Science Policy for the 1970's: Canada Debates the Options

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"For the first time in our economic history, we must become an innovative nation" (*1*, p. 485). These words of warning and exhortation sum up the findings of a Canadian self-examination that is probably the most exhaustive inquiry into national science policy ever made. It was conducted under the auspices of the Senate of Canada, an upper chamber composed of senior politicians with little legislative power, but with more opportunity for sustained investigation than is available to members of the House of Commons.

The inquiry was launched in 1968, with a year of testimony by more than 1000 scientists and administrators. The published text, including submissions, runs to over 10,000 pages. When the sessions were finally completed, the senators and their staff took leave of the hearing rooms in Ottawa—no doubt with a collective sigh of relief—and visited the United States and Europe to learn first-hand about experience elsewhere. Upon returning, they turned their attention to the drafting of a report. Two volumes of this report—known as the Lamontagne Report after the committee's chairman, Maurice Lamontagne—have now appeared, and a third is due soon.

While both published volumes touch on many issues, the keynote, sounded at the outset, is that Canada needs to frame and implement a coherent science policy so that it can compete more successfully in "the international scientific and technological race" (*2*, p. 1). The initial volume recounts the history of Canadian science policy and compares it to the science policies of other countries. The second outlines objectives for the 1970's, emphasizing the need for a "first-generation" policy aimed at promoting economic growth. The final volume is to describe a "second-generation" policy designed to serve a broader range of collective social needs (*1*, p. 333).

Anyone only vaguely familiar with economic conditions in Canada might wonder why the committee should put so much stress on the now unfashionable objective of promoting economic growth. Even those more than vaguely familiar with these conditions know that the Canadian standard of living is second only to that in the United States and that Canada's economy has enjoyed an impressive rate of growth over a sustained period. The Organization for Economic Cooperation and Development (OECD) estimates that, during the remainder of this decade, the Canadian gross national product (GNP) will increase by an average annual real rate of growth of approximately 5.4 percent (*1*, p. 422), a rate most economists would probably consider satisfactory for an advanced economy. It is currently thought that the rate will reach at least 6.5 percent in both 1972 and 1973. Nor are Canadians any less concerned than people in other countries over threats to the environment posed by the unrestrained advance of technology. A Canadian, Maurice Strong, presided over the international conference on the environment in Stockholm. Why, then, should Canadian politicians be so preoccupied with overhauling national science policy for the sake of economic growth?

Part of the answer given by the Lamontagne Report is that Canada has no choice but to keep abreast of the rest of the world. As long as all other developed nations continue to exploit science and technology for economic advantage, it would be imprudent for Canada to stand aside from the competition. As the report observes (*1*, p. 480):

> To insist on an immediate halt in economic growth, even if it were possible, would be to live by fashionable extremes rather than rationalities. We may in time move closer to Zero Economic Growth, as may the rest of the developed world. Meanwhile we need to promote at least an equal economic growth, even if we also have to expend rather more effort than before on minimizing its negative impact on the environment and the quality of life in our large urban communities.

Canadians, the senators might have added, do not need to be quite as concerned about the negative impact of technological progress as Americans or Japanese. With a population of only 22 million occupying the second largest country in the world—much of it admittedly unattractive for habitation—Canada does not yet face as many dangers from resource depletion, pollution, and overcrowding as do other industrialized countries. What therefore strikes the Senate committee, and other thoughtful Canadians, as the more immediate cause for concern is the degree to which Canadian prosperity rests upon an economy in which too much emphasis is placed on the export of raw materials and not enough on the development of secondary manufacturing industry. It is this concern that best explains the Lamontagne Report's stress on the role of science policy in promoting economic growth.

Primary Products Are Leading Export

Exports of primary products have traditionally accounted for the largest fraction of the total of goods Canada sells to other countries. The country's secondary manufacturing sector is too weak to compete effectively in the major industrial markets and is also handicapped by the small size of the domestic market. Canada is one of the few industrially advanced countries that does not have unimpeded access to a market of at least 100 million consumers for its finished products. Natural resources, although gratifyingly abundant in Canada, are not inexhaustible, and it can be plausibly argued that, on its present course, Canada is depleting its mineral resources for minimal economic returns.

The labor force is now increasing at the rate of 2.5 percent each year, one of the highest rates in the world. This growth rate is partly due to the encouragement of immigration, but even more to a sharp rise in the birth-rate in the years after World War II. Although new jobs are also being

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created rapidly, the country is faced with a national unemployment rate of over 6 percent. The rate is considerably higher in the relatively underdeveloped Atlantic provinces and in politically volatile Quebec. Investments in resource extraction and power projects designed to serve American needs, while welcomed by provincial governments, do not provide enough jobs to accommodate the growing labor force.

These considerations are linked to others with political overtones. English Canada's nationalist intellectuals—who, in the words of novelist Mordecai Richler, are "seething with *machismo*" (*3*)—argue that Canada has shed its colonial ties to Great Britain only to have become an economic colony of the United States. Almost 70 percent of Canada's exports are purchased by the United States. A large part of the Canadian manufacturing industry (58 percent is the usual estimate) is owned by foreign investors—45 percent by Americans, and the proportions are considerably higher in certain sectors, notably oil and gas. Subsidiaries of American and other foreign-based, multinational companies make up the largest part of Canada's manufacturing industry. As "branch plants" established mainly to scale the tariff walls, they have little incentive to do much research and development (R & D) or to make an aggressive effort to export what they produce.

It is fallacious, however, to pin the blame for the imbalance of the Canadian economy on American investment. All Canadian enterprise, whether foreign or native in ownership, suffers disabilities that are endemic to the economy. The relatively small size of the market dictates short production runs. Because of a lack of diversity, many items needed in manufacturing must be imported. Markets and suppliers are spread over great distances, and climatic conditions are harsh. As a result, production and transportation costs tend to be higher than corresponding costs in the United States. The American automobile manufacturers claim that Canadian buyers must pay higher prices than Americans for the same model cars because of "the added costs of doing business in Canada." Protectionist policies, moreover, have enabled small, relatively inefficient firms to survive and larger ones to avoid price competition. The result, as the Lamontagne Report observes, is that "secondary manufacturing—whether Canadian-owned or foreign-owned—is rapidly reaching a structural dead end" (*1*, p. 506).

To some extent, Canada's disadvantages vis-à-vis her prime trading partner have been offset by bilateral agreements covering defense and automobile production. These pacts are largely responsible for the recent turnabout of the balance of trade in favor of Canada. The automobile pact, especially, has also significantly affected the ratio of manufactured to raw materials in Canada's exports. In 1955, before the automobile pact took effect, finished goods accounted for only 24 percent of the total value of exports. In 1971, the proportion had risen to 38 percent, largely because of the inclusion of automobiles and automobile parts shipped to U.S. markets (*4*).

Costs versus Benefits of Foreign Investment

Ironically, the nationalist case against American investment in Canada sometimes arouses more sympathy from American commentators than it does from those more familiar with Canadian realities. Thus, after a brief visit to Ottawa, James Reston concluded that American investors "can dominate the life of Canada and even corrupt Canada while enriching it" (*5*). This is to make the mistake—a patronizing one, at that—of imagining that Canada is a politically immature "banana republic" incapable of protecting its national interests. How far this is from the reality may be judged from one recent example. When U.S.-owned oil companies sought permission to sell $1 billion worth of natural gas to American consumers, the request was turned down by Canada's National Energy Board, even though the American companies had spent millions of dollars to discover the gas and even though the government of Alberta was anxious to see the deal go through because of the $4 million in annual royalties the province was to receive from the sale. The energy board ruled that Canada did not have proven reserves in excess of its own requirements for the next 30 years. Far from being subject to corruption, the energy board, which is composed of six civil servants, cannot be overruled in its decisions, even by the federal cabinet.

In the view of many reputable economists, including John Kenneth Galbraith and Harry Johnson, whose opinions carry special weight with Canadians because they are native sons who have achieved international stature, foreign ownership need not imply foreign political domination. A. E. Safarian, an eminent Canadian student of U.S.–Canadian economic relations, argues that much of the agitation over the supposed threat of an American take-over of the Canadian economy is based on faulty reasoning, ideologically inspired exaggeration, and outright myths (*6*). American investment has benefits as well as costs, he contends, and the benefits have clearly outweighed the costs. The best practical evidence that this is so is that, despite the nationalist outcry, both federal and provincial governments have continued to bend every effort to assure that American and other foreign capital continues to flow into Canada. When the United States sought to limit the migration of American capital by imposing the interest equalization tax, Canadian officials went to Washington to plead for exemption, which they obtained on condition that Canada did not allow itself to be used as a conduit for U.S. capital intended for investment in third countries and did not use the exemption to increase its own reserves of foreign exchange.

Safarian points out (*6*) that the main reason American capital has played such an important role in Canada's development is simply that in the past Canada's own capital resources, especially entrepreneurial capital, have been inadequate to the country's needs. In addition, federal legislation has prevented Canada's chartered banks from investing in high-risk enterprises, and private Canadian investors have tended to be more conservative than their American counterparts. He also observes that, if all business assets are considered, rather than manufacturing assets alone, the proportion owned by foreign-owned corporations (mainly by U.S. corporations) is on the order of 27 percent. While even this proportion of foreign ownership is high by ordinary standards, it puts the supposed threat of American domination in more realistic perspective than the higher figures usually cited by alarmists. In view of the unique affinity between Americans and Canadians—an affinity which includes, but transcends, economic relations—it is hard to see how the degree of American investment in Canada could, in itself, reduce Canada to the status of an American colony.

At the same time, as Safarian also points out, Canada's economic depen-

dence on the United States does have certain serious drawbacks. One of these results from the extraterritorial application of U.S. laws and policies. American antitrust laws were applied to break up a Canadian company formed jointly by du Pont and a British firm, even though the company would have been of considerable benefit to Canada by helping to rationalize the chemical industry. American subsidiaries in Canada have been prevented from trading with countries with which the United States does not have trade relations. Canada is extremely vulnerable to the perturbations of the American economy and to the waves of protectionism that, from time to time, wash over the steps of the Capitol. Despite President Nixon's assurance of his respect for Canada's sovereignty and economic strength, Canada has not been exempted from the recently enacted DISC (Domestic International Sales Corporation) legislation, which induces American companies to keep production facilities at home by allowing them to defer taxes on much of their export earnings. The Canadian government had little choice but to offer countervailing tax concessions of its own.

Now that Canada is acquiring investment capital of its own, the ratio of American to Canadian ownership may level off and even begin to decline in a number of sectors. To reduce the extent of foreign ownership still further or more rapidly, without causing economic hardships, will require serious effort in a number of directions. Foreign firms of suboptimal size will need to be replaced by larger, Canadian-owned firms, and small Canadian companies will need to be amalgamated into larger units capable of competing for foreign sales. Canadian businessmen will need to acquire greater entrepreneurial acumen, and investors, more willingness to take risks. Foreign markets will have to be opened for Canadian-manufactured goods. Somehow, the provincial governments will have to be persuaded not to compete with each other so intensely that they forego tax revenue by offering unduly high subsidies to investors interested in extracting natural resources.

"Hidden" Science Policy Did Little to Aid Economy

It is in this economic and political context that the Lamontagne Report's concern with stimulating research-intensive industry arises. Until now, the report maintains, Canada has had a "hidden" science policy that has done far too little to alleviate the country's economic difficulties. This policy has had two principal features: expenditures on basic and applied research have been high compared to expenditures on development, and most R & D has been performed in government and university laboratories rather than in industry.

Data collected and analyzed by the Senate committee and the OECD in its review of Canadian science policy effectively illustrate these contentions. The OECD review points out that in the United States support for R & D is allocated more or less in the ratio of 1 : 2 : 7 for basic research, applied research, and development. The British pattern is similar. Canada's pattern of allocation, however, is like those of the continental states of western Europe, where R & D funds are allocated in the ratio of 2 : 4 : 4 (*7*, pp. 36–38). Measured in terms of the percentage of GNP devoted to R & D, Canada's pattern also resembles that of the continental states. Whereas the United States devotes an average of 3.4 percent of GNP to R & D, and Britain 2.3 percent, Canada averages only 1.3 percent. The OECD cautions against a misleading interpretation of these figures, noting that if military, space, and atomic projects are excluded from consideration, Canada's expenditures on research for "social and economic purposes" are comparatively high and are only one-third lower on a per capita basis than those of the United States (*7*, pp. 24–25). This is small consolation, however, to the Senate committee, inasmuch as these expenditures do not produce a high rate of economic innovation.

With respect to who performs the R & D, the Lamontagne Report notes that Canada's pattern again contrasts sharply with that of the United States. Canada, as the report puts it, "is at the bottom of the list as far as R & D performed by industry is concerned, but at the top when it comes to the government and university sectors" (*2*, p. 128). In the United States, two-thirds of R & D is done by industry, 18 percent is done by government laboratories, and 12 percent by universities and other nonprofit organizations. Canadian industry performs 37.7 percent of R & D, government laboratories 35.6 percent, and universities 25.9 percent (*2*, p. 128).

While critical of past policy, the Lamontagne Report takes pains to give due credit to Canadian achievements. These include a number of noteworthy accomplishments. Although Sir Ernest Rutherford's Nobel Prize was awarded to him after he had settled in England, it was given in recognition of work done at McGill University, where he studied and taught from 1898 to 1908. The synthesis of insulin by Frederick Banting and Charles Best is remembered with pride at the University of Toronto. Canadian agriculture benefited greatly from the development of early ripening Marquis wheat by William Saunders and his son Charles, and from the success of Canadian (and American) efforts to solve the problem of wheat rust. During World War II, Canadian researchers contributed to the development of the atomic bomb, radar, and the proximity fuse. Last year, Gerhard Herzberg, of the National Research Council laboratories, received the Nobel Prize for Chemistry in recognition of his extensive research on the spectra of molecules (*8*).

The Lamontagne Report argues that these accomplishments are counterbalanced by too many other cases in which Canadian ingenuity has not had economic or other benefits for the country. Drawing upon J. J. Brown's *Ideas in Exile* (*9*), the report goes so far as to endorse the claim that "the most famous 'Canadian' invention is of course the telephone," and Alexander Graham Bell is "undoubtedly Canada's greatest inventor." Presumably, the only American contribution to this Canadian achievement was its economic exploitation (*2*, p. 156). A number of less debatable instances are also cited, such as the electron microscope, a commercial model of which was developed by three professors at the University of Toronto in 1938. Typically, the report notes, they emigrated to the United States, where the product was later developed and manufactured.

Support for Industrial Innovation Emphasized

To remedy Canada's chronic inability to capitalize on the products of its investments in science and technology, the report calls for an "industrial revolution," to be accomplished by shifting emphasis from the support of pure science to the encouragement of industrial innovation. The level of expenditures would be raised to 2.5 percent of the GNP by 1980, 3 percent by 1985, by increasing both public and private sup-

port. To allocate basic research funds, three foundations would be created (for the physical sciences, the life sciences, and the social sciences and humanities) under the general direction of a research board. The federal government would be assigned sole responsibility for supporting university research aimed at contributing to the stock of knowledge, while the provinces would bear the full cost of preparing university teachers and of higher education generally, except as they are now assisted by the federal government. By 1980, basic research would claim only 10 percent of the total R & D budget—a sharp relative decline, but not a decline from the present absolute level. The federal government's basic research would be concentrated in a national research academy. The allocation for development would be increased to 60 percent of the total expenditure, an increase to be accompanied by a major reorganization of industry. Existing government laboratories performing industrial or applied research would be brought together and housed in a Canadian Industrial Laboratories Corporation responsible to the Department of Industry, Trade and Commerce. The main emphasis, however, would be placed on stimulating "a high and sustained flow of technological innovations introduced by the secondary manufacturing sector of the economy" (*1*, p. 601).

Sweeping Changes Needed to Stimulate High-Technology Industry

The stress on improving high-technology industry is tacitly supported by the OECD review. "Canadians," the examiners noted with patent approval, "would like to change from the 'continental model' to the 'American model.'" To do this, as they also noted, would require sweeping changes, including "a massive transfer of research potential from the public sector to industry" (*7*, p. 38). This objective also has the support of the Science Council of Canada, although the council has serious reservations about the methods prescribed by the Lamontagne Report.

The science council, which comprises 25 members appointed from industry, the universities, and government agencies and operates with the assistance of a small professional staff, was created in 1966 as a public advisory body on science policy designed to be independent of government control. Under the direction of O. M. Solandt, a distinguished polymath who was originally educated in medicine and who has subsequently acquired administrative experience at the highest echelons of government, industry, and academic life, the council has produced a series of provocative reports on specific issues and areas of science policy.

Like the Lamontagne Report, several of the science council's reports emphasize the need to stimulate high-technology industry. To this end, the science council has urged that the federal government identify a number of "major projects," such as the development of the Canadian North or the manufacture and sale of short takeoff and landing (STOL) aircraft for an international market. Agencies of government, both federal and provincial, would cooperate with universities and private industry in accomplishing the projects, thus overcoming the isolation in which they now largely function (*10*).

Otherwise, the science council takes sharp issue with the Lamontagne Report. In a commentary on the report, it rejects the assumption that a single coherent science policy is either possible or desirable. Since "different regions and different social and economic sectors have different priorities," the council contends, what is needed is a "multiplicity of science policies" (*11*, p. 2). The Lamontagne proposal that a fixed percentage of GNP be made a target for R & D spending is also rejected, in favor of the view that "as much—or as little—R & D should be performed as our national goals require" (*11*, p. 2). The Lamontagne recommendation of separate facilities for the government's basic and applied research is criticized for its assumption that a rigid distinction between the two types of research is feasible and desirable. The science council also claims that the Lamontagne Report puts too much emphasis on the role of R & D in innovation and not enough on other, equally important factors, such as management and marketing. "Pushing on the innovative chain from the R & D end," the science council observes, "is not nearly as practical or rewarding as pulling on it from the market end" (*11*, p. 3). The expectation that much of the projected increase in R & D support can be supplied from industrial revenues is called "totally unrealistic," in view of the likely increase of sales and the usual relation between sales and R & D expenditure (*11*, p. 11).

The common target of both the Lamontagne Report and the science council is the National Research Council (NRC), an institution that combines functions which are usually separate in other countries. The "hidden" science policy criticized by the Lamontagne Report is held to have been the work of "the leaders of the Republic of Science in their capacity as senior government officials" (*2*, p. 152), an allusion to the previous directors of the NRC, notably H. M. Tory, A. G. L. McNaughton, C. J. Mackenzie, and E. W. R. Steacie.

NRC Created to Coordinate Research Efforts

The NRC was established in 1916 on the model of the wartime British coordinating agency created a year before, the Department of Scientific and Industrial Research. It was decided upon because Canadians preferred to establish an organization of their own rather than affiliate Canadian researchers with the British organization. The NRC was supposed to coordinate Canadian research efforts in government, industry, and universities and to provide support for nongovernmental scientific work. Mackenzie, who was president of the NRC from 1942 to 1952, made a well-known comment about the early problems the organization had encountered. "The NRC," he observed, "was instructed to co-ordinate and promote scientific and industrial research in Canada. The NRC soon found that there was little or nothing to co-ordinate" (*2*, p. 41). In 1917, only two Canadian universities, McGill and the University of Toronto, offered work leading to the Ph.D. Between 1898, and 1917, only 11 doctorates had actually been conferred by both universities. University scientists, moreover, showed a distinct aversion toward scientific work with practical applications. Nor was the field any more fertile in industry. A survey of 8000 companies produced replies indicating that only 37 had research laboratories of any kind (*2*, p. 28).

Having discovered this vacuum, the NRC moved to fill it by developing its own research establishments and providing support for graduate training and research in the universities. In 1928, the NRC succeeded in persuading the federal government to establish several laboratories under its jurisdiction in

order to provide a place where basic researchers could work free of bureaucratic restrictions and civil service regulations. During World War II, while the United States was pragmatically creating its present system of supporting research by means of contracts to industry and grants to university scientists, Canada was expanding the NRC. After war, the NRC divested itself of two of its major responsibilities by establishing the Defence Research Board and Atomic Energy of Canada Ltd., now a Crown (public) corporation. Even so, by 1950 there were ten laboratory divisions, and the NRC continued to employ over 2000 scientists, technicians, and supporting staff in its own establishments, which, by this time, had acquired a high reputation for the quality of their work.

Meanwhile, the NRC had also enlarged its role as a dispenser of federal support for university research. In the 1950's, NRC president Steacie described it as an institution with no fewer than five separate roles (*12*, p. 142).

> The first is a government laboratory with certain narrowly defined specific duties: this a minor part of our work. Secondly, we are in many respects a foundation with purposes almost identical with those of the Canada Council. In the third place, we are an industrial research laboratory similar in many ways to places like the Mellon Institute, or to the laboratories of major industrial firms. Fourth, we are a research institution more like the Rockefeller Institute or a university laboratory than a government department. And finally, we have many of the functions of a national academy, functions similar to those exercised in Britain by the Royal Society of London or in the United States by the National Academy of Sciences.

Steacie saw the role of the NRC laboratories as being limited to basic research and long-term applied research. "Long-term investigations, fundamental or applied research, *must* constitute the major effort of the laboratories if they are to keep the scientific reputation they have earned . . ." (*12*, p. 121). Both the Lamontagne committee and the science council contend that the chief weakness of the NRC is that, given this commitment, it cannot be of enough service to Canadian industry. As the report observes, "discoveries made in isolation from industry cannot be transferred easily into successful market-oriented innovations" (*12*, p. 140). Nor is this the first time the NRC has been faulted on this score. In 1963, the Glassco Commission, a Canadian equivalent of the Hoover Commission, reported that the NRC "has not been successful in its role as a promoter of industrial research," at least partly because of its rather academic orientation . . . and its preoccupation with basic research . . ." (*13*). More recently, another independent study has cast doubt on the NRC's use of outside advisers on committees responsible for suggesting where research projects could be performed most appropriately. These committees, Bruce Doern asserts, "were used to legitimize and generate support for research projects and priorities initiated by the NRC laboratories rather than by outside researchers" (*14*).

The NRC's role as a granting agency has also been called into question. A panel appointed by the science council to examine the support of university research concluded that the NRC suffers from a classic conflict of interest—on the one hand performing its own research, and on the other considering applications from its competitors. The panel recommended that the NRC's granting function be divorced from the management of the NRC laboratories (*15*). The Lamontagne Report concurs.

The NRC's role as a source of advice on science policy has been preempted in recent years, in theory if not yet fully in practice, both by the creation of the science council and by the improvement of the governmental structure for considering issues of science policy. When the NRC was established, it was called the "Honorary Advisory Council" and was made responsible for providing advice on science policy to the Privy Council Committee on Scientific and Industrial Research, a committee of the cabinet. With the creation of the science council, the legislation governing the NRC was amended to abolish both the title and the advisory function. The NRC was told, in effect, to confine itself to its other responsibilities.

Secretariat Studies Scientific Aspects of Policy Issues

Within the government, a new cabinet post of Minister of State for Science and Technology has been established. The minister has no departmental responsibilities and presides over a small secretariat, which had been in existence prior to the appointment of a minister and which, unlike the science council, is designed to serve as an intramural base for the examination of questions of science policy. Like the U.S. Office of Science and Technology, the secretariat studies the scientific aspects of policy issues under consideration by the executive, cooperates with operating departments on interministerial committees, and assists the government's budgetary controllers—the Treasury Board—in reviewing the research components of departmental allocations. The first incumbent of the new ministerial post was Liberal member of Parliament from Toronto and former Rhodes scholar Alastair Gillespie. In a recent cabinet shuffle, he was made Minister of Industry, Trade and Commerce and was replaced by member of Parliament from Quebec and former journalist Jeanne Sauvé.

With active support from the ministry, several steps have been taken by the federal government in response to the Lamontagne and science council recommendations. Wherever possible, government departments are now required to have their research done under contract by private firms. The government has agreed to put up $62 million of an estimated $80 million that will be required by de Havilland Aircraft of Canada Ltd. and United Aircraft of Canada Ltd. to develop a new STOL aircraft, aimed chiefly at the American market. It is also reported that new arrangements are to be introduced, including the substitution of the more flexible "research agreement" for the contract and grant, in university research supported by mission-oriented agencies (*16*).

As expected, the Lamontagne Report has come in for a good deal of criticism from the scientific community. The current president of NRC, W. G. Schneider, has contended that the organization's critics have failed to give due consideration to the quality of its work or to the steps already taken to remedy weaknesses and respond to the call for more emphasis on aid to industry. Herzberg has warned that the Lamontagne recommendations threaten the health of Canadian science by paying only lip service to basic research. "What I'm trying to preach," he told an interviewer, "is that you must leave scientists the freedom to do what they think best. . . . That's a strange thing to say to taxpayers, but it's the only way to make discoveries" (*17*). A subcommittee of the NRC's advisory committee on biology has bluntly observed that, if the attitude reflected in the

Lamontagne recommendations continues to hold sway, "there is a serious danger that pure research will be extinguished in Canada" (*18*).

Criticism was loudest in response to the first volume of the Lamontagne Report. A number of scientists complained that the history of past science policy was presented in too self-deprecatory a tone. "In Canada," one physicist remarked, "we're always looking at the negative side" (*19*). The second volume, which contains the policy recommendations, has been greeted with considerably less hostility on the part of leading scientists and with what would appear to be substantial support among the rank and file. The constructive tone of remarks at the fourth annual conference of SCITEC, the recently formed association of scientific, engineering, and technical societies, showed that at least the second volume had made a good impression. A poll of over 5000 members indicated that 67 percent approved the recommendations, 13 percent disapproved, and 20 percent felt they could express no opinion (*20*).

A new report prepared for the Association of Universities and Colleges of Canada acknowledges that universities must adjust their expectations to a more stringent scale of public support for basic research and graduate education. The report calls upon the universities to set internal research priorities, and to encourage multidisciplinary and interuniversity cooperation. It even has a kind word or two for the idea that the universities might cooperate with industry, although no specific recommendation is made to indicate what sort of initiatives would be appropriate (*21*).

Even with support from the scientific community, however, it will not be easy for the Lamontagne recommendations to be implemented without first being considerably modified and diluted. The nature of Canadian federalism poses one hurdle. Although the Lamontagne Report concentrates its attention on the role of the federal government, the Canadian Constitution (the "British North America Act") gives the provinces more authority separate from and coordinate with that of the central government than the U.S. Constitution gives the states of the union. Any coherent policy with respect to higher education and industry would therefore have to be worked out cooperatively by the federal government and the provinces. In view of the extreme regional disparities and of the tension between Quebec and the rest of the country, achieving such cooperation continues to be the central political problem of Canadian confederation.

This problem crops up at every turn, and science policy is no exception. When the science council's panel on the support of basic research recommended that the quality of the researcher and his proposal be made the primary criterion for support, the Quebec representative on the panel felt compelled to file a minority report. He argued that the preoccupation of the majority with the criterion of "high merit" would only perpetuate existing disparities. Such a criterion, if rigorously applied, would be particularly unfair to Francophone universities, which, as he put it, "have never been pampered by gifts or endowments from those financial firms or wealthy people who, we must bear in mind, accumulated their wealth, at least in part, from the French-Canadian consumer or through the exploitation of Quebec's natural resources." Yet these universities incur higher costs because of their need to recruit qualified, French-speaking staff (*15*, p. 358).

The emotional appeal of the campaign to preserve Canadian independence by preventing American takeovers also threatens to divert attention from the full range of proposals put forward in the Lamontagne Report. The report attempts to mollify nationalist sentiment by calling for a "New National Policy"—a term that harks back to the "National Policy" of Sir John A. Macdonald, father of Canadian confederation, a century ago. Its specific recommendations, however, are deliberately designed to satisfy neither of the "two elitist groups, the 'continentalists' in business and the 'socialists' in universities" (*1*, p. 506), which have so far taken the leading roles in the debate over the alleged threat of American domination. In an effort to deal with, and at the same time defuse, the issue, the Trudeau government invested much time and energy debating and formulating a policy on foreign take-overs. The result was a rather mild call for a screening agency to assure that any large take-over is in the national interest. Even as a first step, this move has been considered altogether too weak by extreme nationalists, who continue to campaign for stiffer measures.

Political Leaders Face Conflicting Views on "Americanization"

Given the widespread concern with national unity, identity, and independence, no federal government can afford to appear indifferent to patriotic appeals, however misguided some of them may be. Canada's political leaders are in the awkward position of being counseled by their science advisers to imitate the United States, to stimulate industrial R & D by all possible means, and to open new markets for Canada's secondary manufacturing, while at the same time they are being admonished by nationalists to reject "Americanization" and to make things more difficult for American interests and American multinational companies—whose cooperation is essential if high-technology industries are to be developed more rapidly and if the American market is not to be closed to Canadian manufactures. The cabinet delayed making public its new take-over policy for an embarrassingly long time, obviously out of fear that the policy might upset delicate economic negotiations with the American government. Even when the policy was announced, however, Canadian officials were trying to persuade the U.S. Department of the Interior to choose a Canadian route along the Mackenzie River instead of going ahead with plans for a trans-Alaska pipeline. Given the manifold importance of Canada's economic relations with the United States, it is hard to foresee a time when a Canadian government will be able to satisfy the demands of the nationalists and at the same time sponsor a successful "industrial revolution."

The ecological crusade, which shows no sign of losing its momentum, could prove another obstacle. Protecting the environment and, in general, improving the quality of life are now far more sensitive political issues than the Lamontagne Report appears to recognize. The government cannot afford to concentrate exclusively on a first-generation policy aimed at enhancing economic growth and defer the environmentalist concerns of second-generation policy. In creating a Department of the Environment and in concluding an agreement with the United States to clean up the Great Lakes, the government has shown that it regards protection of the environment as an issue of high priority. Balancing this concern with the development of major new high-technology in-

dustry is, as mathematicians would say, a "nontrivial" problem.

Concern for ecological impact is one factor in the rising opposition to the government's announced plans for a massive effort to exploit Arctic oil and natural gas resources by laying pipelines and roads through the Mackenzie Valley. Another is the view expressed by geophysicist J. Tuzo Wilson that, in view of the growing Canadian demand for energy, to export reserves of fossil fuels before alternate sources of energy are assured is to invite grave hardships (*22*).

Such difficulties will scarcely be resolved by the single stroke of enacting a coherent science policy. It is clear that middle-sized countries like Canada cannot support science and technology across the board, but must adopt a selective strategy (*23*) concentrating on the support of particularly appropriate projects and fields of endeavor. Big science projects, as the Lamontagne Report recognizes, must be done in cooperation with other countries. New technologies that cannot be developed indigenously except at too high a cost should be acquired through deliberately chosen channels for technology transfer, such as licensing or the encouragement of multinational enterprise. Translating this strategy into actual decisions, however, can only be done case by case, taking into account a host of political and economic considerations. This is a formidable challenge, even for a country blessed with Canada's wealth of natural and human resources and its highly developed system of parliamentary and federal democracy.

To make matters more complicated, there are Canadians who have serious reservations about the fundamental proposition underlying the recommendations of the Lamontagne Report—that is, about the belief that, one way or another, the future of the country depends upon its success in the "international scientific and technological race." Two highly respected Canadian thinkers, philosopher George Grant and historian Donald Creighton (*24*), maintain that for Canada to follow such a course would be an act of the gravest folly. They argue that if Canada follows the example of the United States—which, in their view, pursues a spiritless quest for material welfare by the relentless expansion of technological capacities—the country will forego all chance of developing an alternative life-style on the North American continent. If that should come to pass, they ask, what will become of the very premise of Canadian nationhood?

Beset by the shrill accusations of radical nationalists, on the one side, and the troubling, if quieter, laments of philosophic conservatives, on the other, pragmatic Canadian politicians must somehow thread their way through to an effective and acceptable science policy. To the extent that they succeed, the work of the Lamontagne committee could prove to have been an important milestone not only in Canadian history, but in the universal effort to make science and technology the instruments of thoughtful planning in the public interest.

References and Notes

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5. *New York Times* (12 December 1971), sect. 4, p. 11.
6. A. E. Safarian, *J. Can. Stud.* **6**, 21 (August 1971).
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18. Toronto *Globe and Mail* (8 November 1972), p. 9.
19. Toronto *Globe and Mail* (15 January 1971), p. 7.
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