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BUILDING A FEDERAL SCIENCE AND TECHNOLOGY STRATEGY

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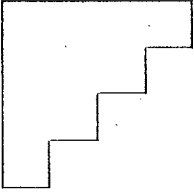
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An Invitation

A federal Science and Technology Review is now under way to determine how federal investment in science and technology can best be applied to support the needs of Canadian society. This document highlights some of the fundamental questions.

The Government of Canada believes that innovation, based upon a sound foundation of science and technology, will create jobs and permit the integration of economic with environmental goals to enhance the quality of life for all Canadians. Recognizing that the earth on which we live has finite limits, the decades ahead will present extraordinary challenges and opportunities. From the largest urban centres to the most remote rural locations, Canada needs to become a nation of experimenters, a nation of entrepreneurs and a nation of innovators.

In these days when governments must exercise unwavering discipline in controlling spending, Canadians must realign priorities to ensure maximum return while creating flexibility to pursue promising new directions.

At the Prime Minister's request, we are leading a review to determine the most effective way for the federal government to invest in science and technology to achieve three important goals: the creation of wealth and jobs within the context of sustainable development, the enhancement of the quality of life, and the advancement of knowledge.

On behalf of the Government of Canada, we invite your views on the issues and questions raised in this document to assist us in developing a Federal Strategy for Science and Technology appropriate to these changing times. Following release of the Strategy early in 1995, the process will be expanded further to seek consensus on a fully national strategy for science and technology.

The Honourable John Manley
Minister, Industry Canada

The Honourable Jon Gerrard
Secretary of State for Science,
Research and Development

Setting the Stage

The global economy is undergoing a technological revolution perhaps as striking as the industrial revolution of the past century.

Knowledge is becoming the most important factor contributing to the health of the economy. It is the essential ingredient permitting people and investment to become more productive.

Canada's rich natural resource endowment, its strength in manufacturing and service industries, its skilled people and its excellence in science all contribute to its economic success. Accelerating global integration of the world's markets and use of ever more sophisticated information technology are radically transforming how goods and services are produced and sold throughout the world. Technologies are also transforming how companies approach the protection and exploitation of natural resources.

This government is committed to promoting a thriving and innovative economy within the context of sustainable development as a strategy for creating jobs, increasing real wages and enhancing our quality of life. To deliver on such a commitment, the government is moving forward with:

- sound fiscal and monetary policies
- responsible social and environmental policies
- policies that will encourage adaptation to changing conditions
- policies to promote an innovative and entrepreneurial business sector.

From the OECD's main science and technology indicators, it is clear that, for whatever reasons, Canada (governments and the private sector) falls far behind in its commitment to investment in science and technology as measured, for example, in terms of R&D expenditures per capita or per GDP. This should be one of the most strategic issues for Canada to address as it comes to grips with the movement toward a knowledge-based economy in a global environment.

Nobuo Tanaka
*International Workshop on Science and
Technology Priority Setting, Ottawa: OECD, May 1994.*

Other nations are adjusting rapidly to the resulting stepped-up competition. The United States, for example, is directing more of its science effort toward making investments in technology development and commercialization in order to strengthen its industrial competitiveness and create jobs.¹

Canada's investment in research and development, about 1.5 percent of Canada's gross domestic product,

remains proportionally lower than that of all other Group of Seven (G-7) most developed countries except Italy.² While this comparative lag does not apply evenly across all parts of the Canadian economy, nor across all industrial sectors, it is still important to ask what impact this has had on Canada's economic performance; and whether it affects its economy's ability to move new technology from the laboratory to the market.

The small and medium-sized business sector has played a key role in the Canadian economy for well over a decade. Competitiveness for Canada's small and medium-sized enterprises is no longer a matter of being successful at the local or regional level. Firms that position themselves in expanding markets and move to the forefront of technology are best placed to stay ahead of competitors. Technological innovation is becoming a critical process in the survival and future success of these firms.

¹ President William J. Clinton and Vice President Albert Gore Jr., *Technology for America's Economic Growth: A New Direction to Build Economic Strength*, Washington: U.S. Government Printing Office, February 22, 1993.

² OECD, *Main Science and Technology Indicators*, Paris: OECD, May 1993. See also *Resource Book for Science and Technology Consultations, Volume I*, Ottawa: Industry Canada, June 1994, Table 4.2.

As advanced technologies are adopted by all sectors — whether natural resource, manufacturing or service — the job market in Canada will increasingly demand people with more skills. According to Human Resources Development Canada, close to half of all *new* jobs created between 1990 and 2000 in Canada will require at least 17 years of training.³ By comparison, only about one quarter of new jobs in 1991 required this level of education. Access to education and lifelong learning have become essential ingredients of success.

Skilled labour, in combination with advanced technologies, leads to improved productivity, more sustainable use of natural resources and the development of breakthrough products and services. All of these provide opportunity for increased sales, improved real wages and creation of new jobs.

If Canada is to realize its potential in the face of growing public debt, increased competition from freer trade and an accelerated pace of innovation worldwide, it has no choice but to support research and develop, apply and exploit new technologies to foster a vigorous and innovative economy. Innovation is key to adding value to Canada's existing products and resources, to developing new products and services, to opening up new market opportunities, and to managing businesses and other institutions in a way that better enables them to respond to changing circumstances. If Canadians want a growing economy, the status quo is not an option.

Innovation must occur as an interactive process, driven by users of technology.

The national system of innovation is not just a set of laboratories but is a cumulative process of learning by producing, learning by using and learning by the interaction of producers and users.

C. Freeman and B. Lundvall (eds.)

Small Countries Facing the

Technological Revolution, London: Pinter Publishers, 1988.

³ See *Resource Book for Science and Technology Consultations, Volume I*, Ottawa: Industry Canada, June 1994, Figure 1.2.



During the past few decades, there have been dramatic changes in our understanding of the innovation process. It is a dynamic process involving scientific discovery, applied research, development, production, marketing and sales.

Every country has a national innovation system. It is composed of individuals, communities and institutions, private and public, who use or develop science and technology as well as the environment in which they function. It is increasingly recognized worldwide that enhancing the performance of institutions that play key roles in the overall system, such as universities and government laboratories, is an important factor in strengthening the national system of innovation. A number of Asia-Pacific nations have moved rapidly ahead in development, largely because of their determined approach to innovation.

Canada's innovation system, first and foremost, should be based upon excellence in all aspects of science, development of technology and engineering. It should build upon strengths, skills and opportunities in all regions of the country, and should catalyze innovation in all parts of society. Lastly, it must meet the competitive challenges of the 1990s and beyond.

Our innovation system must be built upon a culture appreciative of the value of learning and knowledge that is also receptive to new ideas and their potential value. It must provide for the education and training of skilled people. It must accelerate the pace of adoption of existing technologies to boost market success. It must put Canadians in touch with the knowledge needed to develop innovative products, processes and services.

...there must be no gaps in the ability to either make the fundamental discovery, to bring the idea from elsewhere, or in the ability to apply the discovery or to translate the discovery into jobs, products, improved government services etc. ... As with any process which requires a chain of events, our national system of innovation is as weak as the weakest link. It is therefore absolutely critical that we identify and address any weak links and that we put in place a strategy that will correct any deficiencies.

The Hon. Jon Gerrard
Winnipeg, May 1994

Participation in our national innovation system is not limited to the industrial sectors usually identified as users of advanced technologies such as telecommunications, biotechnology, aerospace, defence electronics or computers. It also embraces resource-based industries such as mining, forestry, fisheries and agriculture, which depend heavily upon cutting-edge technology and innovation. Science and technology are particularly important to the long-term maintenance and viability of Canada's natural resource sectors. The need to maintain a constant stream of new disease-resistant varieties of crops is a specific example.

Within the context of [that] National System of Innovation, Liberal policy has three specific goals. The first is to support the creation of vibrant small and medium-sized businesses. The second is to revitalize the manufacturing, natural resource and service industries and to enhance the dynamic ideas-based sectors of our economy. The third is to encourage the communities in which these businesses are to thrive.

*Creating Opportunity: The Liberal Plan for Canada,
Ottawa: Liberal Party of Canada, 1993.*

The challenge for Canadians in all communities, urban or rural, is to become part of the national system of innovation. Governments also have important roles in the innovation system. They can lead improvements in how organizations and systems are managed, how new institutions are developed, and how information is shared.

Building a Federal Strategy for Science and Technology That Meets Canada's Social, Economic and Environmental Goals

The federal government's role in science and technology is to create a climate within which innovation can flourish. It can do this in many ways, for example, by:

- funding research and development directly
- ensuring that Canadians have the skills needed to participate fully in an innovative economy
- providing domestic and international networks to facilitate collaboration and the exchange of information among scientists, the business community and others
- opening up the economy to trade, markets and competition
- performing research to support, enhance and protect the Canadian quality of life, including national and international security
- using science and technology to improve the efficiency and effectiveness of its services and mandated operations.

As a government, we intend to innovate, to look at old problems with fresh eyes ... to measure the long-term outcomes and consequences of our policies and programs.

*Creating Opportunity: The Liberal Plan for Canada,
Ottawa: Liberal Party of Canada, 1993.*

In all of these areas, the federal government has an opportunity to provide strategic leadership. A recent snapshot of federal expenditures reveals that a total of about \$7 billion⁴ is invested in the area of science and technology annually. This includes the following approximate breakdown:

- \$1 billion supporting wealth and job creation through industrial science and technology and support of technology centres
- \$1 billion supporting industrial research and development through tax incentives
- \$1 billion supporting research and development in universities and other non-commercial organizations
- \$1.8 billion performing research and development in federal laboratories
- \$2.2 billion conducting and contracting for related scientific activity.

At a time when all governments must exercise discipline to control spending, the federal government needs to examine its own activities in science and technology to ensure that investments get maximum return in support of social, economic and environmental goals. This consultation process can assist the government in answering some fundamental questions. First, given current needs, what should Canada do in the area of science and technology? Second, given these national priorities, is the federal government doing the best it can with the resources it has?

The remainder of this paper poses some additional questions that the government believes are essential to the development of a new Federal Strategy for Science and Technology that is responsive to society's needs. The questions have been organized around three broad objectives: wealth and jobs in the context of sustainable development; quality of life; and advancement of knowledge.

⁴ See *Resource Book for Science and Technology Consultations, Volume I*, Ottawa: Industry Canada, June 1994, p. 4.

Wealth and Jobs in the Context of Sustainable Development

Canada's comparative advantage does not hinge on its geographical location or its natural resources alone. Within the context of sustainable development, it increasingly depends upon its technological prowess, sophistication of infrastructure, ability to innovate, the education and skill levels of Canadians, and its ability to use resources responsibly.

The creation of wealth and jobs for Canadians depends on their ability to: add value to current products; develop new products and services; exploit existing technologies and develop new ones to increase production efficiencies; conserve and use our natural resource base; and build upon the strengths and diversity of our communities.

To achieve this, Canada must become a society which encourages experimentation and innovation; which seeks and adopts best practices; and which integrates economic, social and environmental goals.

The key is to develop and improve working relationships between companies and organizations to move appropriate technology rapidly into the hands of entrepreneurs.

- How can science and technological innovation improve competitiveness and sustain the creation of wealth and jobs in each industrial sector? What role should the federal government play in this?
- Thinking globally, what are the areas of strategic opportunity in the Canadian economy into the next century? What industries and technologies will be critical for creating sustainable wealth and jobs?
- How can federal science and technology investments best support the integration of economic, social and environmental goals? How will Canadians know if these efforts are succeeding?

Our goal is to ensure that Canadian businesses are aware of and can adopt state-of-the-art technologies in a timely and efficient fashion.

*Creating Opportunity: The Liberal Plan for Canada,
Ottawa: Liberal Party of Canada, 1993.*

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- Some suggest that Canadian firms lag behind international counterparts in adopting technologies.⁵ Is this true? And, if so, why? What can the federal government do to address this situation?
 - What is required to ensure that Canadians are equipped to meet the needs of an innovation-oriented economy? What are the more important of these skills? What should be done to promote lifelong learning? What are the most effective approaches to retraining existing workers? What is the role of universities and colleges? What is the federal government's role in this area?
 - What do Canadian firms and industries need to do to capture the benefits of domestic and international advancements in science and technology? What, if any, is the federal government's role in facilitating this?

⁵ Statistics Canada, *Indicators of Science and Technology 1989*, Catalogue No. 88-002, Vol. 1, No. 4.

Quality of Life

Twice since 1991, the United Nations Development Programme ranked Canada first in terms of human development and quality of life.⁶ To achieve and maintain such a high standard is in many ways related to Canada's ability to generate the wealth which permits all Canadians to apply science and technology to meet broad societal goals.

Governments play a major role in safeguarding and enhancing the health, safety and security of Canadians. They set standards and best practices in areas such as food, drugs, medical equipment, communications, employment, transportation, construction and environment. They regulate and monitor performance and ensure compliance with regulations and standards. They plan ways of avoiding undue loss, damage or harm in the event of anticipated potential problems such as plant, animal or human disease. They examine the human impact of newly emerging technologies.

Governments contribute to the quality of life by establishing systems including justice, defence, education, income maintenance, child support, health care and public security.

Governments are responsible for the funding, construction and maintenance of a large proportion of our physical infrastructure such as roads, bridges, railways, pipelines, sewers and ports.

In the course of all of this work and the mission-oriented research which underpins it, governments collect vast quantities of valuable knowledge and information such as weather and climate data, geographical information, market intelligence, standards, statistics and a broad range of other technical and sociological information.

- What are the areas of strategic importance for Canada regarding quality of life into the next century?
- Some investments in science and technology related to quality of life also have the potential to create wealth and jobs, for example, in the emerging environmental industries and civilian applications of defence technology. How can this be enhanced?

⁶ United Nations Development Programme; *Human Development Report*, Oxford University Press, 1992, 1993, 1994.

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- How can efficiency of regulatory measures be improved so that compliance costs are lowered while maintaining or enhancing standards of health and safety?
 - What investments in science and technology are required to evaluate the human implications of new technologies?

Advancement of Knowledge

Research aimed primarily at the advancement of knowledge can be referred to as investigator-initiated research. It is the foundation upon which a knowledge-based society may be built and is a critical ingredient of the education system. Because of the long-term nature of much of this research and the difficulty in predicting who will benefit, priorities for federal expenditure cannot be based on estimates on the financial return on investment alone. In the area of advancement of knowledge, a long-term perspective in management and funding is necessary.

Excellence in natural, social and medical sciences and engineering ensures Canada a seat at international tables where leading-edge knowledge is exchanged. It also enhances Canada's ability to attract some of the world's top scholars; its capacity to discriminate between first-rate and third-rate science and technology; and its ability to contribute to, and benefit from, national and international deliberations on complex social, legal and ethical questions.

- What should Canada do to benefit from advances of knowledge from around the world and to promote excellence in Canadian science? What is the federal government's role in this area?
- To what extent should research be aligned with pressing social, economic and environmental goals of society? How should this be achieved?
- Does Canada capture adequately the commercial benefits of its research? What can be done to improve its performance in this area? What is the role, if any, for the federal government?
- How can the appropriate level of federal funding be determined for (a) investigator-initiated research; (b) team-based research; and (c) large science projects?

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- Is sufficient emphasis being placed on promoting science with Canada's youth? How should progress toward achieving a science culture in Canada be measured?

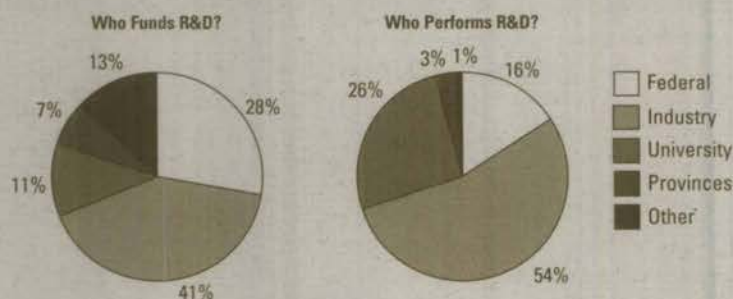
Managing Our Investments in Science and Technology

Government decisions to set priorities for investment in science and technology simultaneously affect all three areas described above: creation of wealth and jobs within the context of sustainable development; enhancement of quality of life and advancement of knowledge. This raises some important cross-cutting management questions.

- What should be the components and characteristics of Canada's national system of innovation? What weaknesses in the current system present obstacles to achieving an ideal system? What should be the federal role in addressing these weaknesses? What institutional changes would strengthen the performance of the national system of innovation?
- Has the federal government done enough to direct the innovation system toward long-term national and regional needs? For example, are environmental and human resource considerations receiving adequate attention?
- What is the state of Canada's science and technology infrastructure? How can it be enhanced or improved within existing budgets? Are there opportunities for cost-savings through collaboration?

- What criteria should be applied to setting priorities among potential investments in science and technology to create wealth and jobs in the context of sustainable development, promote and enhance the quality of life and advance knowledge? Who is best placed to perform research in each of these areas? Who is best placed to fund? [See Figure]

Research and Development in Canada, 1993



Source: Statistics Canada, *Science Statistics*, Catalogue No. 88-001, Vol. 17, No. 5.

- The governments of the U.S., Japan and Germany are increasingly targetting specific technologies for investment. In this context, how should the federal government evaluate and select its investments in science and technology projects? Are unique approaches required to respond to the needs and opportunities of different sectors? Different regions?
- How should the federal government measure results of its investments in science and technology?
- What mechanisms can be used to facilitate access to publicly held information and data?

-
- How can federal government procurement become a more potent tool for promoting innovation?
 - What kind of forum would permit the involvement of the Canadian scientific community in the development of policy advice and priorities related to science and technology?
 - Are Canadian universities and colleges contributing appropriately to Canada's science and technology objectives? What can be done to ensure well-educated graduates have the skills necessary to innovate?
 - Does Canada need to build better linkages to international science and technology? To what extent should the federal government pursue international agreements in this area? What is the role of the private sector?

Participating in the Consultations

The Government of Canada is actively seeking the ideas and suggestions of Canadians, individuals as well as organizations. In addition to welcoming written submissions via mail, fax or Internet, Canadians have opportunities to participate directly in the dialogue through an Internet discussion group or in person through a series of local, regional and national workshops and conferences organized in collaboration with local hosts and a consortium of private sector organizations.

Further information about the Science and Technology Review and the consultations may be obtained from:

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Please note that in order for written submissions to be used as inputs to the regional and national conferences scheduled for the fall, they must be received by the Secretariat no later than 20 August 1994.

You may E-mail your comments, briefs or queries to the above Internet address. The address for joining the electronic discussion group is can.ai. You may also obtain information about electronic retrieval of documents at this address.

If you wish to be kept informed of progress over the course of the Science and Technology Review or if you have a brief comment you would like to make, please fill out the form in the centre of this booklet and mail or fax it to the Secretariat.

A companion document titled *Resource Book for Science and Technology Consultations*, which contains statistics and related information about science and technology in Canada and abroad, is available in both official languages from the Secretariat.

For more information

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