effect on the environment. Such concentrations and pathways concern inland waters, groundwaters, soils, vegetation and wildlife. The service's role in establishing rigid controls on the use of MIREX is a case in point.

MIREX is a toxic compound used as an insecticide and as a fire retardant. Following the initial discovery of MIREX in fish by a scientist from the Environmental Conservation Service, the distribution of the compound in the bottom sediments of Lake Ontario was determined. The resulting sediment distribution maps showed that Lake Ontario has been extensively contaminated and indicated specific sources of contamination. Subsequent analyses of herring gulls' eggs confirmed that Lake Ontario samples were more concentrated in MIREX than samples from the other Great Lakes. This Canadian research eventually resulted in the U.S. Environmental Protection Agency banning the use of MIREX almost completely.

Recent research activities have also detected the most toxic form of dioxin in gull eggs in 12 locations in the Great Lakes Basin. The discovery was made possible by applying recently developed analytical techniques to frozen gulls eggs that have been collected over the past 10 years. The Department of Environment is seeking very strict controls on this lethal chemical as a result of these findings.

During 1981/1982, the Atmospheric Environment Service will continue to carry out research to gain a better understanding of the modes of entry, movement and fate of priority toxic chemicals known to be, or suspected of being, present in the atmosphere. Elucidation of the atmospheric pathways of toxic chemicals, including mechanisms for their removal from the atmosphere, will be pursued through experimental studies and the development and application of suitable conceptual and/or mathematical models. Ongoing monitoring activities will be expanded, as resources permit, to provide much-needed Canadian information on spatial distributions as well as trends in concentrations of toxic chemicals in the atmosphere.

Pollution Control

The Environmental Protection Service of Environment Canada is the focal point for environmental protection activities involving other departments and agencies of the federal government. The service promotes protection of the environment by first identifying pollution problems, then developing and implementing protection and control measures. Its Water Pollution Control Directorate undertakes to clean up water pollution problems and prevent further pollution through national effluent controls and improved wastewater treatment technology. Research priorities in this area include the development of anaerobic, energy-producing sewage treatment systems, the optimization of larger treatment systems, the development of new methods of treating toxic wastes and of waste treatment systems for cold climates.

The Air Pollution Control Directorate seeks to protect public health and the environment from air pollution. It promotes a consistent approach across Canada in control of air contaminants, including the development of strategies to control acidic precipitation. This program is concerned with the monitoring and collection of ambient air data on the most common contaminants. Special air monitoring surveys are also carried out to provide information on specific problem areas. Air pollution research is concerned with improving process and control technologies for industries that emit air pollutants, understanding the nature of the

environmental impacts and the mechanisms of pollution transport.

The Environmental Emergency Branch undertakes scientific studies with regard to risk analysis of activities that could result in environmental emergencies, and with regard to the development of new technology for dealing with spills of oil and other hazardous materials, including the Arctic Marine Oilspill program with an estimated cost of $7 million over five years and the Baffin Island Oilspill Study amounting to about $4 million over a four-year period.

The proper management of wastes, particularly hazardous wastes, continues to be a major priority item. A Federal/Provincial/ Territorial Committee meets on a recurring basis to discuss and resolve matters of mutual concern and joint jurisdiction. Work is continuing on techniques for recovering resources from waste streams. Energy recovery systems development is funded through the DRECT program managed by the Waste Management Branch of the Environmental Protection Service. The Contaminants Control Branch evaluates chemicals—those already in use and those not yet introduced—to determine whether their use will harm human health or the environment. Specific uses of these chemicals may be restricted or banned.

Weather and Climate Services

Virtually all of Canada's resource-based economic sectors are affected by weather and climate. Continuous efforts are being made to apply climate information to maximize benefits from these activities. The Canadian Climate Centre is participating in an international study to provide better regulation of Great Lakes water levels for the benefit of the lakes community. An analysis of the nature and impacts of drought in western Canada is underway as part of an inter-agency program aimed at reducing the adverse impacts of drought. Current work on mathematical models of climate systems will contribute towards providing a sounder basis for prediction of climate as well as providing a basis for assessing the climatic sensitivity of man's activities.

Climate monitoring and information services are maintained to serve the needs of a broad spectrum of users. In response to national concerns about the impacts of climate and climate change, the Canadian Climate program is being developed. Active participation of various levels of governments as well as the private sector and the university community is being sought.

The Atmospheric Environment Service continues to carry out research in large scale numerical weather prediction in support of its national Weather Forecasting System. The service is also engaged in R & D to predict weather on regional and local scales using empirical and dynamic procedures and models. This latter activity and associated meteorological systems design is carried out in support of weather services provided by Regional Weather Centres. Studies are also underway to assess the potential of Telidon technology for internal and external communication and dissemination of weather information.

Other Environmental Issues

The Environmental Conservation Service of the Department of the Environment undertakes activities relating to a wide variety of environmental issues. Research in ecological land classification and its applications will be pursued in part through the use of the Canada Land Data System. This system will also assist in the analysis of Canada Land Inventory data concerning land capabilities and land use issues. The most urgent problems continue to be centered on the conversion of high capability agricultural land to industrial use. The rate and direction of land use changes within major urban centered regions is being monitored and the monitoring of the rural sector is soon to commence.

Additional research activities include captive breeding and reintroduction to the wild of peregrine falcons, behavioral research on polar bears, and research on northern seabird colonies, caribou herds and Canadian migratory birds in Latin America.

Food

Canada has a diverse and efficient food system which continues to provide a wide variety of high quality foods at relatively low prices. Over the years, both food exports and imports have grown but the export value still exceeds the import value. As shown in Table 3.6, Agriculture Canada has the major role in food science activities with 1981/82 estimated expenditures of $154.6 million. It is concerned with all food commodities except fish and fish products. Several other departments are also concerned with one or more aspects of the food processing, distribution and retailing system, sometimes referred to as the "PDR Sector".

Increasing emphasis is being placed on the PDR sector in departmental S & T activities. The Department of Agriculture spends about $9 million a year on food research as such, including approximately $l million on contract research on meat and plant proteins. A PDR contract program, administered by an interdepartmental board, was established in 1978; estimated expenditures for 1981/82 are $0.9 million. The Canadian Dairy Commission estimates approximately $1.0 million for contract research in 1981/82 directed to PDR concerns in the dairy industry.

The industries engaged in the processing, storing, transportation and retailing make up the "PDR" sector of the food industry. These industries play a major role in the Canadian economy. For example, farm products comprise almost one-fifth of total rail freight and one-quarter of the tonnage moving through the St. Lawrence Seaway. Almost one-quarter of all those engaged in general wholesaling owe their jobs to the sale of food products or farm supplies. The share of the consumer's food dollar which goes for all marketing and distribution functions is now up to 65 cents while the farmer receives 35 cents. It is apparent that the overall benefit to consumers depends on the activities in a chain of connecting services that make up the food system.

Examples of research activities concerned with food processing, storage and marketing, include such items as the development of several new skim milk powders, new types of cheeses, and new dairy products such as whey spread, frozen yogurt, milk shakes, sweets and hydrolyzed milk. New processes for blanching vegetables and fruits, making wieners, canning of mushrooms and pouch packaging have been developed and are being transferred to industry. Methods for evaluating meat, adulterated milk, and browning sugar have been developed. Research is being conducted to ensure consumer safety protection, and the nutritional content of food by reducing factors that decrease nutritional value and microbiological and chemical contaminants. New projects that have been developed include low-calorie jams, apple fiber, fruits packed in pear juice, pouch-pack cherries, and saskatoon berry syrups. New methods of producing cottage cheese, sour cream, and flavored milk products were evaluated. New processes for deboning meat are being developed. The quality of asparagus processed in retortable pouches has been found superior to conventional methods. Research is continuing on meat sampling, sanitary practices, nitrosamines in processed meat, and undesirable growth inhibition by lactic organisms.

Improvement of the rapeseed crop over the last twenty years is one of the classic examples of profitable return

Table 3.6

Federal Expenditures for Food Science

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**184.1**	**201.2**	**221.6**
Agriculture (Total)	125.8	140.5	154.6
Agri-Food Development Program	115.2	128.5	139.8
Agri-Food Regulation and Inspection Program	4.7	5.7	7.6
Fisheries and Oceans	36.9	36.3	37.1
National Research Council	10.0	11.8	12.9
Natural Sciences and Engineering Research Council	1.8	2.7	3.9
Statistics Canada	4.5	5.5	8.6
Others	5.1	4.3	4.4

* Directly-related expenditures by other departments in 1981/82: Canadian International Development Agency, $7.3 million.

on monies invested in agricultural research. It is now the second most valuable Canadian crop, surpassed only by wheat. It is the progress made on seed quality through plant breeding that led the Canadian rapeseed industry to adopt the name CANOLA. This crop with its vastly improved quality, achieved by developing low-erucic acid, low-glucosinolate varieties, provides Canada with an edible oilseed for both vegetable oil and protein meal feed purposes. Researchers are seeking further improvements in the quality of rapeseed to fit Canada's domestic and export markets.

The export of cereal crops is an important component of the Canadian economy. Agricultural research aims at producing better grain varieties, developing and disseminating information on improved growth regimes. Genes associated with resistance to some specific pathogen are being incorporated into varieties of several cereal crops. A similar approach to improving insect resistance is also under development.

Although classified under the primary application area of health science, the Department of National Health and Welfare carries out a large S & T program directly concerned with regulating the production and distribution of food to ensure an adequate level of safety and nutrition. The department conducts research to establish criteria and regulations for the control of toxic materials and microbial hazards such as botulism and salmonella. As examples of other food-related science, brief descriptions of three projects follow.

A project of considerable economic importance to Canada is concerned with the occurrence of trichothecenes in grain products. As a result of a fungus infestation in wheat in both Ontario and Quebec in the summer of 1980, the department recommended that certain grades of wheat grown in these two provinces not be used for human consumption. The investigation is being continued and expanded in 1981/82 to other grains, for example, corn, barley, oats and rye. Another project will investigate the migration of vinyl chloride and acrylo nitrile from packaging materials into food. A third project will investigate the occurrence in wheat, flour and bread of residues of herbicides used to reduce the incidence of wild oats in the wheat fields.

The food science activities of the National Research Council—estimated expenditures of $12.9 million in 1981/82—include studies on the production of hydrogen that accompanies the fixation of nitrogen in bacteria resident in the root cells of legume plants. The plant physiologists at the Prairie Regional Laboratory are looking for ways to ensure a more effective symbiotic relationship between plants and microorganisms and are currently examining a number of strains of symbiotic bacteria to measure their hydrogen gas evolution rates and nitrogen fixation efficiencies. The council is also studying fermentation technology for the production of starches, single-cell protein, antibiotics and alcohol from materials such as grain, aspen cellulose and animal wastes.

The Department of Fisheries and Oceans estimates an expenditure in 1981/82 of $37.1 million on food research. Canada is now the world's largest exporter of fish, with exports valued at more than $1.3 billion in 1979. The establishment of effective quotas, and the development of regulations, indeed the very design and basis for regulation, is totally reliant on the continuous acquisition and application of reliable information. With extension of Canadian jurisdiction to the 200 mile limit, economic and operations research in support of fisheries management have also increased.

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 by designing controls to protect fish under the Pest Control Products Act and the Environmental Contaminants Act. Major success has been achieved in rebuilding depleted stocks so that landings will continue to increase, although at a slower rate than before. Catch rates will also continue to increase, reducing the net cost of catching. Energy costs, however, will escalate so studies leading to improved efficiency will be emphasized. Research into factors influencing size and distribution of stocks will continue, with emphasis on the management of multi-species fisheries. Longer-term predictive ability essential to planning is a major objective. Other research is being conducted in aquaculture technology, fish health and fish genetics. Further technology development is directed to improved genetic stocks of fish and to improved production efficiency.

The department has also initiated a major program of salmonid enhancement on the Pacific Coast. The S & T activities within this program include studies on fish diseases and fish nutrition and engineering research to improve the efficiency of the enhancement systems. Also being investigated are several new and promising techniques for lake and stream enrichment, Japanese-type hatcheries, stock transplanting techniques and genetic manipulation techniques. Some of these techniques have been sufficiently developed to enable consideration of pilot demonstrations.

Health

Federal scientific activities relating to health have the ultimate goal of protecting and improving the general health of Canadians. Some particular goals may be defined 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.

As shown in Table 3.7, the Medical Research Council and the Department of National Health and Welfare are the largest spenders on health science activities, followed by the National Research Council and Atomic Energy of Canada Ltd.

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 research in the general fields of medicine and biology. Additionally, some research is directed towards evaluating the effectiveness of new treatments and interventions in various disease states through clinical trials utilizing, in some cases, multidisciplinary team efforts.

In support of national health goals, the Department of National Health and Welfare conducts and supports health-related research and other scientific activities, building on basic knowledge in the biological and physical sciences, the health sciences and the administrative and social sciences. About 75% of its S & T expenditures occur in its Health Protection Program, about 22% in the Health and Social Services Program and the remainder in the Medical Services program. A number of specific projects are discussed below as examples of the department's S & T activities.

A survey of human breast milk will be undertaken during 1981/82, as a monitor of human exposure to environmental contaminants. This survey is repeated every three to four years. Approximately 200 samples, obtained Canada-wide, will be analysed among other things for organochlorine pesticide residues, other organochlorine residues including polychlorinated biphenyls (PCB's) and inorganic residues such as cadmium, lead and fluoride.

A study of the effects of polychlorinated biphenyls in monkeys will be initiated. In particular, the immunologi-

Table 3.7

Federal Science Expenditures on Health Science

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**139.7**	**158.8**	**178.3**
Energy, Mines and Resources	0.9	1.3	0.9
Atomic Energy of Canada Ltd.	7.2	5.3	8.4
National Health and Welfare (Total)	48.4	55.6	62.3
Health and Social Services Program	12.7	14.5	13.8
Health Protection Program	35.6	39.6	46.9
Medical Research Council	70.1	82.0	88.6
National Research Council	9.2	10.1	11.6
Statistics Canada	3.3	3.9	6.0
Others	0.6	0.7	0.5

* Directly-related expenditures by other departments and agencies in 1981/82: National Defence, $5.3 million; Canadian International Development Agency, $5.3 million.

cal, behavioural and general clinical effects in mothers and offspring will be examined with the ingestion by the mothers of closely controlled levels of PCB's. The absorption, metabolism, distribution, and elimination of PCB will also be investigated.

Epidemiological studies are underway at bathing beaches of the Great Lakes, to provide data that will be used by the International Joint Commission and a Federal provincial committee in revising public health standards for recreational water use. The department will be funding a 2-year epidemiological study in 1981/82 of the effects of environmental contaminants on the health of residents of the Saint Regis Indian Reserve, Ontario. It is suspected that the Reserve area is contaminated with such substances as Mercury, MIREX, PCB's and fluorides.

A continuing activity is the evaluation of population doses from terrestrial and cosmic sources of radiation and of the potential health risks from inhaling air-borne radioactive substances and from ingesting radioactive contaminants in drinking water and food. The significance of radioactive fallout and routine radioactive emissions from nuclear generating stations is evaluated, which in turn supports the comparative study of the health impacts of coal and nuclear-powered generating stations.

Within the National Research Council, many of the health-related activities are centred in the Biomedical Engineering Research program which also provides coordination for such activities occurring in many of the council's divisions. There are also some contracts to industry in health-related areas through the council's industrial support programs, the Program of Industrial/Laboratory Projects (PILP) and the Industrial Research Assistance program (IRAP). One of the PILP contracts concerns the evaluation of Blissymbol Terminals used by disabled persons who can neither speak nor communicate with the world around them. Under IRAP two projects are being supported—one for the development of oxygen permeable silicone for lenses, and the other for the development of a blood flow analyzer.

Another health-related activity of the National Research Council concerns the application of interactive computer graphics as a diagnostic tool for the cardiologist, in analyzing heart-related wave forms.

A further example concerns an aid to the diagnosis of gonorrhea, a venereal disease that has reached epidemic proportions throughout the world. Recently, a highly sensitive, reliable diagnostic technique has been developed, based on the council's research involving a study of the structures of complex molecules called antigens on the outer walls of bacteria. An identified lipopolysaccharide structure was found to be common to all tested strains of N. gonorrhea. When injected into laboratory hens, this lipopolysaccharide produced a powerful antigenic response; large numbers of very specific antibodies were generated in the blood of the test animals. This hen antiserum, when mixed with very small numbers of gonorrhea bacteria, causes a clumping or agglutination to occur, which can be readily detected.

The National Research Council makes a financial contribution in the health area to the Canadian Rehabilitation Council for the Disabled. It is used to support an organization called Technical Aids and Systems for the Handicapped (TASH), a non-profit company affiliated with the Rehabilitation Council. The objective of TASH is to market, service and encourage Canadian manufacture of aids to the handicapped which are unavailable through other means.

The Rehabilitation Technology Unit based at the Sunnybrook Medical Centre in Toronto is also supported by the council. The unit's role is to provide a means of developing aids which would otherwise not be developed and to make these aids available to the handicapped. The development of a new aid, from initial concept through to final product that can be purchased from a supplier, may take several years.

Usually the unit becomes involved after a prototype has been made and used successfully by a number of disabled persons. At that stage the developer may approach a commercial enterprise to seek its interest in having the new aid produced and marketed, or as an alternative, may apply to the unit for assistance in producing the new aid. The Rehabilitation Technology Unit relies on institutions and rehabilitation centres across Canada for the evaluation of its products, thus ensuring that the new aids will meet the needs of the disabled.

Atomic Energy of Canada Limited conducts scientific activities related to health, both to reduce exposure to radioactive emissions and to study the effects of radiation on cell biology and biological systems.

A recent health initiative being supported by the federal government is the establishment of the Centre for Occupational Health and Safety. The centre is an independent, self-governing body, reporting to Parliament through the Minister of Labour. Its mandate is to provide a common focus and impetus for activity and progress in all areas of occupational health and safety. The centre's affairs and activities are determined by a

council, comprising representatives of federal and provincial governments as well as the principle labour and management organizations in Canada.

Work planned for 1981/82 includes the development of data bases to provide information concerning occupational safety and health, the investigation of case histories of workers suffering from specific occupational diseases, and research into the special occupational health and safety problems of native peoples.

The Defence and Civil Institute of Environmental Medicine in Toronto is operated by the Department of National Defence as a defence research centre concerned primarily with human performance in adverse environments. It includes the provision of research facilities, medical training and clinical services in support of the human performance interests of other government departments and agencies and of industry. One of its unique facilities is a crash simulator system. The system provides impact simulations which are typical of vehicular crashes and includes a test specimen sled, a 120' long precision track, associated computer monitoring control systems and instrumented dummies for the detection of impact stresses. This facility has been used by the Ministry of Transport in the evaluation of car safety belts and has been used by the institute in evaluating helicopter pilot restraint systems.

The Institute also has Canada's most complete and extensive deep diving facility. It is used as a national facility to train and experiment with personnel involved in diving and especially in deep-diving. Dives in this facility usually last approximately two weeks, including the time needed for compression and decompression of the subjects.

Another device is called a Precision Angular Mover. It is used to provoke and study motion sickness in order to reveal the stimulii causing it, and to test anti-motion sickness drugs. This unique machine was used for motion-sickness tests of the crew of NASA's Spacelab and it will be used for similar tests on the next Spacelab crew, in which it is hoped a Canadian astronaut will participate.

Although not reporting in health science activities, the Social Sciences and Humanities Research Council (SSHRC) assists theoretical, policy-oriented research in various health-related fields—psychology, sociology, social work and education. In other areas supported by the council health-related studies cover broad areas such as the history, economics and politics of health care delivery systems and preventive services, public health policy and administration, and changing population fertility patterns.

In the directly health-related fields, council-funded researchers contribute to an understanding of what induces anti-social behaviour, and what economic and social forces may affect the quality of life and individual adjustment to conditions touching human well-being, such as aging. A medical/social/psychological study of newborn infant behaviour is being funded by the council at Dalhousie University. The study has prompted the establishment in Halifax of an active laboratory for inter-disciplinary research in conjunction with a local obstetric hospital. In the public health policy field, an economist at the University of Calgary has analysed health care financing in Newfoundland, including an economic evaluation and comparison of the dental care programs for children in Newfoundland and Saskatchewan. With a grant from the council's Strategic Grants program, which made its first grants for research on population aging in 1979, sociologists at the University of Manitoba, in collaboration with the university's department of social and preventive medicine, are assessing community support networks for the elderly. Psychologists and educationists in other Canadian universities are exploring the theoretical aspects of individual and community attitudes to aging and the well-being of the elderly themselves.

Natural Resources

This section is concerned mainly with the S & T activities related to the evaluation, development, management and utilization of Canada's water, forestry and mineral resources.

Water

Canada possesses approximately one-quarter of the world's volume of freshwater; freshwater covers nearly 8% of the country's surface. This resource has a profound effect on the economic, social and environmental welfare of the nation. As shown in Table 3.8 essentially all of the federal scientific activities concerned with water as a resource are reported by the Department of the Environment. Although reported under agricultural S & T, the Department of Agriculture has underway the development of agricultural practices to conserve water and to adapt to semi-arid conditions. In addition, some of the S & T supported by the Canadian International Development Agency is related to the water resources application area.

Table 3.8

Federal Science Expenditures for Water Resources

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**16.6**	**16.8**	**20.2**
Environment (Total)	16.2	16.4	19.8
Environmental Conservation Service	16.1	16.4	19.8
Others	0.5	0.4	0.4

* Directly-related expenditures by other departments and agencies in 1981/82: Canadian International Development Agency, $1.8 million.

Within the Department of the Environment it is the Environmental Conservation Service which is concerned with the wise and careful use of Canada's water, including its long-term availability and quality, and also its allocation among competing uses based on sound economic, social and ecological considerations.

The service, in conjunction with various other agencies and levels of government, conducts research, collects data, monitors, and plans activities relating to Canadian waters and also undertakes a variety of activities under specific international agreements. These scientific activities are conducted under a number of programs, which cover a wide range of responsibilities with varying degrees of involvement such as: Flood Damage Reduction activities, Water Quality Management, River Basin Planning and River Basin Plan Implementation, and Water Management Research and Water Management Data. The specific activities cover a wide scope, from those dealing with ice hydrology to those related to the impact of nutrients.

One example of successful applications of the service's hydraulics research is the study carried out in collaboration with the Ministry of Transporation and Communications of Ontario. The hydraulic performance of various standard roadside water inlets was tested to establish the behaviour of each type. The influence of the roadway steepness and cross slope was also investigated. The full-scale experiments in the Hydraulics Laboratory provided accurate information on the hydraulics and inlet efficiencies which permitted a substantial revision of existing design practices. The revision of design criteria for pipe size and spacing of inlets results in a saving of $30,000 per kilometre of four-lane highway. If the new criteria are adopted by others in Canada, there is a potential national saving of $500 million annually.

Studies aimed at improving the capability to predict floods will be continued. Experience with spring flooding in far northern rivers and with joint federal-provincial flood damage reduction agreements has shown that the effects of flooding due to ice-jamming constitute a major problem but are little understood. More emphasis will be placed on research studies of these phenomena.

Forestry Resources

In Canada, with one of the major forests of the world, forest products manufacture and forestry 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. A major consideration in planning forestry R & D is its long term nature. Trees require fifty or more years 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.

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 1981/82 are expected to be some $52.1 million. The intramural expenditures specifically exclude S & T related to forest products. S & T support for forest products is performed extramurally under (i)

Table 3.9

Federal Science Expenditures for Forestry Resources

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**36.1**	**46.4**	**52.6**
Environment (Total)	35.8	46.2	52.3
Canadian Forestry Service	35.6	45.9	52.1
Others	0.3	0.3	0.3

*Directly-related expenditures by other departments and agencies in 1981/82: Canadian International Development Agency, $1.8 million.

a contract with Forintek Canada Corp., for the conduct of certain R & D studies, and (ii) a contribution toward Forintek's cost of maintaining two services from coast-to-coast: a technical advisory service for wood products manufacturers and the general public, and a codes and standards group to assist other government departments and industry associations. The total amount paid to Forintek in 1981/82 is expected to be $4.6 million.

The S & T activities of the Canadian Forestry Service 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 km²) 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. In fact, the extent of the present spruce budworm infestation is about 50 million hectares (500,000 km²) of forest. Various ways of overcoming these problems include increasing the rate of reforestation, tending young stands and breeding better trees that grow faster and are resistant to pests. Environmentally benign methods of controlling pests by replacing chemical spraying with biological methods are being developed using bacteria, hormones and viruses specific to budworm or other organisms. Improved methods of firefighting, involving both equipment and management techniques, are also being developed. Remote sensing techniques are 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. The same satellite data are being used to assist in forest site classification and to develop forest inventories. Remote sensing techniques are particularly useful for updating clear-cut and forest road maps, as well as helping prevent and fight forest fires. Canadian industry has also refined its capability to apply airborne remote sensing techniques (developed by the Canada Centre for Remote Sensing in the Department of Energy, Mines and Resources) to the detection of frost pockets in tree nurseries — an important aspect of modern sylviculture. Canadian Forestry Service's scientists are continuing to use remote sensing data to study spruce budworm defoliation in New Brunswick and Cape Breton Island, species identification and other aspects of damage appraisal.

Within the industry, the increasing need to use trees 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 wafer or particle boards. Machinery is being developed to slice lumber in a sawmill, to minimize production of sawdust, and to make large dimension lumber from small, pulpwood-size logs. 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.

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 policy and coordination. These responsibilities include economic analysis and assessment, transportation and environmental considerations, technology development, the provision of a wide range of geoscience information, the development of mineral exploration techniques and methodologies, and policy recommendations. Within the department, the Minerals and Earth Sciences program collects and disseminates a wide range of geoscience information about the Canadian landmass and continental shelf.

The major federal R & D organization concerned with mineral technology is the Canada Centre for Mineral and Energy Technology (CANMET), which performs, funds and coordinates research to ensure that adequate technical capability is available for the supply, processing and use of minerals. This includes the provision, through formal and informal techniques, of specialized information and advice needed for policy-making and for improved industrial practice.

CANMET cooperates with other agencies to evaluate the technological and economic recoverability of resources such as complex base-metal sulphide ores, platinum-group minerals, and precious metals, but the main thrust of its work is to develop improved technology for mining, processing and utilization. In addition to addressing strictly questions of technical and economic feasibility, the research aims to maintain high standards of energy efficiency, environmental acceptability and health and safety.

With completion of the Pit Slope Manual, a comprehensive design guide for Canadian open pit mines, attention in CANMET's mining R & D is turning to underground mining. A major project has been launched to establish guidelines for mining wide, steeply-dipping, ore bodies deeper than 1000 metres. Health and safety are also major concerns, the objective being to develop measurement and control methods for hazards from noise, vibration, respirable dust, radiation and toxic diesel emissions. The CAMPEDS personal dust sampling apparatus and an alpha-particle dosimeter, both developed at CANMET, are gaining industrial acceptance. Numerical models for ventilation systems are also being developed.

In the long-term national interest, CANMET has traditionally put much of its effort into technology for low-grade, or complex mineral resources, especially those that are of particular regional interest. An example is the massive sulphide ore deposits of New Brunswick, for which CANMET has made progress with several processing options to increase recovery of metals and by-products and to reduce harmful effluents. Scientists are also studying as a potential low-grade source of aluminum, wastes that may be available from coal mines in the Hat Creek area of British Columbia.

Two major projects are directed at reducing environmental pollution in mineral operations. For several years CANMET has been exploring techniques for containment and disposal of uranium mine and mill tailings and the removal of radioactive contaminants from related process and effluent streams. A major effort was recently started on the capture of fixation of sulphur dioxide from non-ferrous smelters, a leading contributor to acid rain.

At the utilization end of the mineral cycle, materials integrity and durability are serious economic concerns, particularly in harsh Canadian climates. Metal corrosion, for example, is estimated to cost Canadians seven billion dollars a year. CANMET is working to reduce corrosion and wear and to improve welding technology in a variety of applications.

Table 3.10

Federal Science Expenditures for Mineral Resources

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**32.8**	**34.1**	**37.2**
Energy, Mines and Resources	32.4	33.7	36.9
Mineral and Earth Science Services Program	32.4	33.7	36.9
Others	0.4	0.3	0.3

* Directly-related expenditures by other departments and agencies in 1981/82: Canadian International Development Agency, $3.7 million.

The importance of metals in transportation systems is recognized through CANMET's metallurgical research. Scientists have investigated options for producing a premium rail suited to Canadian conditions. For automobiles, useful comparative data have been acquired through experiments with lightweight and corrosion resistant steels. Research is also under way on improved alloys for ships in Arctic service.

Cooperation and collaboration with industry are essential to CANMET's mission. Through contracts, joint projects and a sophisticated information transfer system, the centre works to ensure that industrial needs are met and that technical capability is available for prudent and efficient resource development in Canada.

Its leadership in research on concrete was exemplified recently with publication of the monograph, "Progress in Concrete Technology", produced with the assistance of experienced field consultants.

Explosives specialists in the department's Explosives Branch provide the technical expertise needed in the implementation of the Canada Explosives Act. Over the years they have tested many thousands of explosives and incendiary devices for integrity and safety, and developed improved testing and evaluation techniques.

The objective of the Geological Survey of Canada is to provide a comprehensive knowledge base on the bedrock and surficial geology and the mineral and energy resources of Canada. To meet this basic objective, the wide variety of projects currently in progress individually cover specific areas of Canada or specific branches of geoscience. Investigation of the geology and mineral resources of the Selwyn Basin and adjacent areas of the Yukon and NWT continue to attract the interest of mineral exploration companies. Previous studies of the younger volcanic belts of the Cordillera provide the base for advice concerning geothermal energy sources in the area north of Vancouver. Field and laboratory investigations of the sedimentary basins of western, Arctic and eastern Canada enable the provision of biostratigraphic information to petroleum exploration companies and provide basic data needed to supply independent evaluations of Canada's petroleum, natural gas and coal resources. Correlation studies based on samples obtained from drilling and dredging in the Atlantic offshore are being extended to areas of probable petroleum exploration. In anticipation of future exploration in deeper waters, new techniques are being developed to study very thick sedimentary sections.

Deep crustal and shallow geophysical experiments similar to the successful Lorex and FRAM I projects will be continued in the Atlantic and Arctic offshore. These experiments will aid in understanding the evolution of the continent. Studies in the Precambrian Shield will be concentrated in the western Mackenzie valley, where important new theories on the evolution of the shield are being tested, and in the central Keewatin area, where the relation of mineral deposits, in particular uranium, to geology is of great importance. The investigations of occurrences of metallic minerals are being combined with regional geology to provide insight into the origin of mineral deposits. This knowledge is used to prepare mineral assessments of strategic commodities, and of parks and other proposed land reserves in the Northern Territories. Terrain inventory mapping and process studies are planned in order to provide data on probable areas of future development. In the past, aspects of this work have been used to prepare environmental assessment reports of pipeline and other transportation routes. The effect of man-made conditions on the environment, such as acid-rain and waste disposal will require a more thorough understanding of surficial and near surface processes in recent times.

The Geological Survey also undertakes geophysical exploration and geochemical surveys on a regional scale and is deeply involved in developing new techniques and instruments. Recent improvements to aeromagnetic surveying equipment are in the process of being transferred to the Canadian geophysical industry. Promising developments for future technology transfer are arising in borehole logging techniques, airborne detection of natural radioactivity and radar sounding of bedrock fractures. The continued strength of Canada's exploration geophysical and geochemical industry is also aided through the Geological Survey's support of pertinent unsolicited proposals, and the unbiased field testing of new equipment.

Resource analysis and exploration are iterative processes; each iteration reveals the need for more information or for refinement and changes in methodology. The information provided 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 the department continues to make Canada attractive for resource exploration.

The Canada Centre for Remote Sensing has undertaken a number of operational projects jointly with the exploration industry to apply remote sensing technology. These have resulted in significant ore-body discoveries in British Columbia, Alberta and Nova Scotia.

Methods developed recently at the centre use vegetation textures to highlight geological structures and have been widely used. The technique promises to be one having special significance to geological exploration in heavily forested countries, where surveying is more difficult than in open terrain areas.

The Earth Physics Branch conducts interdisciplinary field surveys and research to establish and improve understanding of the basic geophysical framework of Canada, thus contributing to the knowledge base necessary for the effective utilization of the Canadian land mass and its resources. The 1979 LOREX geoscience study of the Lomonosov Ridge near the North Pole has contributed significantly to our knowledge of the evolution of the Arctic. Seismic studies are used both to measure and to attempt to predict earthquakes. The behaviour of seismic waves is used as a tool in determining geological structures below the surface.

Oceans

"A mari usque ad mare"—the statement that Canada extends from sea to sea indicates not only the size of the country but also suggests that the oceans which surround us are part of our national consciousness. Canada touches and is touched by three oceans, has the longest coastline of any country, and has within its jurisdiction massive areas of a resource-rich continental shelf.

Oceans, however, are more than geographic entities. Canada has long been a maritime nation from some social and economic points of view, and is presently in the process of seeing a major expansion in its reliance on ocean resources and marine-based activities. In 1977, for example, Canada extended its fisheries jurisdiction to 200 miles, giving this country full management control and responsibility for fish stocks within those limits. Offshore oil and gas exploration, spurred by energy shortages, has been progressing for several years, and is showing promising results in such hostile environments as the Beaufort Sea, the Arctic islands, the Labrador Sea and the Grand Banks. Associated with these developments are requirements for transportation systems to bring hydrocarbons to market, and major projects are underway in industry, and government as well, to design shipping systems capable of operating in ice-infested waters.

These activities and others depend on a scientific knowledge of the oceans and of the inter-relationships between the marine environment and human activities. As shown in Table 3.11, several federal departments are carrying out S & T programs intended to develop this knowledge.

The major share of the federal oceans S & T effort is the responsibility of the Ocean Science and Surveys activity (formerly the Ocean and Aquatic Sciences

Table 3.11

Federal Expenditures for Oceans Science

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**54.6**	**56.2**	**63.0**
Energy, Mines and Resources	5.6	5.2	5.9
Environment	9.0	9.0	9.9
Atmospheric Environment Service	9.0	9.0	9.9
Fisheries and Oceans	30.9	31.2	31.9
National Research Council	4.5	4.2	4.6
Natural Sciences and Engineering Research Council	1.7	2.5	2.9
Regional Economic Expansion	1.2	2.3	6.0
Others	1.8	1.8	1.8

* Directly-related expenditures by other departments and agencies in 1981/82: National Defence, $3.6 million.

activity) of the Department of Fisheries and Oceans. The science activities under the Fisheries Management and Research activity are discussed in the Special Application—Food section. Major components of Ocean Science and Surveys are the oceanographic research programs of several institutes and the survey activities of the Canadian Hydrographic Service. The capabilities of the department to conduct these activities received a significant boost during 1980 with the opening of a major new addition to the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. The following major priority issues are among those being addressed under the Ocean Science and Surveys activity.

Ocean climate

Ocean properties exhibit variability analogous to the atmospheric characteristic which we define as climate; in fact, the ocean climate is a major determinant of atmospheric climatic conditions. This variability in ocean properties over time, aside from impacting on the weather, has pronounced effects on fisheries and major implications for the design and behaviour of facilities for marine transportation and offshore oil and gas production. A major thrust of the program in the immediate future will be the monitoring of ocean characteristics and the conduct of theoretical and experimental studies directed at ocean climate prediction. Special emphasis in the studies will be on the biological, and hence fisheries, impact of changes in ocean climate, and on linkages between oceanic and atmospheric climates.

Sea ice research

The presence and movement of ice is a major obstacle to marine activities in the Arctic and, to some extent, on the east coast. The department is presently developing a major program of research on the properties of sea ice and on its behaviour in response to oceanic processes like tides and currents. Emphasis will be on information required to permit year-round operation of tankers and liquefied natural gas carriers to and from the Arctic. Much of this work will be contracted-out to C-CORE, Memorial University's Centre for Cold Ocean Resources Engineering.

Remote sensing

The department is increasingly involved, in close cooperation with other departments such as Communications and Energy, Mines and Resources, in the development of remote sensing techniques for the monitoring of ocean properties. A major element of these activities is R & D on the use of high frequency radar to monitor waves, surface winds, ice and oil slicks. Another effort is aimed at the detection, by means of satellite imagery, of chlorophyll concentrations in water bodies.

Arctic hydrography

One of the most serious constraints on the transportation of Arctic oil and gas to the south is the lack of adequate navigation information to permit safe vessel operation. Rectifying this situation through a major Arctic survey and charting effort has been identified as an urgent national priority to be addressed by the Canadian Hydrographic Service.

Ocean information services

As the pace of marine activity increases, there is a growing need on the part of government and industry for information on various oceanic and marine atmospheric properties (e.g. wave height forecasts, iceberg movement predictions, sea-surface temperature charts). The department, in conjuction with other departments, particularly the Atmospheric Environment Service of the Department of the Environment, is expanding its service facilities and delivery capability. The results of a major interdepartmental survey of industry and government requirements in this regard are presently being readied for publication.

Ocean industry development

The Ocean Science and Services program has adopted as one of its objectives the support of ocean industry through both the provision of information services and the enhancement of technology transfer from departmental institutes to industry. Two recent initiatives in this regard have been the establishment of an industrial park adjacent to the Institute of Ocean Sciences complex in Patricia Bay, B.C. and the setting up of the Bedford Institute of Oceanography Marine Advisory and Industrial Liaison Office (BIOMAIL).

The activity continues to be actively involved in technology development and, through contracting-out, Unsolicited Proposals and the Cooperative Projects with Industry (COPI) program in the enhancement of industrial capabilities to develop, adapt, and market these technologies. Among examples of successful activity in this regard have been the development, jointly with the National Research Council, of data buoy technology with Hermes Electronics Limited

under the Canadian Ocean Data Systems program, and the development, with subsequent manufacture under licence by Guildline Instruments, of the BATFISH, a towed body used to collect oceanographic data from the surface to a depth of 300 metres. A Canadian Hydrographic Service project with significant industrial potential is currently under research in cooperation with Canadian industry aimed at developing hydrographic charting capabilities using airborne cameras and laser profilers.

Two specific examples of scientific projects follow. In collaboration with the Fisheries Management and Research side of the department, Oceans Science and Surveys is studying in detail the biological and oceanographic parameters of the waters at the Flemish Cap, a relatively shallow spot in the North Atlantic about 500 km east of the Grand Banks and known for hundreds of years as a productive area. This is a multi-year, comprehensive and intensive study, involving many disciplines, of the marine ecology of the cap. Another project is a large-scale ichthyoplankton study on the Scotian shelf designed to elucidate interactions affecting the production and survival of larral fish.

Among the several other federal departments involved in oceans related S & T programs, the National Research Council is in the final stages of planning for its Arctic Vessel and Marine Research Institute, to be built on the campus of Memorial University in St. John's. This $48 million world-class facility, expected to be operational in 1983/84, will include two model test basins which will allow the simulation of offshore and ice conditions for R & D in the design of vessels and other marine structures. This will permit a major expansion of research, currently undertaken by the Marine Dynamics and Ship Laboratory in Ottawa, on vessel design for both industrial and government clients.

In order to provide an improved Canadian capability for carrying out operations in Canada's harsh marine environment, including ice-covered and ice-laden waters, and to support protection of Canada's coastal and marine environment, the Atmospheric Environment Service of the Department of the Environment is working towards an enhanced sea state and ice prediction service. R & D activity includes development of improved methods for the remote sensing of sea state and ice from aircraft and satellites and of prediction techniques for unconsolidated pack ice, Arctic ocean swell and ice accretion from freezing spray on ships and offshore structures. The service is also expanding its use of drifting buoys which report by satellite communication links. Improvements in the operational systems involve cooperative projects with other departments, industry and U.S. government agencies.

Several activities of the Department of Energy, Mines and Resources have an oceans S & T component. Increased exploration in Canada's offshore areas, mainly for hydrocarbon resources has increased the demand for geological information on these areas. The Geological Survey of Canada provides data on bedrock strata, the ocean floor and the processes operating on the floor and in the coastal zone that are needed for orderly development. The need for informed environmental assessment of proposed offshore dredging and mining and the dumping of waste material has placed a heavy burden on marine geologists. Data gathering in these hostile environments requires the use of ships and equipment designed for these specific purposes. One such system, the Huntec Deep Tow System that maps the seabed and the underlying strata, was developed jointly by industry and several federal agencies, led by the Geological Survey. Improvements to the system and other instruments are expected to result from continued offshore work. The amount of data collected continues to expand rapidly and data handling systems, such as those under development at the Atlantic Geoscience Centre at the Bedford Institute of Oceanography will provide ready access to the data for all users.

The department's Resource Management Branch exercises regulatory control over offshore hydrocarbon exploration and production. The branch is responsible for a 3-year study currently underway to assist in assessing potential environmental impacts of oil and gas developments off the coast of Labrador. This project, Offshore Labrador Biological Studies (OLABS), is funded by the oil industry and is jointly managed by the federal government (the departments of Energy, Mines and Resources and the Environment), the Province of Newfoundland, the Labrador Resources Advisory Council, and the offshore exploration industry.

The department's Canada Centre for Remote Sensing carries on R & D with the objective of developing and demonstrating systems, methods and instruments to acquire, disseminate and analyse remote sensing data obtained from aircraft and satellites. Some of this work, in collaboration primarily with the departments of the Environment and Fisheries and Oceans, is devoted to the observation of oceanic properties and marine pollution. Included in the government's 5-year space plan as major thrust by the centre with marine implications, is the development of satellite and airborne synthetic aperture radar technology and systems.

Within the Department of Indian Affairs and Northern Development, the Northern Environmental Protection Branch is concerned with the protection and preserva-

tion of the Arctic environment and the safe development of northern hydrocarbon resources. A major program in this context is the Eastern Arctic Marine Environmental Studies program. The program was designed to study the offshore waters and marine life of the Eastern Arctic before drilling for oil and gas was allowed to proceed. It began in 1977 with efforts being concentrated in the waters along the north and east coasts of Baffin Island. The presence of potential oil and gas reserves and the biological importance of the area prompted the creation of this program. Studies of the physical environment, including ice forecasting, wave regime and meteorological conditions as well as geological investigations were conducted in this area. Biological concerns prompted studies of wildlife abundance, distribution and behaviour. Efforts were made to evaluate the effect potential spills may have on northern wildlife and to develop effective countermeasures to protect them. The results of these studies provide environmental data to be used in the preparation of an Environmental Impact Statement. Information from Davis Strait has already been incorporated in an Environmental Impact Statement which was reviewed by the Federal Environmental Assessment Review Office in 1978 and exploratory drilling started in 1979. The reports on the studies in Northern Baffin Bay are now being prepared and Petro-Canada expects to submit its impact statement in late 1981.

The program is managed by a joint government-industry-native committee chaired by the department. An Advisory Board, consisting of community representatives and non-government specialists, ensures consultation and communication with the northern communities. Funding of the studies is a joint industry-government effort, though by far the larger share is provided by industry.

Transport Canada carries out various R & D activities relative to ocean science, although the primary purpose of these activities relates to transportation science. The department's Canadian Marine Transportation Administration is very active in the field of marine R & D, especially in the areas of support to Arctic and offshore resource development, safety, pollution control, telecommunications, navigation aids and vessel traffic management. Within the administration, research is carried out in cooperation with the maritime community via the Marine Advisory Board, in cooperation with other components of Transport Canada for the development of high technology and by the internal expertise resident in the Coast Guard, National Harbours Board and Saint Lawrence Seaway Authority.

The major expenditure to date within the Marine Transportation Administration is directed at the development of vessels capable of navigating in the high Arctic on a year-round basis. In this context the Canadian Coast Guard is working on design proposals for a hybrid nuclear-gas turbine powered Class X Icebreaker, as well as a conventionally-powered Class VIII Icebreaker. This latter is proposed as an interim measure to meet anticipated Arctic developments as early as 1986; the former is proposed to meet full scale Arctic developments and sovereignty requirements throughout the late 80's and 90's.

A major activity in the Marine Administration's program to achieve excellence in ice-covered waters is the conduct of an "ice-trials" program. This involves measuring impact, excitation and vibration forces generated by vessels navigating in ice. An important contribution to this program was the recording and assessment of data accumulated by the MV Arctic, a vessel built and operated through a government-industry consortium known as Canarctic Shipping Ltd. This ice-strengthened bulk carrier navigates between Europe and Canada's North each year carrying a variety of bulk cargoes from locations such as Pond Inlet, northern Baffin Island and Churchill, Manitoba. Other contributions consist of recording and/or exchanging data from a variety of Canadian and US vessels which have made various winter and summer probes into Arctic waters; these vessels include the USS Manhattan, the USCGS Polar Sea, the CCGS Louis St. Laurent and the MV Arctic. The results of these ice trials will be used to assess the adequacy of existing vessel standards and regulations pertaining to navigation in Arctic and other ice-infested waters.

A number of other technology-oriented projects are encompassed within the administration's mandate to develop a Canadian competence in ice-covered waters. These efforts are more diverse and cover a range of activities such as ship safety, navigation systems, ice detection systems, pollution control, ports and terminal systems, propulsion systems and navigation/telecommunication systems. An Arctic 5-year R & D Plan is currently under development to consolidate and focus these R & D efforts on the mission-oriented needs of the Marine Transportation Administration in the face of demands for Arctic and offshore resource development.

Transport Canada's Research and Development Directorate also undertakes marine transportation S & T relative to ocean science. Its Transportation Development Centre is involved in a wide range of research activities associated with developing expertise in navigating efficiently, effectively and safely in ice-covered waters and its Strategic Studies Branch is involved in R & D in energy efficiency in marine transportation as

well as R & D in the transportation of commodities such as oil and liquefied natural gas in ice-infested waters, especially in the Arctic.

In pursuit of its R & D objectives with respect to Maritime defence, the Department of National Defence estimates that expenditures related to oceans S & T will be $3.6 million in 1981/82, with 17% spent extramurally. The primary areas of interest include research in acoustics in the ocean environment, hydrodynamics and advanced structural analysis applied to the design and operation of vessels and vessel components, and engineering and materials science aimed at solving problems encountered in operational maritime activities. The department also operates a deep diving facility at the Defence and Civil Institute of Environmental Medicine in Toronto; this facility can simulate deep water depths for research on diving and undersea technology development.

The importance of ocean science has also been recognized by the Natural Sciences and Engineering Research Council. "Oceans" is one of the designated areas of national importance in which university scientists can obtain funding under the council's Strategic Grants Program. Disbursements for 1981/82 in the oceans field are expected to amount to $2.9 million.

With so many departments interested and involved in ocean science, there is often a need for coordination. Those activities with a potential for overlap and duplication are managed and conducted by appropriate interdepartmental groups established on a project specific basis. More general consultation mechanisms include the Panel on Oceans Management, chaired by the Deputy Minister of the Department of Fisheries and Oceans, and the Canadian Committee on Oceanography, a multi-sectoral body with representatives from government, industry and universities.

Scientific and Technical Information

As shown in Table 3.12, in 1981/82 the departments and agencies of the federal government will spend $159.6 million on scientific information services, reflecting the importance of scientific and technical information (STI) as the life-blood of scientific activity and of economic development itself. As a resource accumulated from contributions made all over the world, STI is most useful to countries that collect it aggressively and also develop the systems to deliver it to those who can use it. The Canadian scientific and technical community has, by and large, a good appreciation of the importance of STI and is accustomed to drawing on the world's S & T literature through science libraries and related systems and services.

Foremost among such resources is the Canada Institute for Scientific and Technical Information (CISTI), which holds Canada's largest collection of STI. The institute is a Division of the National Research Council. It has a 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 responsibility of the National Library of Canada).

As part of the National Research Council's establishment and operating side by side with the Council's large multi-disciplinary research laboratories, the institute is ideally situated to serve its clientele in the industrial, university, and government sectors. In pursuit of this mission it has accumulated an outstanding collection of S & T books, journals, reports and reference works and data bases from world wide sources. Its total operating budget for 1981/82 is estimated to be $19.0 million. New techniques have been developed to facilitate access to the information collection of the institute and of cooperating institutions. An example is the pioneer computerized system for search and retrieval of bibliographic references to the STI literature, CAN/OLE (Canadian On-Line Enquiry System). This system now has a special feature whereby a client at a computer terminal anywhere in Canada can request from the institute a copy of any of the millions of documents referred to in current lists and data bases.

In line with the government's concern to foster economic development particular emphasis is placed on delivery of STI to Canada's industrial sector. Service to these very important clients forms a major portion of the institute's workload accounting for some 45% of all loans and photocopies made and 55% of requests received for literature searches on specific topics. For example, the institute received more than 150,000 requests for inter-library loans in the year 1979/80; of these some 39% were for clients in the industry sector.

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

Table 3.12

Federal Expenditures for Scientific and Technical Information

Department/Agency	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**117.1**	**132.0**	**159.6**
Consumer and Corporate Affairs	8.1	9.5	10.1
Energy, Mines and Resources	6.2	5.7	7.1
Environment (Total)	15.2	16.1	18.5
Atmospheric Environment Service	5.0	5.2	5.7
Environment Conservation Service	7.1	7.3	9.0
Fisheries and Oceans	9.6	9.9	9.3
National Library	14.4	16.8	21.4
National Research Council (Total)	17.7	21.1	24.7
Scientific and Industrial Research Program	4.3	4.9	5.7
Scientific and Technical Information Program	13.4	16.2	19.0
Public Archives	9.1	9.7	11.8
Regional Economic Expansion	1.2	2.3	6.0
Social Sciences and Humanities Research Council	4.0	4.6	5.2
Statistics Canada	7.7	8.3	12.9
Others	23.9	28.0	32.6

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.

Libraries are an important element in the provision of scientific information services across Canada. For example, Agriculture Canada 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 federal S & T information activities include the development of source and bibliographic data bases to serve specialized needs, for example those provided by the Department of Energy, Mines and Resources in the fields of geophysics (National Gravity Data Base), geology (GEOSCAN), mining technology (MINTEC) and remote sensing (RESORS); specialized S & T information services are provided by centres such as CANMET's Technology Information Division and the Canada Centre for Geoscience Data. Other examples include the Water Resources Document Reference Centre (WATDOC) and the Air Pollution Information Systems, both operated by the Department of the Environment and the Defence Scientific Information Services of the Department of National Defence.

There are additional interesting examples to be found within the Water Pollution Control program of the Department of the Environment, such as the WATENIS and MUNDAT systems. WATENIS, the Water Effluent National Information System, provides an inventory of industrial and municipal water pollution sources including data on physical, chemical, and toxicological characteristics of effluents and information on water effluent regulations and guidelines. MUNDAT provides a data base covering municipal water works and wastewater systems from coast to coast, including data on federal facilities. It was developed in close cooperation with the provincial governments and the Federation of Associations on the Canadian Environment. The Ocean Dumping Permit System maintains an inventory and detailed information including the status of dumping sites for all permits issued.

Another specialized kind of STI service is provided by the Atmospheric Environment Service (Department of the Environment) which publishes each year more than 30,000 pages of climatic data in periodicals, single

data sheets and statistical booklets. In 1981/82, a ten-year update of means, extremes, durations and frequencies will be prepared for a variety of meteorological parameters. These highly-specialized STI services are supervised by regional climatological specialists who dispense publications, reports and documents, and provide analyzed information to a variety of Canadian users of the data.

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 goals of relevant 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 anticipate social tensions and diminish their consequences.

Within the Department of Labour, the Research and Development Division serves as the planning center for researching, advising and recommending approaches to programs and policies relating to conditions of work. Departmental expenditures in 1981/82 for S & T activities related to social development are estimated to be $4.2 million. The department's Financial Assistance Program for Labour Education was introduced in 1977 as one of its new initiatives aimed at improving the structure and process of labour-management relations. The broad objective of the program is to provide current and potential union officers and other members of labour organizations with opportunities to gain a comprehensive knowledge of the labour movement and its relationship to Canada's economic, political and social framework, and to achieve a more equitable distribution of the public funds made available for educational purposes.

The Quality of Working Life (QWL) program, which was launched by the department in early 1978, is concerned with the promotion of conditions within Canadian work organizations that are supportive of organizational change based on QWL principles, increased worker participation in workplace decision-

Table 3.13

Federal Science Expenditures on Social Development

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**30.3**	**37.3**	**42.5**
Canada Employment and Immigration Commission	5.8	7.8	8.4
Employment and Immigration	1.8	1.9	1.9
Indian and Northern Development	0.8	0.9	1.5
Labour	3.2	3.8	4.2
National Health and Welfare (Total)	9.3	10.4	11.6
Administration Program	5.3	6.4	7.3
Health and Social Services Program	3.8	3.7	4.0
National Research Council	2.7	4.6	4.8
Statistics Canada	2.6	3.1	4.9
Others	4.1	4.9	5.3

* Directly-related expenditures by other departmental agencies in 1981/82: Canadian International Development Agency, $2.0 million.

making and joint endeavours by managers, unions and employees to resolve workplace problems and effect improvements in the general environment within which work is performed. Work restructuring, job redesign and improvements in occupational health and safety and other aspects of the work environment are major program emphases.

Program response has been encouraging as evidenced by an increased awareness of workplace problems and the potential benefits resulting from the application of joint problem-solving processes, the establishment of supporting national and regional networks of qualified resource personnel, the emergence of active regional QWL centres, a growing number of experimental projects and the increased interest and support of the organized labour movement.

With estimated S & T expenditures in 1981/82 of $1.9 million, the Strategic Policy and Planning Group in the Department of Employment and Immigration studies the dynamics of unemployment, participation patterns and the labour market problems of groups including native peoples, older workers and the disabled. It also develops the necessary infrastructure for reexamining immigration selection criteria to improve the achievement of key immigration objectives including a more effective management of immigration levels, maintaining a balance between different classes of immigration and an improved relationship between occupational demand and the skills of immigrants.

In view of the reindustrialization process now underway and anticipated to continue throughout the 1980's, the department is investigating ways to offset the transitional costs of the process to industry and labour. In order to determine future labour market imbalances and bottlenecks, the department has developed an ongoing comprehensive occupational forecasting program to determine skill shortages nationally and on a regional basis with both short and longer-run horizons. In 1981/82, there will be a particular focus on efforts to enhance the match between supply and demand both on an occupational and regional basis. In addition, significant efforts are now in progress to ascertain the quality of manpower planning in the private sector with the objective of enhancing the effectiveness of industry in generating an adequate supply of manpower to meet present and future needs. These and related issues are currently being investigated by the Employment Development Task Force.

While the Unemployment Insurance program within the Canada Employment and Immigration Commission has major implications for, and interactions with, the operation of the labour market, it is also an integral part of the total social security system. The objectives and operation of the Unemployment Insurance program are analyzed and assessed within this context as well as that of the labour market. A major review by the Unemployment Insurance Task Force is currently underway respecting the role of the program in the 1980's and the criteria and design features which will be required to ensure that the program fulfills its assigned roles. S & T expenditures in the social development area by the commission are estimated to be $8.4 million in 1981/82.

The part to be played by immigration in meeting manpower objectives will be assessed with particular attention to demographic and cultural issues. For example, attention will be given to the identification and analysis of the major social and cultural factors underlying the adaptation of immigrants. Among other things, a survey of the Indo-Chinese refugees is in progress in order to study their economic and social adaptation to life in Canada.

Scientific activities related to social development and welfare in the Department of Indian and Northern Affairs encompass a broad range of activities because of the need to support the variety of missions and mandates which it incorporates. These activities are estimated to require $1.5 million in 1981/82.

The Northern Affairs Program undertakes scientific endeavours in many fields in order to meet its legislated mandate to foster knowledge of the North. This work is accomplished through the Northern Scientific Training Grants Programme, the Northern Scientific Resource Centres Programme, and core funding to the Association of Canadian Universities for Northern Studies. In addition, the Northern Program undertakes scientific activities in respect of: the social, economic and political development of the North, projects relating to the transportation of hydrocarbons in the north, environmental assessment and management, and northern socio-cultural processes.

South of 60°, other components of the department (Indian and Inuit Affairs Program and Corporate Policy) focus their scientific activities on improving the social and economic conditions of Indians on reserve, on protecting Indian communities from environmental hazards, and on supporting the process for the resolution of Indian land claims.

Space

This evolving 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 itself, 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. In 1980, the committee prepared the first five-year space program plan. In this plan, departmental and agency proposals are reviewed and, where possible, ranked in terms of relative priority and their relations to the achievement of national goals. In 1981, the responsibility for the committee was transferred to the Ministry of State of Science and Technology.

The major objectives of Canada's space policy are to ensure:

- that space activities meet national goals and service needs;
- 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.
- that space activities be managed so as to achieve maximum benefits for the country.

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 for satellites from other nations. Another element of our space policy is 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, 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.

Canada has not restricted its satellite useage to telecommunications 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, together with the Department of National Defence and the U.S. National Aeronautics and Space Administration, it is studying a multipurpose satellite, (MSAT) for use in mobile communications services for civilian and military users, particularly in the northern and coastal areas of Canada. 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. Satellite imagery is being used by the Geological Survey to provide information on management of sediments in tidal zones of the Bay of Fundy. 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. 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 1983, will provide better color and spatial resolution (30 instead of 80 metres) and, consequently, more detail and an improved identification. It will, however, require that the Canadian earth stations at Prince Albert, Saskatchewan and Shoe Cove, Nfld. be extensively modified.

Furthermore, to meet with a high demand from user groups, it is planned to incorporate a digital image correction system, which becomes operational in 1981, into the daily operations of these two receiving stations. It is also planned to implement a facility named MOSAICS (Multi-Operational Satellite Image Correction System) by 1984/85.

The interdepartmental SURSAT program was established in 1977, to determine the feasibility of using satellites to assist in meeting surveillance needs for the period 1980 to 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 proof-of-concept satellite carrying an advanced radar sensor known as Synthetic Aperture Radar (SAR), a complementary airborne research and development program, and consultation with potential international partners regarding a possible future joint operational system. The program, which included experiments involving over 100 prospective users, has proven the SAR effectiveness for monitoring ice and sea conditions and demonstrated some capability for monitoring shipping. It has confirmed Canada's determination to move towards the operational use of radar satellites, particularly in support of Arctic petroleum operations, for which ice reconnaissance unhampered by cloud, fog or darkness is a critical requirement.

The SURSAT program has also produced sizeable industrial benefits. As a result of the program, the Canadian survey industry now has access to one of the best combinations of both aircraft and radar payload for civilian purposes in the world. Similarly, the Canadian firm of MacDonald, Dettwiler and Associates of Vancouver has developed a unique capability in the computer processing of SAR data.

The next step in the program involves the development, in cooperation with Canadian industry, of a strong R & D program in the critical areas of radar satellite technology and its applications, particularly to ice-reconnaissance in support of Arctic oil, gas, mineral and other operations. This two-year extension is intended to provide the bases for recommendations to the Canadian government in 1982, regarding Canada's options for the development and establishment of a radar satellite system.

As seen in Table 3.14, the Department of Communications is the largest funder of space science and technology. In addition to programs directly in support of

Table 3.14

Federal Science Expenditures on Space Science and Satellite Technology

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**57.8**	**65.7**	**55.6**
Communications	36.6	41.5	30.2
Environment	2.0	1.9	2.1
National Research Council	18.7	21.7	22.7
Others	0.5	0.5	0.5

* Directly-related expenditures by other departments and agencies in 1981/82: National Defence, $3.9 million.

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 technical expertise for SARSAT/COSPAS, a joint Canada-France-U.S.-U.S.S.R. search-and-rescue satellite project, and support to the Canada Centre for Remote Sensing for work on the surveillance satellite project. The Department of National Defence is providing most of the Canadian funding for SARSAT and is also involved with the U.S. in the development of a satellite-based global positioning system NAVSTAR.

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.

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 the definition phase of ESA's L-SAT, a communications platform development and demonstration, and the Preparatory European Remote-sensing Satellite Program has been approved. As a result, Canadian industry has been accepted as the prime contractor for the solar arrays in the definition phase of the L-SAT program.

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 work related to earth terminals. 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 Department of National Defence has recently conducted a study to ascertain which operational requirements would benefit from the application of space-borne systems and to define the R & D which should be performed in support of those applications. The recommended R & D, which has received departmental approval-in-principle, consists of the maintenance of on-going projects in navigation and search-and-rescue, the augmentation of satellite communications development and the initiation of R & D on space-borne surveillance systems. The communications tasks include MSAT project definition with the Department of Communications and the US National Aeronautics and Space Administration. The proposed surveillance projects have evolved out of discussions with the US Department of Defense and include both radar and infrared sensors for the detection and tracking of airborne threats. The level of expenditure for approved space activities is $12 million between 1980/81 and 1983/84. In the interest of rationalizing industrial loading, the departmental space program is reported to the Interdepartmental Committee on Space, although the funding allocation remains a departmental responsibility.

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.

To rationalize its space research activities the council created, in August 1980, a new organizational unit named Canada Centre for Space Science. The programs carried out by the centre will include the existing rocket and balloon program, aimed at providing a better understanding of the earth's space environment

at altitudes in the neighbourhood of 100 km, and a new international program for which the government has recently approved expenditures of some $42 million over the next 6 years. The new program will allow Canadian scientists from government and university laboratories to investigate the properties of plasmas and neutral winds in the space environment of the earth and will involve the development and construction in Canada of a number of major new instruments which will be flown on the US Space Shuttle around 1985. This program will also allow the council to respond more effectively to "Announcements of Opportunity", both from NASA and from other foreign agencies. For example, the centre will participate in the VIKING experiment, the first Swedish scientific satellite, by supplying an ultra-violet imager.

As part of the ongoing rocket and balloon program, the centre is also undertaking a cooperative venture with NASA that will involve 28 scientists (11 from NASA, 6 from Europe and 11 from Canada). This large project, called CENTAUR (Cleft Energetics, Transport and Ultra Violet Radiation), is scheduled for November and December 1981, and will be designed to study the "throat" region of the magnetospheric cleft.

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 have been prepared. The Interdepartmental Committee for Space has brought forward its second Five-Year Plan which includes proposals for starting in 1981/82 and a planning envelope for major projects that may be proposed by departments in later years.

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's role is to attend to the development and operation of a safe and efficient national transportation system which contributes to the achievement of governmental objectives, and to operate specific elements of the system. Since transportation is involved in many activities and responsibilities of the government, transportation-related scientific activities are also conducted by other departments, as shown in Table 3.15.

The coordination of research activities by the various departments is carried out by the Interdepartmental Panel on Transport Research and Development, which is chaired by Transport Canada's Assistant Deputy Minister of Strategic Planning. Special emphasis is given to problems of particular importance to Canadian transportation and to the adaptation of known techniques to satisfy Canadian conditions.

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 science activity. To fulfil its role, Transport Canada requires up-to-date expertise which can recognize and assess the potential of technical advancements for incremental improvements to mature, highly-developed transportation 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.

The majority of Transport Canada's S & T activity for 1981/82—estimated expenditures of $25.1 million—is of an ongoing nature. S & T activity in marine transportation involves the updating of navigation aids, improvement to the handling capacity of the St. Lawrence Seaway, increased effectiveness of icebreaking, especially in the Arctic, investigations related to transportation in ice-covered waters and pollution countermeasures. For air transportation S & T activity is undertaken to incorporate new developments into communications, air traffic control methods, navigation aids and airport productivity. In surface transportation, S & T work continues on projects recommended by the Rail Advisory Committee and some work is carried out in road safety. Transport Canada is also involved in R & D concerned with energy efficiency in transportation and the transportation of energy, as well as R & D

Table 3.15

Federal Science Expenditures on Transportation

Department/Agency*	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**72.5**	**77.1**	**81.0**
Energy, Mines and Resources	1.9	2.1	2.1
Fisheries and Oceans	23.1	23.9	24.5
National Research Council	17.3	20.2	21.0
Statistics Canada	2.6	2.9	4.6
Transport Canada (Total)	24.0	24.4	25.1
Administration	4.6	4.7	6.9
Air Transportation Program	5.8	8.3	6.9
Marine Transportation Program	9.9	11.0	11.2
Surface Transportation Program	3.7	0.5	0.1
Canadian Transport Commission	2.7	2.5	2.7
Others	0.9	1.1	1.0

* Directly-related expenditures by other departments and agencies in 1981/82: National Defence, $11.8 million; Canadian International Development Agency, $3.7 million.

in the transportation, storage and transfer of hazardous commodities.

Early in 1980, Transport Canada identified and proposed seven priority thrust areas for transportation R & D in its report: "A Profile for Federal Government Transportation R & D". In June 1980, the members of the Interdepartmental Panel on Transportation R & D accepted the priority thrusts and directed that five-year plans for transportation R & D be prepared by four interdepartmental working groups in the areas of Arctic Marine, Rail Freight, Urban Transportation and Pipelines Research and Development. It has further directed that in each of these areas particular attention be given to the opportunities for technology in the areas of communications and control, safety and intermodal systems.

In the Department of Energy, Mines and Resources, the Minerals and Earth Sciences Program is involved in providing advice on construction requirements and routing of land transport systems. It is also involved in R & D concerned with 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.

With estimated spending in transportation science in 1981/82 of $24.5 million, 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, sea state 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. The service is also carrying out S & T aimed at improving the weather, sea state and ice information services available in the Arctic. This program, which is part of the government Energy Transportation program, is designed to provide future transport and energy development operations with the environmental forecasts necessary to operate in the most effective and economic manner. This is of great importance in the Arctic when the costs of engineering around environmental obstacles could make the entire development venture impractical. High-quality forecasts can provide the lead time necessary to minimize risks and select the most economic routes. The service is also attempting to develop improved aerial remote sensors.

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. The council plans to spend $21.0 million in this area in 1981/82. These expenditures cover work in diverse areas such as ice-breaking or iceberg towing with the object of devising methods, for example, of keeping icebergs away from drilling rigs operating in the Labrador Sea's notorious "iceberg alley", a treacherous but promising zone for oil exploration.

Currently a major program of the council's Marine Dynamics and Ship Laboratory is concerned with establishing the Arctic Vessel and Marine Research Institute (AVMRI) on the grounds of Memorial University in St. John's, Newfoundland. The new institute will evolve from the laboratory's present facilities now located in Ottawa. This entails the planning, design and construction of the new laboratory, recruiting and training of its personnel, which will be drawn both from industry and from within the council, and adaptation of the Ottawa laboratory's projects to allow a smooth transition when the St. John's laboratory starts operating. Because continuity with the existing Ottawa program is considered important, the research program for the Marine Dynamics and Ship Laboratory is being determined in consultation with the new institute's Advisory Committee, which has representatives from industry, Memorial University and the federal government. The conceptual design of the new institute is now complete, and work has begun on detailed design and construction.

Much of the council's work in transportation is carried out in cooperation with other agencies, such as the Transportation Development Centre of Transport Canada. For example, in collaboration with the Transportation Development Centre (Transport Canada), the council is investigating technical feasibility of utilizing superconducting electric motors for the propulsion drives of the Arctic icebreaking bulk carrier and of the Coast Guard vessel designs, currently being proposed by Petro-Canada and Transport Canada.

With its newly improved test facilities, both in Ottawa and Vancouver, the council's Division of Mechanical Engineering continues to aid railway operators and users, car builders and government regulatory agencies by providing instrumentation and facilities for testing existing and proposed methods and equipment. These facilities include a one million pound compression squeeze frame for full sized cars, a ramp track for generating strength-proving impacts, a self-contained instruments caboose and a collection of track-side, over the road, and laboratory measuring equipment. These facilities have been in continual use by industry for some years.

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 $11.8 million of its S & T expenditures in 1980/81 will be related to transportation, over half of which will be spent extramurally.

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 classified by performing sector are shown in Table 4.1

Since 1978 the government has pursued a renewed policy of strengthening the R & D capacity of the country, primarily in the extramural sectors and particularly in industry, with a target of increasing Canada's Gross Expenditures on R & D (GERD) to a level which approaches those of other industrialized countries. Earlier initiatives to enhance GERD have 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 concern.

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.

The magnitude of the increase in Canadian R & D being sought implies requirements for a major increase

Table 4.1

Federal Extramural Science Expenditures

	1979/80		1980/81		1981/82	
	(millions of dollars and (%))					
Total	**689.6**	**(100)**	**827.8**	**(100)**	**946.4**	**(100)**
% of Total S&T	*36%*		*38%*		*37%*	
Industry	273.4	(40)	327.9	(40)	380.4	(40)
University	256.1	(37)	319.8	(39)	351.2	(37)
Canadian Non-Profit Institutions	25.7	(4)	26.2	(3)	28.4	(3)
Provincial and Municipal Governments	68.8	(10)	84.1	(10)	111.7	(12)
Foreign	49.5	(7)	53.5	(6)	59.2	(6)
Others	16.1	(2)	16.3	(2)	15.5	(2)

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 continued increases in the 1981/82 budgets of the three granting councils: $182.0 million, or 11.5% increase for the Natural Sciences and Engineering Research Council, $88.6 million, or 8% increase for the Medical Research Council and $45.6 million, or 7% increase for the Social Sciences and Humanities Research Council.

For some years now the government has been strengthening the operations of its three main granting councils. 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 formerly operated, respectively, by the National Research Council and the the Canada Council. The mandate of the Medical Research Council was also extended to permit support of 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.

The emphasis given to particular objectives and program elements has varied among the granting councils because of differing circumstances for their clientele but there are certain common features. First and foremost are proposals for increased support for the direct costs of research so as to maintain and strenghten 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. In general, considerable stress has been placed on continuing and expanding support for curiosity-oriented research. Nevertheless, substantial increases in funds have also been proposed for research in areas of national concern. Details of specific programs for each council are discussed in the Major Funders section.

Implementation of the policy to strengthen interfaces between the government, industry and university sectors is proceeding. During 1978, the Government announced its intentions to fund university-based industrial research and innovation centres to aid industry, particularly small businesses and private inventors, in the development of new products or technologies. As a result, the establishment of two industrial innovation centres, one at the University of Waterloo and the other at École Polytechnique de Montréal, has been approved in principal. By mid August 1980, business plans had been completed by both universities, and the centres are scheduled to begin their operations in 1981.

As another means of encouraging R & D in Canada, a new procurement policy has been implemented 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 alternative involving extra costs 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 included the establishment of a federal-provincial working group on Cooperation in Procurement Policy. 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.

Concurrent with the increased emphasis on technology transfer, Canadian Patents and Development Limited has seen a considerable increase in the licensing of "know-how", particularly in areas of unpatentable or unpatented technology. This trend shows no signs of abating. In its more traditional patenting and patent licensing activities, the agency expects that some important scientific advances of the 1970's will be licensed in the early 80's, particularly in the fields of genetic engineering, communications and energy.

The agency continued its funding of the Inventors Assistance Program at the University of Waterloo up until the establishment of the Innovation Centre at the

university, which has assumed responsibility for its operation. By means of a simple registration and disclosure and payment of a fee, an inventor may obtain a confidential feasibility and marketability assessment, made by a select group of professionals drawn from the university staff and elsewhere. From its inception in April, 1976 to September, 1979, there were over 2,640 enquiries, 802 inventions were evaluated and 232 were considered to have commercial potential.

Other measures to improve technology transfer have 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) in other departments. As one of a number of measures to improve access to government programs of industry support, the PILP and COPI programs will be amalgamated in 1981/82. The point of contact will be the National Research Council's Industrial Assistance Office.

Industry

The government's direct support of industry S & T activities is estimated to reach $380.4 million, an increase of 16% over forecast expenditures of $327.9 million in 1980/81, and a 39% increase over 1979/80 expenditures. Data on departmental payments to industry to support S & T activities is given in Table 4.2. Some of the more readily recognized support programs under which these payments are made are shown in Table 4.3.

Major expenditures occur under the industry support programs of the Department of Industry, Trade and Commerce, which is the largest funder of government-supported S & T activities in the industry sector. Increased expenditures of $24.9 million to $110.7 million in 1981/82 are estimated for departmental payments to industry.

The Enterprise Development program is a multi-purpose program incorporating several of the department's former programs. 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 innovation and market research. Eligibility is generally limited to small and medium-sized businesses engaged in manufacturing or processing operations prepared to undertake relatively high risk projects which promise attractive rates of return and good prospects of success. Funding in the form of contributions is available for up to 75% of eligible costs of the following kinds:

- for research, development and design projects provided the project represents a significant burden on the company's resources; and
- to engage consultants for market feasibility studies, productivity enhancement studies, product development and design studies, and pollution control and abatement technology development projects.

Projected science and technology expenditures under the program in 1981/82 are estimated to be $69.4 million, including $14.4 million under a special program section in support of the advanced electronics sector. Forecast S & T expenditures for 1980/81 are $47.0 million and expenditures in 1979/80 were $30.4 million.

The Defence Industry Productivity (DIP) program assists high technology industry in several sectors including aeronautics and electronics. S & T expenditures under this program for 1981/82 are estimated to be $39.3 million compared with $36.7 million in 1980/81. Actual S & T expenditures in 1979/80 were $31.3 million. The program provides assistance for product development, pre-production expenses and capital costs on a shared basis.

The Industrial Energy Research and Development (IERD) program assists Canadian industry in undertaking research development and design activities aimed at the development of new or improved processes or equipment to reduce industrial energy consumption. The technologies developed under the program are made available to other companies. The program has an annual budget of $1.5 million.

Table 4.2

Federal Science Expenditures in Industry

	1979/80	1980/81	1981/82
		(millions of dollars)	
Total Payments to Industry	**273.4**	**327.9**	**380.4**
R&D Grants and Contracts (Total)	**218.0**	**264.1**	**308.3**
Mission-oriented R & D Contracts (Total)	93.0	113.3	130.3
Communications	4.1	7.9	8.9
Energy, Mines and Resources	6.6	6.8	11.5
Atomic Energy of Canada Limited	9.8	10.4	9.8
Environment	7.7	9.7	10.5
Fisheries and Oceans	2.9	3.0	4.8
National Defence	23.3	28.8	34.6
National Research Council (excluding PILP)	15.8	21.2	23.0
Supply and Services (Unsolicited Proposals)	10.3	10.3	10.5
Transport	5.5	6.8	9.5
Others	7.0	8.4	7.2
Technology Transfer R & D contracts (Total)	9.1	11.9	12.7
National Research Council (PILP)	7.0	9.8	12.7*
Cooperative Projects with Industry (COPI)	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	—
R & D Grants & Contributions (Total)	115.9	138.9	165.3
Communications	9.5	11.2	4.0
Energy, Mines and Resources	2.9	15.1	18.4
Industry, Trade and Commerce	74.0	85.6	110.5
National Research Council	25.6	22.4	27.4
Natural Sciences and Engineering Research Council (Industrial Research Fellowships)	1.5	2.3	2.7
Others	2.3	2.4	2.3
RSA Grants & Contracts (Total)	**55.4**	**63.8**	**72.0**
Energy, Mines and Resources	3.6	4.6	4.6
Atomic Energy of Canada Limited	10.0	11.6	13.9
Environment	2.0	2.4	2.8
Fisheries and Oceans	2.0	2.0	3.4
Canadian International Development Agency	22.3	22.8	25.5
Transport	3.2	3.3	3.1
Others	12.3	17.1	18.7

* The two programs will be combined in 1981/82.

Other programs administered by the Department of Industry, Trade and Commerce assist in 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 in the establishment of organizations at Canadian universities which arrange for university faculty to provide contract research and technical services to industry; eight industrial research institutes are now in operation. 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 with industry,

Table 4.3

Federal S&T Expenditures under Selected Industrial Support Programs

	1979/80	1980/81	1981/82
		(millions of dollars)	
Agriculture			
Production, Distribution Retailing (PDR)	0.8	0.9	0.9
Environment			
Energy from Forests (ENFOR)	4.2	4.4	6.4
Industry Trade and Commerce			
Defence Industry Productivity (DIPP)	31.3	36.7	39.3
Enterprise Development (EDP)	30.4	47.0	69.4
Industrial Energy R & D (IERD)	1.0	1.5	1.5
National Research Council			
Industrial Research Assistance (IRAP)	19.5	21.6	22.8
Industry/Laboratory Projects & Cooperative Projects with Industry (PILP & COPI)	9.1	11.7	12.7
Technical Information Service (TIS)	2.6	2.8	3.3
Supply and Services			
Unsolicited Proposals (UP)	14.9	15.0	15.1

assistance with development projects and training and evaluation services relating to that technology; twelve centres of advanced technology are now in operation. The Industrial Research Association program assists groups of firms to undertake cooperative research on common technical problems; four industrial research associations are now in operation. The budget for the three programs in 1981/82 will be $1.4 million, augmented by $0.6 million from the Special Electronics assistance mentioned above. 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 21 centres and institutes established now in operation, 13 are now financially self-sustaining.

The National Research Council is the second largest funder of industrial S & T activities. Council payments to industry for 1981/82 are estimated to be $62.2 million, an increase of $7.9 million from 1980/81. Ninety-eight percent of the National Research Council's industrial funding is for R & D. It is almost equally divided between contracts ($33.6 million) and grants and contributions ($27.4 million). About one-third of the contracted R & D has occurred under the council's technology transfer mechanism known as Program for Industry/Laboratory Projects (PILP). In 1981/82, this program is being amalgamated with the Cooperative Projects with Industry program and some funding will be provided as contributions to cooperating firms. The Industrial Research Assistance Program (IRAP) of NRC provides grants. These programs are further discussed below.

Other major funders of industrial S & T are the Department of National Defence with 1980/81 estimated expenditures of $34.6 million, the Department of Energy, Mines and Resources with $34.9 million, the Canadian International Development Agency with $25.5 million and the Department of Communications with $14.2 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 $7.9 million or 29% increase over 1980/81 in industrial S & T expenditures by the Department of Energy, Mines and Resources, $6.2 million occurs in the Energy Program, in part 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 $2.7 million from 1980/81, is for RSA,

such as feasibility studies concerned with agricultural, industrial and commercial development projects in Third World countries.

Characterized by major satellite projects, estimated 1981/82 industry expenditures by the Department of Communications ($14.2 million) show a decrease of $6.3 million over 1980/81 expenditures, as a consequence of the natural ebb-and-flow of project funding. 1980/81 payments to industry, however, at $20.5 million were $5.8 million higher than those in 1979/80. Masked by these project funding decreases is increased funding to assist industry in exploiting two major high technology opportunities. One concerns the exploitation of Telidon, a departmentally-developed videotex system. The industrial assistance being provided covers such activities as field trials, development of production prototypes, equipment standardization and related activities. Field trials are underway or planned by such organizations as Bell Canada, Alberta Government Telephone and the Manitoba Telephone System.

The other concerns the office automation or "office-of-the-future" development by the department, which started in 1979 with a market study. A joint industry-government Office Communications Systems program has been approved, with government funding for direct program costs of $12.5 million over the life of the program. It is estimated that payments to industry for S & T activities in support of the program will be in the order of $I million in 1981/82. The direct program expenditures on office automation by the department can be complemented by additional expenditures through the Department of Industry, Trade and Commerce's cost-shared programs such as the Enterprise Development Program and the Special Electronics Fund, and through normal office equipment procurement during the life of the program.

This program is being carried out in phases. Phase one, already underway, will last two years and has a budget of $2.5 million. Government and industry are working together to develop office communications systems, to organize field trials, and map out a detailed industrial strategy and to conduct technological, behavioral, social and economic research.

Phase two, which is dependent on the success of the first phase, has received approval in principle for funding up to $10 million. To commence in 1982, phase two of the Office Communication Systems program would fund development of electronic office equipment for field trials in government offices and further research and product development.

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 (on behalf of other departments and agencies) of science contracts with the private sector. The centre is also the focal point for consideration of unsolicited proposals for the conduct of scientific activities. In this connection 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 unable to fund the work from its current budget. Under special circumstances this mechanism can be used to fund all stages of the proposed work. From its inception in 1974, to the end of 1981/82, this fund will have provided a total of $86.4 million. For 1980/81 forecast payments to industry are $10.5 million in support of mission-oriented R & D and $2.2 million for RSA.

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 this program 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.

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. Some examples of these projects are: a modified skim milk drying process; an integrated radio telephone system; side-scan sonars; and synthetic aperture radar. In 1980 Cabinet approved a consolidation program for the PILP and COPI programs to be administered by the National Research Council. The purpose of this consolidation is to make program administration more streamlined and uniform and provide the departments formerly using COPI with greater funding flexibility. Under the combined programs estimated expenditures in 1981/82 are $12.7 million, compared to forecast expenditure in 1980/81 of $11.7 million and 1979/80 expenditures of $9.1 million.

In addition to contracting out 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 1981/82 are $22.8 million compared to $21.6 million in 1980/81, and $19.5 million in 1979/80. The National Research Council estimates that a further $4.6 million will be spent in 1981/82 in other grants and contributions to industry.

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. Total estimated expenditures 1981/82 for the service are $3.3 million, compared to $2.8 million in 1980/81.

University

The federal government supports university science and technology directly, and indirectly through transfer payments to the provinces. Direct support takes the form of (a) grants and contributions and (b) contracts for S & T work in support of departmental missions. Total expenditures in direct support of university S & T in 1981/82 are estimated to be $351.2 million, a 10% increase from those of 1980/81 and 37% from those in 1979/80. Further details are given in Table 4.4.

The greater portion, 81%, of direct payments to universities is made for R & D activities; the balance is for RSA. Most of the direct support takes the form of R & D grants ($272.1 million for 1981/82). The amount spent by the government on R & D contracts in the university sector is expected to be $18.0 million in 1981/82, compared to $17.1 million in 1980/81. Of the expenditures on RSA, 79% ($33.9 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 in RSA).

The three granting councils—The Medical Research Council, the Natural Sciences and Engineering Research Council, and the Social Sciences and Humanities Research Council—provide about 70% of

Table 4.4

Federal Science Expenditures in Universities

	1979/80	1980/81	1981/82
		(millions of dollars)	
Total Payments to Universities	**256.1**	**319.8**	**351.2**
R&D (Total)	**227.4**	**284.1**	**308.3**
R & D Grants (Totals)	203.5	254.4	272.1
Medical Research Council	61.6	72.1	77.8
Natural Sciences and Engineering Research Council	104.1	136.1	144.8
Social Sciences and Humanities Research Council	14.6	17.0	18.4
National Health and Welfare	7.3	8.5	7.4
National Research Council	9.5	13.5	16.8
Others	6.4	7.2	6.9
R & D Contracts	14.6	17.1	18.0
Research Fellowships	9.3	12.6	18.2
RSA (Total)	**28.6**	**35.6**	**43.0**
Total Education Support	21.6	28.0	33.9
Medical Research Council	1.7	2.0	2.2
Natural Sciences and Engineering Research Council	8.2	12.7	17.6
Social Sciences and Humanities Research Council	7.0	8.2	8.2
Others	4.7	5.1	5.9
Other RSA	7.0	7.6	9.1

the total direct federal payments to universities for scientific activities. The remainder is 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 hospital and medical care.

The federal government considers the strengthening of the university research capability to be a national responsibility. The support of university research is aimed at the development and maintenance of our national capacity for fundamental research, at having part of that capacity address problems of national concern, and at underpinning the training of the manpower needed to carry out future research. During 1980/81 the budgets of the three granting councils were significantly increased, allowing the councils to enhance existing programs and to institute new programs to meet national needs.

As provided for in the 1981/82 Main Estimates, university payments by the Medical Research Council are estimated to be $83.6 million, an increase of 8% over 1980/81 and 27% from 1979/80. The major portion of the additional funds in 1980/81 was devoted to increasing the support of existing programs, although two significant shifts in program development were evident during the year. The first was the identification of the field of biological engineering as requiring additional research. Recognizing the potential which this field holds for new diagnostic and therapeutic processes and industrial benefit from them, and at the same time acknowledging Canada's limited capabilities and therefore need for additional manpower trained in this area, the council has decided that the field of biological engineering is to be included among those in which some degree of preference is given to candidates for MRC fellowships.

A second development in the funding of medical research was the awarding of funds under the Subject Research Development program to support research in perinatology. Originally designated by the council as an area of national concern in 1979, perinatology follows heart research as a topic to be singled out by this program. The intention of the council is to create leading centres of research in perinatology, with special emphasis on the causes or management of preterm birth and/or neonatal asphyxia.

The Natural Sciences and Engineering Research Council estimates that, within its Main Estimates budget, payments to universities will be $168.0 million, an increase of 11% over the 1980/81 level and 49% over the 1979/80 level. The implementation phase of the policies and programs contained in its five-year plan began in 1980/81. Various committees and task forces met to establish priorities and allocate additional support both to existing programs and to new

initiatives. As a result of extensive consultation, three new university support initiatives were implemented. One involves research on national concerns, the other two are designed to improve the supply of research trained manpower: these are the program of Undergraduate Summer Research Awards and the program of Research Fellowships.

The Undergraduate Summer Research Awards program is intended to encourage undergraduate students in science and engineering to gain experience in research. During the summer of 1980 over 1,000 awards were offered to undergraduates to work as research assistants at the university. Total cost of the program was in excess of $2 million. Priority consideration is being given to expanding the program to include research awards tenable in industry.

The Research Fellowship program is aimed at developing and maintaining a strong base of excellent research within the university community and retaining some of the involved researchers as the nucleus of a group of young Canadian professors which will be required in the 1990s. In the first year of this program about 100 research fellowships were awarded to researchers holding both a doctorate and other qualifications of the kind usually required for applicants to Assistant Professor positions. Plans have been developed to extend this program to include fellowships tenable in industry.

The third new initiative was the council's invitation to a limited number of applicants to submit research proposals in fields of national concern that lie outside the five areas previously identified for support under the council's Strategic Grants Program.

In line with the recommendations of the council's five-year plan, the largest 1980/81 budget increases were related to equipment replacement and improvement (an increase of 83% over the previous year); target research (63% increase over the previous year); and the training of scientific manpower (52% increase over the previous year).

The Social Sciences and Humanities Research Council in its areas of influence will provide an estimated $35.9 million in 1981/82 for university S & T activities in the humanities and social sciences, compared with $33.5 million in 1980/81. This represents about 87% of its total grants budget. The council's five-year plan, which it presented to government in 1979, proposes four main program thrusts for the 1980s:

- to maintain and expand core activity for support of independent research,
- to substantially expand support of research on subjects of national importance,
- to improve the dissemination of the results of research and scholarship,
- to enhance the quality and extent of basic research facilities and instruments.

The fellowship and scholarship programs, administered by the Fellowships Division, constitute the largest expenditure category in the council's budget: 41% in 1979/80 for the support of over 1,700 students and scholars. These programs include Special MA Scholarships, The Queen's Fellowships, Doctoral Fellowships, Leave and Postdoctoral Fellowships, and Doctoral Completion Fellowships for university faculty in management and administrative studies.

The Research Grants program supports advanced research in the social sciences and humanities. Grants in 1979/80 totalled some $8 million for 603 new and ongoing projects. Fields of research covered a broad range, including social history; economic analysis of Canadian industry and resources; Canadian literature; music and theatre history; education for special population groups such as handicapped children; normal and abnormal psychology; politics and public policy development; and urban and regional studies. Following are some typical projects: the archaeological investigation by Memorial University scholars of the site of a 16th century Basque whaling station on the coast of Labrador; an examination of the level and structure of unemployment in Quebec by a team of Laval University economists; a University of Western Ontario study of ethical issues in family medical practice; the linguistic analysis of native Indian and Inuit languages by McGill and Memorial University scholars, which will assist in the teaching of these languages; and the writing of histories by researchers at the Universities of Guelph and Calgary on the Supreme Court of Canada and on Canadians' role in the events leading up to the partition of Palestine.

The Negotiated Grants program offers support to large-scale research and editorial projects undertaken by eligible institutions—usually universities—by groups of scholars over a period of years. Awards are of two types: Program Grants and Major Editorial Grants. In 1979/80, $4.9 million was awarded to new and continuing projects. Seventeen of these were assisted by Program Grants, including Dalhousie University's study on new directions in ocean law, policy and management, which comprises 12 projects on subjects such as marine pollution, maritime boundary delimitation, Canadian shipping policy, and laws and policies gov-

erning the Continental Shelf; the York University study on the quality of life in Canada; the University of Montreal project on law and urban society in Quebec, and the University of British Columbia program in natural resource economics. Among the nine editorial projects in 1979/80 were 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; the *Historical Atlas of Canada/Atlas historique du Canada,* based at the University of Toronto and involving scholars from ten other Canadian universities; and the critical edition, in English and French, of the collected papers of Louis Riel, being undertaken by scholars at the Universities of Alberta, Calgary and Sherbrooke.

The Strategic Grants program, which provides support for research in areas of national concern and for research resources, funded projects to a value of some $1.4 million in 1979/80. In the field of population aging, Special Research Grants were given for 22 projects on subjects such as the intergovernmental coordination of policies for the elderly in Canada; attitudes toward the aged; the economic and social welfare of the recently retired, and the economic and social implications of an aging population. Reorientation Grants were awarded to scholars wishing to redirect their interests into the field of population aging, and Postdoctoral Fellowships were given for research in aging involving the disciplines of sociology, psychology, anthropology and history. Twenty-nine grants to university libraries went toward strengthening specialized research collections and ranged in amounts from $1,100 to $40,000. In addition, $400,000 was provided in 1979/80 to help speed production of the *Dictionary of Canadian Biography/ Dictionnaire biographique du Canada* mentioned above.

To assist in the process of selecting additional subjects of national importance for Strategic Grants, the council also funds workshops held in various locations across the country, organized by specialists in various fields, on topics suggested by the scholarly community. Findings and conclusions are presented to the council for consideration.

Complementing 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. This program accounts for over 80% of the department's payments for university science estimated to be $10.6 million in 1981/82. During the past five years, the department 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 the possibility of undesirable duplication and overlap between programs of the two agencies while ensuring that every health-related proposal will be considered by one or by the other.

Through the National Research Council the government will provide $16.8 million in 1981/82 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.

The Department of Energy, Mines and Resources through its Research Agreements program, other grants and contributions and contracts supports R & D in Canadian universities. The estimated payments to universities for 1981/82 are $1.6 million, $1.1 million in contracts and $0.5 million in grants and contributions. These arrangements provide an important link between the department and the Canadian research community, ensuring the free flow of information, expertise and technology. It gives the non-federal government research community an opportunity to contribute its expertise to the achievement of national objectives through mission-oriented R & D.

Like other federal science departments, the department is concerned about the future supply of highly qualified manpower in those areas of science and engineering within its mandate. Through the Research Agreement program, graduate students working with the department's grantees can apply their newly gained knowledge to solving real problems. Roughly 65% of the grant funds awarded each year assist in developing this highly qualified manpower through the employment of graduate students.

Support of university research by the Department of Agriculture in 1981/82 is estimated at $3.6 million, of which $1.3 million will be in operating grants, and $2.3 million in contracts for research directly complementing departmental activities. The Department of the Environment will provide $3.9 million in 1981/82 for university S & T 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 $3.2 million in 1981/82, compared to $3.0 million in 1980/81. Almost $0.5 million

will be awarded in addition as grants to universities to endow professorships in strategic studies.

The University Research program in the Department of Communications has been supporting applied research in Canadian universities since 1971. Estimated funds for 1981/82 are $1.1 million. The objectives are to complement the departmental research activities and to develop a cadre of competent university researchers 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. 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.

Departmental payments to provincial governments either directly or through joint programs are shown in Table 4.5. The Department of Energy, Mines and Resources is the largest spender, with estimated expenditures in 1981/82 of $89.7 million on joint programs with the provinces. Payments to the Alberta/Canada Energy Resources Research Fund will remain at $24.0 million in 1981/82. 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 $5.4 million will be contributed by the government in 1981/82 to the joint Canada-Saskatchewan program for the development of heavy oil recovery technology. The federal share of federal/provincial agreements to demonstrate conservation and renewable energy technologies is estimated to be $28.0 million in 1981/82, compared to $7.3 million in 1980/81.

Table 4.5

Federal Science Expenditures in the Provincial Sector

	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**68.8**	**84.1**	**111.7**
Energy, Mines and Resources	54.7	67.7	89.7
Environment	3.5	3.5	4.3
National Health and Welfare	1.5	1.9	2.4
Regional Economic Expansion	1.9	3.2	6.6
National Museums	6.4	5.6	5.9
Others	0.8	2.2	2.8

The Department of the Environment will spend about $4.3 million in 1981/82 on joint ventures with the provinces. Included is $2.2 million for flood damage reduction studies, flood risk mapping and other water resources projects. Agriculture Canada's provincial payments for 1980/81 and 1981/82 are a contribution to the extension of the St. John's West Agricultural Research Station, Newfoundland.

The provincial S & T payments by the National Museums of Canada—an estimated $5.9 million in 1981/82—provide support for regional and provincial museums and are entirely classed as the related scientific activity, museum services.

The Department of Regional Economic Expansion will spend about $6.6 million in 1981/82 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 provinces of Newfoundland, Nova Scotia and Quebec.

Foreign

This section considers the expenditures of various government departments in foreign countries. In general, foreign performers are utilized when needed specific research facilities, capabilities, or training are only available outside Canada. The International Development Research Centre and the Canadian International Development Agency are exceptional in that their mission involves the support of science whose application lies overseas. Consequently, the foreign S & T expenditures of these two federal agencies far outweigh those of the rest of the government, as shown in Table 4.6.

For these two agencies, the use of foreign performers follows naturally from their mandate to aid developing countries, both with tangible material assistance (Canadian International Development Agency) and with assistance in establishing the means for self development (International Development Research Centre). For example, the centre's particular hallmark has been to assist developing countries by supporting research projects that are identified, designed, conducted and managed by developing country researchers both in their own countries and in context of their own priorities. The centre has also helped to create research networks through which developing countries can share common experiences, conduct studies with a common design in areas of mutual concern, and learn from each other as they work towards common goals.

Among the National Research Council's foreign expenditures in 1981/82 are those for the Canada-France-

Table 4.6

Federal Science Expenditures in the Foreign Sector

	1979/80	1980/81	1981/82
		(millions of dollars)	
Total	**49.5**	**53.5**	**59.2**
Communicatlons	1.4	2.5	—
Canadian International Development Agency	10.5	9.6	10.7
International Development Research Centre	24.0	25.4	29.1
National Defence	1.2	1.4	1.5
Medical Research Council	2.6	2.9	3.1
National Research Council	1.0	1.9	2.2
Natural Sciences and Engineering Research Council	2.5	3.3	4.4
Social Sciences and Humanities Research Council	2.6	3.0	3.1
Others	3.7	3.5	5.1

Hawaii Telescope ($1.4 million). This is one of the world's premier optical telescopes and is built on the cinder cone at the summit of an extinct volcano in Hawaii. This is mainly a cooperative venture between Canada and France, with Canadian and French astronomers sharing most observing time and a smaller portion allotted to the University of Hawaii. The National Research Council makes a financial contribution to the International Energy Authority and pays for its affiliation with 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.

Off-shore S & T expenditures resulting from a cooperative agreement between Canada and the European Space Agency are reported by the Ministry of State for Science and Technology, under which the Interdepartmental Committee on Space operates. This cooperative agreement was signed in December, 1978, and took effect in January, 1979. It provides for Canadian participation in the General Studies program of the agency, and will give Canada the opportunity to participate in future applications programs where this is consistent with Canadian policies, and where industrial benefits, including the development of export opportunities, are likely to result. Specifically the Department of Communications 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 similar expenditures in its support for Canadian post-graduate students working for doctoral degrees. Most of these students are in the United States, 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 the support of an international exchange program which contributes to the costs of bringing foreign professors to Canada and of sending Canadian scientists abroad.

5. Major Funders

Introduction

The government's expenditures on science activities in areas of national concern are discussed in the Special Applications section. Those activities frequently cut across departmental mandates and represent the government's aggregated effort in specified application areas. In contrast, this section focuses on individual departmental budgets and in particular on the science programs of the departments, their science objectives and the organization of their science activities. The structure of this section corresponds to the presentation of the Main Estimates, that is, by ministry, department or agency and, within those, by program.

A summary of expenditures in millions of dollars ($M) and person-years (PY) directed to scientific activities for the past, current and estimates years is provided for each department and agency discussed, as well as total program resources. A display of these expenditures with reference to Parliamentary Vote numbers is given in Appendix II. Additional data are to be found in the companion document "Federal Science Expenditures and Personnel, 1981/82".

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 use scientific information and support to achieve their objectives. Within some departments, science activities are largely concentrated in a particular branch, such as the Research Branch within the Department of Agriculture's Agri-Food Development Program. Nevertheless, even in such departments, other parts of its organization may also conduct scientific activities; for example within the department's Agri-Food Regulation and Inspection Program, the Health of Animals Directorate conducts research on diseases causing livestock losses.

It is not feasible to present all departmental scientific and technological endeavours in detail; for several departments much of their 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*	
	1979/80		1980/81		1981/82		1981/82	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Administration	3.6	117	3.8	119	4.3	119	35.0	803
Agri-Food Development	132.8	3,700	140.2	3,696	154.8	3,715	682.1	4,623
Agri-Food Regulation and Inspection	4.7	148	5.7	146	7.6	149	163.3	4,327
Canadian Grain Commission	2.8	92	3.2	92	3.5	92	30.0	863
Total	**143.9**	**4,057**	**152.9**	**4,053**	**170.1**	**4,075**	**910.4**	**10,616**

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

The objective of the Department of Agriculture is to contribute to the development of optimum agricultural and food production and to ensure the continual supply of safe, wholesome, high quality and nutritious food for domestic and export trade. The estimated S & T expenditures in 1981/82 for the department are $170.1 million, an increase of $17.3 million or 11.3% over 1980/81. Approximately 5% of the S & T activities are performed extramurally.

The program and activity structure of the department has been restructured for 1981/82. Under the previous structure the programs of the department were divided into Administration, Research, Marketing and Food Production and Inspection. Under the new structure, the programs are Agri-Food Development, Agri-Food Regulation and Inspection, and Administration. The change reflects new thrusts of the department in food processing, distribution and marketing and the corresponding recent departmental reorganization.

The major portion of the department's science activities is conducted by the Research Branch within the Agri-Food Development Program. The Research Branch is now organized into five regional segments in recognition of the department's regional concerns and in order to build on regional strengths. The aim is to solve the regional problems identified at the 52 responsibility centres located from coast to coast, by working in closer contact with the provincial departments of agriculture, the agricultural industry, and the various farm organizations across the country.

The Research Branch conducts basic and applied research on agricultural problems pertaining to soils, farm animals, plants and pests that occur in the widely differing soil and climatic zones of Canada. Focal topics for scientific work include diseases, insects and weeds, engineering and energy, and food. The branch has increased its emphasis on fundamental research in biology and engineering which will lead to the breakthroughs required for increased efficiency of crop and animal production. The ultimate aim of such research is to increase the production of food, to improve the safety and nutritional quality of food, and to build a profitable food industry.

Research on animal diseases is carried out within the Agri-Food Regulation and Inspection Program. Such research covers new or emergent animal diseases and meat safety, food additives, residues, bacteriology, and food-bore diseases.

Economic and social research on the agricultural-food system is carried on under the Administration Program as a contribution to policy development. Also included in the program is the operation of the department's Central Library.

The Grain Research Laboratory of the Canadian Grain Commission conducts research on the quality of grain and oilseed crops.

Department of Communications

	Science Resources						Total Resources	
	1979/80		1980/81		1981/82		1981/82	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Communications	58.6	640	70.9	661	56.8	642	111.1	1,943
Arts and Culture	0.6	9	0.7	10	0.8	9	29.7	82
Total	**59.2**	**649**	**71.6**	**671**	**57.6**	**651**	**140.8**	**2,025**

The department now comprises two programs, as responsibility for the Arts and Culture Program, formerly in the Department of the Secretary of State, was transferred to the Department of Communications in 1980.

The department's estimated science expenditures for 1981/82 are $57.5 million, compared to 1980/81 forecast expenditures of $71.6 million. These expenditures represent 41% of the total estimates for the department. $15.3 million will be spent extramurally,

with 93% going to industry and the remainder to universities. It is to be noted that a significant fraction of the department's S & T activities is characterized by large satellite development projects, which results in marked variations in the annual expenditure trend.

The bulk of the department's S & T activities under the Communications Program are conducted in the areas of telecommunications research and space technology and applications. Scientific activities are also to be found in other areas relating to policy development, management of the radio frequency spectrum and international arrangements.

Most of the department's intramural research is conducted at the Communication Research Centre, located to the west of Ottawa. The centre is divided into two sections, one for Space Technology and Applications and the other for Radar and Communications Technology Research and Development. Additionally, under an agreement with the Department of National Defence, the department conducts basic and applied research in radar and radio phenomena and in satellite communications on behalf of the Canadian Armed Forces. Aspects of this work have included the development of airborne radar and remote sensing systems, and research into military communications systems. Amongst other work, the Space Technology and Application Branch manages the David Florida Laboratory, which has recently underdone a large expansion in order that it may carry out integration and environmental tests of complete spacecraft, including those designed to be launched from the U.S. Space Shuttle. The laboratory thus provides support for Canadian space activities in industry, universities and other government departments. The laboratory also provides specialized test equipment for satellites including thermal vacuum and vibration testing facilities. Further details on the department's activities may be found in the Special Applications sections—Space and Communications.

The National Library of Canada

	Science Resources					
	1979/80		1980/81		1981/82	
Program	$M	PY	$M	PY	$M	PY
Program Expenditures	14.7	500	17.2	500	21.6	517

The total budget of the National Library constitutes "related scientific activities" in the provision of information services in the human sciences. This activity is performed intramurally. The estimated expenditures for 1981/82 are $21.6 million, an increase of $4.4 million or 26% from the previous year.

To carry out its functions, the National Library's program is organized into five activities: Administration, Library Systems Centre, Collections Development, Cataloguing and Public Services.

As a national institution, the National Library has a responsibility to collect and to promote Canada's printed heritage, and to ensure the proper listing of the nation's publications to facilitate their retrieval, availability and use. It also facilitates the use of the nation's total library resources through the maintenance of a national union catalogue and the publication of union lists of periodicals held in Canadian libraries. Lending and research activities are also supported by the development of a broad collection of books, periodicals and government documents in the fields of the social sciences and humanities.

The National Library assists other libraries in the cataloguing and classification of their own collections by providing them with both current and retrospective bibliographic information in a variety of formats. Data for Canadian publications is created and provided by the Library itself, and data for foreign publications is provided through the international exchange of machine-readable records.

The National Library's automated on-line library data base management system, DOBIS (Dortmunder Bibliothekssystem) currently contains over 1.5 million records describing books and periodicals. The system is currently used by the National Library, the Canada Institute for Scientific and Technical Information (CISTI), the Library of Parliament and four departmental libraries (Finance/Treasury Board, Public Service Commission, Transport Canada and the Atomic Energy Control Board) in a network mode.

National Museums of Canada

Program	Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY
Program Expenditures	50.1	1,013	53.3	1,006	56.1	975

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 agency estimates total expenditures of $56.1 million for 1981/82. Approximately 18% is spent extramurally, in the form of grants to other 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 Programs, 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 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY
Grants & Scholarships	33.1*	—	38.7*	—	41.2	—
Administration	3.5	105	3.9	105	4.4	105
Total	**36.6**	**105**	**42.6**	**105**	**45.6**	**105**

* Includes funds administered for Department of External Affairs: $0.9 million in 1980/81. This responsibility terminated April 1, 1981.

All of the expenditures of the Social Sciences and Humanities Research Council are devoted to S & T activities. The expenditures for 1981/82 contained in the Main Estimates are $45.6 million, an increase of $3.0 over the amount forecast for 1980/81. Expenditures for administration go toward maintaining infrastructure to support the council's relations with a large and heterogeneous scholarly community numbering some 18,000.

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 the results of research and scholarship
- assists in and advises on maintaining and developing the national capacity for research.

In addition to its programs of grants and fellowships, which are discussed in the Extramural-University section, 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. Reports of groups on university management education and research, archives, and scholarly publishing in Canada were published during 1979/80.

The scholarship and fellowship programs, administered by the fellowships Division, represent the largest share of council expenditures—over 41% in 1979/80.

Within its Research Grants program the council's first priority is the support of independent research. Grants in 1979/80 totalled over $8 million for 603 new and ongoing projects. General Research Grants to 71 universities to cover the costs of certain research requirements of their faculty totalled $1.3 million.

Grants under the council's program of assistance to research in areas of national concern, now administered by a Strategic Grants Division, amounted to $1.4 million in 1979/80. Types of assistance included research grants, reorientation grants, postdoctoral fellowships and a research workshop—all in the field of population aging. Grants were made to university libraries for the strengthening of specialized collections and to the *Dictionary of Canadian Biography/Dictionnaire biographique du Canada*. Also funded was Canada-wide consultation, principally through workshops, to identity other subjects for Strategic Grants support.

The Negotiated Grants Program offers support to large-scale research and editorial projects undertaken by eligible institutions—usually universities—by groups of scholars over a period of years. Two types of awards are available: Program Grants and Major Editorial Grants. Payments to these projects totalled $4.9 million in 1979/80.

The Research Communications Division subsidizes learned journals in the social sciences and humanities, publication of scholarly manuscripts, and travel to scholarly conferences in Canada. In 1979/80, grants of some $1.5 million were awarded to 84 learned journals. Among scholarly conferences and seminars supported were the conference organized by the Calgary Institute for the Humanities (University of Calgary) on "Science, Pseudo-Science and Society," the international seminar at the University of Quebec at Trois-Rivières on folk culture of the 20th century, and the Wilfrid Laurier University conference on ethnohistory, which examined the joint contributions of anthropology and history to an understanding of the history and culture of the native peoples of North America. In 1979/80, grants totalling $312,824 were made to 113 such conferences and seminars. Support for Canadian learned societies comprises assistance (totalling $942,770 in 1979/80) to attend annual meetings of these societies and administrative support. A portion of this assistance 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 organizations for the publication of scholarly manuscripts ($858,419 in 1979/80).

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 and China. Grants for such exchanges totalled $373,358 in 1979/80. In the past, council also administered academic exchange programs for the Department of External Affairs with expenditures of over $1 million in 1979/80. As noted in the table, beginning in 1981/82 the council's responsibility for these programs has been assumed by other agencies.

Department of Energy, Mines and Resources

Program	Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	Total Resources 1981/82 $M	1981/82 PY
Administration	—	—	—	—	—	—	20.1	431
Energy	60.5*	46	90.0*	49	151.1*	134	3,833.7***	811
Minerals and Earth Science	102.2**	2,357	110.2**	2,343	124.6**	2,307	165.6	3,027
Total	**162.7**	**2,403**	**200.2**	**2,392**	**275.7**	**2,441**	**4,019.4**	**4,269**

* Excludes transfers to other departments ($32.5 million in 1981/82).
** Includes transfers from other departments ($1.1 million in 1981/82).
*** Includes Oil Import Compensation ($2,655.4 million in 1981/82).

The department's total estimated expenditures for scientific activities in 1981/82 are $275.7 million, an increase of $75.6 million or 38% over 1980/81, reflecting major increases for energy R & D and demonstrations in the National Energy Plan. These S & T expenditures will be 28% of total departmental expenditures, exclusive of expenditures for oil import compensation. Extramural expenditures are estimated to be $129.7 million, $34.9 million to industry, $1.6 million to universities and $89.7 million to provincial governments. The payments to industry represent an increase of 29% from 1980/81, those to provinces an increase of 32%.

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 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.

Energy R & D at the Canada Centre for Mineral and Energy Technology is focussed primarily on fossil fuels such as oil sands and coals, in which the centre has exercised technological leaderships for many years. Substitution for oil, efficiency of use, and development of low-grade resources are stressed. Demonstration projects with the centre's participation, complemented by in-house and contract research, are underway or contemplated in such areas as fluidized-bed technology, coal-oil mixture combustion and heavy-oil upgrading.

Further discussion of the department's energy activities is to be found 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 on land and in offshore regions.

The objective of the Minerals and Earth Sciences Program is to ensure the availability of mineral policies and strategies and timely earth science information, tech-

nology and expertise related to the landmass of Canada and its mineral and energy 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. Estimates of mineral resources and the improvement of methods of resource estimation are provided by the Geological Survey of Canada.

The Geological Survey of Canada is concerned with the provision of geological information on the earth's surficial deposits, crust and upper mantle. This is needed for the identification of the resource base of Canada and the effective exploration of the mineral and energy resources. It provides by means of geoscientific surveys and research an increasingly comprehensive knowledge of the geology of Canada, including its surrounding off-shore areas. The knowledge base is disseminated mainly as geological, geophysical and geochemical maps, reports and open files. The information and knowledge gained from the study of mineral deposits is being used more and more to provide evaluations of the mineral resource base of specific areas, such as proposed national parks. Some of the airborne geophysical and the geochemical surveys are undertaken as shared-cost federal-provincial ventures.

In addition to its energy R & D program, the Canada Centre for Mineral and Energy Technology (CANMET) also conducts S & T activities with the objective of ensuring that Canadian industry has the technology needed to meet national mineral and energy goals and to maintain a competitive position in world market. The centre's research program and information and advisory services extend from resource assessment to end use for a variety of mineral commodities. In its mineral technology work, the centre stresses problems and opportunities that are peculiar to the Canadian scene. Major projects are underway on mining methods for Canadian orebodies and processing of low-grade indigenous resources of long-term interest. Scientists are addressing the critical economic importance of durability, wear and corrosion in the Canadian climate and of the needs of the transportation industry, through research on improved mineral-based materials. Projects are designed to maximize the efficiency of materials and energy utilization while keeping environmental pollution and health and safety hazards at a minimum.

Cooperation and collaboration with private industry is a tradition at the centre. Through contracts, joint projects and a sophisticated information transfer system, the centre works to ensure that industrial needs are met and that technical capability is available for prudent and efficient resource development in Canada.

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. A revised seismic risk map is produced at ten-year intervals and site-specific determinations are made for industry on request. 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. The Earth Physics Branch is the lead agency in the government for research into sources of geothermal energy in Canada and is Program Manager for geophysical research into the problem of underground storage and disposal of radioactive waste from reactors. The Branch planned and was chief investigator on the very succesful LOREX '79 program of geophysical exploration over the Lomonosov Ridge near the North Pole and is presently engaged in planning CESAR '82, a similar program over the Alpha Ridge in the Arctic Ocean. Interdisciplinary studies on earthquake prediction, resources and evolution of the Arctic on the origin and emplacement of mineral resources and evaluation 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 meeting increasing demands for national positional data and mapping services by the development and application of advanced technology. The following are some of the

more significant current branch developments. The geodetic reference system for North America is being improved, in cooperation with the U.S.A. and Mexico, basis for their work. Development of mathematical processes will make the new NAVSTAR satellite system applicable to all orders of ground surveying. Cost effective means are being developed for the automatic digitizing of topographic maps so that digital data will be available and interchangeable between all levels of government and the private sector. A computer based capability for improving the usefulness of national atlas and aeronautical information is being developed. Legal surveys of Canada Lands are being made significantly more cost-effective by the current development of integration of legal survey information with special mapping. The multi-purpose land information product satisfies both land management and administration requirements. The branch is continuing its long tradition of technology transfer to the provinces and to industry.

The role of the Canada Centre for Remote Sensing is to improve the management of Canada's natural resources through the acquisition and use of earth observation data obtained from special sensors mounted on satellites and airborne platforms.

Data acquisition involves the development and operation, in cooperation with Canadian industry, of satellite ground receiving stations, airborne sensors and associated data processing systems. Use of the data for resource management purposes involves the development, in cooperation with industry and the provinces, of data analysis systems and methods to support applications such as forest management, mineral exploration, oil and gas operations in the Arctic, agriculture and environmental protection. Some of the centre's activities are thus also discussed in the Special Applications Section under Space, Natural Resources (Forestry and Minerals), Oceans and Food. The centre currently operates, in cooperation with industry, four specially-equipped aircraft and two ground receiving stations located in Prince Albert, Saskatchewan, and St. John's, Newfoundland, as well as advanced data analysis facilities in Ottawa, Ontario.

The department, through the Canada Centre for Remote Sensing, was the lead agency for the interdepartmental SURSAT program, which is responsible for the assessment of satellite systems for the surveillance of Canadian territory. An experimental program, regrouping over 100 prospective users was completed in 1980. The program demonstrated the potential of radar satellite data, operating irrespective of cloud, fog or darkness, to provide information related to the detection and location of human activity in the Arctic, coastal and ocean areas, as well as the surveillance of ocean pollution, land resources, and weather and sea state conditions. The SURSAT Program Board has thus recommended that Canada continue to move conducting, in cooperation with Canada's aerospace industry, a strong research and development program in the technology and applications of radar satellites. The program will emphasize sea-ice reconnaissance in support of Arctic petroleum operations, and will culminate in 1982 with recommendations to the government regarding Canada's options in the actual construction of such a satellite system.

Atomic Energy of Canada Limited

	Science Resources						Total Resources	
	1979/80		1980/81		1981/82		1981/82	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Nuclear Research and Utilization	88.9*	2,322	98.6*	2,372	111.5*	2,427	166.5	3,428

* Excludes transfers from the program to other departments ($1.3 million for 1981/82).

Science expenditures by Atomic Energy of Canada Limited are estimated to be $111.5 million in 1981/82, an increase of 13% over 1980/81 forecast expenditures. Expenditures for R & D on the safe immobilization and disposal of radioactive materials from the operation of CANDU reactors are expected to amount to $17.5 million in 1981/82, compared to $16 million in 1980/81 and $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 1978 Atomic Energy of Canada Limited was reorganized into a series of subsidiary companies with a corporate head office. With the exception of $12.1 million for feasibility studies related to 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 in the field of atomic energy for peaceful purposes. The results of its R & D programs form the technological base for the engineering, chemical and radiochemical companies of the corporation 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.

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,
- 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 (Pressurized 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 continues to receive significant resources, as it has since 1978. Funding in 1981/82 will be $17.5 million. 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 safe and economical isolation of 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: the main emphasis is on 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. To obtain the necessary understanding, a thorough investigation of different rock formations must be carried out using extensive drilling. Understanding will also be improved through large-scale experiments in a proposed Underground Research Laboratory in a hard rock formation near the Whiteshell Nuclear Research Establishment.

The facility, as now envisaged, would consist of several small rooms at a depth of about 300 metres. Access to the experimental level would be by either a ramp or shaft. The research program would provide information on the effects of excavation on the granitic rock mass and the hydrogeological behaviour in addition to a wide range of geological, hydrogeological and geochemical information in a rock formation typical of the Canadian Shield. It will also provide means to test thoroughly in a realistic environment the models and methodologies being developed to assess the overall concept of deep underground disposal. The laboratory will be the first test facility in the world which will be built below the water table and in an undisturbed rock formation. The U.S. and several other countries have expressed interest in participating in the project.

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 tritium 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, or which could improve the production of oil, such as from the Alberta tar sands. Substitution applications include the use of nuclear electricity in, for example, hybrid heating schemes and the production of hydrogen by electrolysis, the direct use of nuclear heat for industrial processes, and the use of inherently-safe small reactors for space heating. Other applications involve the use of waste heat from power reactors in greenhouses and fish hatcheries.

Department of Environment

Program	Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	Total Resources 1981/82 $M	1981/82 PY
Administration	1.5	41	1.8	51	1.9	47	34.4	838
Environmental Services	207.1	4,688	234.6	4,668	271.0	4,691	338.9	5,699
Atmospheric Environment	102.8*	2,352	117.7*	2,333	133.9*	2,345	—	—
Environmental Protection	7.1	162	8.1	162	8.2	161	—	—
Environmental Conservation	57.4	1,149	58.5	1,148	70.6	1,148	—	—
Canadian Forestry Service	39.8	1,025	50.3	1,025	58.3	1,037	—	—
Parks Canada	11.5**	192	12.6**	194	13.9**	197	245.4	5,057
Total	**220.1**	**4,921**	**249.0**	**4,913**	**286.8**	**4,935**	**618.7**	**11,594**

* Excludes transfers to Transport Canada ($7.2 million in 1981/82).
** Excludes transfers to other departments ($0.2 million in 1981/82).

The department's total estimated expenditures for scientific activities in 1981/82 are $286.8 million, 48% of total departmental expenditures. The majority of the expenditures occur in the natural sciences under the Environmental Services Program ($265.9 million). This program is composed of the Atmospheric Environment Service, Canadian Forestry Service, Environmental Conservation Service (previously known as Environmental Management Service) and the Environmental Protection Service. Parks Canada's S & T expenditures on the other hand are almost entirely in the human sciences ($14.0 million).

The main objectives of the Environmental Services Program are:

- to promote and undertake programs to protect and enhance the quality of the environment
- to promote and undertake programs which support the management of Canada's forests, waters, wildlife and lands in a manner which will minimize the negative impacts on the environment.

In addition to supporting these objectives, another objective of the S & T activities is to provide information services on natural hazards.

The Atmospheric Environment Service will spend $133.9 million in 1981/82 for scientific activities. Acquisition of meteorological data and weather, sea state and ice forecasting are major components of the science activity. The forecasting systems are supported by research programs designed to enhance these systems by, for example, numerical predictive modelling and improved remote sensing such as from aircraft, satellites, radar, and buoy systems.

Climatic information, in the form of historical statistics, near real-time monitoring and impact studies, along with the forecast information, is made available for planning and decision making regarding weather- and climate-affected Canadian activities in such sectors as agriculture, non-renewable energy exploration and renewable energy assessment, forestry, and fisheries. Research is undertaken to develop climate prediction expertise, to assess man's impact on climate and conversely the impact of climate on man.

Other research activities include programs related to atmospheric pollution, acid rain, the impact of man's activities on stratospheric ozone and toxic chemicals in the environment. R & D is also being undertaken to evaluate potential for rainfall enhancement in arid regions, and to assess wind and solar energy potential. Canada is an active member of the World Meteorological Organization and its science activities are supportive of international needs as well as our own domestic needs. Special contributions are being made to the Global Atmospheric Research Program, the World Climate Program, and the precipitation Enhancement Program.

With estimated expenditures in 1981/82 of $58.3 million the Canadian Forestry Service promotes effective management and utilization of Canada's forest

resources. Major programs deal with the development of environmentally benign methods of controlling pests and of improved firefighting equipment and techniques. Research is conducted in tree breeding to develop trees that grow faster and that are more resistant to pests, to support provincial reforestation programs. Under contract, research is conducted to support the continuous modification of codes and standards for wood products; basic research is conducted on wood properties and processing, such as the development of new preservatives; and R & D is proceeding on improved utilization of under-utilized species such as aspen poplar. 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 synthesis gas and other prepared fuels.

The Environment Conservation Service is concerned with the wise and careful use of Canada's wildlife, water and land resources. These concerns are addressed through a variety of program activities designed to improve the management and encourage the conservation of Canada's resource. By way of better understanding the relationships between resources, energy, technology and population, continuing effort is being placed on anticipating problems resulting from the impact of human activities on the environment. The Environmental Conservation Service conducts research activities in three main areas—inland waters, lands and wildlife. These activities will involve an estimated expenditure of $70.6 million in 1981/82.

The Inland Waters Directorate is emphasizing the protection, restoration and enhancement of water quality to protect water users through the development of water quality objectives. The continuing Water Quantity Survey program mesures 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 highly 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 Water Quality Monitoring program continues to assess the quality of the aquatic environment, particularly at transboundary locations.

The Lands Directorate pursues the conservation of Canada's land resource through the promotion of environmentally-sound and effective land use practices. It supports and participates in land-related programs including: inventories of land characteristics, capabilities and use, formulation of land-use alternatives, and promotion of ecologically-sound land-use planning. It supports and participates in the research of ecological methods for land classification and the application of this research. The largest of the directorate's mapping programs is the Canada Land Inventory, which is concerned with land capabilities in the settled areas of Canada. Over 1000 maps have been published. This data base provides a means of monitoring changes in land, of assessing Canada's land resource, and of evaluating effectiveness in conserving Canada's land resource.

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 Service is the control arm of Environment Canada and is required to ensure that the government's responsibilities for the protection of the environment are consistent with national policy and that the appropriate legislative and regulatory requirements are inforced. The service is concerned with air and water pollution control, waste management including resource and energy conservation, contaminants control and environmental emergencies and ensuring that federally-funded or sponsored enterprises or activities are conducted in an environmentally- sound manner. In addition to its regulatory activities, the service has a leadership or advocacy role to ensure that the intent of Parliament is implemented, as expressed in legislation and regulations. S & T activities directly managed by the service in support of its responsibilities are estimated to cost $8.2 million in 1981/82.

The Department of the Environment is developing an environmental protection policy for the 80's with a focus on the control of toxic chemicals. The Environmental Protection Service has been designated as the focal point for the toxic chemicals management program and will oversee all departmental activities in the identification and assessment of problems associated with toxic or potentially toxic chemicals, including hazardous wastes and the actions needed to control them.

In accordance with its mandate to protect Canada's cultural heritage, Parks Canada carries on research designed to identify, preserve and develop national historic parks and sites throughout the country. This research, which is carried out at program headquarters and in five regional offices may be divided into the related fields of history, archaeology and architecture. S & T expenditures by Parks Canada in 1981/82 are estimated to be $13.9 million.

Canadian International Development Agency

Program	Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	Total Resources 1981/82 $M	1981/82 PY
CIDA	37.4	56	37.1	56	41.5	57	787.1	1,029

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 S & T activities, while substantial in themselves, are a small part of its total program. Most of the S & T activities occur in CIDA's Multilateral program which is concerned with giving aid to developing countries in concert with other agencies. For example, it 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.

The agency aids 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.

International Development Research Centre

Program	Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	Total Resources 1981/82 $M	1981/82 PY
IDRC	36.5	217	39.0	227	45.5	238	49.8	353

Estimated expenditures in 1981/82 by the International Development Research Centre are $45.4 million, an increase of $6.4 million or 16% over 1980/81 expenditures. The International Development Research Centre was established by Parliament in 1970 to initiate, encourage, support and conduct research into the problems of the developing regions of the world. It is also concerned with applying and adapting scientific, technical and other knowledge to the economic and social advancement of developing regions. In carrying out these objectives it:

- enlists the talents of scientists and technologists of Canada and other countries in both the natural and human sciences;
- 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 the con-

text 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 — offers direct grants to institutions or individuals. It does not offer conventional technical assistance or capital grants for large scale development programs. Its relatively-small awards (average grants of $177,000) enable the recipients to secure the best available professional skills and finance projects in the most effective way, without regard to the source of the resources 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 under such criteria as: 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 the work have full responsibility for project administration and control. Program representatives make regular visits to project sites and can provide assistance should the need arise.

In 1980 the federal government adopted a policy of encouraging the application of Canadian research capabilities to problems facing developing countries. The centre will be the focal point for this new activity and has set up the Cooperative Programs Unit to give developing countries greater access to Canadian R & D capabilities. The program will respond to requests for collaborative research made either directly by developing countries, or in association with or through Canadian institutions.

The first project under this new program concerns the development of a sorghum milling machine, in cooperation with the National Research Council's Prairie Regional Laboratory in Saskatoon, Saskatchewan. A prototype machine was developed at the laboratory, which will collaborate in the field testing to be conducted in Ethiopia, India and Mali. In all of these countries sorghum is an important food crop and a wide range of types are available for breeding, and development purposes.

Department of Fisheries and Oceans

	Science Resources						Total Resources	
	1979/80		1980/81		1981/82		1981/82	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Fisheries and Oceans	112.7	2,122	116.4	2,143	119.8	2,211	404.0	5,831

The Department of Fisheries and Oceans was created by an Act of Parliament in April 1979. The new department has assumed responsibilities for fisheries, fisheries research, oceanographic research related to fisheries management, hydrographic surveys and charting of navigable waters. The estimated S & T expenditures in 1981/82 will amount to $119.8 million, of which $12.7 million will be spent extramurally.

The general objectives of the Ocean Sciences and Surveys 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.

The department has recently established an ocean climate program, whose objective is to describe and predict changes in the ocean. The work covers physical and chemical oceanographic research and biological oceanographic considerations related to the understanding of the impact of changes in the ocean on fisheries.

Commercial activity in the Arctic has increased enormously in recent years, as a result of new and expanded hydrocarbon and mineral exploration. S & T efforts are being directed to marine transportation and to environmental issues, in particular, to provide information on the inter-relationship of marine life resources and the physical, chemical and biological environments of Arctic Waters.

The Fisheries Management and Research activity 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 are also 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. Responsibility for fisheries research on a national basis is vested in the Assistant Deputy Minister, Atlantic. Both groups will be responsible in their respective areas for:

- biological and biochemical research and quantitative resource surveys, including development of science policy;
- resource assessment and prediction, including analysis of alternative resource management policies;
- 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 the Ocean Science and Surveys activity, other federal departments and agencies, universities, industrial and fishermen's organizations, provincial governments, international commissions and the industry and governments of other countries.

Department of Industry, Trade and Commerce

	Science Resources						Total Resources	
	1979/80		1980/81		1981/82		1981/82	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Trade-Industrial	81.3	268	98.6	337	126.1	337	449.8	2,465
Tourism	0.3	4	0.3	4	0.4	4	34.4	302
Grains and Oilseeds	1.8	3	0.9	3	0.5	3	128.0	58
Total	**83.5**	**275**	**99.9**	**344**	**127.1**	**344**	**612.2**	**2,825**

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 $126 million for S & T activities in 1981/82, an increase of $27.5 million or 28% over 1980/81 forecast expenditures.

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 also to support the development or introduction of new or improved products or processes that offer good prospects for profitable commercial exploitation. In 1979/80 additional funds were 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 $30.4 million. Forecast expenditures for 1980/81 are $56.8 million, a further increase of $26.4 million. It is estimated that these expenditures will increase to nearly $69.4 million in 1981/82 including $14.4 million in assistance to the electronics industry under a special component of the Enterprise Development 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 1981/82 are $39.3 million compared to $36.7 million in 1980/81 and $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. Annual expenditures on this program are $1.5 million.

Through the Technological Innovation Studies Program, the department supports studies and awards scholarships in the practices and management of technological innovation. Other programs support technological innovation through the provision of assistance to Industrial Research Institutes, Centres of Advanced Technology and industrial research associations. In conjunction with the special electronics assistance mentioned above, funding for these activities has been increased $0.6 million to $2.0 million for 1980/81 and 1981/82. In 1979, financial assistance was also provided for the start-up phase of two university-based Industrial Innovation Centres which will provide assistance to inventors for new ideas, processes and products. These incentive programs are also discussed in the Extramural-Industry section of this report.

The S & T activities in the department's Tourism Program involve in-house economic studies of the tourism industry. Among the S & T activities funded by the Grains and Oilseeds Program is the Canola Utilization Assistance program operated by the Canola Council of Canada. This program provides support for research designed to increase the commercial utilization of Canola (rapeseed).

Department of National Defence

	Science Resources						Total Resources	
	1979/80		1980/81		1981/82		1981/82	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Defence Services	87.1*	1,895	98.5*	1,934	110.2*	1,935	6,150.7	117,345

* Excludes transfers to other departments ($13.5 million in 1981/82).

The Department of National Defence's estimated expenditures for scientific activities in 1981/82 are $110.2 million, up 12% from 1980/81. 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 agencies and of Canadian industry, and on the sharing of S & T information with Canada's allies.

The department's 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 natural 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 wide spectrum of scientific disciplines that relate to the interaction of the soldier and the environment(s) in which he will be expected to live and operate. Approximately half of the total resources of this group are devoted to the protection of the soldier against adverse environments, whether natural or artificial, including nuclear, biological, chemical, high altitude and deep ocean. The major concern, however, is protection against chemical warfare agents. Protective ensembles have been developed for general purpose as well as for the crews of high performance aircraft. Other concerns are protection against extremes of cold and heat. Another important research activity is concerned with the effectiveness of the man/machine interface and involves studies of anthropometry, vision, hearing vibration and human-engineering aspects of equipment design. Recently a program of research has commenced on the human performance aspects of command and control, simulation and training and of sustained operations.

In-house programs in Sensors and Electromagnetics include research in underwater acoustics, electronic warfare, 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 growing and demanding an increasing share of the total R & D resources. Results from this research assist in the choice of off-the-shelf purchases or development in Canadian industry of sensor, navigation and communications systems for a wide variety of military operations and on major platforms such as the Long Range Patrol Aircraft, the New Fighter Aircraft and the Canadian Patrol Frigate. Associated electronics systems needed to counter hostile systems, and also to improve the survivability of expensive military platforms, have been receiving increasing attention. A growing effort is occurring in space activities where significant increases in capability for surveillance, accurate navigation and communications are possible. The major activities are in the search-and-rescue satellite (SARSAT) project, the satellite-based global positioning system NAVSTAR program, ground communications terminals and vehicular communications terminals.

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 remains the largest in-house program, utilizing approximately half the available personnel resources. The major activity in this area is in support of the CRV-7 Rocket Weapon System (2.75-inch diameter air-to-ground rocket), for which the motor is being produced by Bristol Aerospace Limited; the first off-shore sales of this rocket were made during the year to Malaysia and other sales are anticipated. A new activity introduced at Defence Research Establishment Suffield involves aerial target and remotely-piloted-vehicle technology; initial emphasis is on targets for ground-to-air gunnery and missile training. Other program changes include a shift of emphasis from electrochemistry to fuels/combustion and on expansion of work on materials.

The department is employing social sciences in its research program to an increasing extent. The Operational Research and Analysis Establishment (ORAE) possesses capabilities for strategic studies and social and economic analysis, as well as for operational research and systems analysis. Areas of study include methods of averting war by deterrence and arms control; socio-economic analyses to evaluate the impact of military forces on the society in which they operate; and analytical studies of logistics and manpower problems. Although most of this work is carried out in-house, some specific studies are contracted-out.

Department of National Health and Welfare

Program	Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	Total Resources 1981/82 $M	1981/82 PY
Administration	5.3	111	6.4	111	7.3	111	28.5	608
Health and Social Services	16.5	51	18.2	59	17.8	58	6,715.0	548
Medical Services	0.1	3	1.4	31	1.6	33	218.5	3,259
Health Protection	35.6	1,004	39.6	1,162	46.9	1,197	77.2	1,906
Income Security	0.5	17	0.5	17	0.5	17	10,487.9	2,972
Total	**58.0**	**1,186**	**66.2**	**1,380**	**74.1**	**1,416**	**17,527.1**	**9,293**

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 resources that are devoted to scientific activities within the department's five budgetary programs.

The science resources identified within the department's Administration Program are almost exclusively those allocated to the Policy, Planning and Information Branch, which serves as a support to the line branches. About one third of these resources support departmental policy development through quantitative analysis and policy analysis, involving applied human sciences. The remainder of these resources are devoted to the development and improvement of computerized information systems and data banks related to the health care and the social welfare systems. The data is obtained both from surveys and from the administrative files of the federal and provincial governments. The program includes a $2 million contributions fund to assist provincial departments to upgrade their information system in the health and welfare areas and to develop nationwide compatability among these information systems.

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 and the National Welfare Grants disbursed by the Social Services Programs Branch. The National Health Research and Development program accounts for approximately half the science resources within the Health and Social Services 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.

An estimated thousand researchers, assistants and technical personnel are supported by the extramural funding activities of the Health and Social Services Program. About three-quarters of the scientific resources are directed to activities classified as human sciences. In the social services field, the National Welfare Grants support 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.

Exclusive of transfer payments, the Medical Services Program is the largest program of the department. 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 been identified as science resources. Also included are those associated with the Northern Medical Research Unit, which carries out health and nutrition surveillance studies in the Northwest Territories, and investigates diseases and environmental contaminants of northern wildlife which may affect the health of northern residents.

The Health Protection Program contains the Food, Drugs, and Environmental Health Directorates, the Field Operations Directorate, and the Laboratory for Disease Control.

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 Food 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 regulations.

In the Food Directorate, scientific activities protect the public against deficiencies in the nutritional quality of foods and from microbial and chemical hazards that might cause illness. Major organizational units are the bureaux of Chemical Safety, Microbial Hazards and Nutritional Sciences. The Food Directorate works together with the Field Operations Directorate in administering the food provisions of the Food and Drugs Act. Research divisions carry out studies on: microbial hazards in food; on the toxicology and food chemistry of food additives, contaminants and components; on nutrient composition of food, nutritional status and bioavailability and effects of nutrients; and develop analytical methods for use in monitoring and surveillance. Scientific evaluation divisions exert influence on food safety through contributions to the development of policies, guidelines and regulations that take account of data from research and regional laboratories and from detailed review of industry submissions (e.g. regarding the use of food additives and agricultural chemicals). The risks and benefits of chemical use and of other changes in foods and eating habits are issues for which a scientific basis for decision is provided.

The Drugs Directorate consists of six bureaux: Drug Quality Assessment, Dangerous Drugs, Drugs, Drug Surveillance, Veterinary Medicine and Biologics, and the Drug Research Laboratory. 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 nationally for safety and efficacy, but also with respect to 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. It 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 Drug Directorate maintains the Drug Research Laboratory which carries out investigations in the fields of toxicology (carcinogenicity, mutagenicity, allergenicity, etc.) and pharmaceutical chemistry and develops analytical methods. The laboratory enables the directorate to make informed decisions on drug safety, efficacy, and quality. As the complexity and sophistication of the science behind newly available products increases, and as the inter-relationship between scientific disciplines deepens, the scientific expertise within the regulatory agency becomes even more essential. The Drug Research Laboratory consists of five divisions: Pharmaceutical Chemistry, Drug Identification, Chemical Standards, Drug Toxicology and Scientific Services. One of the main functions of the laboratory relates to drug standards and the development of assay methods for synthetic drugs, for drugs of natural origin, and for impurities in drugs. Special attention is paid to the detection of impurities which, when discovered, are submitted to toxicological assessment to enable setting specifications for their control.

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 directorate participates in:

- the International Joint Commission, in assessing health hazards from Great Lakes contaminants;
- the Organization for Economic Cooperation and Development, in standardizing toxicity tests;
- the North Atlantic Treaty Organization, in assessing drinking water quality.

The directorate has entered into commitments with the World Health Organization to become a lead institute for international programs on drinking water and pesti-

cides within the new International Program on Chemical Safety.

The past two decades have seen a major change in the practice of medicine arising mainly from the availability of a wide variety of diagnostic and therapeutic devices incorporating new engineering concepts, materials and electronic technology. It is now possible to make accurate measurements of functions whose existence previously could only be surmised and to mimic the roles of many organs to prolong normal life. Like all machines, devices are fallible—especially new and untried ones. The directorate assesses many of these devices, and ensures that performance claims are supported by acceptable tests; develops performance standards where appropriate; conducts premarket evaluation for critical high-risk implants; responds to reports of defective devices; initiates compliance and enforcement action as necessary; and provides technological information to both users and manufacturers. The Laboratory Centre for Disease Control has five scientific bureaux: Epidemiology, Infection Control, Medical Biochemistry, Microbiology, and Tobacco Control and Biometrics. The two disease surveillance bureaux, Epidemiology and Infection Control, monitor the incidence and causes of disease in Canada. They provide epidemiological assistance in epidemic situations and coordinate strategies for the control and prevention of communicable and non-communicable diseases. They also provide a surveillance system to study factors as potential causative agents in congenital anomalies, adverse reaction to drug products, and acute poisoning. In the field of infection control, special programs are designed to assist in reducing the high toll of hospital and laboratory acquired infections.

The Medical Biochemistry and Microbiology bureaux provide services to assist provincial, and clinical laboratories in the diagnosis and treatment of disease. National reference centres are located in-house and in specialized laboratories across Canada. These provide specialized diagnostic reagents for, and direct identification and characterization of, specific causative agents of diseases such as bacteria, viruses and parasites.

The Tobacco Control and Biometrics bureau develops alternative federal regulatory policies concerning the manufacture, importation, distribution, sales and use of tobacco products and psychotropic drugs, together with the provision of advice on statistical design and analysis of directorate projects, experiments and surveys.

The scientific activities under the Income Security Program all involve aspects of the human sciences, such as: 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					
	1979/80		1980/81		1981/82	
Program	$M	PY	$M	PY	$M	PY
Grants and Scholarships	68.7	—	80.5	—	86.8	—
Administration	1.4	40	1.5	39	1.7	39
Total	**70.1**	**40**	**82.0**	**39**	**88.6**	**39**

All of the Medical Research Council's expenditures are for S & T activities. As contained in Main Estimates, the council's expenditures for 1981/82 are estimated to be $88.6 million, 8% higher than in 1980/81 and 26% higher than in 1979/80.

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 science 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	
	1979/80		1980/81		1981/82		1981/82	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Scientific and Industrial Research	187.8*	2,945	221.2*	2,913	254.9*	2,946	255.2	2,946
Scientific and Technical Information	13.6**	215	16.2	212	19.2	226	19.2	226
Total	**201.4**	**3,160**	**237.4**	**3,125**	**274.1**	**3,172**	**274.4**	**3,172**

* Includes the net of transfers from and to other government departments ($1.1 million in 1981/82).

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

The National Research Council of Canada is a departmental crown corporation with a governing council, consisting of a President and 21 members appointed by the Governor-in-Council. The estimated expenditures for 1981/82 are $274.1 million, an average of 15.5% over 1980/81. The council has a broad mandate, "to promote, assist and undertake scientific and industrial research" for national development. The pursuit of this mandate requires a broad spectrum of activities which includes the performance of scientific

and engineering research in response to national, economic and social needs in areas such as transportation, energy, food, building, construction, industrial innovation and development, health, security, safety and environmental quality.

The council's laboratories are located mainly in the national capital region, but substantial regional operations exist or are being established in Newfoundland, Nova Scotia, Quebec, Saskatchewan and British Columbia. These are described in the Special Topics section.

The council's current activities are carried out within two budgetary Programs: the Scientific and Industrial Research program and the Scientific and Technical Information Program. The Scientific and Industrial Research Program (which will spend $254.9 million in 1981/82) is divided among seven activities: basic and exploratory research; research on long-term problems of national concern; 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 the council.

The Scientific and Technical Information Program (which will spend $19.2 million in 1981/82) is centered on the Canada Institute for Scientific and Technical Information. It provides a wide range of information services to the government and private sectors, including access to published material in the world's scientific literature and the delivery of information from computerized data bases. Scientific and Technical Information (STI) Services are an essential adjunct to R & D in that they support its performance, help researchers to avoid unnecessary research, and disseminate results world-wide. Increased activity in R & D automatically generates increased demands for STI services. The council's activities in this area are also discussed in the Special Applications section—Scientific and Technical Information.

In recent years, the council has given priority to policies and programs for advancing and assisting Canadian industrial R & D. Based on the council's particular and sometimes unique research resources, its staff has identified ten activities as constituent elements of a more comprehensive strategy. Foremost among these elements are two direct assistance programs, the Industrial Research Assistance Program (IRAP) and the Program of Industry/Laboratory Projects (PILP). These programs assist Canadian industry in the formation, development and exploitation of its own research capabilities. They are described more fully in the Extramural (Industry) Section.

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 its divisions which are of significance to Canadian industry in improving manufacturing techniques or developing new products and processes.

A part of the Industrial Research Assistance Program is specifically directed to meeting the needs of small-companies that have some technologically related question, problem or opportunity but do not have the internal capacity to investigate it. The program encourages small companies to find the outside resources which can help it in the solution of its technical problem. These resources may be in a provincial research organization, or a university or private consultants.

The council has recently prepared a long-range plan, developed in the context of the current national economic situation. This plan, which provides a blueprint for the council's role and activities over the next decade, stresses the requirement for an immediate increase in the R & D needed to enable Canadian industry to manufacture and export more high technology products. The plan has been submitted to the government for consideration.

Two major projects identified in the plan, those for the construction of a large Vertical Axis Wind Turbine generator and for the construction of a magnetic confinement device (Tokamak) for research into nuclear fusion, have recently been approved. Both these projects will be conducted jointly with Hydro Québec and are part of the council's initiatives in the energy field.

The council also carries out a broad spectrum of investigations designed primarily to expand scientific knowledge and to explore new topics of interest. It is estimated that approximately $48 million will be spent in this part of the council's work in 1981/82, mostly in the fields of astrophysics and molecular biology.

Because of Canada's vast areas of land and water, rigorous climate and scattered population, the energy, food, and transportation fields pose special problems

that are currently engaging a considerable part of the council's research capabilities. It is estimated that 1981/82 expenditures in these three areas are $34.6 million, $12.9 million, and $21.0 million, respectively, both for intramural and extramural work.

Several of the council's divisons have the responsibility for maintaining and improving a wide range of national standards. Examples include electrical and engineering standards, involving the investigation of such things as force or acceleration, and standards related to transportation, construction and safety, such as those embodied in the National Building and the National Fire Codes.

International comparisons of primary national standards are an important facet of the standards activity. Such global participation, under the aegis of the *Bureau international des poids et mesures*, ensures uniform, consistent, physical standards the world over. The standards-related work at the National Research Council has wide-reaching importance outside the laboratory, since it enables the council to provide direct standards services to Canada's industrial sector. For example 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, supports the management of certain major scientific facilities such as TRIUMF, the nuclear physics facility at the University of British Columbia.

In 1981/82, the council will fund the construction of a Solar Energy Testing Facility being built in Toronto by the Ontario Research Foundation. It will also expand its own Acoustic Test Facility, which is used to test delicate communications and other satellites that are subject to the severe vibration and noise associated with launching.

In carrying out its mandate, the National Research Council has long made use of a broad range of committees, and in particular, the Associate Committees. They are established by the council to advise and assist it in dealing with specific concerns of national significance. Not only do these committees assist the council in achieving its objectives but they also provide the Canadian scientific community with an opportunity to influence the course of research and development within the council's laboratories. Some committees have been organized to meet short-term problems while others have longer-term responsibilities. The nature of the problems assigned to these committees call for the contributions of experts in a variety of scientific and engineering disciplines. Members of Associate Committees are appointed by the governing council and are selected on the basis of their specific knowledge or skills. Due consideration is also given to maintaining both regional and sectoral balance on the committees.

In response to the need for a multi-departmental strategy to augment Canada's capability in the field of toxicology, the council has recently formed a new Associate Committee on Toxicology. One of the specific problems facing the new committee is the need to expand the training of toxicologists in Canada as well as toxicological research. Initially, the committee will concentrate on collecting information on various aspects of the problem as well as promoting an exchange of information among Canadian toxicologists.

Acting in support of the Associate Committee on Scientific Criteria for Environmental Quality, the council's Environmental Secretariat collates and publishes scientific criteria bearing on the quality of the Canadian environment. As well as providing information and data derived from the scientific literature, the committee's publications also include discussions on the fundamental principles that relate to contaminant-environment interactions in addition to data on the effects of specific contaminants.

In the international sphere, the council continues to represent Canada's scientific and engineering community within the International Council of Scientific Unions and eighteen of its components, as well as in eight international engineering organizations. The council also continues to share with the Canadian Engineering Societies Committee in the activities of the World Federation of Engineering Organizations and the Pan-American Union of Engineering Societies. The International Energy Agency (IEA) is an important focus for international cooperation in research and development on renewable energy, energy conservation, and nuclear fusion. The council now participates on behalf of Canada in 16 of its projects in cooperation with institutions in other countries.

Natural Sciences and Engineering Research Council

Program	Science Resources 1979/80 $M	PY	1980/81 $M	PY	1981/82 $M	PY
Scholarships and Grants-in-Aid of Research	118.7*	—	159.6*	—	177.7*	—
Administration	2.2	61	3.6	75	4.3	81
Total	**121.0**	**61**	**163.2**	**75**	**182.0**	**81**

* Includes funds from NATO ($0.6 million in 1981/82).

The estimated expenditures of $182.0 million to be made in 1981/82 by the Natural Sciences and Engineering Research Council are $18.8 million or 12% higher than forecast expenditures in 1980/81 and $61.0 million or 50% higher than 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 $4.4 million will be spent in support of Canadians undertaking research or research training outside Canada, and an estimated $2.6 million will be spent for support of S & T in Canadian non-profit institutions. The council also intends to provide $3.0 million for industrial fellowships. The council's program is organized into four activities which are described in the following paragraphs.

Peer Adjudicated Grants will involve estimated expenditures of $118.4 million compared to $109.9 million in 1980/81 and $88.5 million in 1979/80. These are grants awarded to individuals on a competitive basis to assist in defraying the operating expenses of research projects.

Developmental Grants will be awarded up to an estimated $27.1 million compared to $27.0 million in 1980/81 and $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 the Developmental Grants activity—from $17.8 million in 1980/81 to $20.6 million in 1981/82. Expenditures in 1979/80 were $10.8 million. 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. An increase from $1.6 million in 1980/81 to $1.8 million in 1981/82 will also be made in the program of Project Research Applicable to Industry (PRAI), which also comes under the Development Grants activity.

Expenditures for the Highly Qualified Manpower Training and Development activity will be an estimated $29.7 million in 1981/82, compared to $20.4 million in 1980/81 and $12.6 million in 1979/80. This activity provides support mainly to post-graduate students and post-doctoral fellows through bursaries, scholarships and fellowships awarded in national competitions. Highly qualified manpower programs will be expanded to increase the proportion of awards that will be tenable in industry. This expansion is relevant to achieving the national goal of increased R & D, in this case by

encouraging the training of highly qualified manpower particularly at the university-industry interface.

In 1980 the council implemented a system of research fellowships, called University Research Fellowships, for temporary, non-tenured faculty research positions. One hundred fellowships were awarded in 1980 and it is intended to award an additional 75 new awards in 1981/82. 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.

As well both this program and the corresponding program of Industrial Research Fellowships are expected to encourage closer interaction between researchers in the universities and in industry and mobility between these two sectors.

The council contributes up to $26,000 per year towards the salary and fringe benefits of the research fellows, 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.

Expenditures on National and International Activities will increase from $1.7 million in 1980/81 to $1.9 million in 1981/82. These funds are used to support both national and international conferences, the publication of Canadian scientific journals and to assist Canadian scientific societies.

Statistics Canada

	Science Resources					
	1979/80		1980/81		1981/82	
Program	$M	PY	$M	PY	$M	PY
Program Expenditures	122.2	4,534	148.3	4,619	230.0	5,489

Statistics Canada is the nation's central statistical agency. It collects and publishes a wide range of social and economic information. It is also responsible for co-ordinating and monitoring the data collection of other federal and provincial government departments. All of the agency's activities are classified as Human Sciences and nearly all as the related science activity of data collection. The major increase in estimated expenditures of $230.0 million for 1981/82—$81.7 million or 55% over 1980/81—relates to the Decennial Census which will be conducted by the bureau in 1981.

The work of the bureau is organized under seven broad activities:

- Industrial statistics
- Economic Statistics (national economy, international economic transactions, public finance, business finance, prices)
- Socio-economic statistics (health, education, science and culture, justice, labour, personal finance)
- Census (including population estimates and studies, in addition to quinquennial and decennial censuses)
- Research and development
- Communications (marketing, collection, data dissemination, liaison)
- Management and administration

Reference, inquiries and advisory services are provided to the public at the national office in Ottawa and at regional offices in Vancouver, Edmonton, Regina, Winnipeg, Toronto, Montreal, Halifax and St. John's.

Among the more than 500 surveys conducted by Statistics Canada, the highlight activity of the 1981/82 fiscal year will be the Decennial Census on June 3, 1981, a count of every person, dwelling and farm operation in Canada—the largest peacetime operation of government. More than eight million households will be asked to complete a questionnaire for the Census of Population and Housing. The nation's 340,000 farmers with annual sales of $250 or more will on the same day complete a further questionnaire for the Census of Agriculture.

Canadians will spend less time filling out census questionnaires in 1981. Since the last major census in 1971, the number of questions being asked has been reduced by approximately 25 per cent in the Census of Population and Housing. Most people will be asked to answer a basic questionnaire which has 12 questions respecting such matters as age, sex, marital status, language and housing. A sample of households—one in five (compared to one in three in previous censuses)—will be asked to answer a longer version with 34 additional questions on topics such as education, migration, income, labour force participation and occupation.

The questionnaire for the Census of Agriculture which covers all types of farm activity, consists of 134 questions of which the average farm operator will answer less than one third. The number of questions has been reduced by 20 per cent from that of the 1971 Census of Agriculture. The 1981 census will include questions about the farm operator, number of months the operator lives on the holding, type of organization and activities, labour, location of holding and market value.

As the bureau is processing census returns in the latter part of 1981, there will be an important research program with potential implications for future censuses nearing completion. This is a study of the use of administrative records as alternative sources of information to censuses and various kinds of sample surveys. Statistics Canada has long used administrative records as a source of statistics in such fields as education, public finance, international trade and vital statistics. But in respect to social statistics, almost complete reliance has been placed on the censuses of population and household surveys for statistics on households, families and individuals. With the development of large, machine-readable files, the exploitation of these records for social statistics has loomed ever larger as an inexpensive and rich source of small-area social statistics. The study is concerned primarily with the potential use of personal income tax, family allowance, unemployment insurance and old-age security files.

Perhaps the most important potential for statistics derived from administrative records lies in the possibility of providing annual statistics on population migration, population estimation, income by source, the 65-and-over population, gross labour force and gross unemployment, and each of these by small area. Administrative record files should prove to be increasingly useful in future years by statisticians for post-census and post-survey evaluations. It is expected that by late March 1982 the administrative data project will have prepared experimental data for Canada, for all provinces, all census divisions or counties, all cities of 15,000 or more, and for census tracts in selected cities for tax years 1976 to 1979. Tabulations will be prepared on such characteristics as age, sex, marital status, mailing address and sources of income.

Statistics Canada is also exploring the potential of a new electronics method of distributing data. By participating in a number of Telidon field trials organized by the Department of Communications, Statistics Canada will for the first time be able to take its latest changes in economic and social statistics immediately to the home television sets of scores of households across the country. Each family participating in the field trials will be able to call up its choice of thousands of items—or "pages"—of information, including some 250 pages of charts, tables and summaries prepared by Statistics Canada.

The agency's contribution to the Telidon experiments will be accessed in the same way as weather, entertainment and shopping information. In addition to the more serious monthly and quarterly economic indicators such as CPI, users will also be able to watch special features on local area maps, energy in the home and today's economy. All the items will point the users towards sources of further information at Statistics Canada in central or regional offices. Similar tests aimed at offices and small businesses will also be in some of the fields trials. Calgary, Winnipeg (Headingley), Toronto, Montreal, Quebec and Saint John are the cities where trials have started or are expected to start during the 1981/82 fiscal year.

A five-year program to improve data quality of the bureau's monthly employment statistics surveys, speed up results and lessen response burden culminates in January 1981 with the launching of a new broad-based survey covering the entire economy except hunting, fishing, trapping, agriculture, private households and the military. The old surveys will be continued until the end of the 1981 calendar year in tandem with the new survey. The extended survey frame will collect wage and salary data from small firms. This means that the wage and salary data will be

more representative of the universe. This has real implications for improving the estimates of labour income, for which purpose it was previously necessary to assume that small firm earnings moved in the same way as those of the large firms. The survey results will also incorporate for the first time wage and salary data collected from such employer categories as hospitals and religious and educational institutions.

A number of approaches have been taken to reduce the burden of response. Questionnaires have been designed to take advantage of ways in which respondents keep records. Rotational sampling will be utilized, and the survey sample size will be the minimum which will reliably meet users' needs. It is anticipated that there will be an overall reduction of about 25,000 units in the monthly sample size. In the case of firms with fewer than fifty employees, all data will be collected by telephone and the follow-up for firms of all sizes will also be done by telephone.

During a period when the bureau has been forced to curtail some activities, a notable expansion is planned in the scope of family expenditure surveys. Only three national surveys have taken place since World War II—in 1948, 1969 and 1978. The establishment of a regular survey cycle is proposed, with a full-scale national survey every four years, and a smaller survey mid-term. At the end of 1981/82, the first phase of a national survey will begin with the monthly collection of data on food expenditures. In 1982/83, data will be collected on other household expenditures such as shelter, clothing and recreation. In the last two years of the four-year cycle survey activity will be restricted to urban centres.

Transport Canada

	Science Resources						Total Resources	
	1979/80		1980/81		1981/82		1981/82	
Program	$M	PY	$M	PY	$M	PY	$M	PY
Administration	8.2	55	9.4	48	11.7	49	87.5	1,679
Marine Transportation	9.9	28	11.0	27	11.2	27	438.4	6,391
Air Transportation	5.9	122	8.3	164	7.0	133	547.6	10,008
Surface Transportation	3.6	2	0.5	2	0.1	1	791.3	296
Total	**27.7**	**207**	**29.2**	**241**	**30.0**	**210**	**1,864.8**	**18,374**

By comparison with its estimated total resources of $1,864.8 million for 1981/82, the estimated expenditures of Transport Canada on science and technology will be $30.0 million, a relatively small 2% of its total expenditures, which include 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 Canadian Marine Transportation, Canadian Air Transportation and Canadian Surface Transportation Administrations undertake S & T activities that are in support of their direct program functions. The Research and Development Directorate, within the Strategic Planning Group in the Administration Program, has a lead agency responsibility for developing federal and departmental policy, identifying federal and departmental priorities, and coordinating the federal program in transportation R & D. Through its Transportation Development Centre in Montreal, the directorate fulfills its responsibilities for providing S & T support to the other administrations of Transport Canada by providing specific data and conducting research and demonstration projects, and for undertaking R & D projects that both support the department's strategic objectives and are outside the direct program functions of the administrations. The directorate is also responsible for the development of the department's objectives and strategies through the development, coordination and management of R & D in the areas of energy efficiency in transportation and the transportation of energy commodities.

Four modal advisory boards have been created to facilitate integration 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 intramural research and test facilities of Transport Canada are relatively small establishments with budgets totalling about $3.5 million in 1981/82. 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 majority of Transport Canada's R & D activity for 1981/82 is of an ongoing nature, concerned with marine, air and surface transportation and energy matters.

S & T in marine mode involves improving the handling capacity of the St. Lawrence Seaway and extending its 8½-month navigation season. Marine S & T is also undertaken in areas of navigation aids, fleet systems, ice navigating, communication and control, ship safety, pollution countermeasures and the development of a nuclear Class X icebreaker. Much of this is in support of operations in the Arctic. Activities in marine S & T also include investigations related to the shipment and handling of bulk coal, grain and iron ore products, improvements in general cargo handling techniques, the modernization of National Harbours Board ports, and the development of proper facilities and techniques for handling liquified natural gas including the necessary guidelines, regulations and standards for its handling.

In the air mode, the S & T activity is undertaken to incorporate new developments into communications, air traffic control methods, navigation aids and airport productivity. Project areas include continuing investigation of new construction techniques, the performance of airport equipment, design and planning of computer simulation techniques, improvement to air traffic control equipment and procedures, continuing development of air traffic control simulators, safety-related projects and environmental (noise and air pollution) projects.

In the surface mode, the activity is generally broken down into road and rail S & T. Road S & T activities are undertaken in the areas of: transportation technology for the handicapped; road safety; the effects of fatigue, alcohol and drugs on driver behaviour; vehicle operations and maintenance; the impact of road design and traffic operation changes which may be possible due to car down-sizing; the correlation of laboratory tests for fuel consumption and actual road experience; the development of predriver education curricula: basic research on the crash avoidance process; active stability for coupled vehicles; development of radar range and relative velocity transducers; vehicle noise measurement and urban transportation. Rail S & T activity is undertaken in areas of: standards for high speed operations; railway crossing protection; transportation for handicapped passengers; and energy allocation priorities for passenger rail transportation R & D to increase railway efficiency and productivity. Other efforts are in: equipment design; noise reduction in urban areas; rail electrification; track/train dynamics; signalling, communications and control; railway terminal projects; and railway systems. The department also cooperates with VIA RAIL, Canadian National and Canadian Pacific railways in ensuring that S & T in support of their operations is carried out.

Transport Canada is also involved in transmodal energy efficiency in transportation R & D and transportation of energy R & D programs as well as R & D in the transportation, storage and transfer of hazardous commodities.

Two major groupings of new projects being initiated in 1981/82 are associated with developing pollution control equipment, navigation aids and telecommunications and electronics for the Canadian Marine Transportation Administration, and with updating air navigation and traffic control by deployment of recent advances in computing and microprocessing techniques for the Canadian Air Transportation Administration.

6. A Perspective on Science in Canada

The purpose of this section is to provide an international and historical context for Canada's expenditures on scientific activities. It also discusses the implications of the national expenditures target which calls for Canada's Gross Expenditures on R & D (GERD) to be 1.5% of the Gross National Product (GNP) by 1985. The GERD total takes into account only R & D in the Natural Sciences and Engineering because international comparisons have generally omitted expenditures on Social Sciences and Humanities R & D, although a number of countries are now beginning to report expenditures on this latter kind of scientific activity. International comparisons can be useful when looking at national trends over a period of time, but must be used with some caution as there are differences among countries in their concepts and definitions of R & D. Furthermore, expenditure data do not necessarily measure the effectiveness of national scientific efforts.

Table 6.1

1977 International Comparison of R&D Funding by Sector

Country	Government	University	Industry	Other	Total
		(% GERD of GDP or GNP)			
Australia	0.51	0.13	0.24	0.03	0.9
Belgium	—	—	—	—	1.2
Denmark	0.25	0.18	0.46	0.01	0.9
Finland*	0.28	0.15	0.55	0.02	1.0
France*	0.68	0.10	0.74	0.28	1.8
Germany	0.83		1.11	0.06	2.0
Iceland	0.47	0.01	0.05	0.08	0.6
Ireland	0.34	0.06	0.25	0.05	0.7
Italy	0.40		0.46	0.04	0.9
Japan	0.27	0.19	1.12	0.12	1.7
Netherlands	—	—	—	—	1.8
Norway	0.38	0.30	0.49	0.03	1.2
Sweden	0.49	0.24	1.13	0.05	1.9
Switzerland	0.43		1.73	0.04	2.2
United States	1.22	0.07	1.05	0.05	2.4
Canada, GDP (fed/prov) (0.37/0.06)	0.43	0.13	0.30	0.04	0.9
Canada, GNP (fed/prov) (0.39/0.06)	0.46	0.14	0.32	0.04	0.96

* Includes some or all Social Science and Humanities R & D. All others are Natural Sciences and Engineering only.
Source: OECD, International Statistical Year, 1977.

It must be noted also that the historical Canadian GERD data presented in this section are not exactly comparable with the data in other sections of this publication or of its companion report "Federal Science Expenditures and Personnel, 1981/82". There are definitional and other differences between the sets of data. For example much of the data discussed in other sections deal with proposed expenditures which are subject to change as the current financial year passes: the historical data describe the actual expenditures.

International Comparisons

Expenditure data have been collected by the Organization for Economic Cooperation and Development (OECD) covering most western countries' R & D efforts. These data show Canada's R & D expenditures to be lagging well behind those of the industrialized leaders. Table 6.1 relates R & D spending to the Gross Domestic Product of selected countries (GDP differs only slightly from the Gross National Product measure which is used in Canada).

There is wide agreement among economists that the foremost growth opportunities for the developed countries lie in the development and export of high-technology products and in the information field. Canada's relatively low R & D investment is accordingly a matter for concern. Some structural reasons have been identified as the source of this deficiency. Relatively more Canadians are employed in the resource and service sectors, where R & D tends to be lower, in comparison with other countries, fewer are employed on manufacturing. Furthermore, Canada does not have the massive space and defence research programs that are such a significant portion of the U.S. effort. Nevertheless, Canada cannot afford to lag so far behind in its research investments.

Coupled with the relatively low level of Canada's scientific effort is the low level of involvement of the private or business sector. Both as funder and as performer of R & D, the Canadian business sector as a whole trails behind its international competition. This is shown in Table 6.2.

Table 6.2

Business Sector share of GERD (NS), 1977

Country	As Funder	As Performer
	(% of Total)	
Australia	26.2	26.9
Belgium	—	72.2
Canada	35.7	42.4
Denmark	51.3	55.7
Finland	55.3	56.1
France*	41.1	60.3
Germany	55.6	68.4
Iceland	7.8	5.3
Ireland	35.5	34.9
Italy	51.0	57.8
Japan	65.8	65.2
Netherlands	—	57.2
Norway	40.8	53.5
Sweden	59.3	71.0
Switzerland	78.7	77.3
United States*	43.9	66.8

* Includes Social Sciences and Humanities R & D.
Source: OECD, International Statistical Year, 1977.

Historical Trends

Following substantial expansion in the latter half of the 1960s, R & D spending in Canada during the 1970s has remained relatively constant in real terms (as it has in several other countries belonging to the OECD). This is shown in Table 6.3 in which R & D expenditures are presented in both current dollars and constant dollars (computed using the implicit price index for Gross National Expenditure). It can be seen that current dollar expenditures have increased consistently. However, the rate of increase during the early seventies did not keep pace with inflation. The real effort, i.e., in constant dollar terms, diminished between 1971 and 1976, regaining its 1971 level only in 1977.

Although science spending demonstrated little consistent real growth, the economy itself grew substantially. The relative proportion of Canadian economic activity devoted to R & D expenditures has therefore declined since 1967, when the GERD/GNP ratio was 1.29%.

There is some indication that the proportion of our scientific effort performed and funded by the business sector is increasing (Table 6.4). Increased tax incentives and other government policies such as contracting-out the government's scientific activities, are designed to encourage greater involvement of Canadian industry and business in R & D and should reinforce this trend.

Table 6.3

Canadian Gross Expenditures on Research and Development (1963-1980)

	Expenditures		Index		Per cent
	Current $	1971 $	Current $	1971 $	of GNP
	(millions)		(1963=100)		
1963	462.8	618.7	100.0	100.0	1.01
1964	554.2	723.5	119.7	116.9	1.10
1965	664.8	840.5	143.6	135.8	1.20
1966	754.4	913.3	163.0	147.6	1.22
1967	854.2	994.4	184.6	160.7	1.29
1968	909.7	1,025.6	196.6	165.8	1.25
1969	1,002.0	1,082.1	216.5	174.9	1.26
1970	1,061.3	1,095.3	229.3	177.0	1.24
1971	1,157.1	1,157.1	250.0	187.0	1.22
1972	1,184.3	1.127.9	255.9	182.3	1.13
1973	1,266.5	1,105.2	273.7	178.6	1.02
1974	1,485.4	1,124.5	321.0	181.8	1.01
1975	1,663.3	1,136.9	359.4	183.8	1.01
1976	1,798.2	1,122.5	388.5	181.4	0.94
1977	2,008.7	1,171.9	434.0	189.4	0.96
1978	2,328.0	1,277.0	503.0	206.4	1.01
1979	2,499.6	1,243.0	540.1	200.9	0.96
1980	2,737.1	1,237.0	591.4	200.0	0.97

Source: Statistics Canada, Total Expenditures on R & D in Canada, December 1980.

Table 6.4

Industrial Participation in Canadian GERD

Year	As a Funder	As a Performer
	(Percent of GERD)	
1970	31.4	38.9
1980	34.9	43.4

Implications of a GERD/GNP Ratio of 1.5%

The government's policy is to raise the relative level of Canada's investment in R & D to approach that of other countries. Accordingly, it has set a target of having GERD reach 1.5% of GNP by the mid-eighties. The required increase in R & D expenditures must not only increase the proportion of scientific effort in our economy, but must also keep pace with economic growth, since the target is expressed in terms of GNP. In constant dollars, GERD must nearly double over the next five years, if the target is to be met. Continued inflation, when taken into account, will increase the funds required. To achieve the necessary acceleration in spending will require an overall expansion of activities involving all funders and performers. This expansion need not, and should not be identical for all sectors; it provides an opportunity to alter the current distribution of performer and funder activities.

As seen in Table 6.5, industry's share as a funder of the total GERD in 1979 was just over one-third, and its share as a performer was over 44%. In terms of the GERD target, and assuming 1985 goals for industry of a 50% funding share an average annual real growth in science expenditures of about 17% (or about 27% annually taking inflation into account) would be required. Many subsidiaries of multinational companies operating in Canada conduct far less R & D in proportion to sales than do their Canadian competitors. Much of the apparent "short-fall" in R & D expenditures by the industrial sector can be attributed to this situation. However, clearly no component of Canadian industry can afford to be complacent about its investment in R & D.

Consistent with the above assumption about industry's share of GERD in 1985, the federal government's share of funding R & D would drop to about one-third, compared to its 1979 share of 39% (which makes it the largest funder). Nevertheless, its expenditures for R & D would not decline. Rather they would have to grow annually by over 8% in real terms, or about 17% in current dollar terms and increase to 0.5% of GNP. In line with existing policies, such as restricting the size

Table 6.5

Sector Impact of R&D Target

Sector	As a Funder		As a Performer	
	1979	1985	1979	1985
	(Percent)		(Percent)	
Federal	39	33	26	16
Provincial	7	6	4	2
Business	36	50	44	63
Universities	14	8	26	18
Others	4	3	1	1

of the public service and of contracting-out its science requirements, much of the growth in its science expenditures would be accounted for in the form of contracts and grants for industrial R & D and in support for university research. As a group, the provincial governments currently spend proportionally much less on R & D than does the federal government. If the GERD target is to be attained, there must be substantial growth in the funding and performance of R & D by the provincial sector: from .06% of GNP in 1977 to 0.1% in 1985/86.

In terms of the above scenario the university sector is assumed not to expand its own funding of R & D much over the next four years, faced as it is with declining enrolments, and considering that most of its funding comes from government. However, it was assumed that university sector expenditures for performance of R & D would grow by about 4% annually. This would result from receipt of a portion of increased government expenditures, in line with policies to enhance research activity in areas of national priority and to promote cooperation in R & D among industry, universities and government. A comparison is given in Table 6.5 of sectoral shares of GERD in 1979 and in 1985, illustrating the above assumptions.

7. Regional Expenditures

This section provides an overview of the regional distribution of the S & T expenditures of federal departments and agencies (Table 7.1). The section ends with brief descriptions of federal regional establishments. The most recent financial year for which regional data on spending for activities in natural sciences are available (based on Statistics Canada Surveys) is 1978/1979. Data for that year are used in the table and in the discussion which follows.

Regional Expenditures in industry for activities in the natural sciences in 1978/79 totalled $205.1 million, of which $90.7 million was spent in Ontario, $49 million in Quebec, $23.7 million in the National Capital Region, with the balance spent in the other regions of Canada. The National Research Council, the Department of Industry, Trade and Commerce and the Department of National Defence together provide most of the federal government's support of industrial S & T.

The foremost sources of federal funding for scientific activities in the University sector in 1978/1979 were the Natural Sciences and Engineering Research Council, the Medical Research Council, and the Social Sciences and Humanities Research Council. These three Granting Councils collectively through their grants programs accounted for over 80% of the government's direct support of university science and technology in 1978/1979. The Ontario and Quebec universities received $68.1 million and $47.8 million respectively, while the Atlantic, Prairie and British Columbia universities received $14.3 million, $33.8 million and $30.7 million respectively.

Of the $505.2 million spent intramurally in 1978/1979 outside the National Capital Region (NCR), some $64.1 million was spent in Quebec, $166.7 million in Ontario and $274.4 million in the other regions. $390.9 million was spent in the National Capital Region, reflecting the historical concentration of federal scientific activities in the Ottawa/Hull area.

$144 million (86%) of the sum spent intramurally in Ontario in 1978/79 is accounted for by the regional establishments of Atomic Energy of Canada Ltd. and of the Department of the Environment. Some $88.5 million (31.5%) of that department's intramural spending occurred in Ontario and $18 million in Quebec (28% of the federal intramural spending in Quebec). The National Research Council spent some 87% of its intramural funds ($111.3 million) in the National Capital Region, where the majority of its facilities are located.

Intramural expenditures by the Department of National Defence (DND) were $21.4 million in Quebec versus $7.9 million in Ontario and $17.1 million in the National Capital Region. Some $505.2 million (56%) of the $896.1 million spent intramurally in 1978/1979 was spent outside the National Capital Region to support work in regional federal laboratories established primarily to serve national as well as regional needs. Some of the more prominent federal regional establishments are described below.

Atomic Energy of Canada Limited operates Canada's largest nuclear centre, the Chalk River Nuclear Laboratories (CRNL), at Chalk River, Ontario. The centre operates a number of major research facilities which include two high-flux research reactors , NRX and NRU; two zero-energy test reactors; in-reactor loops for fuel testing; an extensive computation centre; a number of accelerators, including a 13 MV tandem Van de Graaff; and sophisticated analytical instrumentation, including electron and Auger microscopes. Underlying research is carried out in such fields as nuclear and condensed-matter physics, the biological effects of radiation, the chemistry relevant to nuclear systems, and materials science. High priority is given at CRNL to applied research and development in support of the Canadian nuclear power program and includes research on fuel and fuel channels, safety, reactor-waste management, reactor control and instrumentation, and heavy water. There has recently

Table 7.1

Regional Science Expenditures 1978/79

Region	AGR	EMR	AECL	ENV	NRC	DND	ITC	MRC, NSERC, SSHRC	Other	TOTAL
					(millions of dollars)					
Grand Total	**122.9**	**126.4**	**96.3**	**319.3**	**194.6**	**80.8**	**60.1**	**191.1**	**224.3**	**1,416.0**
Atlantic	13.4	6.7	0.4	80.4	6.4	8.0	0.4	12.3	11.0	139.0
Quebec—excl. Hull	10.8	3.1	8.7	21.8	6.9	24.9	25.5	47.3	36.2	185.0
Ontario—excl. Ottawa	11.7	4.8	61.8	97.3	43.1	15.3	22.5	68.6	25.0	350.2
Prairies	37.7	22.8	22.4	40.0	9.4	6.5	2.7	30.1	15.6	187.3
B.C.	9.1	4.3	0.1	49.9	14.1	6.1	2.0	20.4	10.0	116.0
N.C.R.	40.2	84.7	2.9	29.9	114.7	19.9	7.0	12.4	126.5	438.1
Intramural Total[1]	117.7	93.3	80.2	280.8	127.7	64.7	3.7	3.5	124.4	896.1
Atlantic	13.1	4.3	–	67.6	4.0	7.1	–	–	0.6	96.7
Quebec—excl. Hull	9.7	–	–	17.9	1.0	21.4	–	–	14.1	64.1
Ontario—excl. Ottawa	10.4	0.8	55.5	88.5	1.7	7.8	–	–	1.9	166.7
Prairies	36.1	7.7	22.0	37.3	6.4	5.9	–	–	0.6	116.1
B.C.	8.6	2.3	–	40.9	3.3	5.3	–	–	1.2	61.6
N.C.R.	39.8	78.2	2.7	28.6	111.3	17.1	3.7	3.5	106.0	390.8
Industry Total[2]	1.4	14.2	15.0	24.1	55.5	13.7	54.5	1.6	35.7	215.9
Atlantic	0.1	0.5	–	10.9	2.0	0.7	0.2	0.1	1.5	16.0
Quebec—excl. Hull	0.3	1.3	8.6	2.0	5.4	2.8	25.3	0.3	5.3	51.3
Ontario—excl. Ottawa	0.5	2.7	5.9	4.4	40.7	6.6	21.9	0.8	9.1	92.6
Prairies	0.3	2.2	0.3	1.4	2.4	0.4	1.9	0.1	5.0	14.0
B.C.	–	1.4	–	4.5	1.8	0.6	1.9	0.2	2.4	12.8
N.C.R.	0.2	6.1	0.2	0.9	3.2	2.6	3.3	0.1	12.4	29.0
University Total[2]	2.6	2.8	0.7	3.7	9.6	2.2	1.1	183.0	27.1	232.7
Atlantic	0.1	0.3	–	0.4	0.1	0.1	–	12.1	3.2	16.3
Quebec—excl. Hull	0.5	0.4	0.1	0.8	0.1	0.7	0.2	46.7	6.9	56.4
Ontario—excl. Ottawa	0.7	0.8	0.4	1.5	0.3	0.8	0.6	67.1	7.4	79.6
Prairies	1.0	0.6	0.1	0.5	0.1	0.2	0.2	30.0	5.4	38.1
B.C.	0.2	0.5	0.1	0.4	8.8	0.2	0.1	20.2	3.3	33.8
N.C.R.	0.1	0.2	–	0.1	0.2	0.2	–	6.9	0.9	8.6
Others Total[2]	1.2	16.1	0.4	10.7	1.8	0.2	0.8	3.0	37.1	71.3
Atlantic	0.1	1.6	0.4	1.5	0.3	0.1	0.2	0.1	5.7	10.0
Quebec—excl. Hull	0.3	1.4	–	1.1	0.4	–	–	0.3	9.9	13.4
Ontario—excl. Ottawa	0.1	0.5	–	2.9	0.4	0.1	–	0.7	6.6	11.3
Prairies	0.3	12.3	–	0.8	0.5	–	0.6	–	4.6	19.1
B.C.	0.3	0.1	–	4.1	0.2	–	–	–	3.1	7.8
N.C.R.	0.1	0.2	–	0.3	–	–	–	1.9	7.2	9.7

[1] Only natural science expenditures included.
[2] Natural plus social science expenditures.
Source: Science Statistics Centre, January 1980.

been a shift in emphasis towards finding ways in which nuclear energy can substitute for oil.

Atomic Energy of Canada Limited operates a second nuclear research centre, the Whiteshell Nuclear Research Establishment (WNRE), located at Pinawa, Manitoba, 100 km northeast of Winnipeg, on the Winnipeg River. The research facilities at this site include the WR-1 research reactor; a facility for reactor-containment studies; an accelerator for materials-science studies; fuel-test loops; computational facilities; and modern analytical instrumentation. An underground research laboratory for waste management studies is planned for a site near the establishment. Research at the Pinawa establishment is primarily concerned with radioactive waste management and nuclear-reactor safety, with significant effort devoted to health and environmental effects of radiation, chemistry, materials science, and fuel, including fuel for advanced fuel cycles employing thorium.

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

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

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

Another collection of federal environmental laboratories is concerned with fisheries and with water-related problems. The Department of Fisheries and Oceans operates two large institutions—the Bedford Institute of Oceanography at Dartmouth, N.S., and the Institute of Ocean Sciences, at Patricia Bay, B.C.—housing hydrographers, marine scientists and engineers who study the aquatic environment found in Canada's coastal waters and oceans. These institutions, along with other smaller specialized laboratories perform research and related scientific activities in the areas of fisheries management, physical and chemical oceanography, aquaculture, hydrography, water quality monitoring and management. Their work is largely in support of the operational responsibilities of the Department of Fisheries and Oceans fisheries management.

Agriculture Canada operates 52 research establishments of varying size and degree of specialization, located from coast to coast. The research programs are aimed at alleviating current and anticipated agricultural problems in the many soil and climatic zones of Canada. Each research establishment is specifically designed to serve the agricultural needs of the area in which it is located and/or to conduct research on agricultural problems of national concern. Some examples of special interest are the programs of the Beaverlodge Research Station, Alberta, working on northern agricultural problems; those of Summerland, B.C., and Kentville, N.S., on tree fruit research; and those at Swift Current Research Station, Saskatchewan, on dry land farming.

An expansion is currently under construction at the department's research station at St.-Jean, Quebec. This facility is being built to provide a focus for national research programs on organic soils. Space will also be provided for the use of researchers from the provincial Department of Agriculture. The increased research will be beneficial not only to regions near Montreal and St.-Jean, but to the other regions in Canada with organic soil resources. A new building at Kentville, Nova Scotia, is also in the final stages of construction.

As mentioned above, a major emphasis at Kentville is research on treefruits.

The Department of National Defence maintains five research establishments outside the National Capital Region. Those in Halifax and Esquimalt, Defence Research Establishments Atlantic and Pacific respectively, concentrate mainly on defence research oriented toward naval matters, including undersea warfare. The Defence Research Establishment Valcartier, near Quebec City, undertakes R & D projects mainly on armaments, but has diversified in recent years into electro-optics, tactical data systems and laser research. It is credited with inventing the world's first atmospheric pressure gas laser. The Defence Research Establishment Suffield near Medicine Hat, Alberta, develops and tests counter-measures against chemical and biological agents, has undertaken major shock and blast trials, and has diversified into research on vehicle mobility, military engineering and hazardous waste disposal. The Defence and Civil Institute of Environmental Medicine in Toronto conducts research on human protection and performance in adverse environments. Its programs include deep diving research, human engineering and the man-machine interface in aircraft and vehicles.

The National Research Council also maintains a number of regional centres, which form the subject of a Special Topic Section.

8. Special topic

National Research Council Regional Laboratories

The National Research Council has a unique role in Canada's scientific and technological infrastructure because of the range and diversity of its interests, which are derived from its broad mandate to provide a national foundation for the creation and application of scientific knowledge. The council's interests overlap those of other departments and agencies with major science and technology activities, which are more restricted in their breadth and application according to their mandates. Although the promotion of interdisciplinary exchanges of ideas and the use of common facilities and services is a compelling reason for functioning at a single location, there are in some instances equally compelling reasons for regional location of science establishments. One such reason is the promotion of the transfer of the council's scientific output to the private sector for exploitation, i.e., technology transfer. The location of programs in regions where resources and associated industries are to be found encourages the interaction of council scientists and private sector counterparts with beneficial information flow in both directions. This is a major consideration in the establishment of the five regional laboratories of the National Research Council. Three of these laboratories have been in existence for several years:

- the Atlantic Regional Laboratory, on the campus of Dalhousie University, Halifax, Nova Scotia
- the Prairie Regional Laboratory, on the campus of the University of Saskatchewan, Saskatoon, Saskatchewan
- the Mechanical Engineering Western Laboratory, at Vancouver, British Columbia

Two new laboratories are in the process of being established:

- The Arctic Vessel and Marine Research Institute, to be located on the campus of Memorial University, St. John's, Newfoundland
- L'Institut de génie des matériaux, in the South Shore region near Montreal, Quebec.

The Atlantic Regional Laboratory (ARL)

This laboratory was established in 1952 to complement and assist other research facilities in the area. Its basic policy has been to engage in fundamental, long-term research in support of resource development in the Maritime provinces. It is research which industrial firms can not generally afford to undertake because of a low, immediate commercial application and profitability. The laboratory's research has three main thrusts: marine plant studies, microbiology and high temperature chemistry.

When ARL was established there was very little scientific information available on the local marine plants, particularly the algae. Because these marine plants have developed in an environment vastly different to that of terrestrial or fresh water plants, the associated biochemical evolvement is also dramatically different. Apart from the intrinsic fundamental scientific interests in studying the unique life cycles, growth processes and reproductive mechanisms, there are also possibilities for commercial exploitation of the unusual natural products. One of the principal success stories in marine algae research has been the work on Irish Moss, the source of carragreenan, an important industrial gelling agent. ARL maintains an extensive collection of seaweed species which provides a reference library for scientists.

Modern microbiological techniques are being employed to investigate the effects of certain environmental conditions in the Atlantic region on the health of sheep and cattle. Working in conjunction with Agriculture Canada at its experimental farm in Napan, Nova Scotia, ARL scientists are studying the toxin-producing abilities of fungi which cause a decline in the necessary population of stomach bacteria in animals. This is believed to be responsible for a retardation of livestock growth known as "ill thrift". It is expected that information from the study of fungal characteristics will eventually lead to simple farm management techniques for controlling this condition. Information gathered on numerous fungi in this comprehensive survey is being stored in the Dalhousie University computer facility.

The high temperature chemistry activities of ARL are of direct interest to one of Nova Scotia's largest industries, steelmaking. Researchers are particularly interested in studying the interaction between the constituents of molten metal and molten slag, the latter being used to control the carbon levels in steels. Investigations have led to new understanding and interpretation of the nature of silicate slags. Polymer theory, which is most generally confined to organic chemicals, has been found to be applicable to the behaviour of phosphates and silicates in glasses and slags. Specialized techniques and equipment have been developed for studying and working with these materials at high temperatures. The laboratory has also been carrying out coal-related research over the last four years, notably in coking technology. It is a founding member of the Atlantic Group for Research in Industrial Metallurgy (AGRIM).

The Prairie Regional Laboratory (PRL)

The Prairie Regional Laboratory was established in 1948, on the campus of the University of Saskatchewan in Saskatoon. The laboratory's program is agriculturally-oriented with a major theme of plant science, based on long-term fundamental studies of the physiology of plants and micro-organisms, and of the chemistry of their natural products. Projects are selected which will expand the fundamental knowledge base while contributing to problems of the prairie region. The scope of research is broad, ranging from the biochemical microcosm of single cells to the larger practical considerations of protein crop development. An earlier emphasis on utilization of agricultural waste and surpluses has led to activity in support of introducing alternative crops in place of grain production.

The Plant Cell Culture Group has developed a method of producing hybrid cells from the somatic or body cells of plants by inducing the fusion of cells from distantly-related plant varieties. Hybridization of such distantly-related varieties by conventional cross-fertilization methods is usually not possible because of evolved sexual barriers. The production of agriculturally-valuable plants from this breakthrough also requires elucidating the factors that influence the subsequent stage of inducing these hybrid cells to grow into mature plants (morphogenesis). The laboratory has successfully achieved morphogenesis with rapeseed and carrots, in which mature plants have been grown from protoplasts which have not undergone fusion. The next step is to achieve morphogenesis with protoplasts which have been obtained by fusion. Work is also underway in recombinant-DNA techniques, in which isolated pieces of genetic material (DNA) are introduced into the genetic material of other species, to impart new inheritable characteristics.

Development of crop plants rich in proteins has become increasingly important because of a recognized world shortage of edible protein and PRL scientists are experimenting with protein-rich plants suitable to supplement present prairie crops. The Biotechnology Group in cooperation with the University of Saskatchewan and local industries has been investigating the potential of field peas with considerable success in such aspects as selection of pea varieties, growth and processing and possible food products. The World Pea Collection, which is maintained on the University of Saskatchwan campus, contains most of the known pea varieties, and can be screened by geneticists for characteristics of interest.

Fundamental research is being conducted into the means by which atmospheric nitrogen is converted into a form available to living cells for producing proteins. The nitrogen fixation process in legumes depends on a complex symbiotic relationship between the legume plant and bacteria living in nodules on the plant roots. A basic understanding of the roles of these two partners could lead to methods of increasing the efficiency of the fixation process with consequent reductions in the need for expensive nitrate fertilizers. PRL scientists have focused their attention on the legume host and the various parameters and conditions affecting entry of the bacteria into the plant roots, the nature of the accommodation within the roots and the methods by which the plant induces the micro-organisms to fix nitrogen.

Fermentation technology stems from the early work of the laboratory in the use of microorganisms to produce new and valuable products from agricultural wastes

and surpluses. A broad range of fungal and bacterial growth has been studied as well as the end products that these micro-organisms produce and the chemical variables that affect this production. The results of such fundamental studies assist in optimizing conditions for maximum yield of desirable products and are valuable in planning industrial exploitation of the fermentation process. A more recent role for the fermentation process has been in the degradation of undesirable chemicals in the soil such as industrial wastes and pesticides.

Although falling outside the main theme of the laboratory, its forest product research has led to a classification method for pine trees, based on the terpene differences among varieties. Insect pheromones, chemical attractants produced by insects, are also being studied as a potential method of controlling insect populations.

The Mechanical Engineering Western Laboratory

This laboratory was established in Vancouver in 1971 by relocation of part of the Division of Mechanical Engineering from Ottawa. Mainly concerned with conducting R & D in response to industrial needs, its program concentrates on three main areas: tribology, special instrumentation and numerically-controlled machining processes.

Tribology is the science of lubrication, friction and wear. Application of the knowledge derived from this field of study can reduce the damage to industrial machinery from friction and wear, leading to an extended operating life time and reduced replacement costs. Reduction of friction is also desirable in many circumstances, resulting in reduced power requirement and energy consumption. Although work is carried out on problems of national scope the emphasis is on local industrial problems.

The development of specialized instrumentation is mainly to support the tribology program but is also directed to some separate problems of industrial instrumentation.

Numerically-controlled machining is a valuable labour-saving industrial technique most generally applied to metal shaping but more recently applied to machines other than metal-cutting ones. The laboratory also undertakes an educational role of introducing the advantages of these techniques to local industries.

The Arctic Vessel and Marine Research Institute

Construction of a building and facilities for the institute on the campus of Memorial University, St. John's, is expected to begin in 1981 and be completed during 1984/85 at a current estimated cost of approximately $47 million. Present intentions are that half of the projected staff level of one hundred will be council employees, the remainder to be drawn from the St. John's area. The institute's program will be similar in content to that of the council's Marine Dynamics and Ship Laboratory in Ottawa, where studies of the characteristics of marine models enables scientists to predict and evaluate the performance of full-scale structures and vessels. This new facility will extend Canadian capability to develop marine technology for operating in ice-covered and ice-laden waters. Included in the facilities will be an ice towing tank 80 metres long by 12 metres wide and 3 metres deep, with towing carriage, wave making equipment, under-water closed circuit television and refrigeration. Support facilities will include a machine workshop for model design and fabrication, data acquisition and processing systems and a complementary open water tank.

L'Institut de génie des matériaux

This new institute is also referred to as the Industrial Materials Research Institute. Considerable progress has been made in establishing the institute, with priority being given to recruitment of staff. A permanent site has been purchased at Boucherville on the South Shore region near Montreal and completion of a permanent building is expected in mid-1983 at a currently estimated cost of $22 million. In the meantime staff is being lodged in rented office space in Longueil and in temporary laboratory facilities installed in a rented warehouse near Boucherville.

When fully operational in 1983/84, the institute will have a total staff of about 210, 120 of which will be temporary and permanent council employees, and the other 90, researchers from industry and universities. A significant portion of the program will be contracted-out. French will be the working language in recognition both of the milieu and the emphasis on aid to Quebec industry. During the transitional period, the institute has been receiving an excellent response from potential industrial partners and some 69 projects have been identified. About half of these are short-term projects, which the institute has combined into a useful short-term industrial program of technology transfer and direct assistance. All of the projects have been classified into four groups, which may well constitute the initial scientific sections of the institute, as follows:

- The process technology group includes studies of material preparation, forming, solidification, welding and joining and finishing.
- The material characterization group includes projects to develop a competence in standardized and reproducible testing and analysis.
- The materials performance group comprises projects which are concerned with the behaviour of various materials presently in use, from the aspect of their suitability for particular applications as determined from such criteria as resistance to corrosion, wear, aging and fatigue.
- The system and instrumentation group of projects involves the development of computer aids for work in the other three groups. As a means toward increasing productivity, models will be developed for the forming, solidification and welding processes. Projects will be undertaken to assist closed-loop process automation by adapting and developing real-time sensors and transducers to measure process and product parameters. High frequency sensors for non-destructive testing will also be developed.

In order to ensure the industrial applicability and usefulness of its programs the institute will operate in a matrix-type management structure. Operating funds will be controlled by program managers, and projects will be executed by multi-disciplinary teams formed to complete specific projects.

Appendix I

Federal S&T Expenditure Data

Some readers of this publication may wish for an overview of the scope and limitations of the science expenditures data used herein. Additionally, the foremost definitions employed to categorize science expenditure statistics, are given in this Appendix, as well as some details about the collection process.

Collection is undertaken to gather essential data describing the recent, the current, and the proposed state of the federal resources allocated to scientific activities. Data on the scientific expenditures in more than 100 programs of some 60 federal departments and agencies, covering three financial years, are collected annually by means of Science Addenda to the Main Estimates of departments. The focus of attention is on the upcoming financial year; also collected are historical data for the past year, as well as confirming data in respect of expenditures in the current financial year. The collection of such data from the financial administrations of departments and agencies is carried forward by the Ministry of State for Science and Technology (MOSST), in cooperation with the Treasury Board Secretariat and the Science Statistics Centre of Statistics Canada. Statistics Canada maintains the historical expenditure series in: natural and human (social) sciences, and has done so since 1963; historical, regional and other science statistics tabulations are available from that source. Also involved is the Interdepartmental Committee on Scientific Expenditures which is the formal mechanism for necessary liaison, and discussion of broad problems arising in the gathering of federal science expenditure data.

Expenditure Breakdowns

When science expenditure data are collected, departments and agencies are asked for information respecting their various budgetary programs, as defined in the Estimates to be voted upon. A program, or some given activity within it, may be scientific in whole or only in part. It is just the expenditures on scientific components of a program or its activities which are reported upon in the science expenditures survey. Within each budgetary program separate reports are requested for *natural and the human sciences activities* which may occur within it.

Within the major fields of science expenditure, additional breakdowns are made under the major headings of *Research and Development* (R & D) and *Related Scientific Activities* (RSA) which are themselves further sub-divided better to indicate the "how" and "what" of a department's scientific effort. Expenditures on the broad categories of scientific activity (R & D, RSA) are also sub-divided into the "current" and also the "capital" expenditures for such things as new laboratory buildings or major facilities. Furthermore expenditures are additionally sub-divided to show "by whom" and in which sector the activity is performed (e.g., federal intramural in-house, in universities).

The industry sector performance data are further supplemented and expanded upon in the course of the "Regional" Survey undertaken by the Science Statistics Centre, in order to identify both the geographic (regional) distribution of R & D contracts to industry as well as the regional distribution of federal science expenditures.

The "why" of departmental scientific activities is broadly addressed in the Main Estimates Science Addenda by asking departments to identify areas of expenditure application (e.g. oceans, energy), as well as to identify the sector of performance (intramural or extramural). Furthermore, the human resources allocated to scientific activities are summarized in terms of the personnel categories (executive, scientific

and professional, etc.) and the principal foci of their efforts (e.g., R & D, RSA, administration of extramural programs) are also identified.

Comparability

In addition, readers may wish to note that for purposes of the present budgetary analysis it is the convention to deal only with direct expenditures on activities, rather than the total expenditures which would include so-called "non-program" or overhead costs, such as accommodation costs and proportionate share of overall program administration costs. Such exclusion is therefore necessary to provide a consistent base for comparison of expenditures for science and technology with direct expenditures for other kinds of activities in the federal sector. The inclusion of the costs of departmental administration programs for example, if made for S & T activities, would necessitate parallel adjustments to other items as reported in the budgetary process. This publication, therefore, presents expenditures that do *not include non-program costs*.

Nevertheless, there are circumstances in which it is usual to compare total costs of activities, including overheads. For example, if one's purpose is to compare the magnitude of federal S & T activities with those in other sectors or other countries, then it is the custom to include non-program costs. In this context the sum of direct expenditures plus non-program costs represents the "total" cost of the federal scientific and technological effort. With appropriate caution, this figure may be compared with the total spent in industry where all costs, direct and indirect, are reported. For such purposes, among others, *Statistics Canada* publishes *The Annual Review of Science Statistics* (Cat. No. 13-212, and its *Service Bulletins* (Cat. No. 13-003). The intramural expenditures reported in those publications will thus appear greater than in this publication by the amount of non-program costs. The extramural expenditures are not affected and will appear the same in both sets of publications. The grand total for intramural plus extramural expenditures will naturally differ in these two series of publications by the amount of non-program costs.

Terminology

Many of the terms employed in the description of scientific expenditures have quite specific meanings. Activities involving *science and technology* (S & T) are understood to mean those involving the generation, dissemination and initial application of new scientific knowledge and related technology.

Such activities may involve the fields of *natural sciences* or the *human sciences*. The *natural sciences* consist of disciplines 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 "social sciences and humanities": it includes the disciplines involving the study of human actions and conditions as well as the social, economic and institutional mechanisms affecting humans. The human sciences include such disciplines as anthropology, business administration and commerce, communications, criminology, demography, economics, geography, history, languages, literature and linguistics, law, library science, philosophy, political science, psychology, religious studies, social work, sociology, and urban and regional studies.

The two main categories of S & T activity are research and experimental development (R & D) and related scientific activities (RSA). R & D consists of creative work undertaken on a systematic basis to increase the stock of scientific and technical knowledge or to discover new applications for existing knowledge. RSA generally complement and extend R & D. In the natural sciences, for example, the RSA group includes such things as scientific data collection, scientific information services, testing and standardization, feasibility studies, education support and museum services.

Some other terms with specific meanings in this publication are:

a) performer or 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, grants or contributions—*contracts* are legal undertakings between two or more parties for the conduct of S & T activities and the provision of the results of those activities according to an agreed schedule and cost. For most departments, the Department of Supply and Services acts as the contract manager, with the other department providing the scientific or engineering manager. A *contribution* 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; the government does not necessarily receive any goods or services as a direct result.

c) *person years*—a measure of the time actually devoted to the conduct of scientific activities. An employee who is engaged in scientific activities for half a year has, for example, a person-year equivalence of 0.5.

Detailed definitions of terms used in scientific expenditure surveys are presented in the sister publication "Federal Science Expenditures and Personnel 1981/82".

Appendix II

Science Expenditures by Vote for Major Funders

	Vote	Gross Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	Total Voted Estimates 1981/82 $M	Total Voted Estimates 1981/82 PY
Agriculture—Total		**143.9**	**4,057**	**152.9**	**4,053**	**170.1**	**4,075**	**910.4**	**10,616**
Administration—Total	1 & S	3.6	117	3.8	119	4.3	119	35.0	803
Agri-Food Development—Total		132.8	3,700	140.2	3,696	154.8	3,715	682.1	4,623
Operating	5 & S	111.6		124.5		138.1		176.0	
Grants & Contributions	15	4.9		5.2		3.1		492.3	
Capital	10	16.3		10.5		13.6		13.8	
Agri-Food Regulation and Inspection—Total		4.7	148	5.7	146	7.6	149	163.3	4,327
Operating	20 & S	4.3		5.0		6.5		152.2	
Grants & Contributions	30	—		—		—		5.2	
Capital	25	0.4		0.7		1.1		5.9	
Canadian Grain Commission—Total		2.8	92	3.2	92	3.5	92	30.0	863
Operating	35 & S	2.7		3.1		3.4		29.2	
Grants & Contributions	35	<0.1		<0.1		<0.1		<0.1	
Capital	35	0.2		0.1		0.1		0.8	
Communications—Total		**59.3**	**649**	**71.6**	**671**	**57.6**	**651**	**135.7**	**2,025**
Communications—Total		58.6	640	70.9	661	56.8	642	106.0	1,943
Operating	1 & S	31.4		41.6		45.2		91.2	
Grants & Contributions	10	11.0		13.7		4.0		6.0	
Capital	5	16.3		15.6		7.6		8.9	
Arts and Culture—Total		0.6	9	0.7	10	0.8	9	29.7	82
Operating	15 & S	0.6		0.7		0.8		6.4	
Grants & Contributions	20	—		—		—		23.3	
Capital	15	—		—		—		<0.1	
National Library—Total		**14.7**	**500**	**17.2**	**500**	**21.6**	**500**	**21.6**	**517**
Operating	70 & S	14.3		16.8		21.4		21.4	
Grants & Contributions	70	<0.1		<0.1		<0.1		0.1	
Capital	70	0.4		0.4		0.1		<0.1	
National Museums—Total		**50.1**	**1,013**	**53.3**	**1,006**	**56.1**	**975**	**56.1**	**975**
Operating	75 & S	39.2		43.1		46.3		46.3	
Grants & Contributions	80	9.7		9.4		8.9		8.9	
Capital	75	1.1		0.8		1.0		1.0	

Appendix II Science Expenditures by Vote for Major Funders (continued)

	Vote	Gross Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	Total Voted Estimates 1981/82 $M	Total Voted Estimates 1981/82 PY
Social Sciences & Humanities Research Council—Total		**36.6**	**105**	**42.6**	**105**	**45.6**	**105**	**45.6**	**105**
Operating	90 & S	3.5		4.0		4.4		4.4	
Grants & Contributions	95	32.3		37.8		41.2		41.2	
Capital	90	<0.1		<0.1		<0.1		<0.1	
Energy, Mines & Resources—Total		**162.7**	**2,403**	**200.2**	**2,392**	**275.7**	**2,441**	**1,350.0**	**4,269**
Administration	1 & S							16.1	431
Energy—Total		60.5	46	90.0	49	151.1	134	1,168.3	811
Operating	5 & S	3.3		7.2		40.1		92.8	
Grants & Contributions	15	57.2		82.8		108.3		1,064.4	
Capital	10	—		—		2.7		11.1	
Minerals & Earth Sciences—Total		102.2	2,357	110.2	2,343	124.6	2,307	165.6	3,027
Operating	55 & S	94.1		100.7		114.8		153.5	
Grants & Contributions	55	3.1		2.7		2.3		3.5	
Capital	60	5.1		6.8		7.6		8.6	
Atomic Energy of Canada Ltd.—Total		**88.9**	**2,322**	**98.6**	**2,372**	**111.5**	**2,427**	**277.6**	**8,072**
Operating	70 & S	82.9		91.2		100.4		249.2	
Grants & Contributions	70	—		—		—		—	
Capital	75	6.0		7.4		11.1		28.4	
Environment—Total		**220.1**	**4,921**	**249.0**	**4,913**	**286.8**	**4,935**	**599.1**	**11,594**
Administration—Total		1.5	41	1.8	51	1.9	47	34.4	838
Operating	1 & S	1.5		1.8		1.9		34.1	
Grants & Contributions	1	—		—		—		0.1	
Capital	1	—		—		—		0.1	
Environmental Services—Total		207.1	4,688	234.6	4,668	271.0	4,691	319.3	5,699
Operating	5 & S	189.5		206.9		239.8		279.4	
Grants & Contributions	15	6.3		8.4		9.2		16.2	
Capital	10	11.4		19.4		22.2		23.7	
Atmospheric Environment—Total		102.8	2,352	117.7	2,333	133.9	2,345		
Operating		96.9		106.6		120.0			
Grants & Contributions		1.1		1.0		1.0			
Capital		4.9		10.1		13.0			
Environmental Protection—Total		7.1	162	8.1	162	8.2	161		
Operating		6.5		7.6		7.7			
Grants & Contributions		—		—		—			
Capital		0.6		0.5		0.5			
Environmental Conservation—Total		57.4	1,149	58.5	1,148	70.6	1,148		
Operating		49.1		50.1		61.5			
Grants & Contributions		3.3		3.4		4.1			
Capital		5.0		5.0		5.0			
Canadian Forestry Service—Total		39.8	1,025	50.3	1,025	58.3	1,037		
Operating		37.0		42.6		50.6			
Grants & Contributions		1.9		4.0		4.1			
Capital		0.9		3.8		3.7			

Appendix II Science Expenditures by Vote for Major Funders (continued)

	Vote	Gross Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	Total Voted Estimates 1981/82 $M	Total Voted Estimates 1981/82 PY
Parks Canada—Total		11.5	192	12.6	194	13.9	197	245.4	5,057
Operating	20 & S	7.1		7.8		8.6		157.9	
Grants & Contributions	20	—		—		—		0.2	
Capital	25	4.4		4.8		5.3		87.3	
Canadian International Development Agency—Total		**37.4**	**56**	**37.1**	**56**	**41.5**	**57**	**787.1**	**1,029**
Operating	30 & S	2.0		2.1		2.4		46.9	
Grants & Contributions	35	35.5		35.0		39.2		740.2	
Capital	30	—		—		—		0.1	
International Development Research Centre—Total		**36.5**	**217**	**39.0**	**227**	**45.5**	**238**	**47.2**	**353**
Operating	65	0.8		0.5		0.4			
Grants & Contributions	65	35.7		38.6		45.1			
Capital	65	—		—		—			
Fisheries & Oceans—Total		**112.7**	**2,122**	**116.4**	**2,143**	**119.8**	**2,211**	**400.5**	**5,831**
Operating	1 & S	97.9		101.0		109.6		315.6	
Grants & Contributions	10	0.6		0.6		0.5		10.5	
Capital	5	14.2		14.8		9.7		74.4	
Industry, Trade & Commerce—Total		**83.4**	**275**	**99.8**	**344**	**127.0**	**344**	**612.2**	**2,825**
Trade-Industrial—Total		81.3	268	98.6	337	126.1	337	449.8	2,465
Operating	1 & S	6.6		9.7		10.6		150.2	
Grants & Contributions	10	74.7		89.0		115.5		298.5	
Capital	1	—		—		—		1.2	
Tourism—Total		0.3	4	0.3	4	0.4	4	34.4	302
Operating	45 & S	0.3		0.3		0.4		34.3	
Grants & Contributions	45	—		—		—		0.1	
Capital	45	—		—		—		<0.1	
Grains & Oil Seeds—Total		1.8	3	0.9	3	0.5	3	128.0	58
Operating	50 & S	0.1		0.1		0.1		3.1	
Grants & Contributions	55	1.7		0.9		0.5		124.9	
Capital	50	—		—		—		—	
National Defence—Total		**87.1**	**1,895**	**98.5**	**1,934**	**110.2**	**1,935**	**5,906.6**	**117,345**
Operating	1 & S	77.7		90.7		101.4		4,413.6	
Grants & Contributions	10	—		—		—		333.4	
Capital	5	9.4		7.8		8.8		1,159.7	
National Health & Welfare—Total		**58.0**	**1,186**	**66.2**	**1,380**	**74.1**	**1,416**	**17,497.8**	**9,293**
Administration—Total		5.3	111	6.4	111	7.3	111	27.9	608
Operating	1 & S	4.2		4.9		5.2		25.7	
Grants & Contributions	1	1.1		1.6		2.1		2.1	
Capital	1	—		—		—		0.1	
Health & Social Services—Total		16.5	51	18.2	59	17.8	58	6,715.0	548
Operating	5 & S	1.7		2.6		2.9		28.2	
Grants & Contributions	10	14.8		15.6		14.9		6,686.8	
Capital	5	—		—		—		<0.1	
Medical Services—Total	15 & S	0.1	3	1.4	31	1.6	33	218.5	3,259

Appendix II Science Expenditures by Vote for Major Funders (continued)

	Vote	Gross Science Resources 1979/80 $M	1979/80 PY	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	Total Voted Estimates 1981/82 $M	Total Voted Estimates 1981/82 PY
Health Protection—Total		35.6	1,004	39.6	1,162	46.9	1,197	77.2	1,906
Operating	25 & S	33.8		36.8		43.6		75.2	
Grants & Contributions	25	0.8		1.1		1.2		0.1	
Capital	25	0.9		1.7		2.1		1.9	
Income Security—Total	30 & S	0.5	17	0.5	17	0.5	17	10,459.1	2,972
Medical Research Council—Total		**70.1**	**40**	**82.0**	**39**	**88.6**	**39**	**88.6**	**39**
Operating	35 & S	1.4		1.5		1.7		1.7	39
Grants & Contributions	40	68.7		80.5		86.8		86.8	
Capital	35	<0.1		<0.1		<0.1		<0.1	
National Research Council—Total		**201.4**	**3,160**	**237.4**	**3,125**	**274.1**	**3,172**	**266.1**	**3,172**
Scientific & Industrial Research—Total		187.8	2,945	221.2	2,913	254.9	2,946	249.5	2,946
Operating	5 & S	126.3		151.6		170.8		165.5	
Grants & Contributions	15	37.2		38.7		47.4		47.4	
Capital	10	24.4		30.9		36.7		36.7	
Scientific & Technical Information—Total		13.6	215	16.2	212	19.2	226	16.6	226
Operating	20 & S	13.4		16.2		18.9		16.2	
Grants & Contributions	20	—		—		0.1		0.1	
Capital	20	0.1		<0.1		0.3		0.3	
Natural Sciences & Engineering Research Council—Total		**121.0**	**61**	**163.2**	**75**	**182.0**	**81**	**181.5**	**81**
Operating	25 & S	2.2		3.6		4.3		4.1	
Grants & Contributions	30	118.8		159.6		177.7		177.1	
Capital	25	<0.1		0.1		<0.1		<0.1	
Statistics Canada—Total		**122.2**	**4,534**	**148.3**	**4,619**	**230.0**	**5,489**	**222.6**	**5,489**
Operating	10 & S	121.1		147.7		229.4		222.1	
Grants & Contributions	10	<0.1		<0.1		<0.1		<0.1	
Capital	10	1.1		0.5		0.5		0.5	
Transport Canada—Total		**27.7**	**207**	**29.2**	**241**	**30.0**	**210**	**1,682.7**	**18,374**
Administration—Total		8.2	55	9.4	48	11.7	49	81.3	1,679
Operating	1 & S	7.1		8.9		11.5		74.5	
Grants & Contributions	1	1.0		—		—		1.1	
Capital	5	<0.1		0.5		0.2		5.6	
Marine Transportation—Total		9.9	28	11.0	27	11.2	27	472.5	6,391
Operating	10 & S	6.7		6.0		5.6		355.5	
Grants & Contributions	10	—		—		—		0.5	
Capital	15	3.2		5.1		5.6		116.4	
Air Transportation—Total		5.9	122	8.3	164	7.0	133	337.6	10,008
Operating	50 & S	5.2		6.3		4.9		245.9	
Grants & Contributions	60	—		—		—		14.9	
Capital	55	0.6		2.0		2.1		76.8	
Surface Transportation—Total		3.7	2	0.5	2	0.1	1	791.3	296
Operating	65 & S	<0.1		<0.1		<0.1		581.9	
Grants & Contributions	70	0.1		0.1		0.1		205.9	
Capital	65	3.5		0.4		—		3.5	