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Science Council of Canada

April 1973
Report No. 20

Canada, Science and International Affairs

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This report is about the interaction of politics with Canada's participation in international scientific affairs. The focus is on science rather than technology. The problems identified are not amenable to a quick organizational fix, and so we make no cook-book recommendations. Attitudes must change before substantial progress can be made. There are specific problems which we have identified; we state the implications and outline the directions in which solutions will probably be found. However, the attitude, the desire to do better and the willingness to move in these directions must come first. We are optimistic that this is beginning to happen.

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January 10, 1973*

The Hon. Jeanne Sauvé, P.C., M.P.,
Minister of State for Science and Technology,
House of Commons,
Ottawa, Ontario.

Dear Minister:
In accordance with sections eleven and thirteen of the Science Council of Canada Act, I take pleasure in forwarding to you the Council's Report No. 20, *Canada, Science and International Affairs.*

This Report, which deals with the problems of the interface of scientific affairs and international politics, is something of a departure from previous Science Council Reports. The focus of the Report is on the need for new attitudes, rather than on structural recommendations for better coordination. It is recognized that in the complex, ever-changing world of international relationships formal, rigid approaches would fall far short of meeting the challenges, both current and future.

Yours sincerely,

Roger Gaudry,
Chairman,
Science Council of Canada.

*This is the date on which this Report went to the printer.

Summary

High priority is not given to international scientific affairs in either foreign policy or national science policy. Indeed, official reports and documents on the research, science or foreign relations of most countries are eloquent witnesses: the chapter on "international scientific cooperation" is usually the weakest, squeezed in somewhere at the end, often garnished with lofty and virtuous but unsubstantiated statements. Ritualized adherence to the truism that science is intrinsically non-political enters into conflict with the inescapable need to demonstrate the international effort's social usefulness (which means, in most cases, the need to identify benefits accruing to the nation).

There is an obvious reluctance to recognize openly that the advances in science and technology raise as many possibilities of conflict as they create opportunities for cooperation, and that international scientific and technological affairs cannot be separated from political activities. Participation in international science and technology is but one instrument among many with which to defend the nation's interests and to create its image at the international level. Regardless of the impact that science and technology can make in a particular sector, the choices that governments have to face are basically political. Although scientific and technical aspects have to be thoroughly understood in order to deal successfully with a problem, many purely political factors will nevertheless have to intervene in the shaping of final decisions.

Within the area examined by this report, science enters the international scene in at least four ways:

1. As the force binding individual scientist to individual scientist, resulting in the "international community" of international science: This occurs in a variety of ways, including non-governmental organizations, and is largely self-organizing. The external constraints and controls may comprise merely decisions on the amount of money available to support travel and collaborative endeavours. It is an important, highly specific vehicle for information exchange, and should be encouraged.

2. As an organized activity which appears largely through the specialized agencies of United Nations and similar intergovernmental organizations: This involves substantial amounts of money and many man-hours; it has chiefly been carried out by scientists in government aided by scientists from universities. Hopefully, the development of an industrial strategy will bring a larger involvement of Canadian industry. Better coordination, improved information flow in both directions, and better linkage with External Affairs and the Ministry of State for Science and Technology are urgently required. Priorities need to be set.

3. As an optional strategy for the diplomatic contacts between countries: Bridges can be built through scientific contacts, hockey games or ping-pong matches; frequently, scientific contacts will be found to be the best option. In this context, the scientific content of the discussion is of secondary importance. Much better contact and understanding between the diplomat and the scientist is needed, but so far the surface of the problem has hardly been scratched. Overall coordination belongs to the

political sector; that is, to the Department of External Affairs or, on vital issues, the Cabinet. The scientific expertise remains in the mission-oriented agencies or the scientific community at large. Foreign relations – no matter in what field – cannot be left to the well-intentioned amateur. However, the foreign service will need to collaborate with the specialist.

4. As an input in aid programs to developing countries: Canada has an acceptable record in this area and communications are reasonable, but the strategies are undergoing re-evaluation by both the giving and the receiving nations. The Canadian International Development Agency (CIDA) and the International Development Research Centre (IDRC) should play critical roles in this process.

The role of science and technology will continue to expand. It is probable that, not more than ten or twenty years from now, the locus of decision-making in many sectors will have to shift from the national to the international level. Sacrifices of national sovereignty may become necessary. Thus, the need to develop a capability for properly assessing costs and benefits, in both the political and the scientific spheres, will be increasingly felt. The Science Council believes that, in order to be better able to integrate Canadian science policy considerations with international affairs, it is essential to act at three important levels:

1. Canada must develop the *mechanisms* necessary to obtain an overview of the extent of Canadian participation in international scientific affairs. It is therefore essential to establish a centralized information service on participation in scientific affairs. The Ministry of State for Science and Technology is the appropriate Ministry for assuming this responsibility, since it appears to be the link between Canada's scientific representation abroad and national needs and opportunities. It must be remembered that there is normally an obvious logic in assigning responsibilities to various government departments and agencies – and that this logic should prevail over artificial attempts at coordination. It is imperative that Canadian representatives to international meetings be briefed by and report to the agency or agencies most directly concerned with the substantive issues while, of course, keeping the Department of External Affairs and other interested parties informed.

2. Mechanisms such as those described above must then be used as a *basis for selecting* those domains of international scientific affairs where Canada feels it wants to participate. Selectivity must of course depend not only on the needs of the scientific community and on those areas of scientific expertise necessary for industrial development, but also on the overall appreciation of our national interests (e.g., our concern with "transnational phenomena" such as environmental problems). It is only through such an appreciation that we can fully assess the potential benefits which may accrue to Canada by extending national policy to the international level.

3. It is through such an integrated outlook that science can become a truly useful *instrument for foreign policy* and help Canada decide on its role vis-à-vis the advanced and the less developed countries. An essential prerequisite to policy-making in this area is the availability of persons having a particular blend of scientific and diplomatic expertise. In order to obtain

the best possible results from such individuals, there is a needed mobility in highly flexible structures. This, of course, can come about only through a change in existing attitudes (people should modify structures, and not vice-versa); the basic problems are in the attitudes and minds of people. Both scientists and diplomats must recognize the plurality of goals and the areas in which each has greater competence than the other. In bringing this about, the Ministry of State for Science and Technology must play both a catalytic and a coordinating role, but no mechanisms will work well until attitudes are changed.

This report is but a first, "broad-brush" attempt to shed some light on the complex issues surrounding international scientific affairs. A better appreciation would undoubtedly come about through further studies in such particular areas as the workings of the "invisible college", the organization of scientific representatives abroad (e.g., attachés), the specialized needs of particular disciplines (e.g., oceanography) and the role of federal-provincial relations in those particular areas of national policy which fall under provincial jurisdiction.

Such studies could lead to better coordination of Canada's efforts in international science. However, continuous refinement of coordination mechanisms would rapidly reach the threshold of diminishing returns. It has become a habit, and is tempting indeed, to throw the blame for half-successes and for failures on the lack of adequate coordination, when it would be more realistic to take a harder look at the quality of the competing substantive inputs. Without giving undue praise to the vision of a "fertile chaos", little benefit would come from the stifling universe of perfect coordination. The importance of coordinating mechanisms should not, in any case, be overstated. Scientific and technical excellence cannot be brought to bear on a country's domestic standing and its international position, unless attainable objectives are clearly defined. In other words, there is – to paraphrase the Brooks Report[1] – no technical, managerial or social substitute for the expression of political will.*

There is an important technological dimension to this whole subject which involves the commercial counsellors, as well as the scientific attachés at our embassies, Canadian industry and the multinational corporations. This side of the problem is not probed by this report. The issues in this area are extremely important, but in order to provide a discrete focus for the report, a decision was made at the outset to concentrate on international science only.

*All reference material will be found in the section entitled "Notes and References", pages 48-49.

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Introduction

Science has become relevant to international politics. New challenges have arisen, in addition to the more traditional concerns of national security and economic competition. New scientific and technological capabilities have evolved – capabilities which at times create opportunities and problems that cannot be dealt with on an exclusively national basis. In the network of international relations and commitments, scientific and technological matters play an increasingly important role.

Canada's international relations actually reflect the general trend. Canada has adhered to the growing number of international treaties and organizations in the area of science and technology. Delegations travel back and forth to attend meetings, to observe developments abroad, to discuss and to negotiate. Already heavily involved on the multilateral level, the Canadian government now seems to be on the point of embarking on a policy of bilateral agreements, where scientific cooperation holds a prominent place. At the same time, international scientific relations of the so-called non-governmental (but nevertheless, generally government funded) type are increasingly being established in almost all fields.

While, in principle, nobody seriously questions the need for Canada to participate in international scientific affairs, the government's actual efforts to assure this participation are meeting with growing scepticism. In the mounting tide of criticism, three issues emerge very clearly:

a) the *randomness* of government policy in this field;

b) the *lack of coordination* between the different sectors and the different levels of activity;

c) the *inadequate input of scientific expertise* into the political process.

This report focusses on the questions raised by these criticisms. It is therefore concerned with the interaction of scientific activities with politics; that is, it deals with the interface where Canada's participation in international science enters into collaboration, competition, or conflict with Canada's policy in other sectors of international and domestic affairs.

Science, not technology, is the focal point of the report. It should be kept in mind, however, that no neat line can be drawn between science and technology. Part of the problem hinges on the complex, chicken-and-egg-type relationship between the two and the semantic problem of clear-cut meaning. However, we must also recognize above all that in the last analysis it is concern about technology which makes science policy one of today's most topical issues.

It is essential at the outset to clarify the term, *international scientific affairs*. In its broadest sense, it reaches far beyond mere international agreements, organizations, joint projects, academic meetings, exchanges and travel. Intellectual migrations, information transfer and the particular access road to the advanced technology of foreign countries which is offered by the multinational corporations are other, and certainly not less important, ways of participation. There is little doubt, however, that these latter activities can escape more easily from what is to be regarded as the main concern of the following analysis: improvement of the current situation by rational policy-making.

A major concern of this report was to look beyond the details of alleged or actual shortcomings and to elucidate the more general aspects of government policy in the field of international relations in science – or, in other words, to explore the difficult problem of *integrating international scientific relations into national science policy on one hand and into foreign policy on the other.* The current dialogue between the Ministry of State for Science and Technology and the Department of External Affairs is an indication of the seriousness of the problem.

There are some good reasons to doubt that the inherent complexity of the problem will allow for any general theory or fool-proof organizational set-up. What is needed first is a *new attitude to the problem*, a new way of looking at it, and, above all, a realization that there is no substitute for clear articulation of goals and objectives, difficult and humiliating though the exercise may be.

Goals, objectives, overlapping margins of expertise, availability of information, and clear and focussed thinking by bright people are the essential ingredients. The necessary friendly environment will be a willingness by those departments, agencies and institutes holding entrenched positions to have a new look at the situation. It is important that we do so.

I. Concepts and Facts

Trends

International relations in science have a long tradition. Originally, they were of an essentially private nature, involving individuals, learned societies, or institutions. The objectives of international scientific interchange were obvious and non-controversial: collaboration, exchange of information, intellectual enrichment, etc., with well accepted side effects of individual and collective self esteem. Political benefits resulted from the ensuing prestige and, consequently, governments and the public vicariously enjoyed the glory of the scientists. Official involvement with international scientific activities was limited to what would today be called elements of "cultural foreign policy", concern for scientific prestige abroad. Public support of the international movement of science and scientists was slight, and the activities of intergovernmental scientific organizations or institutions (such as the International Bureau of Weights and Measures, or the International Institute of Agriculture) were relatively unknown.

The years between the First and Second World Wars brought new perspectives. The First World War had shown science and scientists to be a national resource whose potential extended beyond military concerns. While public expenditure remained rather low, and the organization of research in most countries did not develop beyond loose and half-hearted efforts, the economic relevance of science had become a matter of public discussion. In March 1918 George E. Hale, the astronomer who was Foreign Secretary of the U.S. National Academy of Sciences, had already told President Wilson that America would not be able to "compete successfully with Germany in war or peace unless [she utilized] science to the full for military and industrial purposes"[2]. And Fritz Haber, the chemist, considered Germany's future to be dependent on manpower productivity, which was in his view "totally dependent on our scientific knowledge"[3]. This new concern challenged the traditional political value of prestige in international science.

However, the really decisive change in perception of the international significance of science took place in the wake of the Second World War. Science as a national resource – economic and military – now became a recognized field requiring government support. National access to the whole spectrum of international scientific knowledge was considered to be necessary. But, along with the recognition of the need to participate in international scientific affairs, the suspicion grew that "spying" was possible through the channels of traditional scientific intercourse. This resulted in a reluctance to share too much national knowledge in international collaboration in the applied sciences. New sets of goals – economic and military – were thus definitely added to the concern, centred mainly in the scientific community, for national prestige and about the functional objectives of technical government agencies working in areas where phenomena were transnational in character (e.g., meteorology, seismology, telecommunications, public health).

The impact of scientific activities on international relations was considered from a quite different viewpoint as well. It was generally understood that excessive nationalism and ideological irrationalism had played a

decisive role in the genesis of the Second World War. On the grounds that "war begins in the minds of men"[4], UNESCO launched its impressive program of fostering mutual understanding through education, science and culture. The idea that wars should be replaced by methods of rational problem-solving and that conflicts should be prevented by better mutual knowledge among the world's nations had been championed since the end of the 19th century. Among the ways of promoting this mutual knowledge, much attention was given to the impact of common professional training and activities, common intellectual interests, and common moral concerns. In the 1930s, functionalism[5] emerged as a doctrine; it has since then contributed to spreading the belief that international collaboration in specialized, or "functional", fields would, in the long run, dispose of nationalism by creating transnational loyalties.

In the years following the Second World War, international cooperation on a functional basis became perceived as a good thing *per se*, since it was thought to promote mutual knowledge and thus to contribute to international peace. Beyond the fact that science was, as an intellectual endeavour, particularly suited to enhancing mutual understanding, it has already built an impressive record in the field of international cooperation. It is therefore not surprising that science was considered the central thrust in the movement toward a peaceful unified world.

It may be naive to assume that the governments were always completely convinced of the merits of international scientific activities. But, due to the general historical context of the Fifties and Sixties, the "spirit of collaboration" became a powerful norm of behaviour; consequently, the mere gesture developed into an instrument of great usefulness.

Decolonization was perhaps the major historical event of the postwar period. In the wake of formal political emancipation, more fundamental problems of national existence were to arise, especially those of economic viability. The role that science and technology had played in the development of the advanced Western societies is too obvious not be considered as a model for the countries of the Third World. Transfer of scientific and technological capabilities has become an important element of international aid programs, thus adding a new dimension to the traditional forms of scientific cooperation.

Science and politics both extend beyond national boundaries, but their international dimensions develop according to quite different rationales. This fact accounts for most of the current haze of ambiguity that surrounds the problem of national participation in international science. For a long time, international scientific relations were so marginal to foreign policy, and foreign policy so marginal to international science, that problems of overlapping or conflicting rationalities arose only occasionally. This began to change in the last decade. There can be no doubt that traditional attitudes toward national participation in international science – *laissez-faire* or half-hearted coordination – are increasingly challenged by technological advances and changes in the national and international environment. One has to admit that it is only recently that Canada's participation in international scientific affairs has entered the arena of public debate. This interest is still largely derived from the attention given

to other matters: concern over the economy, debate over public expenditure, criticism regarding the planning and conduct of foreign policy. But there is also a growing awareness of the transnational character of many areas related to science and technology: protection of the environment, uses of outer space, marine resources, the earth's atmosphere, intercontinental communication.

Since accepted doctrine and institutions are, as usual, lagging behind current reality, governments of scientifically and technologically developed nations like Canada now face the necessity of defining new policies and monitoring activities in a field where vested interests have for a long time been accustomed to being the unquestioned suppliers of "national goals". Governments have therefore to develop a new blend of expertise. However, no country so far seems to have achieved the symbiotic combination of scientific and political expertise that is needed.

On the international political scene, Canada is a newcomer among the industrialized countries. This could turn out to be an advantage, in that it gives a greater chance to be innovative in an emerging field of international politics, in which Canada commands considerable assets.

Inventory

Intergovernmental Relations

At first sight, Canada's record is impressive. This country is present in almost all intergovernmental organizations of some significance.[6]

Canada belongs to all organizations of the so-called "United Nations Family" and is consequently a member of the various Specialized Agencies. It participates in joint programs which have been launched within the framework of these organizations, such as UNESCO's International Hydrological Decade (IHD) and the World Meteorological Organization's (WMO) World Weather Watch (WWW). Canadians sit in the scientific committees reporting to the UN General Assembly, to the Secretary General or to the Economic and Social Council (ECOSOC). Canadian delegations attended all the great United Nations Conferences, such as the four International Conferences on the Peaceful Uses of Atomic Energy, the Conferences on the Application of Science and Technology to the Benefit of the Less Developed Areas (1963), and the Stockholm Conference on the Human Environment (1972), and are participating actively in the preparatory work for the forth coming Law of the Sea Conference.

Regional organizations such as the Organisation for Economic Cooperation and Development (OECD) and the North Atlantic Treaty Organization (NATO) have developed concerns and activities with scientific and technological content. Committees relating to scientific problems have also been established within the Commonwealth structure. Canada participates.

Outside the United Nations and the regional systems, more than fifty intergovernmental organizations are listed as devoting themselves to scientific or technical matters. Canada is a member of virtually all of them, from the International Bureau of Weights and Measures to the International Whaling Commission and Intelsat.

It is only recently that public attention has focussed on bilateral agree-

ments in the field of scientific and technological cooperation. Four such agreements were signed in twelve months: two with the Soviet Union, one with the Federal Republic of Germany, and one with Belgium.[7] The four agreements are so called "umbrella agreements", frameworks for particular cooperative ventures which they encourage and facilitate. Scientific relations are not restricted to this particular kind of legal instrument. Science and technology are the bases for other – some half hundred, in fact – more specific bilateral agreements, especially in the field of atomic energy, defence research and cultural exchange.

Academic exchange, for example, has been established as part of intergovernmental cultural agreements or, in the special political context of the East-West tensions, by informal understanding between the National Research Council and the Academies of Sciences of the Soviet Union (in 1958 for the first time) and Czechoslovakia (1970). Since 1949, the Commonwealth Scholarship Program provided the legal basis for another specific form of exchange.

To the list of formal agreements must be added those which are concluded by exchange of notes and the numerous informal arrangements which are made at the departmental level or between provincial and state governments. This type of bilateral relations has developed especially between Canada and the United States.

Science and technology are also involved in Canada's foreign aid commitments. Although the contribution of science and technology to foreign aid is difficult to compute in detail[8], it should not be forgotten when considering Canada's overall effort in international scientific affairs. By granting to scientists from the less developed countries the CIDA-NRC Research Associateships, CIDA and the National Research Council contribute to the solution of one of the major problems which beset the advance of science and technology in the countries of the Third World: the isolation of their scientists from the mainstream of work at the research front.

Non-Governmental Relations

Proper evaluation of activities in this sector creates problems of definition. "non-governmental" does not necessarily mean "private". An overwhelming portion of so-called non-governmental scientific relation is, in fact, financed by public money (federal or provincial). Government influence is, theoretically at least, possible and is, therefore, already the object of some debate.

Canada's membership in the International Council of Scientific Unions (ICSU), the major international non-governmental organization in the field of science, has a long tradition. Canada was, in fact, among the founding members of the ICSU's predecessor, the International Research Council (1919). It is a member of the affiliated Unions, and usually participates in such comprehensive endeavours as the International Geophysical Year (IGY), the International Biological Programme (IBP) and the Joint ICSU-WMO Global Atmospheric Research Project (GARP). ICSU has also initiated the creation of a number of Special Committees in which Canada

is represented.[9] Outside the ICSU system, Canada belongs to the two other great federations of scientific societies, the Council for International Organizations of Medical Sciences and the Union of International Engineering Organizations, and has adhered to about two-thirds of the identifiable international non-governmental organizations and associations devoted to scientific subjects.[10]

Formalized relations are, of course, only part of the network which links Canada's scientific effort to that of other nations. Little is known in detail about the orientation and intensity of individual relations. This is obviously an area requiring a study. It is unquestionable, however, that the figures for official academic exchange[11], for example, are far from giving a reliable picture of the movement of scientists and students from and to Canada. They have to be put into perspective by taking into account temporary movements of scientists and students which are not covered by official agreements. Statistics show that 40.9 per cent of the Canadian graduate student population in 1970 were foreign.[12]

Rank and Potential

Questions regarding scope and volume are, however, only part of any evaluation. In the final analysis, it is not the quantity of relationships that matters, but their quality. In other words, it is not the number of organizations, committees, joint projects, agreements or scientific exchanges which deserves critical evaluation, but the degree of actual involvement in their activities.

The quality of this involvement rests mainly on three conditions: the level of participation, the expertise of national representatives and the ability (will and mechanisms) to integrate this participation with all other national efforts. The second and third points will be discussed later. What can be said about the level and the intensity of Canadian participation in international scientific affairs?

In-depth case studies would be needed to give a reliable answer to this questions. The crude, but so far the only, available indicators of the Canadian contribution are: the number of positions held in the organizations (executives, permanent staff, temporary experts, chairmen and secretaries, on assemblies, committees or working groups); the number of documents submitted to the organizations and their meetings; attendance (strength and delegations); or playing host country (to international organizations or their meetings).

In both governmental and non-governmental organizations, Canada ranks rather high in the lists of the member states[13]: 6th or 7th at the average, if attendance of meetings, participation in committees or working groups, are considered. With the exception of some strong, although isolated, variations, Canada's position never seems to fall below the tenth. Among host countries to international scientific congresses, Canada ranks 7th, although at some considerable distance from the preceding countries. From 1950 to 1965, the total number of international scientific congresses roughly doubled every seven years, but the growth rate levelled off to 7.6 per cent for the last seven-year period. Canada has been a host to a fairly

even proportion of these congresses – 2 to 2.5 per cent. In the Cold War period, mainly because of the U.S. State Department's more restrictive visa policy, a certain number of scientific congresses gathered in Canada which otherwise would have taken place in the United States. This may explain why Canada attains the highest percentage – 2.5 per cent – in the Fifties and why, from 1961 to 1965, Canada's share did not quite keep up with the general increase. However, Canada did host considerably more in the period from 1965 to 1970, with a peak in Centennial Year 1967.[14]

Quantitative evaluation of national participation in international scientific activities has, of course, only indicative value; it does, however, provide a useful check for current opinions which are entirely impressionistic. At first sight, Canada's rank among the other participating countries seems surprisingly high. Will those critics who denounce Canada's involvement in international scientific affairs as excessive and out of proportion with her means be proven right? How can a country's means be correctly evaluated?

Objective evaluation of scientific productivity has been attempted for generations. Counting memberships in foreign academies was once very popular. In the 19th century, and during the First World War, belligerent countries lined up their famous scientists and their Nobel Prizes to show the world the superiority of their national genius. Methods have been refined since then: investment in R & D, strength of scientific manpower, etc. have also earned recognition as useful tools for comparison. On the output side, counting discoveries, patents and licence fees has lost a great deal of its significance, since high mobility of brain-power makes it more and more difficult to assign "national origins" to particular advances. This lack of significance is compounded by the fact that an increasing part of technological innovation is transferred within the system of multinational corporations.

Counting published papers may be an absurb device for evaluating individual scientists, but it has by now become a recognized yardstick by which to compare the scientific productivity of nations.

Canada's share of abstracted papers in chemistry (and related fields) oscillates just above the 2 per cent mark, yielding a ninth place on the ranking list.[15] In 1971, Canada ranked 6th on the list of 148 countries arranged by number of publishing authors – ten times less than the United States, slightly more than Japan, four times more than Czechoslovakia.[16]

Consideration of the number of abstracted papers or publishing authors by number of inhabitants may be more enlightening: for every 10 000 inhabitants, Canada produces roughly 2½ abstracted papers (in *Chemical Abstracts*) – about 20 per cent more than Japan or France, and 45 per cent less than the United Kingdom or the United States. Considering the ratio between publishing authors and number of inhabitants, Canada ranks very high, with four publishing authors per 10 000 inhabitants – slightly more than the United States and other countries of the top group, such as the United Kingdom, Sweden or Switzerland.

Comparisons of publishing authors have the unquestionable advantage of being based on clear definitions. However, the significance of such comparisons is challenged on the grounds that the number of publishing

authors does not provide a reliable indicator for the strength of scientific manpower in a given country. In fact, as can be seen from the following Table, the Canadian picture darkens slightly when per capita ratios of qualified scientists and engineers are compared, for example.

Table 1 – Qualified Scientists and Engineers (QSE) in R & D, 1967

Country	Total Number of QSE in R & D[a]	Total Population[b]	QSE per 10 000 Population
U.S.A.	537 273	199 118 000	26.98
Germany	61 559	59 879 000	10.28
France	49 224	49 866 000	9.87
Canada	19 350	20 441 000	9.46
Sweden	7 395	7 869 000	9.39
U.K.	50 345	55 202 000	9.12
Belgium	7 945	9 581 000	8.29

Sources:
[a]OECD, 1970, Document DAS/SPR/70.48, Table VII (full-time equivalent).
[b]OECD *Observer*, February 1969.

Canada's obvious excellence in the academic sector is still more puzzling, if one looks at the origins of the Canadian scientific community. Neat definitions are difficult because of the strong interpenetration between the Canadian and the United States scientific communities. It is an increasingly accepted idea by now that Canada has passed from the state of a "peripheral" scientific power – that is, from a country where scientists finish their training in universities or laboratories in a "central" country, with a high scientific reputation – to that of a "central" scientific power. This should mean that Canada is autonomous in its training and standards, and in its choice of problems and publications.

There may, however, be reasonable doubts that Canada has yet fully completed the transition. Of the publishing scientists resident in Canada in 1971, less than 25 per cent had their articles published in Canadian journals.[17] More than half of the faculty members [18] in Canadian universities and of the scientific staff of the National Research Council got their final degrees outside Canada. This may vary from discipline to discipline, from institution to institution, from region to region, but the proportion of Canadian final degrees in the physical sciences, in engineering and in the life sciences settles at an average just at the 40 per cent mark.[19]

The phenomenon certainly deserves more detailed study. It should be recognized that quantitative analysis yields valuable indicators, but not the full array of relevant facts. Nevertheless, Canada's involvement in international scientific affairs cannot be considered without taking into account this background of heavy dependence on imported expertise. The question should at least be asked whether a country, which in some respects still seems scientifically rather peripheral, can afford a degree of international activities which brings it so close to scientific "great power" rank.

Ranking – which is, nevertheless, a useful tool of analysis – is no substitute for thoughtful evaluation. Comparisons show only the degree of conformity or dissimilarity of a country's situation or behaviour with respect to those of other countries. In the highly complex field of science

policy, and especially where it acquires an international dimension, problems are too closely linked to the political, economic and social texture of a country to make analogy a useful tool for action. It would be hardly advisable, moreover, to emulate other countries at the very moment when, in virtually all advanced countries, past policies dealing with participation in international scientific affairs meet with growing skepticism.

II. Goals and Criteria

What is Canadian participation in international science expected to yield?

This question is difficult to answer without reference to the general problem of national goals. Basically, governments try to secure access to international science for the national pay-off they expect to derive from it. In this perspective, a national contribution to international knowledge appears to be merely the necessary price of admission. The fundamental criterion of the profitability of participation in international scientific affairs is therefore the national benefit which it is able to generate.

But according to what criteria is this benefit to be evaluated? According to the criteria of the scientific community – to those of the mission-oriented departments – to those of the technology-intensive industries – to those of foreign policy – or to those of political leaders? Their criteria may be the same and their priorities may be compatible, but this is not necessarily so; it is only via very tortuous paths, if any, that some of the aforesaid benefits may accrue to the nation as a whole.

It would be belabouring the obvious to demonstrate that, stripped of generalities, "national interest" reveals itself as a wooly concept, feeding on successive layers of accepted truths handed down from former generations. This comment on "national interest" applies to science policy as well as to any other field, including international relations in science. Nineteenth century élitism still flavours much of the debate on public support for basic research and the political bearing of scientific universalism; the science-technology-prosperity argument remains largely axiomatic in spite of the fact that the principle of economic growth itself comes increasingly under fire. There is little doubt that the mystique of national goals still conjures up fundamental unity when, in fact, political, economic and cultural disparities have long since undermined the sense of a common purpose. When it comes to day-to-day realities, no one foregoes his exclusive right of interpretation.

Areas of Concern

Growing disillusionment with the achievements of international scientific and technological organizations and concern over rising financial commitments in this area have led to the formulation of a general guideline which, at first sight, appears to be quite a useful criterion: international scientific activities should be initiated and pursued according to the goals and priorities of national science policy, since such activities are in fact the extension on the international level of national policy. This would, indeed, be a useful criterion, provided national science policy had grown beyond the state of honest concern and haphazard actions: in other words, provided that the goals and priorities of national science policy had been clearly stated.

When the concept of science policy is extended beyond a "policy *for* science", then it becomes hopelessly intertwined with problems of industrial strategy, balance of trade, manpower policy, concepts of education and the still highly subjective debate over "quality of life". This complex web of interactions is widely recognized in the field of national science policy. But there seems to be a temptation in science policy-making circles to

leapfrog domestic entanglements by focussing attention on the international scene. The hope is that, by initiating international action away from domestic preoccupations, goals and priorities will emerge more clearly at the periphery than they do in the middle. However, instead of becoming easier to handle, problems grow even more complex on the international level. Dealing with the general question of national goals from the periphery is bound to be non-productive, if not counter-productive!

Goals for Canada's participation in international scientific affairs have to be linked to specific concerns, such as:

a) the requirements of Canadian science in its own right;

b) the effectiveness of Canadian activities which depend on scientific inputs;

c) the safeguarding and advance of Canadian interests in a context where science can serve as a useful instrument.

It is not possible to show the full array of problems linked to each sector of concern just described. Some selected examples should be enough to highlight fundamental issues.

Science in its Own Right

Advancement of knowledge (especially the study of phenomena which are intrinsically transnational), mutual intellectual enrichment, enhancement of the quality of scientific life – these are the non-controversial goals of national participation in international science as they are perceived by the members of the scientific community. Rapid advances in many fields have given unprecedented importance to person-to-person interaction, discussion and collaboration. More direct contacts have become necessary to keep abreast of scientific developments: more travel, more meetings, more coordination and, with equipment becoming more and more expensive, more joint ventures on an international cost-sharing basis.

After years of almost unquestioned expansion, however, increasing costs are now hitting a level where greater selectivity becomes imperative. In political circles and among the informed public, science is no longer viewed as an infallible instrument to generate collective wealth and welfare. International collaboration will not escape the lean years which are looming large on the horizon for a number of sectors of scientific research at the national level.

The costs of international scientific cooperation should not be calculated exclusively in terms of financial expenditure; active participation in international scientific affairs also draws on human resources. Smaller countries, including Canada, have to face the risk that attendance even at only the most important international conferences or working sessions, plus travel abroad for information or research purposes, may leave nobody at home to mind the store. At least, it can dissipate the energies of a country's most sought-after scientists. Larger countries can also face this problem in emerging areas in science and technology.

When it becomes obvious that one has to restrict, or at least to direct, international activities and commitments, on what criteria is selection to be based? Should priority be given to undertakings in fields where Canada's

excellence is already well established or, instead of reinforcing the Matthew effect[20] of giving to the rich, should participation in international science be directed toward fields which are lagging behind? Choices of this kind depend quite clearly on, and have to be consistent with, criteria which have been agreed upon at the level of national science policy. It has to be kept in mind, nevertheless, that Canada contributes only a small fraction, perhaps less than 3 per cent, of the total world effort in scientific research and, like most countries, has to import much of the knowledge needed. Thus, it is important that Canada have a sufficiently large and competent scientific population, linked to the international scene either formally or informally through the so-called "invisible colleges", which can be relied upon to act effectively as the country's sensorium in fields which have been recognized as relevant.

The definition of relevance, however, has become increasingly controversial. After a long period of virtually unchallenged autonomy, scientists are now denied the monopoly of expertise in matters of research policy, its orientation, its organization and its consequences. Sobering views are publicly expressed in the framework of official bodies like OECD; for example, the Brooks Report points to the fact that international cooperative research "has often been initiated by successful pressure groups of specialists in particular disciplines... rather than for reasons of overall policy, involving more systematic review of alternatives".[21]

In other words, goals of international scientific cooperation have to be evaluated with reference to broader objectives. The broader objectives most often cited are directly linked to the second of the three areas of concern mentioned above: the effectiveness of Canadian activities which depend on scientific inputs.

Scientific Inputs

Industrial Development

Innovation has become the focal point of science policy in all industrialized countries. If the priorities of a Canadian industrial strategy are set, they will then be fed back into the process of science policy-making and help to define guidelines for international activities. This should not be understood exclusively in the sense that a country like Canada has to draw on all available sources of information, to acquire by exchange foreign knowledge and techniques, in order to remain competitive in the international technological race (if indeed this goal survives the scrutiny it is presently undergoing). The relationship is more complex than that: the success of an industrial strategy is probably more dependent on possibilities of sales than it is on possibilities for production. Scientific competence can be a valuable asset on that very level, because international research collaboration is being traded for access to foreign markets.

The image of the scientifically advanced middle power which Canada projects on the international scene, and especially in some international organizations, suggests objectives in the science-cum-industry field which might deserve greater attention. It has to be kept in mind, however, that a considerable proportion of Canadian high-technology industry escapes science policy-making at the government level. As subsidiaries of foreign-

owned or multinational corporations, such industries are easily geared to particular sets of corporate priorities, and customarily rely, by their very nature, on autonomous networks of international collaboration. Industry-related criteria for international scientific activities cannot realistically be defined, therefore, without taking into account the narrow margin of manoeuvrability. This applies to multilateral as well as to bilateral relations, to industrial research as well as (and even more) to the important sector of defence research in which, due to Canada's international commitments, the margin of manoeuvrability is virtually nil.

International Regulations

What is the weight of science in the expanding field of international treaties, agreements and regulations concerning transnational phenomena such as those related to the atmosphere, to the oceans or to outer space?

The identification of the prospects and the limits of economic and military exploitation, and of potential threats to national interests (or national security), has to rely so heavily on the contribution of science that advanced research capabilities in a given field constitute a major national asset. Results of scientific research are no substitute for political decisions, but they are an invaluable basis for rational action. In such areas as jurisdictional problems relating to the Continental Shelf, navigation in the Arctic Ocean and joint ventures in outer space, the quality of decisions depends to a great extent on the scientific expertise which the country is able to muster. Where international regulations involve acceptance of certain standards – which is usually the case – Canada must be able to assess whether these standards interfere with national interests (e.g., with the marketability of Canadian products).

Science and technology provide an increasing array of instruments and methods which interfere with the world's natural environment. The problems that arise will be essentially transnational in character, and an increasing amount of international collaboration will be required to find and to implement appropriate solutions.[22] It remains imperative for an advanced country like Canada to build up and to maintain scientific excellence in the fields to steer a difficult middle course between well-understood national interests and international solidarity. (The more elegant diplomatic terms of an official document would say, to contribute to the international effort of creating the necessary legal framework, "if the danger of chaos of lack of law, hindering orderly and equitable development, is to be avoided".[23])

Science as an Instrument of Foreign Policy

Science is a power factor.

The relationship between scientific excellence and national wealth may be difficult to demonstrate in detail. Even if the technological race is denounced by some as a dangerous delusion, economic growth is still the master goal of all official science policies. And who would deny, in the atomic age, the intimate relationship between scientific capability and military strength?

A nation's scientific excellence therefore does not fail to impress

potential or actual allies and enemies – as an indicator not only of its economic and military potential, but also of its intellectual vitality. Scientific achievements and cultural attractions are highly valued assets in the competition for international prestige. Cultural foreign policy has enjoyed widespread popularity and, before the "moon-doggle" raised the problem to the level of astronomical expenditure, the question of comparative cost-benefit (i.e., the possibility of alternative use of funds) had never been seriously debated. There is little doubt that Canada's political acceptability and reputation as a scientifically and technologically advanced middle power might on occasion confer an advantageous position on international markets where, for example, potential customers may shun dealing directly with the United States.

It is in this context of United States predominance in world science and technology, and its overwhelming presence on the Canadian scene, that Canada's scientific competence acquires an important political dimension. As the White Paper on Canada's foreign policy[24] states, with some resignation, "It is clear that in the absence of conscious effort most scientific and technological activities in Canada will remain largely oriented toward the United States, in keeping with the dominant north-south axis of the economic relationships between the two countries....It is not realistic to imagine that the present trends could be changed 90 degrees in direction, even if it were deemed desirable to make the attempt, but there would be much merit in seeking to develop at least some measure of countervailing influence." Here lies one of the most crucial issues on this country's political agenda.

Beyond commercial advantages and political leverage, scientific capabilities may enhance the country's international position as a whole. Scientific prestige usually generates flows of information and collaboration which are certainly among the most unobtrusive ways of "opening doors" and are, as such, greatly appreciated in foreign policy. This aspect of enlightened self-interest is usually under-emphasized. The alleged apolitical nature of scientific enterprise is brought to bear on foreign policy in yet another respect: the fact that experience has shown that science as a universal language of discourse can bridge political and ideological differences has not been lost on political leaders. Again and again, scientific relations have served as substitute for otherwise inachievable political contacts. Politically unobtrusive, they perform – even better than ballets, orchestras, ping-pong or hockey teams – the valuable function of signals in the complex game of international politics.

Friendly relations and partnerships are encouraged by more intensive communication between scientific élites and, generally, the mosaic of relationships that the international scientific community spreads over the world helps to keep alive the atmosphere of *détente* which is one of the major objectives of Canada's foreign policy. Here again, there is little evidence available to demonstrate the ultimate political bearings of these scientific contacts. It may not be surprising that the most vocal advocates of their usefulness are the groups who are the direct beneficiaries from these international circuits, and who see their socio-professional status enhanced by having world-wide political significance attributed to their

rehearsal of a New Atlantis. Be that as it may, in all foreign ministries, participation in international scientific organizations and projects remains in favour as a way of establishing discreet contacts and attesting cooperative spirit.

It is obvious that the three areas of concern thus identified are to a large extent overlapping, which does not necessarily mean that they join each other in harmony. But before turning to the problems of compatibility and conflict, it is essential to mention yet another area – that of domestic concerns – whose goals and the motivations which derive from them may account for a good deal of the maze which plagues policy-making in the field.

International Scientific Relations and Domestic Interests

International relations enhance domestic status.

Recognition abroad – for an individual, for a team, for a project, for an emerging discipline – is a valuable asset in the competition for funds and power. It may offer, for some scholars, compensation for continued lack of appreciation at home. It is difficult to evaluate, and impossible to prove, how many international ventures – joint research projects, institutional partnerships, coordinating committees and scholarly meetings – are valued more for the touch of merit they confer to the participants than for the substance of the work carried out.

Scientists like travelling. So do civil servants. Itinerant scientists and government delegations swarming across the Atlantic may be conspicuous and arouse criticism. They are, however, secondary symptoms.

There is little doubt that the desire for successful accomplishment of their missions induces a growing number of departments to engage in international relations. International responsibilities, by their distant flavour of regal prerogatives, may satisfy a hidden relish for prestige. But they do more than that: linked to the agency's mission, they demonstrate (if successful) the legitimacy of its function and therefore enhance its power and rank. The problem is compounded by the fact that, within the departments concerned, administrative subdivisions entrusted with international matters tend to develop a momentum of their own and, hence, behaviour dominated by the need to assert their usefulness.

Examined in this light, many international activities are, at least partially, domestic operations. Although the underlying rationale will not very often be referred to, it does provide one of the major sets of goals shaping national participation in international scientific affairs.

Compatibility and Conflict

International scientific activities are greatly facilitated if their objectives are compatible with priorities in more than one of the defined areas of concern or, at least, do not run against recognized priorities in one or the other.

Canada's participation in the International Biological Programme (IBP), for instance, is considered to have been a success. International programs of this sort, which mainly initiate and coordinate nationally

defined and nationally financed research, can be beneficial for the disciplines involved, stimulated as they are by the powerful incentives of collaboration, competition and, of course, available funds. In countries as large as Canada, they also usually perform a useful integrative function by bringing together the scattered parts of the national scientific community.

In comparison, UNESCO's "Man and the Biosphere" program meets with less approval. Scientists tend to consider the IBP formula more efficient. Criticism focusses on the institutional constraints of the program: whereas only about 60 countries participate formally in the IBP, UNESCO's undertakings are usually handicapped by the large number of participating states. Many of these states – who nevertheless join the programs and contribute to determining their content – do not have the scientific capacity required to make their collaboration useful. For political reasons, however, it is advisable for Canada to participate in UNESCO programs.

Scientists are also concerned about the certainty that industrialized nations can be out-voted by the less developed countries in the UN's specialized agencies. To prevent mission-oriented technical organizations from becoming levers for more or less disguised aid operations, the advanced countries tend to keep budgets low, but try to avoid tarnishing the image of world-wide solidarity they try to project in their foreign aid policies. These are only some of the possible conflicts of priorities, rather inoffensive examples at that.

In the web of rivalries and coalitions of goals and motivations, one conflict emerges quite conspicuously: the competence and authority of the Department of External Affairs in dealing with scientific affairs, versus the mission-oriented departments' or the scientific community's competence and authority to interfere with Canada's foreign relations. This conflict arises not only in scientific affairs but also in other areas such as economic and trade matters, energy and natural resources questions, and so on. The spectrum of opinions extends from those who claim for scientific expertise a greater share of responsibility to those who defend the case of the diplomats as a necessary filter for all activities abroad. Opinions vary, as usual, according to convictions and experience.[25]

Diplomats and Science

Ministries of foreign affairs in virtually all countries have, for years, taken little notice of how science and technology are pervading more and more aspects of international politics. Not enough importance was attached to the phenomenon to entrust a particular administrative unit with the responsibility are looking after international scientific affairs. Almost without exception, particular administrative units were not created until the Sixties.

This is not to say that international scientific affairs had previously escaped government attention. Other departments or agencies had taken care of them, as far as they were considered to relate to their missions. By the time that foreign policy tried to include science and technology more thoroughly in its area of concern, other bureaucracies had established a tradition of international responsibilities in the field, which they were quite unwilling to yield. Mission-oriented departments or bodies like NRC not

only questioned the wisdom of turning over scientific and technical affairs from the hands of the expert to the judgement of the generalist; they were also apprehensive of the interference of foreign policy goals in the rationality of their missions.

One of the most frequently cited arguments in favour of concentrating in the Department of External Affairs the exclusive responsibility for international activities is the hardly questionable assertion that it is only at that level that the necessary overview exists to evaluate properly the respective merits of competing priorities. This is precisely the same reasoning which motivates mission-oriented agencies not to abandon responsibilities they hold (or, in the case of the new departments, which they try to assert), since they have misgivings that their interests might be used as trade-offs in the international bargaining process.

This apprehension surfaces quite obviously, for example, in the widespread scepticism vis-à-vis "umbrella" agreements on scientific cooperation. Politicians are accused of resorting too readily to innocuous "scientific cooperation", when absence of agreement on any other domain or sheer lack of imagination threaten to have them return empty-handed before their nations. Agreements on scientific cooperation have become such a handy means of expressing international goodwill, that it is perceived almost as an unfriendly act not to have such an agreement with another country. Critics feel that in many cases the interests of science are sacrificed to foreign policy goals, in the sense that these agreements tend to give research activities a direction which may not fit the priorities of national science policy and, by the same token, to divert funds and energies from more promising orientations. Criticism is not confined to bilateral relations: Canada's alleged over-commitment to scientific activities in a growing number of international organizations is held responsible for dissipating national brain-power resources on a craving for international goodwill.

Scientists and Diplomacy

Criticism, as usual, flows both ways.

No one in foreign policy quarters seems to dispute seriously historical neglect and shortcomings in the diplomats' handling of scientific affairs. Nor is there much questioning of the scientific and technical competence of specialized bureaucracies in dealing with international activities in their fields, or especially of the value of their expertise and of the international connections they enjoy. Opinions diverge on the problem of coordination and control, which is, essentially, the problem of an indispensable hierarchy of goals.

It is easy to demonstrate in many cases that representatives of scientific disciplines or specialized bureaucracies have a simplistic tendency to equate their own goals with those of the nation as a whole more readily than is prudent for balanced policy-making.

Diplomats, in their efforts to support their department's authority, contend that scientists (academics or civil servants) are not sufficiently aware of the implications their objectives have for the interests of other groups – and, as a socio-professional group, not particularly attuned to the

shifting realities of international politics. Scientists may, for example, give high priority to international exchange of scientific information without much concern for the commercial or military implications this information may have (e.g., the commercial value of migratory species of fish). To illustrate the second point, scientists may not understand either that the rules of international bargaining sometimes require only gradual use of their accumulated expertise. There is little doubt that the broad sector of environmental problems is particularly afflicted by communication gaps of that kind especially when scientific expertise takes something of a messianic tone, which honours the individual, but which the diplomat may hesitate to endorse in the name of the national collectivity.

The diplomat will defend "umbrella" and bilateral agreements in general by pointing to the services they may render, facilitating contacts with otherwise almost inaccessible countries. He will argue that sacrifice, if any, may be worthwhile in view of an agreement's main objective: for example, the effort to reverse somewhat Canada's dependence on U.S. science and technology.

While scientists will work against the constraints which sovereign rights tend to impose on freedom of scientific exploration (e.g., of the oceans), the diplomat will tend to show more scepticism, especially in a field where it may be difficult to distinguish research for scientific motives from research for exploitation motives. In these cases, Canada's desire to project the image of an internationally-minded middle power may not enjoy high priority.

Although many of these conflicts of priorities are – at least for public consumption – drowned in the noble rhetoric of international solidarity, this solidarity reveals itself to be a very porous structure when it comes to practical decisions on scientific activities. Solidarity does not rank very high in the hierarchy of goals when it has to compete with such down-to-earth problems as "keeping up with development in key areas of scientific research", or "diversifying international trade", or "cost-sharing for cooperative research projects", or "collaborating in international regulations for safeguarding the environment". In the face of political realities and the international balance of power, it is impossible to separate collaboration from competition. The goal of sharing knowledge for the benefit of international understanding or the developing countries remains a complementary, but not necessarily hidden, objective of international scientific activities, and the principle of give and take remains the determining guideline.

Variations in the hierarchy of goals will be the permanent condition of policy-making for national participation in international scientific affairs. Science being so often a means to other ends, the priorities for international involvement are necessarily affected by the rank these ends enjoy. Canada's participation in international scientific affairs cannot be dissociated from its political aspects; it has to be considered as one element among others of Canada's presence on the international scene.

Randomness, waste of scientific knowledge, lack of coordination – these were the major criticisms identified at the start. In the mind of the informed

but dissatisfied public, the three are not totally unrelated: lack of coordination prevents, among other things, appropriate input of scientific knowledge, resulting in randomness. This underlying causal link probably accounts for the fact that proposed reforms deal mostly with changes in mechanisms and structures. Since our "areas of concern" have long since been integrated into administrative networks (public and private), conflicts of objectives are easily viewed as matters of jurisdiction or inadequate organization. Instead of taking a close look at the hierarchy of goals involved, critics tend to concentrate on the problems of coordination.

We chose to look at goals first. Analysis may be distorted, in fact, if functional organizational problems are broached without first ascertaining the objectives. Organizations, programs and activities in general should not be blamed for falling short of goals they were not designed for; and one should not frown upon randomness when, in fact, necessary trade-offs between conflicting priorities have led to decisions which do not meet the observer's standards of rationality.

One would hesitate to expect, however, that unrelated or contradictory moves in Canada's dealing with international scientific affairs would all reveal themselves to be based on debatable but conscious decisions on conflicting priorities.

III. Methods and Mechanisms

Canada, like most other advanced countries, has moved into the era of multi-bureaucratic decision-making, with a remarkable reliance on improvised solutions. The number of interdepartmental committees and advisory bodies is impressive, but this is not necessarily a reliable indicator of effectiveness. The situation is bound to become even more complex. With the expanding need for initiating, monitoring and regulating international activities, the number of viewpoints to be integrated into Canada's "one voice" will certainly increase. Which department will take the leadership? To be effective, coordination depends on discipline, on a dominant department or a dominant policy-maker able to insist on fusion or reconciliation of interests.

The traditional primacy of the Department of External Affairs in foreign policy planning and implementation is now being challenged in many functional areas. Because of their scientific and technical skills, other departments can take initiatives and show independence. The Departments of Transport, of Energy, Mines and Resources[26], of Communications and of the Environment, and the Ministry of State for Science and Technology are among the principal contenders.

As the official representative of Canada's scientific community, the National Research Council holds an unusual position: while accomplishing advisory functions within the government system, it enjoys direct access to the tightly interwoven network of non-governmental international science.

Lack of awareness and appropriate skills have certainly been responsible for the tendency toward *laissez faire* and improvisation in the Department of External Affairs' dealing in international scientific affairs. But, increasingly, the involvement of mission-oriented departments in international activities generates problems of its own. Because of the growing complexity of matters to be dealt with, it is not unusual to find official representatives from a number of departments operating independently at different levels within the same multilateral negotiation, with or without knowledge of the others' presence or intentions. The more technical the issues, the greater the power of the specialized bureaucracies and expert groups. Beyond that, scientific and technical negotiations in a multilateral setting may acquire a momentum of their own which is difficult for the policy-maker to direct. Consequently, there is a danger of severe discrepancies between a final agreement hammered out by a delegation of experts and what is acceptable to the policy-makers in domestic and international political terms.

The threat of uncoordinated policies does not arise in the multilateral sector alone: bilateral relations are equally affected. With a little more than 4 000 Canadian civil servants and support staff working in other countries (international organizations not included), less than one-half come from the Department of External Affairs (1891). The rest are administered by and report to other departments, such as Industry, Trade and Commerce (798), Manpower and Immigration (576) or National Defence (439).[27] In an era where national boundaries – at least those between the "Western Countries" – have become increasingly porous, foreign policy may some day be suspected, like science policy, of being a misnomer. Before that day arrives, however, the possibility that Canada may be heard speaking with

more than one voice on the international scene, or may not be heard at all on vital issues, will be considered a major shortcoming of present government organization.

Canada is, of course, far from having a monopoly on unresolved problems in the planning, coordination and implementation of international science policy. However, it should be recognized that some efforts toward better coordination have not been altogether without success. The Department of External Affairs has reacted to this challenge to its authority, and has refined the structures of its functional divisions. In the topical field of environmental problems, for instance, it chairs the Interdepartmental Committee on International Environmental Activities (ICIEA).

We still should not delude ourselves into expecting substantial improvement merely from changes in structures and mechanisms. Ways must be found which will, instead of inflating even more the existing apparatus for coordination, increase its efficiency. An apparatus whose prime function is to serve as a crucial link in the machinery of organized conflict cannot fulfill this purpose when it is used only as a means of channelling information and of conveying some basic understanding of the issues to the participants. That is an inappropriate exercise which prevents it from serving its main purpose. Information and understanding should be considered as prerequisites for efficient coordination.

These considerations should not be misunderstood; they are not meant to wither away as pious claims for more information. More information is meaningful only if it is gathered, disseminated and interpreted in the light of combined expertise and within the framework of comprehensive planning.

Planning

The crucial question is not whether Canada should participate more or less in international scientific activities, projects or organizations, but rather how she could participate with greater benefit to the country's interests. Canada's involvement in the scientific activities of international organizations is an apt example of the government's need to come to grips with practical problems.

From the late Sixties on, the proliferation of international scientific and technical organizations, committees and programs began to create some uneasiness. New bodies were created, and even those which had been created for other purposes felt the need to add scientific and technological components. The expanding role of science and technology in international relations seemed, for a while, to assimilate quite easily into these burgeoning activities. But it soon became evident that unrestrained growth of this sort would involve the risk of considerable duplication.

Critics pressed for adequate coordination. Secretariats of international organizations were exhorted to show more concern for balanced development of international scientific activities and to refrain from dissipating their human and financial resources (and those of their member states) in areas which were already taken care of elsewhere.

To believe in the usefulness of such exhortations is to fail to recognize

the underlying logic of the system. International bureaucracies tend to develop a dynamic of their own and to behave like states – except that they have no territory. They have to prove their legitimacy, and for that they rely on a number of clienteles. Concern for recognized crucial issues help to demonstrate usefulness, and segments of national scientific communities are, in most cases, readily mobilized as legitimizing reference groups. Legitimization is reciprocal, since endorsement of a research orientation or a specific program by an international organization tends to be a powerful asset in the competition for funds and recognition on the national level.

The symbiosis which frequently exists between an international organization and, within national borders, "clienteles" in academe or mission-oriented government agencies makes it difficult for a government to rationalize its involvement in this sort of scientific undertaking. Evaluation is not easy, and is most cases no attempt is made to assess participation because of the general political context. Also, it is hardly possible for a member state, acting in isolation, to impose better coordination by exerting direct influence on the activities of the various organizations from within. In fact, the only way to rationalize the highly dispersed and potentially overlapping efforts of science-related international bodies seems to be through the concerted policies of the member states.

Before resorting to concerted influence, however, clear objectives and alternative strategies have to be established on the national level. Strategies for orienting the activities of science and technology-related international bodies are but part of the general process of planning, in which multilateral and bilateral relations should not be considered separately.

Apart from those limitations to planning which relate to the general problem of national goals, there are other constraints due to the decentralization built into political structures. An important segment of Canada's international relations involving science and technology lie beyond the reach of Federal Government coordination, because of provincial jurisdiction. Better procedures are needed for associating provincial governments and their mission-oriented agencies with the activities of the Federal Government in international scientific or technical matters.

Impediments to planning and coordination do not arise at the intergovernmental level alone. On the grounds of scientific universalism and traditional academic freedom, scientists reserve to themselves the right to collaborate with whom they consider appropriate, and tend to consider efforts toward orientation and coordination as illegitimate interference. Difficulties are compounded by developments within the Canadian scientific community. Scientists from outside Ottawa seem less and less inclined to accept the leadership of the National Research Council or an essentially Ottawa-based Establishment's influence in Canada's involvement in international scientific affairs. The representativeness of the National Committees through which Canada adheres to the various international unions is questioned because of the notoriously limited turnover in the membership of such co-opted bodies. Even if the representativeness of the scientific circles involved is open to debate, opinions will certainly differ on the relevance of genuine representation to profitable

national participation in international scientific affairs. Tensions of this sort make planning and coordination more difficult, although they may be consciously used in the build-up of alternative sources of advice.

The fact that scientific research and international scientific relations depend heavily on public support and federal support provides, at least in theory, means for exerting some influence on the level and the orientation of international scientific activities. This applies to both the governmental and the non-governmental sector, but especially to the former.

In many countries, and especially in politically decentralized countries like Canada, science policy is implemented mainly through the allocation of financial resources. For years, for the political reasons mentioned above, "extra" money was easily available for governmental and non-governmental international undertakings.

Trends have reversed. Puzzled scientists are now facing critical evaluation of their projects, and hearing epithets like "a Giant's expensive toy" applied to such sacrosanct experiences in international cooperative research as CERN (Conseil éuropeen pour la recherche nucleaire). "Extra" money is drying up. In Britain, financial support for the international scientific activities of government agencies "remains with the responsibility of the appropriate government departments, on the grounds that international action is just one of the ways of enabling departments to do the things they consider need to be done".[28] In France, the limits of the "enveloppes-recherche" cut right through nearly all sectors of research expenditure, and the financing of international activities has to compete with national projects.

How will the drying up of the "extra" money affect science and scientists in the future? There is little doubt that it will help to discourage international activities which are motivated by little more than irrepressible "me too-ism". Moreover, it must be recognized that national priorities and competing projects in general do not necessarily flow from the sources of ultimate wisdom and disinterestedness, nor carry the promise of innovative genius. However, even if for a number of years "extra" money was too easily available, it would on the other hand be harmful if a backlash were to lead to excessive cut-backs!

A federal constitution and a pluralistic political system make it impossible for Canada to aim at something close to normative planning (i.e., definition of objectives and subsequent adjustment of means). Selective allocation of means and identification of objectives in a delicate bargaining process is the only practicable way. Constitutional and political realities impose on this bargaining process a specific blend of procedures: consultation and coordination, drawing and expertise and interests which revolve at different distances from power and authority.

The State of Canadian Participation

Not only must participation in international scientific affairs be consistent with previously defined objectives, but also the chosen vehicles for participation in international organizations, bilateral agreements, joint projects must be consistent with the benefits this participation is expected to yield.

There are reasons to suspect that potential bilateral agreements are not always assessed in depth before spectacular contacts are initiated, and one can fairly assume that the world of international organizations is not completely familiar to many of those who help shape the Canadian policy with respect to them. The politician and the diplomat may be ignorant of and inattentive to matters of science and technology, but the scientist tends to discard as a byzantine exercise the penetration of the complicated web of international law. It is important not to confuse OECD with a United Nations agency, for example; furthermore, it is necessary to evaluate properly the possibilities and limits of the action such organizations offer to the member states. It makes a difference if an organization is universal or regional in scope. Also, different possibilities are presented through the differing activities of particular organizations: forum for discussion, general assistance (information, coordination, consultation), regulation (standards, control, enforcement), operation (research, development, application), settlement of disputes. It must also be considered whether an organization is totally or only partially devoted to scientific affairs. National influence must be directed at different levels and different procedures must be used, according to the legal status and the original purpose of the organization.

It may be important in certain cases to see that Canadians join the permanent staff of the secretariat, and that they join at levels which secure insight, influence and a valuable line of communication to national needs and opportunities (without necessarily interfering with the deontological standards of the international civil service).

The often-denounced "imperialistic tendencies" of international bureaucracies are, frequently, simply the consequence of the member states' inertia. Their delegations fail to exert on the organization the influence they could command.

In general, Canada seems to enjoy a good reputation in international scientific organizations. Scientific and technical competence, the national capabilities it is possible to muster in cooperative undertakings, and the quality of Canadian delegations and the work they accomplish are highly valued. In organizations such as the United Nations specialized agencies, where the less developed countries are openly looking for leadership, Canada's position is quite advantageous, as one of the few technically highly advanced middle powers which have a spotless record in matters of colonial conquest. Moderate neutrality, a heritage from the Pearson era, is still part of the Canadian image – a reputation which is certainly not altogether unrelated to the fact that Canada provides a relatively important share of presidents and secretaries in the network of international organizations (two chairmen of the International Council of Scientific Unions in two decades, the first Director General of the World Health Organization, etc.).

In Canada, comments tend to be somewhat less optimistic. It is frequently stated that scientific expertise and political presence are improperly harnessed in the briefing and de-briefing of delegations and representatives, when it happens at all. It may be difficult, in any case, to strike a proper balance between precise instructions and the indispensable flexibility, but

the main problem seems to reside in the absence – or lack of clear expression – of possible objectives and the determination to exploit the relative advantages Canada may enjoy.

Hesitation and what some would call excessive timidity or naivety seem to be the major impediments to a more successful assertion of Canada's presence in the organizations with more restricted membership, the organizations in which the technological gap among members is diminished so that Canada's relative advantage consequently narrows. The emergence in some of these organizations of a "European caucus", which is now a serious worry in political circles, could have been predicted some time ago. Scientific and technological cooperation appear to be privileged tools which, if used properly in the near future, could prevent Canada's one day finding itself kept hopelessly at the periphery of a compact economic entity.

Bilingual proficiency is an unquestionable asset, and one wonders if it is given the attention it deserves. It can provide more than just direct access to French science and technology, which may be more difficult for even France's European partners to obtain. French is still widely spoken in Eastern Europe; it is the second official language in a large number of less-developed countries. In international negotiations and in the current activities of international organizations, the ability to work both in English and in French gives Canadian delegations a mobility unequalled in the Anglo-Saxon world.

It would require several volumes to review *all* possible means of enhancing Canada's international position in the field of science and technology. Organizations and issues are essentially diverse, and so are the political initiatives they permit and the adjustments they require. What is needed to fully exploit the advantages of the Canadian situation and to neutralize as much as possible potential handicaps is a high degree of political sophistication (i.e., expertise, broad understanding and some ability to analyze as objectively as possible).

Toward a Better Combined Expertise

There is little hope that the necessary combined expertise could be achieved without profound changes in both the organization of available information and the reshaping of career patterns in the groups of specialists involved.

Information

One should not delude oneself about the difficulties of establishing the inventory of international commitments and activities whose absence is now unanimously deplored. It is true, for example, that budget presentations do not facilitate the analysis of international involvement. Budgetary analysis would greatly improve the prospects for planning and coordination. One would be a blind optimist, however, to expect that a reform of the present budgetary method and the resulting visibility of activities and intentions would be received enthusiastically by the bureaucracies concerned. This visibility would, indeed, seriously affect the bureaucracies'

positions in the delicate bargaining process which is supposed to lead to the establishment of priorities. This is but one aspect of the problem of sectorial science policies, which make it so difficult for national science policy-makers to get an accurate picture of overall national capabilities and requirements.

There is nevertheless an urgent need to establish an inventory of Canada's participation in international scientific affairs, including: treaties and agreements, memberships in international organizations, participation in joint projects; responsible administration and number and composition of national bodies involved; expenditure engaged. This information should be centralized and easily accessible (except, of course, for matters which relate to the current policy-making process).[29]

Now that bureaucrats and scholars have been exposed to cost-benefit analysis, questions of follow-up, evaluation of impact, and feedback have become highly fashionable. These evaluations are extremely difficult to make; in most cases criteria seem to remain closely linked to sectorial concerns. However, useful efforts have been made in some quarters, and the study of the Telecommission on "International Implications of Telecommunications"[30] can be considered the minimum that should be expected from a government agency involved in international activities.

Gathering and dissemination of information is, of course, an ancillary activity. However, the establishment of a centralized information service for participation in scientific affairs would fill a serious gap in the infrastructure of science policy-making in Canada. The Ministry of State for Science and Technology seems to be the appropriate Ministry for assuming this responsibility, since it appears to be the link between Canada's scientific representation abroad and national needs and opportunities. However, this specialized information service should be integrated in the existing national information system. One of the major problems which is obviously haunting the scientific counsellors and attachés of all countries is not the question of how to gather information in the country of their mission, but rather the question of knowing where this information is going – who is the user? There seems to be a widespread tendency in domestic administrations to neglect the problem of analysis and dissemination of the information that the person was appointed to collect. By concentrating on gathering information, one easily forgets the goal – its use! Of course it is more difficult to organize for use than it is to gather information; but gathering remains sterile if the goals remain obscure. Criticism has focussed on the isolation felt by scientific counsellors in the diplomatic milieu. One wonders if they do not often have to face similar isolation with respect to their countries' scientific, technological and industrial communities, which they are supposed to serve.

The problem of dissemination is handled in different ways from one country to the other. In some posts, scientific counsellors concentrate on responding to requests for information; in others, they take the initiative of sending home, for more or less restricted distribution, newsletter-type information. The Swedish scientific counsellors, for example, answer requests, but collect fees for the services rendered. Effective dissemination is recognized everywhere as a most arduous task. The extent of these

difficulties does not seem to be affected by the choice of the Ministry to which the counsellors report (e.g., Foreign, Industrial, Scientific Affairs), although the process of dissemination is easily delayed when Foreign Ministries are involved – which is the case with Canada. There is little doubt that in the matter of dissemination the government department to which the scientific counsellors should, most appropriately, report would be the one which has the closest links with the potential customers.

However, the gathering and dissemination of information is but one of the problems that arise with regard to scientific representation abroad, and it is not the most complicated one.[31] The case of the scientific counsellors provides an excellent illustration of more intricate aspects, especially those of training and career.

Training and Careers

It should now be obvious that dealings in international scientific affairs require more than scientific training alone. There is a need for more knowledge of foreign policy matters and a general understanding of the international dimension of issues under consideration. The current solution is to throw the scientist and the diplomat together and to hope that some kind of interdisciplinary wisdom will flow from this collaboration. However, these hopes are not usually fulfilled.

In many cases, failures can be attributed to the ill-defined functions of the counsellor. He may pursue activities more attuned to his personal interests than to political requirements, or, on the contrary, he may be buried under the burden of mundane activities, paper-shuffling and public relations, thus wasting his scientific competence. Interdisciplinary collaboration is more than the sum of different competences. It requires a margin of overlapping knowledge and interests which the present system leaves almost entirely to chance.

To continue pondering the recruitment of scientists for the foreign service or international lawyers for mission-oriented agencies, or to refine the definition of the science attaché, is largely futile. It is not mere accident that the generalist (not the specialist) has been the norm in the foreign service; but now this dogma seems to be on the way to being abandoned in favour of the more flexible concept of "multiple specialization". Shifts of emphasis are hardly less frequent in international scientific affairs than they are in political affairs. There is common agreement on the need for flexibility, in the mandate given to a scientific counsellor and in his background and training. Here, the engineer type would be needed; there, the distinguished scientist turned administrator would be useful to project the image of high scientific achievement. Requirements at one particular post may vary in time, depending on the evolving political situation.

A particular blend of competences is needed, and the supply of these competences should be planned for and not left to improvisation. For the time being, the position of scientific counsellor seems to be not part of a professional career pattern, but an accident in a personal career. Problems of re-integration after the usually-temporary appointment with the Department of External Affairs are frequent; and international experience can easily be wasted if the re-integration into government administration,

industrial work or university life does not offer adequate opportunities for exploitation.

Instead of focussing so much attention on the function of scientific counsellors, more thought should be given to creating the required "overlapping competences", not only for diplomats dealing with scientific and technological matters, but also for scientists working in the international sphere. In an era where science and technology pervade practically every sector of administration, the capacity to grasp the essential impacts of both science and politics should be a common requirement.

The margin of "overlapping competence" can be created and enlarged in different ways:

1. By a greater mobility between the sectors involved: government administration, including the foreign service; university teaching and research; government research and industry.

2. By concentrated short-term training, in order to initiate scientists to the problems of international and foreign policy, and to give non-scientists a better understanding of the impact on international politics of scientific and technical problems.

3. By promoting interdisciplinary teaching and research at the graduate level in the universities.

One should not underestimate the difficulties which will occur if these suggestions are to be translated into practice. Mobility may impose sacrifice: leaving one's own well-shielded specialization and position to enter a new field may hamper career expectations; interdisciplinary teaching and research will have to rely on very strong motivations, as long as degrees continue to be conferred by the traditional departments.

It should, however, be recognized that major impediments to good and efficient collaboration seem to be less a problem of professional training than a problem of attitudes (i.e., crystallized, two-cultures behaviour). To put it more bluntly, the problem lies: on the one side, in the indifference to science and technology shown by the traditional civil servant who, steeped in his humanities-oriented concept of culture and wisdom, can be condescending when lecturing the scientists about problems of the "real world"; on the other side, in the "everything yields to scientific method" attitude of the scientists, in their contempt for politics which is matched only by the politicians' nonchalance with regard to science and technology.

Before the gap between these two attitudes is filled by common knowledge, common methods and concerns, it will be difficult to "coordinate by proximity", or in other words to integrate successful problems of international science with broader national concerns, both scientific and political. But if some iota of overlapping competences can be created, many of the present shortcomings and muddles may disappear. Scientists may then need less briefing than they now feel the need of, and diplomats may realize more fully the advantage of securing the collaboration of the scientists.

Notes and References

1. *Science, Growth and Society, A New Perspective* (the Brooks Report), OECD, Paris, 1971.

2. D. Kevles, G.E. Hale, *The First World War and the Advancement of Science in America*, ISIS, Winter 1968-69. 59(4), p. 432.

3. *Fünf Vorträge aus den Jahren 1920-1923*, Berlin, 1924. p. 24.

4. United Nations Educational Scientific and Cultural Organization (UNESCO), *Constitutive Act*, Preamble, Paris.

5. Functionalism is defined as "the theory or practice of achieving cooperation or union between governmental units by gradual integration of economic and other functions rather than immediate political federation". Webster's Third International Dictionary, Y. & C. Merrian Co., Publishers, Springfield, Mass., 1966.

6. For details, see Appendix A.

7. With the Soviet Union on January 27, 1971, on cooperation in the industrial application of science and technology; on October 20, 1971, on general exchanges, with the Federal Republic of Germany, on April 16, 1971, on scientific and technical cooperation; with Belgium, on April 21, 1971, on scientific, industrial and technological cooperation.

8. Not quite 3 per cent of the CIDA budget was devoted to science and technology in the fiscal year 1972-73.

9. Such as the Special Committee on Ocean Research (SCOR), the Committee on Space Research (COSPAR), or the Special Committee on Problems of the Environment (SCOPE).

10. See *Yearbook of International Organizations*, R.A. Hall, ed., Union of International Associations, Belgium, 1971.

11. See Appendix B.

12. In 1970 there were 9 579 full-time doctoral students in Canadian universities. Of these, 4 773 students were Canadian and 4 806 were citizens of other countries.

Of 18 918 full-time students at the master's level, 12 938 were Canadians and 5 980 were from other countries.

There was a considerably higher proportion of Canadian citizens among part-time graduate students. Of 1 969 engaged in doctoral studies, 1 389 were Canadian citizens. At the master's level, 7 337 students out of 8 775 were Canadian.

The proportion of Canadians to non-Canadians varied widely from one field of study to another. For example, Canadians made up 82 per cent of the full-time master's degree enrolment in Education, but only 47 per cent in Engineering. At the Ph.D. level, Canadian citizens accounted for 67 per cent of the doctorial candidates in Education, but only 37 per cent in Engineering.

Source: Statistics Canada, Education Division, *Citizenship of Graduate Students at Canadian Universities*, 1970-71, catalogue 81-001 annual, vol. I. no. 2.

13. These date are based on official documents and archives of WMO, WHO, ITU, UN Library-Geneva and the Royal Society, London.

14. See Appendix C.

15. Behind the U.S., U.S.S.R., East and West Germany, U.K., France, Italy and India (cf. Dale B. Baker, "World's chemical literature continues to expand", *Chemical and Engineering News*, Washington D.C., July 12, 1971. p. 37-40). Canada's share of abstracted literature in biology oscillates around 1.95 per cent of the total output, Canada ranking 12th (see Biological Sciences, List of Serials, Bioscience Information, Science of Biological Abstracts, Philadelphia, Pa., 1967-71).

16. Institute for Scientific Information, *Who is Publishing in Science?* Philadelphia, 1972.

17. See Appendix D.

18. A portion of these faculty members are non-Canadians, but unfortunately statistics could not be obtained. Cf. also M. von Zur-Muehlen, *The PhD Dilemma in Canada*: *Canadian Higher Education in the Seventies*, Economic Council of Canada, Ottawa, May 1972, p. 92-101.

19. See Appendix E.

20. *The Bible*, New Testament, St. Matthew, 13: 12.

21. *Science, Growth and Society, A New Perspective* (the Brooks Report), OECD, Paris, 1971, p. 48.

22. Cf. Eugene B. Skolnikoff, the *International Imperatives of Technology* (Technological Development and the International Political System Research Series No. 16) Institute of International Studies, University of California, Berkeley, 1971.

23. Canada, Department of External Affairs, *Foreign Policy for Canadians: the United Nations*, Queen's Printer, Ottawa, 1970.

24. *Ibid.*, Europe, p. 27.

25. This is the synthesis of the views gathered during more than one hundred interviews with scientists and public servants in both national and international administration, in Canada as well as in Washington, Paris, Bonn, London and Geneva.

26. For example, this department is an official member of (or delegate to) 53 international (governmental and non-governmental) organizations. Cf. Brief to the Senate Special Committee on Science Policy by the Department of Energy, Mines and Resources, Dec. 11, 1968, *Hearings*, p. 2481.

27. Figures for 1971-72.

28. Private communication.

29. Alphabetical partial lists of international activities, such as those which are published in the Annual Reports of the Department of External Affairs, are useless and confusing, and the usual glossy-paper publications of other departments do not meet the standards of serious information.

30. Study 3(a), Telecommission Study, International Implications of Telecommunications: *The Role of Canada in Intelsat and Other Relevant International Organizations*, Department of Communications, Information Canada, Ottawa, 1971. 59 pp.

31. On the function of Scientific Attachés, see J.W. Greenwood, "The scientist-diplomat: a new hybrid role in foreign affairs", *Science Forum*, February 1971. 4(1), p. 14-18; "The science attaché: who he is and what he does", *Ibid.*, April 1971. 4(2), p. 21-25; and D. de Solla Price, "The world network of scientific attachés", *Ibid.*, June 1971. 4(3), p. 34-35.

Appendices

Appendix A. Canadian Membership in Organizations Totally or Partially Devoted to Scientific and Technological Affairs*

Intergovernmental Organizations

1. United Nations Agencies and Institutes

Food and Agriculture Organization of the UN (FAO)
General Agreement on Tariffs and Trade (GATT)
Inter-Governmental Maritime Consultative Organization (IMCO)
International Atomic Energy Agency (IAEA)
International Bank for Reconstruction and Development (IBRD) – (also known as the World Bank)
International Civil Aviation Organization (ICAO)
International Finance Corporation (IFC)
International Monetary Fund (IMF)
International Telecommunication Union (ITU)
International Trade Centre – UNCTAD/GATT
UN Conference on Trade and Development (UNCTAD)
UN Committee on the Peaceful Uses of Outer Space
UN Educational, Scientific and Cultural Organization (UNESCO)
UN Industrial Development Organization (UNIDO)
UN Institute for Training and Research (UNITAR)
World Meteorological Organization (WMO)
World Health Organization (WHO)

2. Other Intergovernmental Organizations

American Institute of Aeronautics and Astronautics (AIAA)
Asian Development Bank (ADB)
Bank for International Settlements
Columbo Plan Council for Technical Cooperation in South and Southeast Asia
Committee on Space Research (COSPAR)
Commonwealth Advisory Aeronautical Research Council (CAARC)
Commonwealth Agricultural Bureaux (CAB)
Commonwealth Committee on Mineral Resources and Geology
Commonwealth Foundation
Commonwealth Scientific Committee
Commonwealth Telecommunications Board
Commonwealth Telecommunications Organization (CTO)
Convention on Great Lakes Fisheries
European Nuclear Energy Agency (ENEA)
Group of Ten (Paris Club)
Institute of Electrical and Electronics Engineers (IEEE)
Inter-American Tropical Tuna Commission
Intergovernmental Copyright Committee (IGC)
Intergovernmental Oceanographic Commission (IOC)
International Bureau of Weights and Measures

*This is a representative list taken from the *Year Book of International Organizations*, R.A. Hall, ed., 13th edition, 1970-71.

International Commission for the Conservation of Atlantic Tunas
International Commission for the Northwest Atlantic Fisheries (ICNAF)
International Computation Centre – Intergovernmental Bureau for Information Technology
International Cotton Advisory Committe (ICAC)
International Council for the Exploration of the Sea (ICES)
International Exhibition Bureau
International Hydrographic Bureau (IHB)
International Institute of Refrigeration (IIR)
International Lead and Zinc Study Group
International North Pacific Fisheries Commission (INPFC)
International Pacific Halibut Commission
International Pacific Salmon Fisheries Commission
International Poplar Commission (IPC)
International Rubber Study Group (IRSG)
International Sugar Council
International Telecommunications Satellite Consortium (INTELSAT)
International Tin Council
International Union for the Publication of Customs Tariffs
International Whaling Commission (IWC)
International Wheat Council
International Wool Study Group (IWSG)
North Pacific Fur Seal Commission
Organisation for Economic Cooperation and Development (OECD)
Pan American Institute of Geography and History (PAIGH)

Non-governmental Organizations

1. Scientific Organizations

Association of Official Analytical Chemists
Central Bureau for Astronomical Telegrams
Commission on the Nomenclature of Plants
CODATA: Committee on Data for Science and Technology
Committee on Science and Technology in Developing Countries
Committee on Space Research
Commonwealth Consultative Space Research Committee
Commonwealth Geographical Bureau (CGB)
European Association of Exploration Geophysicists
European Society for Comparative Endocrinology
Hibernation Information Exchange
Institute of Mathematical Statistics
Institute of Tables of Constants
International Academy of Astronautics (IAA)
International Association for Analogue Computation
International Association of Botanic Gardens
International Association for Cybernetics
International Association of Geodesy
International Association of Geomagnetism and Aeronomy
International Association of Meteorology and Atmospheric Physics
International Association of Microbiological Societies

International Association for Plant Physiology
International Association for Plant Taxonomy
International Association of Scientific Hydrology
International Association of Sedimentologists
International Association of Seismology and Physics of the Earth's Interior
International Association for the Study of Clays
International Association of Theoretical and Applied Limnology
International Association of Wood Anatomists
International Association of Volcanology and Chemistry of the Earth's Interior
International Astronomical Union
International Botanical Congress
International Cartographic Association
International Commission for Optics
International Commission on Physics Education
International Commission on Radiation Units and Measurements
International Commission on Zoological Nomenclature
International Committee of Electro-Chemical Thermodynamics and Kinetics
International Committee of Food Science and Technology
International Committee of Photobiology
International Confederation for Thermal Analysis (ICTA)
International Council for Bird Preservation
International Council of Scientific Unions (ISCU)
International Federation of Clinical Chemistry
International Geographical Union
International Institute for Conservation of Historic and Artistic Works
International Institute of Space Law
International Mathematical Union
International Mineralogical Association
International Organization of Palaeobotany
International Organization of Plant Biosystematists
International Ornithological Congress
International Phycological Society
International Primatological Society
International Scientific Radio Union
International Seaweed Symposium
International Society of Biometeorology
International Society for Cell Biology
International Society for Human and Animal Mycology
International Society for Photogrammetry
International Society for Plant Geography and Ecology
International Society of Radiographers and Radiological Technicians
International Society of Soil Science
International Society for Stereology
International Society for Tropical Ecology
International Speleological Congresses
International Standing Committee of Carboniferous Congresses
International Union of Biochemistry

International Union of Biological Sciences
International Union for Conservation of Nature and Natural Resources
International Union of Crystallography
International Union of Directors of Zoological Gardens
International Union of Game Biologists
International Union of Geodesy and Geophysics
International Union of Geological Sciences
International Union of the History and Philosophy of Science
International Union of Physiological Sciences
International Union of Pure and Applied Biophysics
International Union of Pure and Applied Chemistry
International Union of Pure and Applied Physics
International Union for Quaternary Research
International Union of Radio Science (URSI)
International Union of Theoretical and Applied Mechanics
Inter-union Commission on Allocation of Frequencies
Inter-union Commission on Science Teaching
Inter-union Commission on Solar Terrestrial Physics
Joint Commission on Applied Radioactivity
Pacific Science Association
Rehovoth Conference on Science in the Advancement of New States
Scandinavian Society for Plant Physiology
Scientific Committee on Antarctic Research (SCAR)
Scientific Committee on Oceanic Research
Scientific Committee on Water Research
Special Committee for the International Biological Programme
Society for Biological Rhythm
World Wildlife Fund

2. Technical Organizations
ACCRA Assembly
Asia-Pacific Rodent Control Society
Association for the Taxonomic Study of Tropical African Flora
Commonwealth Council of Mining and Metallurgical Institutions
Commonwealth Engineering Conference
Inter-American Planning Society
International Association for Asphalt in Building Construction
International Association for Bridge and Structural Engineering (IABSE)
International Association for Earthquake Engineering (IAEE)
International Association for Hydraulic Research (IAHR)
International Association of Public Cleansing (INTAPUC)
International Association for Shell Structures (IASS)
International Briquetting Association
International Bureau of Rock Mechanics
International Commission on Glass (ICG)
International Commission on Illumination
International Commission on Irrigation and Drainage (ICID)
International Commission on Rules for the Approval of Electrical Equipment

International Committee for Organization of Mining Congresses (IOC)
International Conference on Large High-Tension Electric Systems
International Council for Building Research, Studies and Documentation
International Council for Local Development
International Electrotechnical Commission
International Federation of Aerospace Technology and Engineering
International Federation of Airworthiness Technology and Engineering
International Federation of Automatic Control (IFAC)
International Federation for Housing and Planning (IFHP)
International Federation of Municipal Engineers (IFME)
International Federation of Operational Research Societies (IFORS)
International Federation of Prestressing
International Gas Union (IGU)
International Gravimetric Bureau
International Gravimetric Commission
International Institute of Welding
International Institution for Production Engineering Research
International Iron and Steel Institute
International Lead Zinc Research Organization, Inc.
International Mining Congress
International Organization for Standardization (ISO)
International Research Centre on Ancient Textiles
International Society for the Abolition of Data Processing Machines
International Society of City and Regional Planners (ISCRP)
International Society for Soil Mechanics and Foundation Engineering
International Society for Terrain-Vehicle Systems (ISTVS)
International Union of Testing and Research Laboratories for Materials and Structures
Nuclear Public Relations Contact Group (NPRCG)
Pan-American Federation of Engineering Societies
Permanent Council of the World Petroleum Congress
Von Karman Institute for Fluid Dynamics (VKIFD)
World Energy Conference (WEC)
World Federation of Engineering Organizations (WFEO)
World Power Conference (WPC)

3. Health and Medicine Organizations
American College of Chest Physicians
Aerospace Medical Association
Council for International Organizations of Medical Sciences
International Academy of Aviation and Space Medicine
International Academy of History of Medicine
International Brain Research Organization
International Dental Federation
International Federation of Physical Medicine
International Medical Association for Study of Living Conditions and Health
International Union for Health Education
World Federation for Mental Health

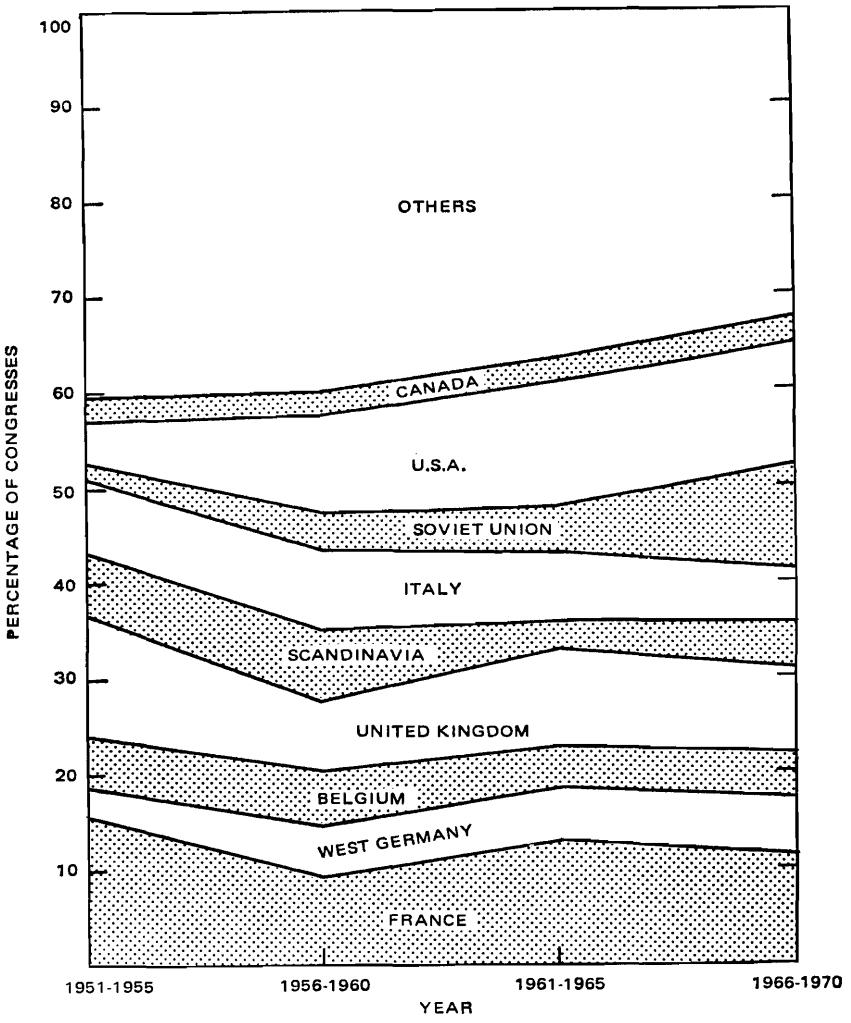
Appendix B. Exchange Programs Administered by the National Research Council

Table B

Date of Agreement	Man-Years	
1968	Brazil to Canada 9.6	Canada to Brazil 5.4
1970	Czechoslovakia to Canada 5.5	Canada to Czechoslovakia 0.8
1965	France to Canada 15.8	Canada to France 30.7
first: 1958	U.S.S.R. to Canada 20.4	Canada to U.S.S.R. 17.6
Total	**To Canada** **51.3**	**From Canada** **54.5**

Appendix C. Relative Distribution of International Scientific Congresses Held in Various Host Countries

Figure C



Source: International Associations (Brussels 1950-1970); forthcoming meetings.

Appendix D. Methodology for Determining the Number of Articles Published in Canadian Journals by Scientists Resident in Canada

A list of published articles was obtained from *Current Contents: Physical and Chemical Sciences*, Volume II (1971). Out of a sample of 2382 articles, it was found that 528 (or 22.2%) were published in Canadian journals.

The "physical and chemical sciences" include the following disciplines: Acoustics, Aeronautics, Analytical Chemistry, Spectroscopy, Astronomy, Atmospheric Science, Computers and Automation, Crystallography, Earth Sciences, Electronics, Information Science, Cybernetics, Inorganic Chemistry, Instrumentation, Materials Science, Mathematics and Statistics, Metallurgy, Nuclear Science, Oceanography, Optics and Photography, Organic Chemistry, Physical Chemistry, Physics, Plastics and Polymers, Space Science, General Chemistry, Chemical Engineering, Structural Chemistry, Oil Chemistry, Soil Chemistry, Fuel Chemistry, and Organometallic Chemistry.

Appendix E. Country of Origin of Final Degrees of Faculty Members in Canadian Universities and of the Scientific Staff of the National Research Council

Discipline	Year	Number of Degrees*	Percentage							
			Canada	U.S.A.	U.K.	France	Other Commonwealth	Other Country	Not Given	Total
Sciences	1966	2 910	46.0	26.0	18.5	1.2	2.3	7.3	0.7	100
	1969	3 877	41.3	25.2	20.8	1.2	3.1	7.7	0.6	100
	1970	4 197	42.38	25.66	18.32	2.02	3.31	7.57	0.71	100
Engineering	1966	1 508	51.9	22.3	14.9	1.3	2.2	6.1	1.3	100
	1969	2 079	44.3	26.9	17.7	1.1	1.9	6.6	1.5	100
	1970	2 266	45.93	25.15	17.91	1.32	1.36	6.26	2.03	100
Life Sciences	1966	1 462	41.2	36.5	13.3	0.7	1.4	6.2	0.6	100
	1969	1 493	38.1	38.4	15.1	0.9	2.9	3.8	0.7	100
	1970	1 564	40.66	37.21	14.51	1.15	2.04	3.64	0.76	100

*either Master or Doctorate degrees.

Source: Commonwealth Universities Yearbook, 1967, 1970, 1971, Association of Commonwealth Universities, London.
National Research Council, *Annual Report, 1967, 1970, 1971,* Ottawa.

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