CANADA

Report of the
National Advisory Board
on Science and Technology

HEALTHY, WEALTHY AND WISE:

A Framework for an Integrated Federal Science and Technology Strategy

Presented to the
Prime Minister of Canada

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April 1995

CANADA

National Advisory Board on Science and Technology

Conseil consultatif national des sciences et de la technologie

The Right Honourable Jean Chrétien, P.C., M.P.
Prime Minister of Canada
House of Commons, Room 309-S
Ottawa, Ontario
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Dear Prime Minister:

On behalf of the National Advisory Board on Science and Technology (NABST), we are pleased to submit our report on a framework for a federal Science and Technology (S&T) Strategy.

We are convinced that research and development are key to meeting Canada's difficult social and economic challenges, and that federal S&T assets and investments are vital national resources. However, they require much improved integrated management. In this report we have provided güidelines for developing a federal S&T strategy, including priorities which we believe are critical at this time. The report also suggests approaches for the system of governance necessary for coordinating the direction and accountability of all federal S&T investment.

We agree with the statement in the Auditor General's Report to the effect that "nothing new" had emerged from thirty years of S&T reviews. Although circumstances today are markedly different than they were even ten years ago, we have addressed this lack by preparing a federal S&T strategy framework based on what we believe is a new concept...that *economic goals and social goals are closely related.* A federal S&T strategy that improves the health, safety and motivation of Canadians, and does so cost-effectively, will strengthen the economy. Such a strategy builds upon the mutual relationship between the quality of life, the creation of wealth (and jobs) and the advancement of knowledge.

Throughout the summer and autumn of 1994 the federal government conducted an extensive Federal S&T Review. This review included an examination of federal S&T activities and policies, and broad public

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consultations with scientists, academics, industrialists and other Canadians. At your request, NABST undertook an independent assessment of both the public consultations and internal components of the review, and used this information, in combination with its own expertise, to prepare this report.

It should be noted that considerable interest and effort was expended by many people in the external consultations and the internal reviews. The ideas and information provided proved very useful to NABST. While clearly the social and economic context has changed since previous S&T policy reviews, the many inputs we have received have convinced us that the need for a goal oriented action plan for S&T is greater than ever before.

This report was prepared at the same time that the federal Budget (February 1995) was brought down. You will see in our report that we had anticipated certain directions the government is taking. NABST appreciates that tough choices had to be made in government funding; however, we regret that substantial cuts have been made to the overall level of federal S&T investments before a federal S&T strategy was instituted. Investments in scientific and technical competence are among the most important factors for a nation's competitiveness and for the quality of life of its citizens.

In the Program Review process leading to the selection of programs to reduce or cut, it appears that Ministers have collectively established *de facto* guiding principles to assist their decisions. We endorse many of these principles. This is particularly true regarding the changing role of the federal government in policy development and in the facilitation of S&T undertaken by industry, the universities and the provinces.

We recognize that certain cuts can be justified if there is a lack of evidence that federal S&T investments are being well spent, however, we similarly lack the evidence to conclude that spending less on S&T is appropriate. We do know, nevertheless, that Canada's national S&T investment today does not measure up to that of our strongest competitors and the reductions announced in the Budget have worsened this position. Given this reality, we must do better with less. The need for a federal S&T strategy to set priorities is even more critical.

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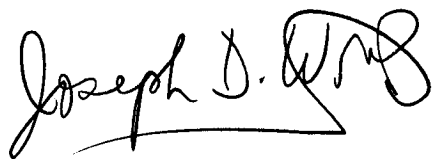
NABST urges the government to act swiftly and decisively to implement a federal S&T strategy along the lines we are recommending. We also call upon the government to set up an effective system of governance for federal S&T to ensure that the goals of the strategy are met.

Respectfully submitted,



Dr. Joseph D. Wright
Vice Chair, NABST

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Challenge Statement – The Imperative for Change

Change is all around us. Globalization, trade liberalization, changing demographics, stressed ecosystems, and the galloping pace of technological advances are exerting enormous pressures on society. Communication and information technologies are revolutionizing the way we work, learn and interact.

Our ability to sustain our quality of life is being threatened by Canada's declining international competitiveness, the rising costs of government programs and the burden of escalating national debt. The choices that we make over the next few years will determine our destiny. It is imperative that we take bold and innovative steps to meet these challenges if we are to retain the aspects of Canadian life that we value most.

Science and technology can increase economic growth

Science and technology (S&T) are driving international competitiveness. Nations that cannot deploy S&T in order to compete effectively in global markets will stagnate or decline. Our international competitors have recognized the important links between S&T-based innovation, economic growth and social progress. Canada must become better able to exploit these links if we are to compete in the changing global environment and make the transition to a knowledge-based economy. Fundamental to our success is an educated and innovative population able to adjust to, and benefit from, technological, market and social changes.

Science and technology can reduce the cost of social programs

Science and technology are also important tools in our efforts to reduce the costs of health and social programs while maintaining, and even enhancing, their effectiveness. Research into the underlying causes of health, social and environmental problems can assist governments in identifying risks, enabling earlier and less costly intervention. The innovative application of S&T towards developing new technologies, and the strategic direction of research funding towards improving the design and effectiveness of existing programs, can lead to more efficient and cost-effective delivery of services.

An integrated model is the key to success

Science and technology are key to our future prosperity and well-being. The social and economic challenges facing Canadians require innovative solutions. An S&T strategy must recognize the interdependence of *wealth and job creation, quality of life* and the *advancement of knowledge*. The interconnections between these three factors must be acknowledged and incorporated into a cohesive, *integrated model* if we are to succeed in creating a more productive and humane society.

Healthy, Wealthy and Wise:
A Framework for an Integrated Federal Science and Technology Strategy

Executive Summary

As Canadians approach the end of the 20th Century, we face a challenging future. Globalization, rapid technology change, stressed ecosystems, and increasing tensions within families and communities challenge us to rethink our view of ourselves and of the world around us. Our understanding and effective use of science and technology (S&T) are critical factors in our response to economic and social change where knowledge has become the most important competitive factor. Our competitors are mobilizing S&T for national advantage — so too must Canada. We must become more efficient at generating and exploiting S&T-based innovation if we wish to grow and prosper. NABST agrees with a recent statement by the Auditor General that, *"a society that pursues well-being and prosperity for its members can no longer treat [innovation] as an option."*

The capacity to develop and apply S&T is key to the development of a more innovative, flexible, and sustainable society.

In 1994, the federal government launched a major federal S&T review. NABST was asked to assess the results of the public consultations and internal studies that were undertaken as part of the review process, and to provide advice on the direction and structure of a federal S&T strategy. NABST formed three committees, whose reports comprise Chapter Two (Quality of Life), Chapter Three (Wealth and Job Creation in the Context of Sustainable Development), and Chapter Four (Advancement of Knowledge) of this document. These reports, together with Chapter One (A Framework for a Federal Science and Technology Strategy), recommend directions for federal priority-setting and resource allocation.

A National Vision:

Canadians aspire to a more productive and humane society, with a quality of life incorporating a high level of social, cultural and economic well-being; affordable and effective health care; environmental quality; and personal security.

The cornerstone of a federal S&T strategy is a national vision towards which our S&T resources and talents can be directed. The federal government should take the lead, in close consultation with other major stakeholders, in setting national goals and priorities, and in marshalling the necessary resources towards those goals.

The federal government must establish a coordinated, goal-oriented S&T strategy, which clearly defines appropriate federal roles and establishes priorities based upon consistent and measurable decision-making criteria.

Canada does not invest as much in S&T as most other advanced industrial countries. With regard to industry, our level of industrial investment in research and development is less than one-half the OECD average. Government investment in S&T is closer to that of other countries; however, it often has not been adequately focused towards clear and measurable goals. The federal S&T strategy must realign federal policies, programs, and the work of federal laboratories if we are to increase the benefits that we derive from our national investment in S&T.

The time has come **to act** on the recommendations of the many previous reports which have identified the need for a better system of S&T governance. Chapter One highlights the need for Cabinet to take direct responsibility for the management and coordination of federal S&T. The commitment and accountability of Ministers to implement an S&T strategy will be critical to its success.

A strong and expert system of governance, implemented at the Cabinet level, is needed to develop, articulate, and monitor the implementation of the strategy.

An *S&T Champion* in Cabinet should be identified and made responsible for developing the federal S&T strategy. This S&T Champion would bring S&T considerations to all major policy initiatives. To assist the Minister, the position of Chief S&T Advisor should be established. This Advisor should be supported by a small, expert staff, and should be given the responsibility to recommend national S&T goals and priorities, to develop and coordinate the S&T strategy, and to monitor its implementation. Public accountability for the strategy should be ensured through specific S&T commitments and targets within departmental business plans, and the publication of an annual *State of S&T Report.*

A cohesive, integrated model linking S&T policies for the advancement of knowledge, quality of life and wealth and job creation is needed to direct the growth of a ***healthy, wealthy and wise*** *nation.*

Priority-setting must become better focused at the government-wide and departmental levels. Chapter One recommends that all federal S&T programs be subject to strict selection criteria, and should also have their outcomes measured against pre-determined targets and performance indicators. External advice and evaluation should become the norm for all federal activities.

The federal S&T strategy should be based on a model that acknowledges and builds upon the interrelationships between wealth and job creation, quality of life, and the advancement of

knowledge. Chapter One outlines the interactive nature of these three factors and presents the rationale for developing a cohesive, integrated model as the basis of a federal S&T strategy. This collaborative approach is needed to create a more productive and humane society.

A HEALTHY NATION

A healthy and well-educated workforce is a prerequisite for a successful economy.

The productivity and competitiveness of any organization depends on the quality of its human resources. Chapter Two points out that education, training, good health and social support networks are key to the development of a motivated, skilled and flexible workforce. It recommends two broad priority areas for federal S&T: to ***improve the effectiveness*** and ***reduce the costs*** of public health and social services.

Innovative applications of S&T and the strategic direction of research funding towards improving the design and delivery of health, social and other quality of life programs can increase their effectiveness and reduce their cost.

In the short term, research should focus on measuring the effectiveness of existing programs against established targets and benchmarks; and it should ensure that programs deliver their services efficiently. In the longer-term, research should focus on gaining a deeper understanding of the underlying causes of poor health and social problems, thereby allowing us to anticipate and prevent problems, and to design more effective policies and programs.

NABST recommends that the government commit to investing approximately 1 percent from its health care budget and 0.5 percent from its social programs budget in such research. Chapter Two identifies criteria for this research, and recommends targets and timeframes, to ensure that the research undertaken will pay for itself in reduced program costs.

Basic and applied research, particularly in the social sciences, are critical to the identification of high-risk populations and issues. Such research cuts across departmental mandates and political jurisdictions. For this reason, the investment in research should be managed collaboratively and performed in multidisciplinary fashion. Since the national dissemination of relevant information is essential to achieving the recommended goals, Chapter Two also recommends that all relevant federal data be made available to qualified researchers and program administrators on a timely and affordable basis.

A WEALTHY NATION

The capacity to develop and apply S&T is key to the development of a more innovative, efficient, flexible, yet sustainable economy. The private sector has the primary responsibility for commercialization of technology. The federal S&T strategy must provide a business environment in which businesses that develop and market technology-based products and services can thrive. Their success creates jobs, wealth and growth for their companies and for their suppliers, and new opportunities for their R&D partners.

The key components of a wealth and jobs strategy: refocussing government investment in S&T, mobilizing industry and facilitating the enablers.

The development of a sound S&T strategy demands a clear understanding of the challenges of a competitive global economy, of rapid technological advance, and of the corresponding S&T strengths required to deal with them.

The federal role in performing S&T should be smaller and more focused.

To refocus government investment in S&T requires first that government understand how its S&T dollars are invested and why. Each laboratory should be evaluated by an external panel of experts to determine the continuing relevance, impact and priority of its programs in light of the priorities of the federal S&T strategy. Government S&T policy should aim to increase the amount of research performed outside of government. Chapters One and Three provide criteria for the performance of federal intramural S&T. Where programs do not meet these criteria they should be terminated or devolved to the private or academic sectors.

In this way the needs of the government will be met and the additional benefits of economic development and education will simultaneously be gained. NABST notes that some departments and agencies have already started this refocusing. These initiatives should be encouraged and extended to all parts of government.

To mobilize industry, government must improve the business climate so that entrepreneurs are stimulated to seek out and commercialize the results of research. It must reduce the disincentives of unnecessary regulation and punitive taxation on successful businesses.

To improve the climate for wealth and job creation governments must establish industrial and taxation policies that encourage entrepreneurship and innovation, and that mobilize industry to increase its effective use of S&T.

Government can and should assist profit and non-profit organizations which transfer technology effectively and which form effective partnerships to commercialize S&T. There are many examples of successful technology transfer organizations, such as incubator facilities, which link university or government laboratories with entrepreneurs and encourage the start up of new companies. Government policies should build on these successful models.

Chapter Three provides a framework for how repayable federal R&D funding to larger companies should be levered by requiring that they form partnerships with small businesses, universities or colleges. Procurement policies should be used more effectively to enhance the export potential and technological capabilities of small businesses.

S&T can help make sustainable development both a standard business practice and an export opportunity for Canadian entrepreneurs.

S&T can be used to set strict science-based standards for sustainable development. Firms should be challenged to meet and surpass these environmental and sustainable development standards. Canada can be a world leader in environmental industries, products and services.

Government should facilitate enabling technologies and support the creation of a strong technological infrastructure.

To facilitate the enablers, government should improve business access to new enabling technologies and help Canadians understand their impact on business, education and everyday life. Securing the benefits from pervasive new developments, such as the Information Highway, requires a new policy climate and a sound infrastructure. Education and training are also key enablers for development of a workforce skilled in ways that meet the needs of research and industry in creating wealth and jobs.

A WISE NATION

Strengthen the advancement of scientific knowledge and training leaders.

The degree to which Canadians excel in the advancement of knowledge will determine our success in economic growth and social progress. This success is contingent upon a variety of mediating social and economic conditions. Accordingly, components of an S&T strategy must enable Canadians to:

Sustain strength in discovery. A vibrant and robust S&T base is the source of unanticipated advances and discoveries and the basis from which the research community can respond to changing societal demands and goals. By participating on the leading edge of international S&T, Canadians are able to identify and obtain more timely benefit from new breakthroughs. However, new social and economic realities demand a shift away from the status quo. Chapter Four encourages the implementation of new and innovative ways to carry out and to fund excellent research in universities, industry and government laboratories.

Promote collaborative support for research infrastructure.

The federal government should promote partnerships and collaboration among S&T stakeholders in order to sustain and improve national S&T competence, and collaborate with the provinces to ensure a strong university research infrastructure. Chapter Four challenges universities to change the way they perform and fund research by moving towards diversified funding sources and performing more collaborative multidisciplinary research. NABST encourages universities to build on local strengths while actively partnering with other research organizations to develop a strong ***collective*** strength in Canadian R&D. Taken together, these actions will permit Canadian universities to retain their important role as educators of our future leaders and researchers, and as a source of the basic research competence and knowledge essential for future development.

Encourage collaborative and multidisciplinary research, and access to knowledge pools in Canada and abroad.

Improve capacity to adapt and apply knowledge. Canada's ability to apply research results should attain a level of excellence that matches our current level of excellence in research. Canadians must be developers and exporters of the products of R&D, not just producers of the knowledge itself, if wealth, job creation and a high quality of life are to flow from a strong knowledge base. Chapter Four identifies models that encourage and strengthen strategic collaboration among academia, government and industry, promoting cross-sectoral and multidisciplinary partnerships. It also calls for improved accessibility to knowledge in Canada and abroad, and effective intellectual property safeguards on the Information Highway.

Establish an integrated plan for science culture activities.

Foster and sustain a strong S&T culture. S&T culture is strongly coupled to the quality of our education system. Together these are the underpinnings for future social and economic growth. The value Canadians place on S&T has implications for the transfer and innovative application of knowledge and for the development of a versatile and scientifically literate workforce. Chapter Four recommends the establishment of an integrated plan for science culture initiatives to ensure that they are effectively targeted and rigorously evaluated.

Ensure a strong S&T learning environment from primary through post-secondary education.

Improve education and training standards and science literacy. Canadians must recognize that to be fully functional in the modern world a solid knowledge and skill base in science, technology and mathematics is as essential as the ability to read and write. The development of science literacy among all Canadians must be viewed as an extension of national social and economic policy. All sectors must take an active role in ensuring a strong learning environment from primary through post-secondary school levels.

CONCLUSION

Social, technological and economic change demand that the federal government redefine its role in shaping Canadian S&T. The time to act is now! Our future wealth generating capacity and the quality of our social and physical environments depend on our ability to use new knowledge to innovate and adapt. Since, in the short term, federal resources for S&T will not grow, it is crucial that the federal government be strategic in making S&T policy and investment decisions, in order to generate the greatest benefit to all Canadians. NABST proposes a framework for an integrated federal S&T strategy to guide these decisions. This strategy requires dedicated leadership and an effective system of ongoing governance to set, implement and evaluate national S&T goals and priorities.

CHAPTER ONE A FRAMEWORK FOR A FEDERAL SCIENCE AND TECHNOLOGY STRATEGY

1.0 A VISION FOR CANADA

Canadians aspire to a more productive and humane society, with a quality of life incorporating a high level of social, cultural and economic well-being; affordable and effective health care; environmental quality; and personal security.

Science and technology (S&T)[1] are integral to achieving this quality of life, for it is only through the effective utilization of S&T that we can release the innovative capacity of Canadians to advance knowledge, generate wealth, and sustain and improve our social and physical environment. The dynamic interplay of these elements is key to realizing our vision. The creation and application of new ideas, and the motivation and ability to acquire new knowledge, are central to an advanced society. Application of the results of S&T, coupled with a productive workforce, will generate wealth, jobs and an advanced quality of life.

2.0 GOALS FOR CANADIAN SCIENCE AND TECHNOLOGY

Leadership is required if we are to realize our vision. The federal government should develop a strategy to apply S&T to economic, environmental and social challenges. This strategy will need clearly articulated goals, towards which S&T programs and policies can be targeted, and against which performance can be measured. The National Advisory Board on Science and Technology (NABST) proposes that we strive to achieve the following national goals:

- A more innovative, efficient, flexible and internationally competitive economy that is continuously repositioning itself to produce value-added goods and services to world-wide markets.
- A level of research and development (R&D) capacity and excellence that is competitive with that of leading countries.
- A dynamic workforce with the skills, knowledge, flexibility, motivation and incentive to adapt S&T to the changing economy.
- A culture that values S&T and can apply S&T not only to wealth creation for all Canadians, but also to find innovative solutions to major societal problems (e.g., safety, environmental protection, education).

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1 UNESCO defines science and technology as systematic activities that are closely concerned with the generation, advancement, dissemination and application of scientific and technical knowledge, including such activities as research and development, scientific and technical education and training, and scientific and technological services. In this report, we include the social sciences in the definition of S&T.

- A more innovative, efficient, and flexible government service sector, which applies S&T expertise to improve its services (e.g., to reduce the cost and increase the access to health care) and to help all Canadians attain a high quality of life.

3.0 CONTEXT AND CURRENT SITUATION

Globalization, trade liberalization, rising government debt, changing demographics, stressed ecosystems, and the galloping pace of technological change are challenging us to take stock. Canadians have built a society whose quality of life is envied around the world. However, we cannot afford this standard of living without major, even radical, changes to the status quo.

Most industrialized countries have recognized the critical role of S&T in facilitating economic growth and enhanced well-being. Australia, the United Kingdom, the European Community and others have initiated ambitious S&T strategies, and made changes to the organization and structure of decision-making in attempts to optimize the social and economic benefits of S&T.[2] Canada has been slow to respond. Failure to take swift, deliberate and strategic action to apply S&T for national advantage will lead to a deterioration in our future ability to generate wealth and thus, will threaten our physical and social environment.

It is not a question of spending more money overall, but investing more strategically in S&T. Canada's public expenditure on health care, as a percentage of gross domestic product (GDP), is already the highest among Organization for Economic Cooperation and Development (OECD) nations. The growth rate of our social spending is also high compared to other countries. Health and social programs account for over half of total federal spending. Yet we are plagued by persistent unemployment, high rates of illiteracy, skills mismatches and employment disincentives that rob the economy of significant creative and productive capacity. The effective application of S&T can improve the design and delivery of our health and social programs, increase their effectiveness and reduce their cost.

Science and technology are contributing to the changing rules of international competition and industrial structure. In the past, Canada's economic prosperity was founded on the wealth of our natural resources. However, in a complex and rapidly evolving knowledge-based society, our future ability to sustain a high-wage, high-employment economy will depend upon how well we combine our wealth of intellectual resources with these natural advantages. Canadians must not only increase the productivity of current businesses, but also create new and growing businesses based on ever-higher value-added goods and services.

Canadian investment in research and development (R&D) is below the average for most industrialized nations (Table 1.1). In particular, industry spending on R&D is less than one-half of

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2 In May 1993, the United Kingdom released a White Paper, *Realising our potential: A Strategy for Science, Engineering and Technology,* which identified new management and direction for government S&T support. Australia has also made significant changes in its management of S&T to improve priority-setting and establish national goals.

the average for OECD countries. Government investment in R&D is somewhat better, but is still significantly below the OECD average.

The low level of private and public sector R&D investment is a critical national issue. The Chairman of the Bank of Nova Scotia has noted that, *"because economic success now depends more than ever on innovation and mastery of technology, public support for science and early stage R&D is one of the very few categories of government spending that deserves to be increased ...studies have shown conclusively that the overall return to society from investment in knowledge creation is extremely high."* [3]

Just increasing the level of S&T activity in Canada will not be sufficient, since Canada produces only a small fraction of global S&T. We must be alert to emerging global trends, and become smart consumers of new ideas and technologies produced elsewhere. We must develop a population knowledgeable about S&T, with the motivation to apply it in productive and innovative ways. While Canadians are becoming more technologically sophisticated, too often we have lagged behind our competitors in adopting and adapting new technologies that can transform how we work, how we learn and how we relate to our social and natural environments.

Table 1.1 Gross Expenditures on R&D (GERD) 1992

Country	GERD (U.S. $B)	GERD as a Percentage of GDP			
		Total	Government	Domestic Industry	Other Private Sector & Foreign
U.S.	167.0	2.81	1.09	1.66	0.06
Japan*	68.3	2.80	0.49	2.13	0.18
Germany	36.2	2.50	0.91	1.52	0.06
France	25.6	2.40	1.06	1.10	0.24
U.K.	20.0	2.12	0.75	1.05	0.32
Italy	13.1	1.31	0.59	0.67	0.05
Canada**	**8.1**	**1.51**	**0.67**	**0.62**	**0.22**
Netherlands	4.8	1.86	0.86	0.98	0.08
Sweden***	4.2	2.86	1.01	1.73	0.12
OECD Average	N/A	2.29	0.81	1.36	0.12

Source: OECD, *Main Science & Technology Indicators*, December 1994
* Japanese data adjusted by the OECD Secretariat
** GERD/GDP ratio adjusted by the OECD from Statistics Canada data
** 1991 data

[3] Ritchie, C.E., Chairman of the Board of the Bank of Nova Scotia. *Putting Canada Back to Work,* a speech to shareholders in Halifax on January 18, 1994.

The federal government invested almost $6 billion in S&T in 1994/95,[4] approximately five percent of its total program spending.[5] As well, it foregoes another $1 billion of potential revenue annually through the scientific research and experimental development tax incentives. Federal S&T resources are applied to almost every facet of government activity — from industrial development to health, and from environmental protection to defence.

It is often difficult to categorize federal S&T investments, since they can have multiple purposes. For example, environmental S&T can help improve and protect the environment (quality of life), but may also contribute to industrial development through the creation of new products, services or markets (wealth and jobs). Some estimates suggest that approximately half of all federal S&T spending is applied to wealth and job creation, roughly 30 percent to quality of life, and 20 percent to the advancement of knowledge.[6] As to whether this is deliberate or appropriate, a previous NABST report on S&T priorities noted that, *"the government has no grounds for concluding that the current distribution of S&T spending among federal organizations reflects the government's strategic objectives."* [7] Nor does the current system ensure that these objectives are being set, let alone met.

Thirty years of S&T policy reviews have provided a wealth of good ideas, but these have not been effectively implemented within an integrated S&T strategy. The Auditor General noted recently that some of the fault *"can be attributed to a lack of overall government-wide leadership, direction, focus on results and accountability for implementing desired changes."* [8] The federal government has acknowledged this fact and in the 1994 Budget it promised to develop an S&T strategy *"with real priorities, real direction and a real review of results."* [9]

Current fiscal pressures have caused significant disruption and dislocation within the scientific and non-scientific communities. However, the necessity for change also represents an opportunity for progress. We have an opportunity to re-evaluate and redefine our fundamental goals and priorities as a nation, as well as the role of the federal government in achieving these goals. We must establish a truly results-oriented action plan to prepare Canada for the 21st Century.

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4 Approximately $3.5 billion is spent on research and development and $2.4 billion is spent on related scientific activities (e.g., data collection, policy studies, scientific information, museum services).

5 The 1994/95 budget totalled $162 billion which comprised program spending of approximately $121 billion and interest on the debt of $41 billion. Not included is another $12 billion provided to the provinces through tax point transfers.

6 Secretariat for the Science and Technology Review. *Resource Book for Science and Technology Consultations, Volume I.* (Ottawa: 1994) p. 4. As estimated by Industry Canada.

7 National Advisory Board on Science and Technology. *Committee on Federal Science and Technology Priorities: Phase II.* (Ottawa: February 1994) p. 20.

8 Auditor General of Canada. *Report of the Auditor General of Canada to the House of Commons 1994,* Volume 6, Chapter 9. (Ottawa: November 1994) pp. 9-16.

9 The Honourable Paul Martin, P.C., M. P., *The Budget Speech,* February 22, 1994, p. 7.

4.0 A FRAMEWORK FOR AN INTEGRATED FEDERAL S&T STRATEGY

Throughout the summer and fall of 1994, an extensive Federal S&T Review was undertaken. This review included public consultations, almost 350 written submissions, and internal studies of federal S&T activities and policies. As part of the overall process, NABST was asked to assess the outcome of the S&T Review, and to provide the Board's own recommendations on the basis for a federal S&T strategy.

This report does not itself constitute a federal S&T strategy. Instead, it provides a framework (goals, criteria, and roles), and it sets out some specific priorities for action in key areas of federal S&T that NABST believes should be the basis of an effective federal S&T strategy.

The federal S&T strategy should ensure that federal research and S&T infrastructure provide the maximum possible public benefit, and that they are linked closely with other government program and policy initiatives. It must also *set the stage* so that individuals, the private sector, educational institutions, and communities can make more effective use of the results of S&T for social and economic advantage.

The ultimate goal of a federal S&T strategy is to maximize the short- and long-term benefits of public and private sector investments for our quality of life, wealth and job creation, and the advancement of knowledge. In a rapidly changing global environment, this requires new ways of conceptualizing S&T, new ways of performing S&T, new ways of governing it, and new ways of evaluating outcomes.

An S&T strategy must be based on fundamental principles. It must insist upon continual benchmarking of performance and results against international best practices. It must encourage building on existing strengths, expertise and assets. It must enhance current policies that have been effective at technology transfer and diffusion, and it must improve cooperation, partnerships, and shared learning among stakeholders. There are many positive examples of change based on these principles in both the public and private sectors. Educational institutions, government laboratories, industry and research institutes are collaborating in innovative and productive ways. We should learn from such initiatives, and build upon their successes.

The success of the strategy will be determined by how well all aspects of the S&T system can be integrated into clearly defined priorities and goals upon which progress can be effectively measured and evaluated. The following sections elaborate on what NABST believes to be the requisite foundation for a federal S&T strategy: an *integrated model; clear roles*; an *effective* system for ongoing *governance*; and *decision criteria* and *measurable performance* indicators.

4.1 AN INTEGRATED MODEL

Government has traditionally treated wealth and job creation, quality of life, and advancement of knowledge independently when developing policies for S&T. The advancement of knowledge was seen to provide new ideas, primarily through unanticipated advances, which would lead to technological progress; technological progress would generate increased wealth; this wealth

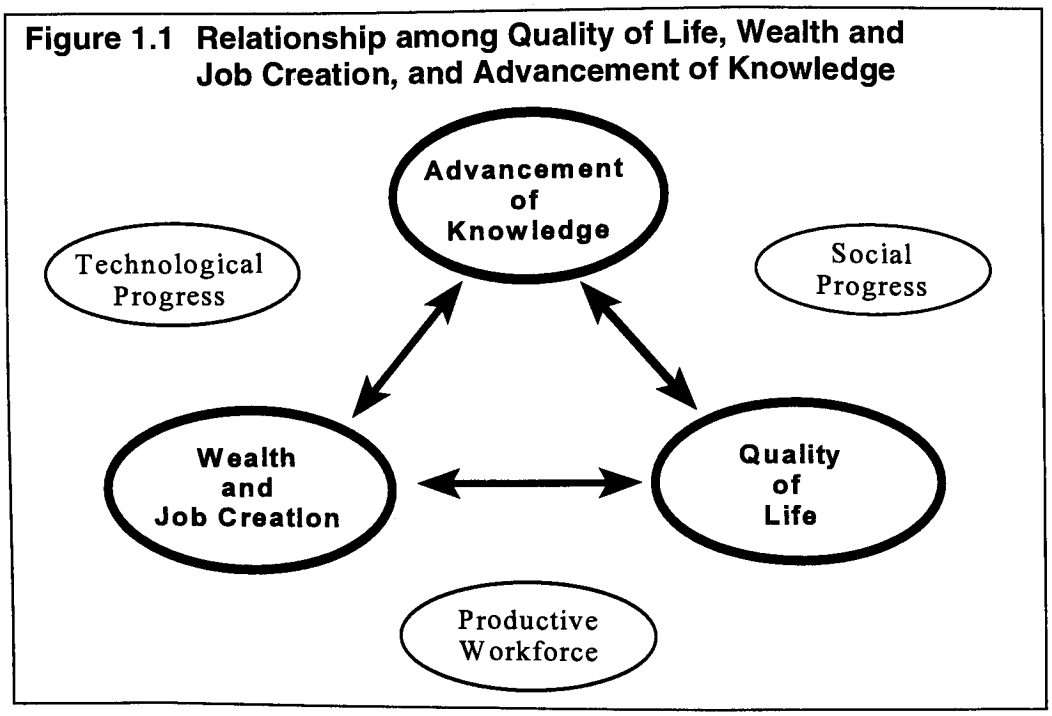
would, in turn, be used to improve the quality of life. This linear approach does not recognize the dynamic interplay among these three factors. The federal S&T strategy must be based on a model that integrates and optimizes the interrelationships among wealth and jobs, quality of life and the advancement of knowledge. We cannot consider one without the other.

Figure 1.1 illustrates the complex and interactive nature of the three factors in such a model. Although Canada's economic prosperity is linked to technological progress, it is also increasingly dependent upon social advances that result in a high quality of life and a productive workforce. Social stability is a pre-requisite for the creative and productive citizenry needed to support an agile and innovative economy.

Fundamental and applied research provide a flow of new skills, ideas, technologies and policies that will assist in ensuring technological and social progress. Successful use of technology is critical for economic growth, but an emphasis on technology alone will not succeed without some understanding of its underlying principles and without a qualified and motivated workforce. Research on social issues and into social and health care program delivery will contribute to a better quality of life, thereby ensuring a more productive and humane society. Technological and social progress are often the outcome of research, but may also facilitate research and even open up new research avenues.

We should conceptualize an S&T strategy that honours the interdependence of wealth and jobs, quality of life and the advancement of knowledge.

Figure 1.1 Relationship among Quality of Life, Wealth and Job Creation, and Advancement of Knowledge



4.2 ROLES WITHIN THE S&T STRATEGY

It is possible for industry, the research community and governments to contribute individually to wealth and job creation, increased innovation and improved quality of life, but there is a powerful synergy from a combination of their efforts. To realize our national goals, the federal S&T strategy must provide for an unprecedented level of cooperation and sharing of public and private sector resources and talents.

4.2.1 The Role of Industry

Primary responsibility for the advancement and use of technology with commercial potential rests with the private sector. Governments normally are not and should not be directly involved in commercial research. Industry uses S&T to help create competitive advantage by introducing new or improved products, processes and services to capture market share, to create new markets, and to lower costs through increased productivity. Long-term competitiveness requires that firms make adequate investments in employee and organizational skills development, and in product and process research and technology. Firms, particularly small and medium-sized enterprises (SMEs), must improve their capacity to receive, develop and exploit S&T.

4.2.2 The Role of the Research Community

Universities and other research organizations develop fundamental and applied research programs that contribute to the advancement of knowledge and that help to educate and train qualified people. As described in the integrated model, the research community generates new ideas at the frontiers of knowledge, and develops new skills and technologies that are essential to create wealth and to address societal needs. It also provides access and understanding of scientific developments in other countries.

Researchers must take more responsibility for the results of their publicly funded research to benefit Canada. Canada has a strong base in research, but too often this valuable resource has not translated into economic or social benefit for Canadians. Better mechanisms are needed to ensure that, where appropriate, this research is transferred to Canadian receptors in the private sector who can commercialize or apply it. This research and new knowledge must also become better integrated into the policy development and operations of the public sector. Researchers must also become more adept at communicating the social and economic value of their research to a public that continues to be sceptical of the value of this investment.

4.2.3 The Role of the Federal Government

The federal government plays a central role in shaping Canadian science and technology. This role involves three distinct aspects:

- *policy,* with which the government seeks to influence the S&T activity of others;
- *support* for S&T performed by others, through tax incentives, grants, contributions, collaboration, partnerships, procurement, and the provision of information; and
- *performance*, which involves the actual *doing* of S&T within federal organizations.

The federal government should place priority on the first two of these roles — the setting of policy and the encouragement of S&T by others. Industry and the research community should have a greater role in the actual *doing* of S&T, within an S&T policy framework. The government's role in performing S&T should be limited to critical, well-defined functions.

The Federal Government's Policy Role

Federal S&T policy should enhance, not inhibit, the speed and intensity of innovation to support economic growth, improvements to quality of life, and the advancement of knowledge. It should strengthen the capacity of all sectors of the economy to use the results of S&T. Key activities include legislation and policy development (e.g., in regulation, standards setting, intellectual property rights, and environmental protection), as well as promotion of international, regional and sectoral coordination, and the encouragement of technology transfer and diffusion.

The Federal Government's Support Role

The federal government plays an important role in support of S&T by others through direct contributions to university-based researchers, and through grant programs, technical assistance, provision of infrastructure, procurement, and tax incentives which lever private sector and other investment in innovation. In this support role, government should act as a catalyst for innovation and as a reliable partner to other stakeholders. The government can also reduce governmental performance of S&T by continuing its policy of contracting out S&T to the private sector, wherever possible.

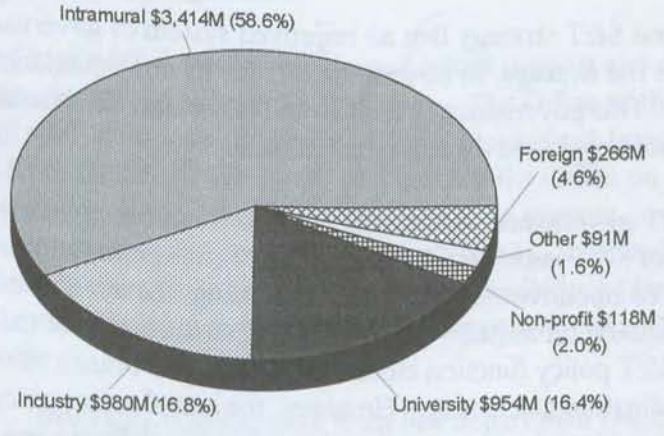
Another key aspect of the federal support role is in the provision of information. Where appropriate, the information that the government collects should be widely accessible and available to researchers on a timely basis. In the future, federal government policy instruments will focus more on information than on expenditure to effect change. As the federal government develops information-based products and services that support the decisions and activities of others, it must work with the provinces, communities and other stakeholders in the collection and dissemination of this information, the assessment of emerging trends, the development of outcome measures and the adoption of best practices.

The Federal Government's S&T Performance Role

The federal government is the single largest performer of S&T in Canada.[10] Despite the existence since 1978 of a government policy to encourage contracting out, the percentage of in-house or intramural performance of S&T has declined only slightly.[11] It is increasingly important that more federal S&T be done by others. **The federal government should focus its own S&T performance on areas of need where *only* government can and should act**, such as the following *strategic* S&T activities:

- those of such a scale, scope or level of risk that their benefits or results cannot provide a sufficient return to warrant investment by any one firm or group of firms, although the overall benefit to the economy is high (e.g., generic pre-competitive research);
- those requiring a degree of national or international standardization, control, uniformity and continuity (e.g., standards, data collection); and
- those with national security, policy or regulatory requirements that preclude private or academic performance.

Figure 1.2 Federal S&T Expenditures 1994-95, by Performing Sector



Source: Statistics Canada, Catalogue No. 88-001.

Figure 1.2 shows the current distribution of federal S&T expenditures.

In performing S&T, the federal government's activities must be rigorously evaluated against the appropriate roles of government, as well as against the vision, goals and criteria laid out in an S&T strategy. **Where it is more appropriate, feasible or cost-effective, federally funded S&T activities should be performed in the private sector or in universities.** Even where federal intramural S&T is justified, this justification should be reassessed regularly.

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10 In 1994-95, the federal government spent $3.4 billion on S&T activities within 150 labs and other establishments, staffed by over 35 000 people (including 11 800 scientific and professional staff and 8 600 technicians). Scientific activities support a number of objectives including economic and regional development, environmental protection, health and safety, national security, support of decision- and policy-making, and advancement of knowledge. Federal facilities and expertise comprise a significant portion of Canadian scientific and technological infrastructure.

11 Treasury Board Administrative Policy manual number 314 (1978) directed departments to contract out the S&T requirements for departmental missions in all but a limited number of cases. In 1987, this policy was reaffirmed by the Decision Framework for Science and Technology. However, the net result of this policy has been minimal. Between 1981 and 1991, extramural expenditures by the departments targeted by the policy remained almost constant.

Federal laboratories represent a significant resource with their knowledge base, infrastructure and considerable expertise. In conducting S&T activities appropriate to the focused federal role, the laboratories should also enhance their linkages with industry, universities and other parts of the research community. Such linkages will promote the transfer and diffusion of knowledge, improve the quantity and pace of innovation in Canada, and ensure that the maximum potential for social and economic benefit is derived from public investments. Each department should implement a formal priority-setting and decision-making process for S&T, and report on their targets, activities and results in annual business plans. The government must also do a better job coordinating activities and sharing resources across departmental boundaries.

Recommendation:

Establish a goal-oriented S&T strategy with clearly defined roles for government, in the context of a model integrating the quality of life, wealth and jobs, and the advancement of knowledge.

4.3 Governance of Federal S&T

It is imperative for the success of a federal S&T strategy that an improved system of governance be established to develop and to monitor the strategy, to be accountable for its implementation, and to measure and evaluate the results. This governance system would target limited federal resources towards clearly articulated priorities, based on consistent criteria.

NABST reviewed several models of S&T governance. Most OECD nations have recognized that, given the all-encompassing nature of S&T issues across every area of endeavour, and the significance of S&T to future economic competitiveness and social well-being, the development of national S&T policies and strategies should be centrally coordinated. Canada is one of the few nations that has not positioned its S&T policy function close to the executive branch of government or developed a strong coordination mechanism. However, the actual structure or placement of the governance mechanism is secondary to ensuring that it has the ability to see that S&T considerations are well incorporated in all decision-making. What follows are the general principles and functions of a potential system of S&T governance for Canada.

Authority

Just as a large corporation recognizes that S&T is a strategic component of its business, and mandates someone to be responsible for ensuring its effective use, so too must government. A federal S&T strategy needs **a senior Cabinet Minister to act as a strong S&T champion** and as an agent of change both within government and across the country. This Minister would be designated by the Prime Minister to develop the government's overall S&T strategy and priorities, and to ensure that the government's S&T efforts are appropriately designed so as to

be integrated into major policy initiatives. Individual Ministers would remain accountable for the implementation of those aspects of the strategy that fall within their mandates.

The Cabinet Minister should be supported by a Chief S&T Advisor. This individual would be a well-respected scientist or policy-maker appointed as a senior civil servant, to ensure continuity. The Chief S&T Advisor would lead the setting of cross-departmental priorities that govern and influence the S&T activities in all departments, and would provide advice and help coordinate areas of multi-disciplinary interest or resource demands that go beyond the mandate of any one department. However, neither the champion nor the Chief S&T Advisor should try to micro-manage regular departmental S&T activity from a central authority.

Cabinet Oversight and Coordination

Cross-departmental issues and the necessary discussion and agreement on the S&T strategy would be facilitated by **a Cabinet Committee on S&T**, chaired by the Minister responsible for the S&T strategy. This committee would provide overall direction, coordination and evaluation of the S&T strategy. As part of their annual planning cycle, **departments should establish S&T business plans** to indicate how they propose to implement the priorities and meet the targets of the strategy.

Support and Coordination

The Chief S&T Advisor would need expert support and continuity to assist in the formulation and monitoring of the federal S&T strategy. The Office of the Chief S&T Advisor should have a small staff, composed primarily of senior executives from science-based agencies and departments and from outside government, seconded to the Office on limited terms. The Office would be mandated to assist the coordination effort, to prepare government-wide goals and priorities, and to review/assess implementation and outcomes. This body would assist Cabinet in its overall leadership role, while recognizing the responsibility of line departments to manage the strategy's implementation and to be accountable for performance. Desired characteristics of such a body include:

- neutrality (independent from line department responsibility for S&T performance);
- responsibility for recommending, evaluating and adjusting S&T policies and priorities, including the development of criteria, performance indicators and measurable targets;
- cooperative decision-making structure to coordinate S&T policy-making and implementation across departments and agencies;
- influence over resource allocation and human resource management; and
- advice on major new domestic and international initiatives.

This organization should also draw advice and assistance from and provide services to **a revised interdepartmental committee structure that provides a forum for priority-setting and collaboration on cross-departmental issues.** These committees would have direct influence on various aspects of the S&T strategy. The role of the existing Committee of Assistant Deputy Ministers of science-based departments and agencies could be enhanced to undertake this activity.

External Advice

The government must become more adept at using external advisory bodies in the management and evaluation of programs. Such bodies should be the norm for major federal S&T activities, and should comprise those knowledgeable of both performance and use of the research.

At the highest level, that of advice to the Prime Minister and the Cabinet, a national advisory council (i.e., NABST, or its successor) should be mandated to continue to advise the government on S&T matters, and to oversee the S&T strategy development process. This council would act as a board of external directors to the Office of the Chief S&T Advisor by reviewing plans and priorities. The government would also receive specialized advice on national issues from learned societies, individual experts and professional organizations.

Accountability

Accountability for federal S&T investments should be improved, perhaps through **the publication of an annual *State of S&T Report***. This report would identify key decisions and highlight the progress that the federal government is making towards current priorities. It would also be the basis for generating public discussion on future priorities.

Parliamentarians should play a greater oversight role on the implementation of a federal S&T strategy. Both the *State of S&T Report* and departmental S&T business plans should be tabled at a House Standing Committee for review and debate.

In implementing its strategy, the federal government must work with the provinces and other stakeholders to ensure a coherent and cohesive agenda for innovation at the national level.

Recommendation:

Establish an effective S&T governance system, led by a Cabinet-level S&T Champion, supported by a senior Chief S&T Advisor with a dedicated staff of inside and outside experts, advised by an external advisory board, and implemented by responsible line departments.

4.4 Criteria for Setting Priorities

The S&T strategy should contain a decision-making process with clear authority, accountability and measurement of outcomes. The priority-setting process of the federal S&T strategy should be as clear and as consistent as possible across departments. All federal S&T activities should be subject to rigorous selection criteria, to be applied in a consistent manner. The following broad criteria should guide the government's priority-setting (see Appendix I for more details on specific criteria):

- Does the investment clearly and measurably relate to the federal S&T strategy and goals within the context of the integrated model?
- Is the S&T activity appropriate to the federal role?
- Is there a good return on investment?
- Does the activity meet or surpass international benchmarks?
- Is the S&T activity responsive to client needs?

A factor that frustrates better management of federal S&T is the lack of quantifiable data on the return on investment of the outputs of federal S&T expenditures. Available data tend to measure inputs or levels of activity, but not their impact or effectiveness. **Government-wide benchmarks and performance indicators must be developed** and maintained to allow progress to be measured across and within departments.

Some federal departments and agencies have made considerable progress in setting priorities and measuring outcomes at an operational level; however, there are no overall priorities for federal S&T investments. By articulating their goals and expected outputs within the context of the overall federal strategy, departmental decisions regarding trade-offs between policy instruments will become more transparent. Explicit targets should be set in consultation with the clients of the S&T activity, and with managers held accountable for reaching them. Evaluation should be undertaken with the full participation of external advisory bodies, to ensure objective review.

Recommendation:

Establish and apply consistent and measurable criteria and performance indicators to help establish priorities and measure outcomes.

5.0 SUMMARY

The success of a federal S&T strategy requires that government take a more systematic approach with respect to the public policies that address S&T issues. To provide for effective management of its assets and investments, NABST urges the government to:

- develop a goal-oriented S&T strategy with clearly defined roles for government, in the context of a model integrating the quality of life, wealth and jobs, and the advancement of knowledge;
- establish an effective S&T governance system, led by a Cabinet-level S&T Champion, supported by a senior Chief S&T Advisor with a dedicated staff of inside and outside experts, advised by an external advisory board, and implemented by responsible line departments; and
- set and apply consistent and measurable criteria and performance indicators to help establish priorities and measure outcomes.

CHAPTER TWO REPORT OF THE NABST COMMITTEE ON QUALITY OF LIFE

1.0 CONTEXT

Equal access to quality of life is a distinguishing feature of Canada's national identity. We wish to maintain that identity. However, in order to do that, we will have to improve the effectiveness and efficiency of our existing quality of life programs. The level of spending on quality of life programs, such as health, social and education programs, simply cannot be sustained, with spiralling costs and growing concern about whether they are delivering full value for the money expended. On the other hand, the demands on these programs are growing. It is within this context that NABST examined the role of federal S&T in quality of life.

This chapter focuses on three issues with respect to quality of life, within the context of an integrated model for S&T:

- **the key relationship between quality of life and economic growth;**
- **the fact that the federal government is in the business of quality of life; and**
- **the role of federal S&T in improving the cost-effectiveness of quality of life programs.**

1.1 QUALITY OF LIFE IN THE 21ST CENTURY

In the opening chapter of its 1994 report, the Ontario Premier's Council on Health, Well-being and Social Justice described trends in the youth population today: a growing proportion of children living in poverty (over a 5 percent increase in three years); suicide rates three times higher than 30 years ago; increasing family violence; unacceptable rates of functional illiteracy; and high-school drop-out rates that are entirely out of keeping with the level of education required to gain entry to knowledge-based jobs. The report warns that these trends are also occurring across a broad spectrum:

> *"For a long time, we have been able to live with the fact that some of our children and youth would 'drop out' along the way — not just from school, but from becoming active and contributing members of society. It was assumed that as long as most children 'made it,' there would be enough social and economic productivity to carry the society along. That assumption may no longer be true. We need all members of society to help us meet complex social, economic, and political challenges.*

"But there is something else happening. Because of the magnitude of change, particularly in the economy, the children and youth that we have traditionally assumed would 'make it' are at increased risk. If a significant number of young people who come of age now and into the next century lose hope of being participating members in the economy, if they do not find a future for themselves as full and active members of our society, what does that say about our future as a province and as a country?

"We are in danger of losing the living standard and social stability we have created, with hard work and commitment, over many years. It is not that our support and helping systems have suddenly become dysfunctional. But they are being overtaken by a massive change in society and the economy." [1]

In fact, our quality of life programs are being challenged on two fronts: by increasing demands, which result from the societal changes noted above, and by increasing pressure on all governments to reduce the costs of these programs. Federal S&T can help the federal government to respond to both pressures by identifying areas for early intervention, thereby reducing the need for costly remedial programs, and by identifying ways to deliver programs more efficiently.

1.2 Elements of Quality of Life

The United Nations' *Human Development Report* defines quality of life as including the elements of health, safety, security, environmental quality, social well-being and cultural heritage.[2] Education is also given prominence as an indicator of quality of life (one key reason why Canada ranks highly in the U.N. report). A U.S. government report, *Science in the National Interest*, includes equality of opportunity ("full participation in the democratic process") as another element of quality of life.[3]

Since nearly half of the federal program budget is spent on health care and social programs (see Section 2.0), and since these programs are most vulnerable to current fiscal pressures, NABST has focused its review on these two areas of federal S&T related to quality of life. The following analysis and recommendations, however, are relevant to federal S&T related to all the other elements of quality of life, i.e., environmental quality, personal safety, cultural heritage and security.

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1 Premier's Council on Health, Well-being and Social Justice. *Yours, Mine and Ours: Ontario's Children and Youth, Phase One.* (Toronto: Queen's Printer of Ontario, May 1994), pp. 16-20.

2 United Nations Human Development Programme. *The Human Development Index Revisited, Chapter 5, Human Development Report: 1994.* (New York: Oxford University Press, 1994), pp. 90-101.

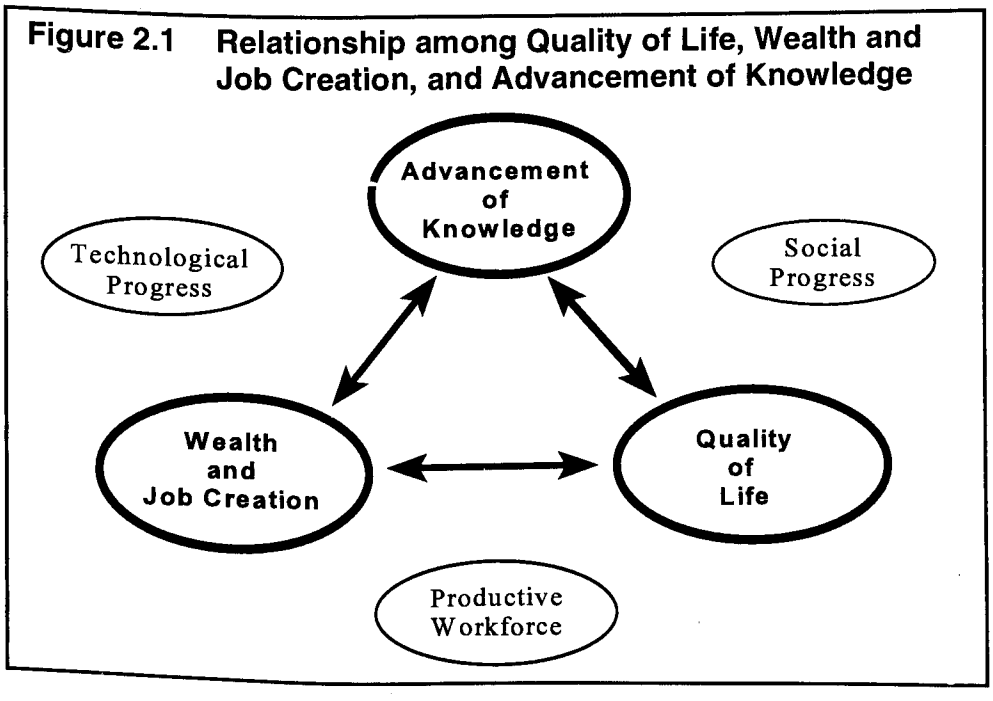
3 Office of Science and Technology Policy. *Science in the National Interest.* (Washington D.C.: Executive Office of the President, 1994).

1.3 The Relationship between Quality of Life and Economic Growth

It seems to be an axiom for many that economic growth, by itself, is sufficient to guarantee a high level of quality of life. In the national wrap-up to the public consultations, representatives from both academic and business communities agreed that a healthy, growing economy was necessary for developing and sustaining a high quality of life. There was a consensus that government should focus support programs on the commercialization of ideas and technologies to achieve economic growth through increased productivity. Quality of life programs were not considered as important, because increased productivity, it was assumed, would automatically generate higher levels of quality of life as part of the economic growth process. This report challenges that assumption, on the basis that the relationship between quality of life and economic growth is much more integrated and holistic. While a healthy economy is absolutely necessary for developing and sustaining a high quality of life, an innovative, productive workforce is just as critical to achieving that economic growth as is the development of new technologies. We need to identify and promote those factors that contribute to the kind of adaptive and motivated workforce necessary for maintaining a competitive edge in a knowledge-based economy.

A productive workforce that is healthy and educated, motivated to engage in life-long learning, and capable of operating in the global economy is essential to Canada's productivity and competitiveness. While it is clearly important to develop and commercialize new technologies, it is equally important to support programs in education, health, and social well-being to provide for a productive workforce. **Canada needs both healthy people and social stability for sustained economic growth. Quality of life and economic growth are directly related and equally important** (see Figure 2.1). *This is the first key message on quality of life.*

Figure 2.1 Relationship among Quality of Life, Wealth and Job Creation, and Advancement of Knowledge



The process of creating a productive workforce includes: developing a mobile, flexible, highly skilled, and motivated workforce capable of operating in the global economy; involving population groups that have traditionally been excluded from the workplace (single parents, aboriginals, persons with disabilities); and supporting the transition of young men and women (fifteen to twenty-four) into a workforce in which knowledge-based activities will be increasingly important. By one estimate, nearly half of all new jobs to be created in the 1990s will require at least 16 years of education.[4]

The relationship between quality of life, a productive workforce, and economic growth is highlighted in a December 1992 report by the State of Oregon:

> *"The trend toward a globally integrated economy and new technology is putting a premium on those with high work skills, while it reduces wages for those with relatively fewer skills. Social distress and family dysfunction is accelerated by these circumstances. Education and workforce preparation must be job No. 1 in Oregon. If everyone can be brought into a high-wage economy, the cycle of family distress and dysfunction that shatters and destroys lives and diminishes our community can be broken.*
>
> *"The quality of life in Oregon also gives the state a competitive economic advantage. It helps us retain and attract skilled and productive people to work in and build our economy, especially among knowledge-intensive industries where capable people make a critical difference."* [5]

2.0 Federal Spending on Quality of Life

The federal government is in the business of quality of life — it spends the bulk of its program budget in delivering quality of life programs to Canadian citizens, either directly or through block transfers to provinces. *This is the second key message on quality of life.*

With respect to all dimensions of quality of life (i.e., environmental quality, safety, culture, and defence, in addition to health and social programs), the federal government spent $83.4 billion in 1994-95 (see Figure 2.2). That amount represented 70 percent of the government's $120.9 billion *program* budget for 1994-95 (and 51 percent of the total federal budget).[6] As depicted in Table 2.1, the amount of federal spending on social and health programs (consisting primarily of cash transfers) constitutes the greatest part of the government spending

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4 Human Resources Development Canada. *Improving Social Security in Canada: A Discussion Paper.* (Ottawa: Minister of Supply and Services Canada, October 1994), p. 16.

5 Oregon Progress Board. *Oregon Benchmarks: Standards for Measuring Progress and Government Progress* (Salem: Government of Oregon, December 1992), pp. 8, 41.

6 The federal government spent $42 billion on servicing the public debt in 1994-95, in addition to what it spent on programs.

on quality of life; and adding tax point transfers to the provinces and tax credits to individuals would raise social and health expenditures by a further $20 billion.

Figure 2.2 Total Federal Spending 1994-95 ($162.9 billion)

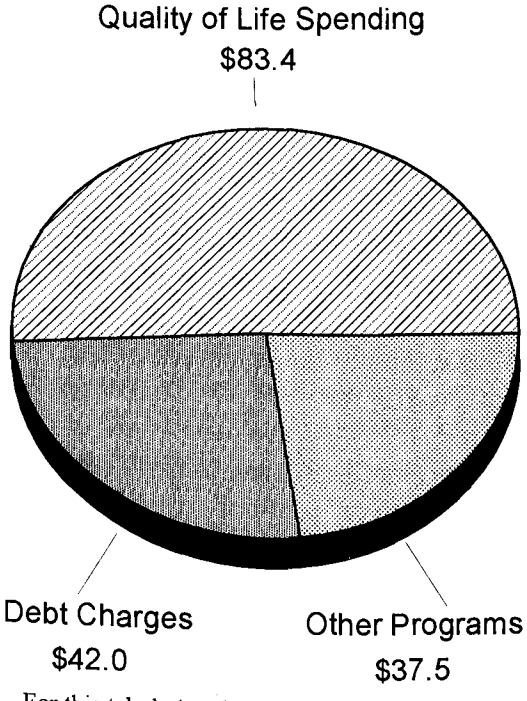

Table 2.1 Federal Quality of Life Spending 1994-95

Area	$ Billions
Health & Social	59.0
Defence	11.6
Indian & Northern Affairs	3.8
Safety	3.3
Heritage & Culture	2.9
Housing	2.1
Environment	0.7
Total	**83.4**

For this tabulation, health and social spending includes departmental spending by Health Canada and Human Resources Development, cash transfers to the provinces via the Established Programs Financing (EPF) and Canada Assistance Plan (CAP) mechanisms, and transfers to seniors, veterans, and U.I. recipients. Adapted from the Budget Plan, Department of Finance, February 27, 1995.

It is difficult to assess how much of the $83.4 billion spent on quality of life was invested in S&T. The total federal investment in S&T (in 1994-95) was approximately $6 billion (with another $1 billion in tax credits). Of that $6 billion, the Internal Review Task Force attributed less than $2 billion to the area of quality of life.

3.0 The Role of Federal S&T in Quality of Life

The public consultations revealed that most people associate federal S&T with the *hard* sciences and technology; when they do associate S&T with quality of life, they define it in terms of *medical* science and technology.

NABST supports the approach taken in an American report, *Science in the National Interest*, wherein George Brown, the former Chairman of the House Committee on Science, Space and

Technology, called for American research resources to be redirected towards a broader set of quality of life issues:

> *"Over the last half century, we have achieved spectacular scientific and engineering accomplishments in the service of a Vigilant Society. We now need to enlist our science and technology in the service of a Humane Society where work is meaningful, families are secure, children are well fed and well educated, where prevention is the first line of defense in health care, where the environment is respected and protected for future generations, and where sustainable development becomes the conscience of our progress."* [7]

3.1 Federal Performance of S&T in Quality of Life

Chapter One set out that the federal government has three roles with respect to S&T: the development of policy frameworks for S&T; the support and encouragement of S&T performed by others; and the (limited) performance of S&T itself. Examples of the latter include the identification and mitigation of threats to human health and safety.

Risk identification and risk management are critical in the areas of health and safety, in dealing with both the immediate concerns (e.g., threats involving epidemics and blood supply) and the long-term ones (e.g., assessing the impact of climate change and bio-accumulation of toxic chemicals). Federal S&T that helps to identify and manage risks is directly relevant to our quality of life. It is fairly well understood, in terms of its objectives and its methodologies, and there continue to be improvements in managing such S&T, for example, through the use of external advisory bodies and peer review.

There is another important role for federal quality of life S&T, which relates to the kind of research that the federal government (and other levels of government) must undertake in order to evaluate and improve program efficiency and effectiveness. As noted above, this chapter focuses on health care and social well-being. However, programs directed to the other dimensions of quality of life are also amenable to the approach set out below, i.e., programs related to environmental quality, personal safety, defence, and cultural heritage.

Like any other enterprise, the federal government should invest a sufficient proportion of its budget in researching ways to improve its core products and services. Federal S&T should reflect the scale and importance of the primary business of government; and, as we have seen from the numbers quoted above, the federal government is certainly in the business of quality of life. **This means that government should direct appropriate S&T resources, including the use of social sciences, to improving the effectiveness of quality of life programs, and to finding ways to reduce their costs.** *This is the third key message on the contribution which federal S&T can make to the quality of life in Canada.*

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[7] Office of Science and Technology Policy, p. 17.

It was not possible to determine the proportion of federal S&T dedicated to improving the efficiency and effectiveness of federal quality of life programs. Based on discussions with officials at Health Canada's Extramural Research Program, the Medical Research Council, and Human Resources Development (HRD), it appears that less than $100 million per year is invested in cost-effectiveness research. That level of investment would amount to approximately one tenth of one percent of federal quality of life spending ($83.4 billion in 1994/95).

This report recommends that the federal government increase its level of investment in cost-effectiveness research, and that it take both a short-term and long-term approach to such research.

3.2 Short Term (Improving Effectiveness and Reducing Costs)

The government can take a number of actions in the short term to improve the cost-effectiveness of programs, i.e., to develop more effective programs and to deliver them more efficiently.

All governments can build upon the potential of the information highway, including the use of 'tele-diagnostics' and 'tele-medicine' to provide more efficient and effective health care to remote areas, and the streamlined processing of requests for social assistance and the responses to those requests (see inset).

In addition to such improvements in *efficiency*, government should also monitor and evaluate the *effectiveness* of programs in the short term. Policy makers are constantly being asked to make difficult choices about the allocation of scarce resources. These decisions need to be based on solid evidence with respect to relative effectiveness. For example, are programs actually assisting people to enter the workforce; are they contributing to enhanced health; and are they achieving this in the most cost-effective manner possible? The only way to ensure that this happens is for the government to identify the intended outcomes of these programs, and to establish solid benchmarks by which to measure progress.

Short-term Efficiency Improvements:

The federal government can use information technology to accelerate response times while dramatically reducing administrative burdens on individuals and government. The Employment History Reporting project is responding to business requests for a streamlined, electronic reporting system, saving government and businesses paper, time and money. Other efficiency-enhancing measures at Human Resources Development include telephone reporting and direct-deposit systems.

Through the experience gained in *applying* research, government will be better able to identify reasonable outcomes and set achievable targets. By determining which approach works best, government will gradually be able to substitute less costly types of service delivery and programs without compromising the effectiveness of the services and programs. Federal-provincial collaboration in conducting this research and exchanging information will lead to the replication of each other's best practices.

3.3 Long Term (Addressing Root Causes and Reducing Demands)

Perhaps even more fundamental is the long-term approach which government must take if it is to significantly improve the effectiveness, and reduce the costs, of quality of life programs. Long-term, basic research is required to better understand those human factors that are producing the increased demands on remedial programs, such as unemployment insurance and welfare assistance. Simply cutting the programs, without addressing the underlying causes, is not a solution. Applying the results of research on the underlying causative factors should lead to the development of strategies and actions to address the *source* of the demands for remedial programs. Over time, this approach will provide a more effective means of reducing the costs of our social programs.

The health care field is most advanced in its study of causative factors, e.g., the determinants of health (see Section 5.1.2 below). The early identification of physiological, behavioural, motivational, genetic, socio-economic and environmental factors that can influence the health of individuals or populations permits government to begin redirecting attention and resources to those factors. The potential is enormous for anticipating and preventing problems, thereby reducing both future demands and future costs.

Long-term research can be applied in the other social program areas: identifying the determinants of poverty, unemployment, crime, violence, illiteracy, high-school drop-out rates, drug dependency, and welfare dependency. While the challenge may appear overwhelming to some, it is no more insurmountable than some of the challenges facing medical researchers who are seeking to identify the underlying basis of specific pathologies or diseases. As with medicine, conducting basic research aimed at understanding the underlying causes of social problems will better equip us to design and implement cost-effective quality of life programs.

4.0 Criteria for the Allocation of Federal S&T Resources

Much of the S&T that the federal government undertakes in the area of quality of life is directed to public health and safety, i.e., risk identification and response, and the establishment of standards and regulations. The broad criteria for federal S&T that are set out in Chapter One would apply to such activities. However, this report is recommending that government introduce a new element in its approach to quality of life S&T. In addition to supporting biomedical, environmental, and security-related S&T, government should identify priority areas of health care and social programs, and dedicate a portion of its S&T resources to finding ways to deliver these programs more effectively and efficiently. It is with respect to such *cost-effectiveness* research that NABST recommends the following criteria be applied by the appropriate line departments:

(1) Does the research address the right questions? Specifically, will it contribute to any of the following:

- the identification of underlying causes of health and social problems;
- an increased shift to prevention (identifying risks, and anticipating and preventing problems, thereby reducing demand and costs); and
- ongoing evaluation (including the use of benchmarks), leading to improved design of programs, and increased efficiency of delivery.

(2) Does the research employ scientifically sound methodologies, designs, and analyses? Specifically, are the scientific standards for research in quality of life as scientifically defensible as those used for research in the natural, biological and engineering sciences? The introduction of consumer-oriented, participatory research will be critical to the design and evaluation of programs. Therefore, rigorous methodologies and controls should be developed and applied to ensure that this research is valid and can be replicated.

(3) Does the research provide for a *return on investment*? Specifically, is there evidence of a mechanism to apply the findings in terms of changes in social policy, reallocation of resources, restructuring of social programs, and/or reduction of costs? Just as the research findings arising from the natural, biological and engineering sciences must be transferred from the university and government laboratories to the industrial sector, so must the findings from research on social issues be transferred from universities to governments and applied, if change is to occur in how governments respond to social problems, including government decisions on which programs are to be cut or reduced, retained or improved.

The responsibility for conducting periodic reviews of the *application* of federal research and benchmarks in the ongoing evaluation of program efficiency and effectiveness should form part of the mandate of a federal mechanism for the governance of S&T, as described in Chapter One.

5.0 Priority Action Areas for Federal S&T

5.1 Priority Action Areas for Health Care

During the public consultations, the need to examine methods of *delivery of health services*, and to seek more efficient and more effective alternatives, such as community-based models, was stressed on many occasions. Participants emphasized the need for evaluation of both old and new medical practices, such as hospital practices and procedures, the administration of tests, and the shift to home care.

The federal government's internal S&T review emphasized the need for *policy shifts*, in order to promote prevention, risk analysis, cost-effective delivery of services, and greater sharing of information:

- an emphasis on prevention would include putting priority on addressing the determinants of health, rather than focusing primarily on medical care;
- a shift to risk identification and analysis entails a greater emphasis on science as the basis for identifying those risks and for regulatory reform; and
- more cost-effective methods of delivering health care include the use of information technology to develop a public health intelligence system.

5.1.1 Health Care Delivery Costs

While there are variations on how governments and agencies calculate total (public and private) health care costs in Canada, a recent report by Health Canada put the figure for total public and private spending at $72 billion (1993), of which the federal government spent nearly $17 billion (in direct spending and transfers to individuals and to provinces).[8] The $72 billion expenditure represented 10 percent of Canada's GDP in 1993. Canada's costs are lower than those for the U.S., but they are higher than those for every other OECD country (see Table 2.2). Given that there is no evidence that higher Canadian costs result in superior Canadian health, this report recommends that government investigate means of reducing these costs to a level comparable to that of other OECD countries. The objective is not simply to reduce costs, but to ensure that we provide the most effective health care in the most efficient manner possible. This is necessary if we are to maintain a high quality of health care, and to ensure that quality health care is accessible to all Canadians.

Table 2.2 Health Expenditures in OECD Countries

Country	Total Exp. as % GDP	Public Exp. as % GDP
United States	13.4	5.9
CANADA	**9.9**	**7.5**
France	9.1	6.7
Sweden	8.6	6.7
Australia	8.6	5.8
Germany	8.5	6.1
Netherlands	8.3	6.1
Italy	8.3	6.5
Japan	6.8	4.7
United Kingdom	6.6	5.5
OECD Average	**8.1**	**6.1**

Avge: 22 OECD countries.
Source: *OECD Health Systems*, 1993.

[8] Health Canada. *National Health Expenditures in Canada, 1975-1993*. (Ottawa: Minister of Supply and Services Canada, 1994).

5.1.2 Priority Areas for Cost-Effectiveness Research

The following areas have been identified as being among the more promising for enhancing effectiveness and achieving cost-reductions:[9]

- identifying the **determinants of health**, and intervening accordingly, rather than focusing primarily on medical illness — some of the health determinants that have already been suggested include early childhood nurturing and nutrition, housing, environmental quality, and community and social support mechanisms;
- utilizing other, **less traditional methods** for delivery of health care, including alternative health care professionals, community health centres, and remote diagnostics;
- **primary care**: early interventions, and continuing care, are cheaper, simpler, and more effective than episodic, highly technical specialist care, and community-based health services could be an effective vehicle for improving the delivery of primary care;
- downsizing and **rationalizing hospital care**, including controls on the proliferation of new, expensive, but sometimes low-value-added technologies; conducting objective reviews of hospital practices, including the use of laboratory tests and length of stay; and consolidating the administration of hospitals within a given urban or regional area; and
- focusing on **population aging** (home care and community-based alternatives to institutional care are relatively under-developed in Canada compared to the U.K. and other European countries).

In January, Queen's University and the University of Ottawa released the results of a three-year research project, entitled *Sustainable Health Care for Canada.*[10] The report, often referred to as the "Maxwell Report," focused on hospital care and alternative methods of delivering medical, surgical and recuperative care services. It identified the potential for major cost savings in Canada's health care system.

NABST agrees with the Queen's/University of Ottawa estimate that $7 billion or more could be saved from national health care costs of $72 billion (although it favours *reducing* budgets by that amount, while the Queen's/University of Ottawa report favours *reallocating* that amount to other areas of health care). According to the report, the savings can be achieved, without jeopardizing

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9 Pran Manga. "Health Care in Canada: A Crisis of Affordability or Inefficiency?" *Canadian Business Economics* (Summer 1994), pp. 56-70. See also J. Fraser Mustard and John Frank, *The Determinants of Health* (Toronto: Canadian Institute for Advanced Research, Publication No. 5, August: 1991), and the Premier's Council on Health, Well-being and Social Justice, *Health For All Ontarians: A Provincial Dialogue on the Determinants of Health* (Toronto: Queen's Printer for Ontario, 1994).

10 Douglas E. Angus, Ludwig Auer, J. Eden Cloutier and Terry Albert. *Sustainable Health Care for Canada: Synthesis Report.* (Ottawa: Queen's/University of Ottawa Economic Projects, 1995). The project was launched in 1991 by the Economic Council of Canada, but was later moved to a new home at the University of Ottawa. Judith Maxwell was the Executive Director of the Queen's/University of Ottawa Economics Projects.

health outcomes, through more cost-effective use of facilities and services, through exploring alternative methods of service delivery, and by provinces adopting *best practices* from other jurisdictions.

The public consultations generated many anecdotes concerning routine medical tests and procedures which could be discontinued without affecting health outcomes, thereby saving millions of dollars. However, these accounts, and the Queen's/University of Ottawa report, primarily addressed institutionalized medical interventions (e.g., physicians' services and hospital care). They did not evaluate the full potential for community-based health care, or the use of alternate professionals (e.g, nurse practitioners), to be more cost-effective methods of delivery, nor did they assess the potential of health determinants research for intervening in the situations that create the demands for health care.

> "Efficiencies can be realized by changing the mix of services among the four major sectors — institutions, professionals, continuing care, and pharmaceuticals — as well as within them. Other efficiencies can be gained by reducing and/or eliminating marginally useful or ineffective procedures and services. Any change that reduces the aggregate cost of health care without reducing the system's effectiveness is ethically defensible. The overriding goal is to ensure that the appropriate interventions are carried out on the appropriate people at the appropriate time."
>
> Source: *Sustainable Health Care in Canada, p. 114.*

Based on a growing body of research and practical experience, NABST recommends that the federal government propose a national target for cost reductions — to be achieved without reducing the quality of health care or health outcomes. Using the international benchmark of percentage of GDP, it is recommended that government reduce its expenditures to between 9 percent and 7 percent of GDP (Canada is currently at 10 percent while the OECD average is 8 percent). A time-frame of five years is proposed for achieving this target. As additional information becomes available on new ways to enhance effectiveness and efficiency, the target should be revised downwards accordingly.

5.1.3 Recommended Re-allocation for Cost-Effectiveness Research

As noted in Section 3.1, it has been difficult to determine the proportion of current federal S&T spending dedicated to enhancing the effectiveness and efficient delivery of services, e.g., research into health services delivery or into reducing future demand for these services. Our estimates suggest that approximately 0.1 percent of total expenditures on quality of life are being spent on cost-effectiveness research.

NABST recommends that an identified amount from the federal health care budget *should* be allocated for cost-effectiveness research, and that it should be considered a strategic investment. This approach is routine in industry — some large corporations invest between 3 to 6 percent of their budgets for new or improved products and services. This is also the approach being followed

in the U.K., where the National Hospital Service has designated between 1 and 1.5 percent of the budget for local hospital authorities to be set aside for coordinated research, including research into health services.

Based on a growing body of knowledge, both formal research and practical experience, it is anticipated that such an investment in health services research would be repaid quickly in the form of reduced costs of program delivery, i.e., as a result of improvements in effectiveness and efficiency. Longer-term research into the determinants of health, and application of the results of this research in the development of more effective social and health care programs, have the potential to generate even more fundamental improvements.

A federal fund for health services and health determinants research, as recommended below, should be used as a base to lever additional funds from all parties that stand to benefit from more effective and efficient health care, including provinces, major employers, insurance companies and pharmaceutical companies. Federal-provincial consultation and collaboration is essential.

Recommendation:

Allocate an amount of funding from the federal health care budget, in the range of $100 to $200 million annually, for health services and health determinants research. This amount is roughly equivalent to 1 percent of federal spending on health care.

A coordinating mechanism should be established to manage this research. Health Canada should be the lead department (accountable for results); the granting councils[11] should provide peer review of work proposed and conducted; and both Health Canada and the granting councils should contribute to the coordination of federal-provincial, inter-departmental, and cross-disciplinary research.

5.2 Priority Action Areas for Social Programs

Neither the public consultations nor the internal S&T review addressed the area of social well-being in great detail, with respect to federal S&T. The consultations did, however, conclude that Canada requires a workforce that can create and support a knowledge-based economy; that social safety nets need to be overhauled in order to allow all Canadians to participate productively; and that the social sciences and humanities have a critical S&T role to play.

[11] The granting councils are: the Medical Research Council (MRC); the Natural Sciences and Engineering Research Council (NSERC); and the Social Sciences and Humanities Research Council (SSHRC).

5.2.1 Social Program Delivery Costs

The Caledon Institute of Social Policy recently described how Canada's public and private expenditures for social programs have risen dramatically over the past thirty years. *"In constant 1994 dollars, total social spending went from $26.3 billion in 1966-67 to $147.8 billion in 1992-93, representing respectively 8.3 percent and 21 percent of the GDP."* [12] As set out in Table 2.3, a comparison with other OECD countries shows that, while Canada's social program costs in 1990 (as a percentage of GDP) were only slightly higher than average, Canada's *growth rate* in real social expenditures was second only to Italy, and was two to three times higher than that of the U.K., the U.S., and Germany.

5.2.2 The Need for Cost-Effectiveness Research

While there appears to be consensus on the need to evaluate health services, this is not the case for social services, even though the federal government spends over four times as much on social programs as it does on health care. The apparent reasons for this are intriguing: health issues are more easily viewed as part of a coherent whole; the *health community* is more integrated than that for social programs; social issues such as employment, crime, housing, and violence against women and children tend to be treated separately; and, social issues, and the socio-economic origins of those issues, are seen to be so diffuse and overwhelming that they are often perceived to be insoluble.

Table 2.3 Social Expenditures in OECD Countries[1]

Country	Social Expenditure Share of GDP (%)		Annual Growth Rate of Real GDP (%)		Annual Growth Rate of Social Expenditure (%)	
	1980	*1990*	*'75-80*	*'81-90*	*'75-81*	*'81-90*
CANADA	**17.5**	**20.2**	**3.9**	**2.8**	**3.9**	**4.4**
France	24.7	26.7	2.8	2.5	5.2	3.2
Germany	24.6	22.0	2.7	2.5	2.3	1.4
Italy	21.2	26.3	4.0	2.4	---	4.5
Japan	14.3	14.4	4.4	4.2	6.6	3.9
U.K.	18.0	16.9	1.3	3.1	---	1.8
U.S.A.	13.1	12.4	3.0	2.7	1.9	2.0
Average[2]	19.0	19.9	3.2	2.9	---	3.0

[1] Defined as expenditures on health, education, pensions and unemployment compensation.
[2] Unweighted average of above countries.
Source: *OECD Economic Surveys*: Canada, 1994, pp 85-86.

Nevertheless, the fiscal, economic and psycho-social costs of these issues are such that they must be addressed. The rate of growth in demands for social services over the last five years is alarming. All levels of government need to evaluate the effectiveness of their programs and the efficiency of delivery;

[12] As quoted in the Auditor General's report. Office of the Auditor General, p. 6-13.

and they need to begin to understand the underlying causes, in order to reduce the overall demand for remedial social programs. NABST believes that social science and humanities research may be the key to responding to these issues.

As with research into the determinants of health, research into the determinants of social problems should be built upon basic, multidisciplinary, and longitudinal research. A good example of required longitudinal research is the National Longitudinal Survey of Children (NLSC) project, which is part of the federal government's *What Works for Children* initiative. The NLSC will follow 25 000 children, including aboriginal children, from infancy to eleven years of age, for twenty years. The project will develop a national database, based on the experiences of these children in their homes, schools and communities. The aim of the project is to contribute to the development of health and social policies, through the identification of biological, social and economic risk factors.

Social science research must also play a role in the (shorter-term) evaluation of existing social programs, as in the case of the Human Resources Development (HRD) project described in the inset below.

Both short-term and long-term social program research represent an *investment* in the same manner that health services and health determinants research represent an investment (which will be paid back through reduced costs).

5.2.3 Recommended Reallocation for Cost-Effectiveness Research

NABST believes that research initiatives similar to those proposed for health care should be undertaken in the area of social programs, for the purposes of both increasing effectiveness and reducing costs.

First, government should identify areas of priority for research, both short-term research directed to program efficiency and effectiveness, and long-term research directed to the underlying causes of social problems.
Second, government should set a series of benchmarks or targets to be achieved, either in terms of reductions in the costs of those programs, or in terms of targets for specific population groups or priority areas. The following examples are illustrative of the kind of targets that should be established in the area of social well-being: to reduce costs proportionate to a percentage of the GDP; to reduce the level of high-school drop-out rates by 25 percent by

The Self-Sufficiency Project (SSP) of the federal department of Human Resources Development addresses the challenge faced by income assistance recipients when they must choose between their benefits on social assistance and the wages paid by lower-paying entry-level jobs (the "welfare trap"). The SSP will provide a temporary earning supplement to long-term single-parent income assistance recipients. If this method of making work pay more than welfare is successful in inducing such recipients to choose work over welfare, it will provide a cost-effective alternative to current income support programs (the cost of the supplement is less than the cost of the welfare payments).

the year 2000; to reduce the functional illiteracy rate for Canadian adults from 38 percent in 1994 to 25 percent by the year 2000; and to increase employment rates for single parents, aboriginals, and disabled persons by 25 percent by the year 2000.

Recommendation:

Allocate an amount of funding from the federal social programs budget, in the range of $200 to $300 million annually, for research into the efficiency and effectiveness of social programs. This amount is roughly equivalent to 0.5 percent of current federal spending on social programs (unemployment insurance, social assistance, education and seniors).

Third, the government should allocate an amount of funding from its social programs budget, on an annual basis, for the purpose of conducting this short-term and long-term research. A coordinating mechanism should be established to manage this research. HRD should be the lead department accountable for results; the granting councils should provide peer review of work proposed and conducted; and both HRD and the granting councils should be responsible for collaborating with other interested departments (including Indian Affairs, Justice, Solicitor General, and Health Canada), and for ensuring federal-provincial cooperation and cross-disciplinary collaboration.

5.3 The Availability of Information (and the Data Liberation Initiative)

Today's computer systems and information technology permit cross-disciplinary information sharing, multivariable monitoring and evaluation, and longitudinal follow-up, all of which are essential to both the short-term and long-term research described in Sections 5.1 and 5.2. However, the information systems by themselves will be of little value if the information is not available. Two issues are involved: the need to develop an information base; and the need to make existing information available.

Developing an accessible information base is fundamental to the integrated model of science and technology set forth in this report. The information base should address a broad range of issues, encompassing not only quality of life, but also the advancement of knowledge, and wealth and job creation. A concerted effort should be made to build linkages within this storehouse of data, to support the development of a productive workforce and innovative industries. The federal government has an important national role to play in ensuring that domestic and international information is available. Indeed, as the federal government redefines its role, including the reduction of direct subsidies and transfer payments, the collection, analysis and dissemination of information will become an increasingly important means by which it influences and establishes national standards and policies.

In the case of data concerning quality of life, and health and social programs in particular, the federal government's role is critical in establishing national priorities for research; in developing national standards to ensure compatibility of data; and in providing for research support to ensure that the data base is comprehensive and coherent on a national basis.

With respect to the accessibility of existing information, the Social Science Federation of Canada (SSFC) has demonstrated that there is indeed a problem. In those instances where data have been collected by government departments, the information is often too expensive for university researchers to access. This situation is serious enough that a consortium of Canadian universities recently agreed to pool their funds in order to purchase access to more affordable American data, using it to extrapolate to Canadian situations.

Recommendation:

Develop a first-class data management and access system, ensuring timely and affordable access to Canadian government-held data for researchers and students. An important step in this process is for government to support the Data Liberation Initiative.

In working to increase access to data, the SSFC and Statistics Canada have developed a proposal, titled the *Data Liberation Initiative*, which would provide Statistics Canada data and other government-held information as it becomes available, in electronic form, to universities, and through them, to individual researchers. NABST supports this initiative. It recommends that the federal portion of the necessary funding (less than $1.5 million over five years) be provided by Treasury Board, Statistics Canada, and those departments whose data would be involved.

5.4 BENCHMARKING

Between 1986 and 1992, the State of Oregon developed a remarkably bold, and exceedingly detailed, set of benchmarks by which it holds itself accountable for both the resource allocations and the effectiveness of its health, safety, social, environmental, and educational programs.[13] In its 1992 report, the State documented the status of 272 benchmarks. Each of those benchmarks plotted a course from the real situation in 1990 and 1992 to the desired situation in 1995, 2000, and 2010.

The benchmarks cover everything from the percentage of children living above the federal poverty level, and the percentage of babies whose mothers received adequate prenatal care, to the percentage of high-school students enrolled in structured work experience programs, the percentage of Oregon seniors living independently or with adequate support, and the percentage of Oregonians with developmental disabilities who are employed.

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13 Oregon Progress Board, pp. 11-59.

Recommendation:

Establish targets and benchmarks (or indicators) by which to measure progress in all areas that fall under the umbrella of quality of life, including environmental quality, personal safety, defence, and cultural heritage, as well as health and social programs.

Establishing benchmarks is an essential tool for evaluating the effectiveness of government programs, and for assessing the implications of redirecting federal spending. In large part, it is this kind of information that the Auditor General found lacking in his assessment of federal social program spending.

5.5 Collaborative and Multidisciplinary Research

The design and evaluation of programs that address complex issues require a collaborative, multidisciplinary approach. Health and social issues cut across departmental and jurisdictional boundaries; and the research response must be equally collaborative. Examples of such issues include: mechanisms for providing cost-effective health care to rural and remote communities; developing and diffusing technology that will allow non-traditional members of the workforce to be productive from their home or community; and measures for the reduction of poverty.

Society cannot afford for any one department or jurisdiction to assume total ownership for research directed to a high-risk population, whether it be aboriginal persons or an aging population. Neither can any individual government afford to support research into all of the areas that have potential for savings. Federal-provincial collaboration is necessary. As indicated in the Queen's/University of Ottawa report noted previously:

> *"A comparison of the cost drivers in Ontario, Quebec and British Columbia indicates that all three could gain efficiencies by adopting the 'better' features of each other's health care systems without damaging health outcomes."* [14]

Recommendation:

A federal mechanism established to coordinate federal S&T (as recommended in Chapter One) should have as part of its mandate the responsibility to ensure that departments, agencies and granting councils give priority to collaborative and multidisciplinary research in the area of quality of life.

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[14] Angus, Auer, Cloutier and Albert, p. 120.

6.0 SUMMARY OF QUALITY OF LIFE RECOMMENDATIONS

1.0 HEALTH CARE

The proposed national target is to reduce the level of total public and private health care expenditures ($72 billion in 1993) to a level equivalent to between 9 percent and 7 percent of the GDP by the year 2000, thereby placing Canadian expenditures on par with those of other OECD countries. In order to achieve this target, without jeopardizing the quality of health care, it is recommended that the government:

1.1 identify an amount of funding to be set aside for a comprehensive cost-effectiveness research program, including short-term health services research (i.e., the identification of methods for more effective and less costly delivery of services), and longer-term health determinants research;

1.2 allocate this amount of funding from the federal health care budget, in the range of $100 to $200 million per year (roughly one percent of the federal health care budget);

1.3 establish criteria for this research that emphasize applicability of results (relevance) as well as excellence;

1.4 coordinate the research and development program to be based on this funding in an interdepartmental, federal-provincial, and multidisciplinary manner; and

1.5 initiate the development of this R&D program immediately, in order to ensure that the initial target for cost reductions is achieved by the year 2000.

2.0 SOCIAL WELL-BEING

This report calls for a comprehensive research program, which would address both the short-term evaluation of social program delivery and longer-term research into the factors that contribute to social problems. An initial step should be to identify priority areas for both short-term and long-term research. Within this comprehensive program, specific consideration should be directed to high-risk groups, including those described below.

An educated, skilled and flexible workforce is critical to Canada's productivity. A key element in increasing the productivity of the national workforce will be the degree of success we achieve in improving the participation rate of groups that have traditionally been excluded: single parents, aboriginals, and persons with disabilities.

It has long been suggested that early intervention with high-risk children would be more cost-effective in the long run than remedial programs directed at adults. Longitudinal research involving children, and research into the root causes of social problems, should guide governments in developing earlier and more effective responses to those problems.

A third concern is Canada's aging population. At present, growing numbers of seniors in need face either neglect or expensive (and often alienating) institutionalized care. We need to ensure that our health and social services provide more effective forms of care.

It is recommended that the government:

2.1 identify priority areas for research involving high-risk populations and social policy issues;

2.2 identify an amount of funding to be set aside for both short-term and long-term research in the priority areas identified above, i.e., for applied research into more effective and less costly methods for the delivery of federal social programs, and for basic, multidisciplinary research into the origins of priority social problems;

2.3 allocate this amount of funding from the federal social program budget, in the range of $200 to $300 million per year (roughly 0.5 percent of the federal budget for social programs); and

2.4 begin immediately to put in place a collaborative, inter-jurisdictional research and development initiative, based on this funding, in order to ensure that the social policy research priorities and targets for literacy, education, and employment of minority groups, are met.

3.0 Recommendations Regarding Other Elements of Quality of Life

The approach set out for health and social research is equally applicable to environmental quality, personal safety, cultural heritage, and security. An overall objective for government should be to promote a shift to prevention in all dimensions of quality of life. Evidence-based risk assessment will lend credence to the identification of priority areas for early intervention; for example, the source of threats to personal safety and to ecosystems. Early intervention will pre-empt subsequent, costly, react-and-cure responses by governments. In addition, the government should develop a comprehensive system of targets and benchmarks in each of these areas. It is recommended that the government:

3.1 adopt the approach to cost-effectiveness research (funding, targets, criteria, and governance) recommended for health and social programs, and apply it to environmental quality, personal safety, security, and cultural heritage.

4.0 Supporting Recommendations

Collaborative and Multidisciplinary Research

It is increasingly important that collaborative and multidisciplinary approaches to research on quality of life issues be instituted across government departments, research institutions, and granting councils. It is recommended that the government:

4.1 give priority to ensuring the kind of collaboration and multidisciplinary research and development that is required to define and address priority, cross-cutting quality of life issues.

Availability of Data

Canada needs to develop a first-class data management and access system, ensuring timely and affordable access to Canadian government-held data for qualified researchers and students. As a first step, it is recommended that government:

4.2 support the Data Liberation Initiative.

Benchmarks

Even though benchmarking is implicit in the cost-effectiveness research being recommended, several factors justify setting this out as a separate recommendation: the importance of federal quality of life programs to the health, safety, participation and productivity of Canadians; the unsustainable growth in spending in these areas; the lack of information by which to evaluate the relative effectiveness of these programs, and their subsequent vulnerability to across-the-board budget cuts; and, finally, the fact that Oregon was able to establish such benchmarks. The government should develop a comprehensive system of targets and benchmarks in each of the areas of health, safety, environmental quality, social well-being, security and cultural heritage. It is recommended that the government:

4.3 direct all line departments to establish benchmarks for federal quality of life programs, and ensure that regular assessments of progress are carried out.

CHAPTER THREE REPORT OF THE NABST COMMITTEE ON WEALTH AND JOB CREATION IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

1.0 CONTEXT

1.1 ACHIEVING OUR VISION

The quality of life Canadians value both requires and enables us to build a more innovative, efficient, flexible, yet sustainable economy. The dynamics of global competition and technological change add ever-increasing challenges to economic growth, which demand that businesses continually reposition themselves to produce higher-value-added goods and services for worldwide markets.

1.2 OUR OBJECTIVE: WEALTH CREATION FOR ALL CANADIANS

Wealth is created in economies when companies produce new goods and services and sell them to others. Entrepreneurs who strive to develop new products or to increase their wealth and income create jobs. To develop new business and cost-effective practices, they draw on the skills of highly-qualified individuals and competitive suppliers and on technologies resulting from research and development, whether in-house or in other institutions. The net wealth of a nation is increased when its goods and services are exported.

The goal of sustainable development broadens our understanding of wealth to include explicit recognition of the value of our stock of natural capital, represented by natural resources and critical life-support systems for both human and non-human life. Wealth creation requires a satisfactory return on the investment of both natural and financial capital. There is evidence that our investment in the sustainable exploitation of our resources has not been sufficient.

1.3 OUR CHALLENGE: THE DYNAMICS OF GROWTH

1.3.1 Global Competition and Value Added

Nations and economies in the global marketplace are dynamic, continually moving to lever their assets and resources to meet challenges from emerging competitors. The forces are relentless and a constant search for new opportunities and new ways to add value motivates the leaders. Those who can neither adapt nor find new advantages lose markets and thereby the ability to generate the wealth their societies need to support and maintain their desired quality of life. Canada and Canadians are a part of this dynamic.

Although the United Nations ranks Canada's quality of life highest in the world, the World Economic Forum placed Canada's competitiveness in the OECD at fourteenth in 1994, down from its high-point of fourth in 1989.[1] Since Canada's economy depends on trade beyond its own small domestic markets, we must be able to respond to the demands of a world marketplace undergoing change and turbulence. Indeed, the access to larger markets through free trade has enabled Canadian companies to reap the benefits of economies of scale through exports, while continuing to provide quality goods and services to our small internal markets.

Access to markets and resources throughout the world becomes easier every day. Industry is free to choose the most beneficial and cost-efficient sources for its materials. It can locate its new facilities anywhere in Canada or abroad based on factors such as local wage rates, transportation costs, taxes and the availability of qualified personnel. Decisions on the development, application and marketing of Canadian strengths must be made in this context. We must be aware of our resource strengths, our areas of natural comparative advantage and our competitive skills. We must ensure that education and training are constantly upgraded to meet the global challenge and to enable continual growth up the value chain.

1.3.2 Technological Change and the Pace of Progress

Telecommunications and information technologies are transforming the way that Canadians interact and do business with the world, opening up new opportunities in both domestic and international markets. The impact of new information-based processes such as Electronic Data Interchange (EDI) represents a paradigm shift comparable to those of earlier revolutions in industrial machinery, production processes, transportation and electronics.

Geography no longer imposes constraints on learning or on many forms of work, although capital-intensive companies may still concentrate their activities in fixed locations. Through advanced telecommunications systems we can, in principle, exchange information anywhere, in any format, and conduct transactions electronically over any distance. This rapid exchange of information accelerates the demand for new products and services and drives them to market. Knowledge-based industries will define the new opportunities.

> *"The globalization of world markets will be exacerbated by the development of the new technological revolution resulting from the convergence of industries such as computers, telecommunication and consumer electronics. Tomorrow, the competitiveness of a country will very much depend on its ability to quickly develop an advanced technological infrastructure (information highways, etc.)."* [2]

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1 World Economic Forum. *The World Competitiveness Report 1994.* (Geneva: 1994).

2 World Economic Forum. Press Release: *World Competitiveness Report.* (Geneva: 1994), p. 5.

To prosper in this new era, Canadians must actively participate in this transformation, not passively accept its outcome. Opportunities abound for those best able to develop and use the hardware and software of the information highway. Training that keeps pace with new developments is essential to bring successful participation to the greatest number of Canadians.

1.3.3 Building Sustainability into the Economy

Canadians are increasingly aware of the ecological context within which we all must operate. It is no longer acceptable to exploit renewable resources at rates beyond their ability to replenish themselves, or pollute beyond nature's capacity to repair. The demise of the Atlantic groundfish stocks is a sobering reminder that, when natural resources are lost, economies, cultures, communities and people are lost as well. Never before has the need for the Canadian economy to work within natural limits been more clearly understood. Today's economy must be structured to ensure that we bequeath to future generations a supply of wealth, both manufactured and natural, at least as extensive as that enjoyed by current generations, and that we maintain the integrity and resilience of critical life-support and ecological systems.[3]

Sustainable exploitation and management of natural assets is a key element of our economy. Canada is rich in natural resources and should continue to utilize them for long-term benefit, while recognizing their limits. Renewable resources such as our forests demand sustainable modes of management, utilization and consumption. Non-renewable resources require an understanding of how quickly they will be consumed, together with a plan to develop alternative materials or sources of energy.

Stewardship and sustainability must become the watchwords for economic development. We require S&T to support the shift towards sustainable use of natural resources; prevention of environmental harm and remediation of past environmental damages; and development of replacement strategies for non-renewable resources. We must marshall state-of-the-art technologies, backed up by ecosystem-based scientific knowledge, to set and to achieve sustainability targets across all industries.

1.4 The Issue: Strategic Direction for Investment in Science and Technology

Canada has significant capacities in research and development, science and technology. Without strategic direction, however, our nation's investment to develop these capacities will not result in their most effective application as tools for wealth creation. Our national expenditures on research and development are well below the average for major industrial nations. Although investment in R&D by Canadian governments has gradually increased over the past twenty years, it remains below average as a percentage of GDP and, more importantly, it has not been sufficiently productive in enhancing economic growth and international competitiveness.

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3 Howatson, Allan. *Reforming Public Policies for Sustainable Development.* Conference Board of Canada. (Ottawa: 1994).

The added fiscal constraints of 1995 make it even more important that this investment be wisely and effectively managed. **A new strategic approach is needed, within which the federal government can reassess the goals and redirect the distribution of its investment in S&T.**

Canadian industry's expenditure on research and development is far below international norms. These investments are a critical element of our wealth creation system. Government grants and incentives, which reward R&D activities but not necessarily their results or outcomes, have not addressed the root cause of this under-investment. There is an urgent need for the federal government to improve the operating conditions for business, particularly the tax system, so as to facilitate the development of new products and services and the commercialization of new technologies. This should be a key element of the federal government's S&T strategy, which must focus on encouraging industry to recognize the value of investing in S&T, not only as a business tool, but as a necessary condition for long-term competitiveness and even survival. Companies, for their part, must be ready to assume the risk as well as to reap the benefits of embarking on new technological developments.

2.0 Key Components of an S&T Strategy for Wealth and Job Creation

We expect governments to develop and articulate national goals, which will influence and stimulate the actions of the private sector. NABST supports the federal government's goals as expressed in the *Jobs and Growth Agenda*,[4] and welcomes the recognition of sustainability as a requirement for economic development. It emphasizes that S&T are essential ingredients in formulating a strategy for achievement of the government's goals in a way that is consistent with the overarching Canadian goal of maintaining our quality of life.

NABST proposes three key components of a federal S&T strategy to enhance the impact of government action on wealth and job creation in the context of sustainable development. The federal government should aim to:

- **Refocus Government Investment in S&T**
- **Mobilize Industry**
- **Facilitate the Enablers**

Achievement of these objectives requires the cooperation of all partners — government, the research community and industry — in recognizing and executing their appropriate roles and actions.

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4 Department of Finance Canada. *A New Framework for Economic Policy.* (Ottawa: 1994).

2.1 REFOCUS GOVERNMENT INVESTMENT IN S&T

It is imperative that the federal government adopt a new approach to its investment in S&T, in recognition of the key contribution that well-directed S&T can make to economic growth. A new focus is required to clarify the objectives and maximize the benefits of this investment and to apply it in the context of the integrated model described in Chapters One and Two.

As noted by the Auditor General, a critical prerequisite to sound planning and management of this element of the federal budget is strong direction at Cabinet level. This must be supported by a management mechanism that demands accountability, as proposed in Chapter One.

> *"The government should put in place an effective framework to coordinate the activities of departments and agencies in achieving the intended results of its new science and technology strategy. Sustained political will and leadership are needed to bring about change."* [5]

2.1.1 Federal Performance Measures for Wealth and Job Creation are Required

It is not clear how much the government invests in S&T with the objective of creating wealth and jobs. Estimates offered by sources such as the OECD, Industry Canada and Statistics Canada vary from 30 to 50 percent of the $6 billion total federal S&T investment (1994). There seem to be no good estimates of the return on this investment. The Auditor General stated in his 1994 report that government needs statistical measures to support decision-making, while acknowledging that it is *"often difficult to make the connection between the outcome of a research project and, for instance, the creation of jobs."* [6] The report noted that some government organizations had made efforts to develop performance indicators and that Statistics Canada had proposed development of a nationwide framework for evaluating the results of the federal investment. However, many departments have no organized procedure for collecting the data that would provide such a system with the necessary input. Data on the investment in S&T by industry and government, and on the resulting benefits, can help Canadians measure the degree to which this contributes to wealth and job creation.

NABST endorses the conclusion of the Auditor General that a business-like approach is needed to provide the government with a means of making appropriate investment decisions and that, in support of this:

> *"The government should define, design and implement a framework for assessing its science and technology policy and program initiatives. The information should link planned results, progress, actual achievements, expenditures and foregone revenues."* [7]

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5 Auditor General of Canada, p. 9-19.

6 Ibid., p. 9-20.

7 Ibid., p. 9-22.

Recommendation:

Establish and maintain an effective and accurate system of S&T data collection and performance measurement to support government decision-making on S&T investments that are intended to create wealth and jobs.

2.1.2 Federal Government Laboratories

Research and development in the federal government's laboratories accounted for some $1.7 billion of its total $6 billion S&T expenditures in 1993-94[8] and will continue to represent a significant percentage of any federal S&T budget. Since it largely serves the separately defined missions of each Ministry, **there is no central point of accountability for federal intramural R&D.**[9] Nor is there an external advisory board, able to draw upon designated qualified experts, specifically tasked with providing overall strategic and technical guidance for this investment.

NABST agrees with the many participants in the public consultations of the S&T Review who demanded a critical review of the role of federal laboratories, particularly those that are mandated to service industrial needs. While some federal laboratories have become more relevant to their industrial clients in recent years, they continue to lack the guidance and direction of an integrated S&T strategy. Managers of all federal laboratories must be held responsible for ensuring that all of their programs and projects fit within the priorities and directions of an overall federal S&T strategy. The Program Review carried out in 1994-95 was essentially an internal government exercise with fiscal, not S&T, objectives; it therefore provided an incomplete assessment of, and little guidance for, federal R&D in terms of S&T priorities.

Consequently, NABST proposes that **federal laboratory programs be evaluated by an independent external review board** to examine their continuing relevance, impact and priority. The board would direct and coordinate assessments undertaken by panels of qualified experts, which may be drawn from laboratories' existing external advisory boards.

The Wastewater Technology Centre (WTC), formerly a federal government laboratory, has become the foremost Canadian private sector facility in the development and evaluation of treatment and disposal technology for municipal and industrial waste-waters and associated residues. Established in the 1970s as a necessary element of the federal Department of the Environment, the WTC was given over to RockCliffe Research Management Inc. to operate in 1991. In addition to providing services to government programs, the WTC is now better positioned to develop and commercialize innovative technology in support of Canada's environmental protection needs.

8 Secretariat for S&T Review, p. 16.

9 Auditor General of Canada, p. 9-23.

The assessment process should enable laboratory managers to conduct ongoing evaluations of their activities and should address two issues. First, it should seek to justify R&D activity against the role of the federal government and its strategic S&T goals. Justifiable activities might include those that:

- are of scope and scale beyond the reach of a private sector company or group;
- convey broad societal benefit; and
- are in the national interest.

Those activities that fail to conform to an exacting definition of government's role should be devolved to industry or academia or should be terminated.

In a second step, facilities and activities that are judged to be appropriate to the government portfolio should be evaluated against strategic goals specific to their field, not just research excellence. The objectives should be to ensure effectiveness, to assess potential synergies and overlaps among departments and to identify work that could more effectively be performed entirely outside government or in partnership with industry or academia. Ongoing planning and management of government R&D facilities should continue with such strategic goals in view.

Input to the S&T Review led NABST members to conclude that there is significant scope for re-engineering federal intramural R&D activities against national priorities to improve their efficiency and impact, and to develop effective collaboration with university, non-profit and provincial S&T organizations. **Such redirection of federal R&D activity would make available S&T funds that could be more effectively used to facilitate higher-priority S&T activities.**

Recommendations:

Evaluate and justify federal laboratory activities against strategic needs.

Establish accountability procedures for federal intramural S&T.

2.1.3 Government as Facilitator

Government is primarily an S&T policy-maker, and should have a strictly limited role as a performer of S&T. In advancing Canada's wealth creation capability, government has a complementary role as facilitator, to stimulate the private sector to implement the policy directions it proposes. As facilitator, it may provide information or guidance based on its role as legislator and regulator of business, trade and employment in Canada and internationally. It may also provide partial, limited or repayable funding: to start up or accelerate new S&T-based ventures or alliances; to catalyze the formation of consortia; to help build infrastructures; or to share the risk of leading-edge competitive industrial projects. The specific activity that delivers wealth and jobs remains the responsibility of the private sector.

Representatives of industry commented forcefully in the public consultations of the S&T Review that, **if government fails to operate in tune with the pace and direction of its commercial clientele, it presents barriers to progress.** Government regulations affecting industry must help, not hinder, commercial activity. Incentive programs intended to encourage firms to enter technically new and risky areas should be strictly limited in number and be designed for simple access, particularly by small and medium-sized enterprises (SMEs). Commonality of approaches across departments is a key requirement for simplicity. Government response time must always recognize the need for a firm to take advantage of immediate market conditions or of a window of opportunity.

As facilitator, government should remain aware of Canada's competitive standing in areas of R&D crucial to key national areas of interest, such as environment, natural resources, telecommunications, aerospace and defence, to name only a few. It should recognize those sectors of industry that represent the major share of Canada's economy, as shown in Appendix II, and those that offer the best prospects for future growth. It should not attempt to choose winning firms but rather to focus its support to industry on strategic sectors and on the processes, products and services that contribute to their success. **It should facilitate Canadian industries' efforts to benchmark themselves against their competitors** and to use S&T to meet and surpass international best practices.

Government can help the private sector effectively by taking a strategic approach to certain areas of government responsibility. For instance, **international strategic partnerships with other governments can open doors to private sector alliances** in fields ranging from basic science and pre-competitive research to industrial development and product distribution. Related S&T policies can facilitate foreign technology acquisition and joint projects. Government assistance can include introductions to trade and technology contacts, access to sources of information, or involvement of industry in government-level international negotiations. **A stronger government role in international standards-setting**, in partnership with industry, could provide a vital service to business in anticipating or leading in world development of new technologies.

The Canadian Space Agency's (CSA's) agreement with the European Space Agency has enabled Canadian firms to play a major role in developing leading-edge technologies for European Earth observation and communications satellites. This has led to significant spin-off products and has promoted strategic alliances between Canadian and European space companies. An agreement with the French space agency (CNES) provides for possible cooperation in design of a future third generation of Canada's RADARSAT family of satellites. CSA's agreements with other countries, including the United States, Japan, Russia and Sweden, provide Canadian companies and researchers with extensive opportunities to develop space-related technologies and equipment.

Recommendation:

Government should facilitate, rather than engage in, market-driven S&T.

2.2 MOBILIZE INDUSTRY

Government should aim to stimulate Canadian industry to increase its S&T activity in strategic areas, to match the level of its OECD partners, although decisions to use or apply specific strategic technologies should rest primarily with companies. The need for such stimulus is clear: **Canada has a lower level of industrial R&D investment than most developed countries**. The capacity of Canadian firms, particularly SMEs, to make effective use of S&T has been found to be lower than desired. Canadian R&D institutions in university, government and non-profit sectors are well regarded but often fail to commercialize their S&T results. In redesigning its approach to industry, it is critical that government understand the reasons why years of R&D tax credits have not had the desired impact on industrial R&D leading to new business growth. In addition, it should not focus so completely on the present that future opportunities are missed. Government policies, while strongly oriented to the strategic technologies of today, should nevertheless leave room to support new ideas that may lay the groundwork for the strategic technologies of the future.

The following sections lay out the principal factors that would underlie federal support for industrial innovation, as well as a general framework for programs that may be set up to facilitate industrial S&T activity.

2.2.1 Improve the Business Climate

As legislator, regulator and tax collector, government can control much of the operating framework for Canadian businesses and can influence their ability to access, develop and apply S&T effectively.

It is widely held that Canada lacks a significant class of entrepreneurs. In fact, there are many very successful Canadians with these skills. That far too many of our entrepreneurs are working elsewhere in the world gives cause for concern. **The business climate in Canada does not meet international benchmarks for the support of entrepreneurs and innovators;** it must be adjusted with the goal of wealth creation in mind. The Small Business Working Committee has noted that, whereas small businesses pay a reduced rate of tax (12 percent vs. 28 percent) on the first $200,000 of taxable income, this cutoff level has not been revised since its introduction in 1982, in spite of inflation and significant increases in profit-insensitive taxes such as Unemployment Insurance and other premiums.

It recommends changes in this structure to encourage, rather than inhibit, business growth and job creation, since:

> *"...the current corporate income tax structure for small businesses no longer supports small business growth to the extent that it once did, since smaller firms still pay higher effective tax rates when all taxes are considered."* [10]

Although the system of Scientific Research and Experimental Development (SR&ED) tax credits[11] has clearly benefited many firms that perform R&D in Canada, there is currently some confusion as to how it should treat R&D in emerging areas, including new branches of information technology. Furthermore, it is only one element of the tax system on which decisions to locate business in Canada are based.

NABST supports in principle the existing system of SR&ED tax credits, but concurs with the Small Business Working Committee that government must have a clear and consistent system for regulating and handling claims for these credits. This requires a sound understanding of the nature and objectives of the R&D they are intended to support.

> *"The government must implement procedures to ensure consistency of interpretation, including a pre-approval and/or summary approval procedure and simplify audit procedures relative to the Scientific Research & Experimental Development tax credit. Government must establish an appeal process that is clear, fast and independent, as this is crucial to research performers."* [12]

The federal government should re-examine its approach to entrepreneurs and others wishing to develop or apply S&T. It should **remove barriers to establishment or expansion of business** and streamline all processes where it interfaces with business. It should benchmark its practices against those of leading industrial nations.

The Ottawa-Carleton Entrepreneurship Centre is a not-for-profit partnership between the Regional Municipality of Ottawa-Carleton and the Ontario Government. Together with corporate financial support, the Entrepreneurship Centre provides services to the region's small businesses. In 1993, the centre assisted in the opening of over 300 new businesses, creating approximately 600 new jobs, and invested $7.6 million into the local economy.

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10 Small Business Working Committee. *Breaking Through Barriers*. (Ottawa: Industry Canada, 1994), p. 14.

11 Scientific research and experimental development is defined under Income Tax Regulation 2900 as a "systematic investigation or search carried out in a field of science or technology by means of experiment or analysis." Work undertaken to advance scientific knowledge or to achieve technological advancement for the purpose of creating new, or improving existing materials, devices, products or processes will qualify. Activities such as market research or sales promotion are specifically excluded.

12 Small Business Working Committee, p. 52.

NABST welcomes recent government proposals to reform the regulatory system to minimize costs and other impediments that hamper the ability of Canadian businesses to innovate, access markets and create jobs.[13]

The overall fiscal environment in Canada, including business and profit tax rates, tax on capital gains, and tax credits, needs to be redesigned to reward entrepreneurial activities and to reduce disincentives to risk-taking. The result could be a return to this country of a talented pool of business leaders.

Recommendation:

Improve the business climate and reward system for successful entrepreneurs and innovators, by revising overall tax structures and removing barriers that inhibit business expansion.

2.2.2 Enhance Global Competitiveness by Increasing the Focus on Value Added

Canada is in a very enviable position in the global marketplace. The value of the Canadian dollar, the relatively sophisticated Canadian workforce, and our access to, and competitiveness in, the U.S. and other markets offer significant opportunities for export. Canadian companies, however, too often fail to take advantage of this. Too few firms have the strong global orientation necessary to continually re-evaluate their position and potential in worldwide markets and thereby to identify new areas of focus for their product lines.

Canadian industrial development must be aligned with the rapid pace of evolution of global competition, in which countries seek to position their output of goods and services at increasingly higher levels on the value chain. Companies must move to redefine their business in these terms and to increase the value-added components of their operations. Failure to do this risks their falling into a state of complacency and missing the opportunity to move on to the next level in the value chain, inevitably leading to failure through lack of competitiveness in international markets.

For Canada, moving up the value chain does not imply abandoning existing sectors and moving to new ones, but rather building on current strengths. For instance, the future focus of the resource industries, an essential part of the Canadian economy, must be on higher quality, value-added products, and on knowledge-based processes and technologies. At the same time, however, we must seek new opportunities in the direct knowledge-intensive growth areas driven by information technology. Some of these will be extensions of existing industries; others will be new applications. From our research in health care delivery and diagnostic systems, for example, we should become suppliers of state-of-the-art systems to world markets. Similarly, there are market

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13 Industry Canada. *Building a More Innovative Economy.* (Ottawa: November 1994), pp. 26-33.

opportunities related to the use of electronic, multimedia educational tools for site-independent and lifelong learning.

In the last twenty years, computer-generated animation has grown from a curiosity, produced a few seconds at a time, to the basis for an entire new industry. The ultimate goal of computer graphics is to communicate, and while a picture is not always worth a thousand words, a thirty-second animation is worth a thousand pictures. We have reached the point where, for some cases and for some purposes, computer-generated animation can be blended smoothly with film or video. Computer-based animation is already at the core of a large industry in which Canada plays a prominent role, with leading companies in software systems, animation (both computer-based and traditional), information and telecommunications. In addition, any organization that has to communicate and/or educate is, or will be, using computer-based animation because emerging multimedia hardware and software provide a vehicle that can deliver custom-animation to a wide audience for cultural enrichment, entertainment, training and education.

In the world of multimedia there are several key areas where new business opportunities abound. *Delivery* of multimedia messages (information), including systems for delivery, search and retrieval, and systems integration, relates to the Information Highway and is discussed later in this chapter. Production of *tools* for multimedia content creation is an entire industry by itself and is one in which Canada excels. The tools are used for *content creation*, which offers huge new opportunities for teaching and training, advertising, graphical rendering and design, animation for entertainment, diagnosis, and communication in general. And finally, *use* of these new multimedia techniques will create entirely different ways of accomplishing tasks we do now, and will open up avenues for provision of services not yet available.

Canada's role in computer graphics and computer animation has been a leading one from the beginning. From the pioneering work at the National Research Council by Burtnyk and Wein, to the business successes of well-known companies such as Alias Research (Toronto) and Softimage (Montreal), Canada has maintained a dominant position in the world. Other companies, such as Discreet Logic (Montreal), Taarna and Side-Effects (Toronto), Kinetic Effects Research (Burnaby), and Vertigo, Wavefront Canada, and Motionworks (Vancouver), are part of the growing list of players. The applications from these companies range from high-end animation, animation rendering, and industrial three-dimensional design, to life-form simulations, choreography, and character animation.

Opportunities exist for the development of many such new technologies into business successes. More Canadian firms must learn how to evaluate the strengths of their competitors and how to reposition themselves to overtake rivals or, alternatively, to redefine their markets. Companies must continually benchmark themselves against their best competitors. To apply S&T in the most effective ways, they must develop and maintain sound connections into the world technology base, which offers opportunities to bring in new ideas and techniques from abroad, or to market unique Canadian products and processes.

In encouraging firms to embark on new areas of business with the help of S&T, government should expand its selection criteria to include a **focus on value-added products and services, including new kinds of service delivery, for world-wide markets**, to increase value-added exports. Government can encourage enterprises to identify, acquire and adapt new technologies aimed at adding value, and can share the risk of a company's first approaches to such new areas.

Recommendation:

Encourage industry to focus on value-added products and services for export to world-wide markets by sharing the risks of acquisition, development and adaptation of new technologies.

2.2.3 Help New Companies Commercialize Research Results

Chapter Four tells us that *"Canadians must be developers and exporters of the products of R&D, not just producers of the knowledge itself,"* and emphasizes the need for strong linkages between universities, or other centres of research, and companies. However, it is not always easy to link researchers, whose talents lie in proof of scientific concepts, with industrial partners who can develop such concepts into commercially viable products or services. Where Canadian firms and their financial backers are reluctant to invest in new Canadian research results, foreign firms often step in, gaining not only immediate rights to the Canadian technology but also the potential for jobs, profits and long-term development.

Entrepreneurs can often be encouraged to commercialize research results by making it easy for them to locate close to the research group in which the technology originates. Researchers who are readily available to work closely with firms can offer a lifetime of fundamental knowledge to support commercial development of their ideas. In many countries, including Canada, universities are effectively spinning off their research results in incubator facilities located on or near the university campus.

The federal government has in the past shown some understanding of the value of this synergy. In the 1980s, the National Research Council's Industrial Research Assistance Program (IRAP) funded technology transfer offices at a number of universities, as did the Province of Ontario, to help start the flow of research results from university to industry. Variations of these offices exist at different levels of sophistication across Canada to support new Canadian companies. In Calgary, the university is able to benefit from the services

The Calgary Research and Development Authority is a tripartite initiative of the City of Calgary, its university and Chamber of Commerce. It manages a range of physical facilities and services, such as business counselling, to assist companies in start-up, pilot-scale and standalone R&D. Its Technology Enterprise Centre ranks in the top 6 percent of incubators in North America in terms of participants and job creation.

and facilities of the Calgary Research and Development Authority, which manages physical facilities and provides counselling for business activity ranging from start-up to standalone R&D. While experience elsewhere has shown that there may be limits to the degree to which a university alone can sustain this kind of intermediary role, Calgary has broadened its client base to provide a more complete range of effective services.

The University of Guelph is planning to introduce a novel scheme to involve alumni in the support and financing of firms or projects that commercialize the university's research results. It proposes to set up a limited partnership called GUARD (Guelph University Alumni Research and Development), intended to evaluate the commercial potential of new inventions or discoveries and to develop and implement commercialization plans. It will draw on the business skills and connections to financial resources of its alumni to turn these ideas into market realities.

Wider recognition and support of these activities is needed. In January 1995, the federal government announced a proposal to introduce a Technology Partnerships Program, which would help transfer output from university research to the market. This is a potentially valuable initiative. A new federal S&T strategy should include specific measures to help universities and other research laboratories commercialize their output in Canada. Incentives are particularly needed to support physical facilities and counselling services, which may be key factors in a potential entrepreneur's decision to start a new technology-based company.

Recommendation:

Provide incentives to support entrepreneurs and new companies that commercialize research results from universities and government laboratories.

2.2.4 Build on Successful Models of Partnership and Technology Transfer

Canada has significant areas of strength in S&T that could be put to more effective commercial use. There are some successful models of technology transfer and partnership but we need more. To generate new wealth on a long-term basis, **Canada must build on and significantly expand its successful approaches to applying, transferring and commercializing knowledge and technology.**

Government laboratories have specific S&T strengths and should be encouraged to apply their research results to meet industrial and market needs. Scientists must recognize the links between their research and the key economic interests of the country and be ready to transfer their results to entrepreneurs promptly for effective commercialization. The transfer process must, however, incorporate safeguards, possibly in the form of a competitive review of proposals, to ensure that the recipient company is well qualified and has serious intentions to develop real and ongoing business from the technology in question. **Current research programs could deliver important commercial spin-offs**. Two generic examples might be new strains of agricultural products or methods of environmentally benign pest control.

Private sector organizations already play an important role in innovation and technology transfer, principally by creating and sustaining partnerships. Innovatech, in Montreal, brings both financial and technological expertise to assess the commercial potential of invention. The Canadian Institute for Advanced Research, in its brief to the S&T Review, noted that conversion of new knowledge and technologies into new products requires *"financial investments and wise nurturing by those experienced in world markets and in the processes of successful product development"* [14] and pointed to *"several successful examples of institutional innovation in Canada"* [15] such as the Advanced Systems Institute (ASI) in B.C., the Centre de recherche informatique de Montréal (CRIM) in Quebec, and PRECARN based in Ontario.

These consortia models provide innovative ways to connect university research groups with firms, which often do not have the expertise necessary to link themselves with researchers, especially if many different skills are required. A consortium can arrange for research space off-campus or in company locations. Research focus can be very specific to industry-defined needs. While these models aid companies, they also provide invaluable skills and experiences for students and academic researchers. Such intermediary organizations are key to bridging the often profound institutional cultural differences between governments, companies, universities and other research organizations. They help reconcile incompatible expectations in areas such as publication of research results and market readiness of potential products. They reduce the knowledge gap by competently managing the transfer of technology from research sources to firms. They help develop a networking culture.

Community colleges and similar institutions have traditionally been viewed as training centres, providing experienced personnel to industry. More recently they have become effective test beds for operation of industrial-scale (or pilot-scale) process equipment, donated by industry. Industrial donors often have preferred access, although other companies can access the equipment to meet their own research or development objectives.

Networking and clusters are critical enablers of successful innovation. Successful examples, based on shared technology interests, include industrial consortia conducting pre-competitive R&D. While networking can be at the national level, industrial innovation is frequently a local phenomenon, in which clusters of firms build on local assets and advantages, and grow through the synergy of related research interests and community infrastructure.

Effective clusters may also develop out of shared business interests. Successful large companies can provide the leadership for clusters of increasingly sophisticated SMEs to access world markets through technologies developed in partnership. Larger companies focus on their own core competencies and out-source, often to SMEs, those activities not critical to their economic survival. They engage their suppliers in their strategic plans, teach them to meet ever-increasing quality levels, and integrate them into a larger network of interacting companies.

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14 Canadian Institute for Advanced Research. *Science, Technology, Innovation and Economic Change in Canada.* (Toronto: August 1994), p. 7

15 Ibid., p. 6.

These partnerships can enable SMEs to apply the technology to new markets, internationally, through the credibility and access gained from their association with the larger firms. This practice has become the new driver for adding value to products and services and is an engine of job growth in SMEs that offsets the shrinking employment in large industries.

Multinational corporations play another role in Canada's S&T strategy. There are excellent examples of major firms that have given world product mandates to their Canadian subsidiaries while providing Canada with access to broad markets through their world-wide operating companies. Other multinationals have established research and development laboratories in Canada, encouraged in part by favourable tax incentives such as the SR&ED tax credits, by the availability of excellent research talent, and by the very desirable quality of life in Canada.

Magna International Inc. (no longer an SME) is an excellent example of how a small company grew from its beginnings as a supplier of specialized small piece parts to Canadian automobile companies. It has kept its entrepreneurial style and has been extremely aggressive in pursuit of quality manufacturing of increasingly complex and sophisticated parts. Its partnership with BMW, announced in late 1994, signals a new level of acceptance in premium automobile companies and, more significantly, is Magna's first contract to supply an integrated shell and underbody to an automobile manufacturer. Out-sourcing from large companies continues and quality world-class suppliers continue to grow.

Government, in its role as facilitator, can recognize and help build on these successful technology transfer models and mechanisms. It can provide start-up or limited operational funding to organizations that develop partnerships and promote technology transfer. It can provide information and encouragement to develop a networking culture and to establish clusters based on existing strengths. However, government should not buttress communities and regions that attempt to artificially erect clusters for which there is no foundation.

Companies must share the responsibility by learning to understand the dynamics and benefits of introducing technological change. The ideas of third-generation R&D management[16] show that there are opportunities for research and invention at every stage of development of a new product. Innovation is the entire process from fundamental research to marketplace success, and presents opportunities and needs for S&T at every link in the chain.[17]

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16 Roussel, Philip A.,Saad, Kamal N. and Erickson, Tamara J. *Third Generation R&D, Managing the Link to Corporate Strategy.* (Arthur D. Little, Inc., Harvard Business School Press, 1991).

17 Kline, Stephen J. and Rosenberg, Nathan. "An Overview of Innovation," in *The Positive Sum Strategy, Harnessing Technology for Economic Growth.* Landau, Ralph and Rosenberg (eds.). (Washington D.C.: National Academy Press, 1986), pp. 275-305.

Innovation is the most important determinant of success. A recent study of SMEs found that the most successful and innovative firms were those that invested human and financial resources in R&D.[18] These were all able to grow relative to their competitors and to increase their profitability relative to the industry mean. This reflects policy choices that were primarily related to innovation.

In addition to its broad understanding of the strengths and prospects for growth of various industrial sectors, as shown in Appendix II, government should be aware of Canadian industry's leaders and winners — those companies capable of driving innovation and technology development and creating competitive, world-class products. It is imperative that the number of such companies within Canada be increased and that these companies continue to thrive in world-wide markets. Government's S&T policy should include the possibility for short-term repayable funding to such firms, to help them meet critical market opportunities, by sharing the risk and cost of creating exportable products or of increasing productivity. The policy should demand accountability, to ensure that objectives are met. **Government should lever its assistance to larger companies** by obliging them to develop clusters that use and develop the skills and facilities of SMEs, as well as those in colleges or universities.

Rainmaker Imaging Corporation, of Vancouver, B.C., is a fully integrated digital post-production facility. Interest by Eastman Kodak in Rainmaker's proprietary software has led to a strategic partnership to create special effects for film, video, and interactive multimedia productions in entertainment and education. Specially trained personnel create a digital 3-D imaging environment, which uses modelling, animation and the rendering of computer graphic images as objects, foregrounds, and backgrounds. The company's open-architecture environment provides for easy adaptation to future changes in technology. Rainmaker receives both marketing support and sponsorship from Eastman Kodak to assist its entry into the digital imaging market. This example indicates how partnerships with world-class multinational companies can leverage local expertise to new markets.

The federal government can use its procurement policies to help enhance the scientific and technological capabilities of SMEs. It can seek out Canadian companies as primary suppliers to government and require that a portion of the contracted work flows from these companies to local SMEs. NABST welcomes the recent announcement of a small business set-aside policy, to be implemented later in 1995,[19] but believes that broader-based initiatives are possible, particularly those which facilitate inclusion of research partners such as universities and colleges.

"Government must re-evaluate its in-house purchasing requirements to ascertain the amounts that are currently supplied by SMEs, and mandate an increase in the amounts of these purchases from SMEs by a minimum of ten percent over the next five years." [20]

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18 Baldwin, John. *Strategies for Success*, (Ottawa: Industry Canada, February 1994), pp. 31-38.

19 Industry Canada. *Building a More Innovative Economy*, p. 22.

20 Small Business Working Committee, p. 53.

Recommendations:

Facilitate and build on successful examples of partnerships, pre-competitive consortia, clusters and networking.

Lever government incentives that fund industrial R&D by requiring involvement of SMEs, universities or colleges.

Use government procurement policies to help elevate the capabilities of Canadian suppliers and their SME and research partners.

2.2.5 The Challenge and the Opportunity of Sustainable Development

The integration of sustainable development concepts into the wealth creation process presents both a challenge and an opportunity, in which S&T have a profound role to play. As new sustainability targets are set, companies will restructure their decision processes and will look to state-of-the-art scientific knowledge in seeking the most appropriate technological solutions. New applications and new industries will emerge. Government, in its legislative and regulatory capacity, can help both define the challenge and enhance the opportunity.

Governments must work with industry to establish the standards necessary for sustainability to be achieved and must challenge Canadian industry to meet them.

By keeping the regulatory regime simple and by supporting training, investment and innovation, governments can help firms find new opportunities for wealth and job creation. Experience in Germany and Japan has demonstrated that, when countries set very high standards for air quality, waste management and energy efficiency, companies become more competitive by leaping to second- and third-generation innovations.[21] Canadian industry has already used its expertise in new processes and

As part of an "ozone depleting products replacement program," a Montreal aerospace and electronics company sought to replace the freon used to cool large test chambers (−175°C). Following a cost and feasibility study, a process using liquid nitrogen was adopted. This eliminated CFCs, increased reliability and significantly reduced noise. The company achieved a one-time saving of $231,000 in operational and maintenance costs over the initial eight-month phase-in period, largely due to the elimination of unneeded equipment, and will save $43,000 in annual operating costs. The company plans to pass on the idea to others, including provincial government laboratories.

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21 Doering, R. and Runnalls, D. "Sustainability: The Key to Competitiveness in the 21st Century," in *Prosperity and Sustainable Development for Canada: Advice to the Prime Minister*. National Round Table on Environment and Economy and Institute for Research on Public Policy, Sustainability and Prosperity Program Working Paper No. 1.

techniques to influence the development and adaptation of world standards. **A strategic and accelerated approach to sustainable development could help Canada become a supplier of environmental technology and management systems to the world.**

Industry must rise to the challenge and take advantage of the opportunities inherent in the concept of sustainable development. Companies must be accountable for the environmentally responsible exploitation of any resource; for applying the principles of sustainable development both to eliminate waste and to use the resources for the highest possible value; and for seeking knowledge and supporting research into the functioning of the ecosystems they exploit. Communities can play a useful complementary role as identifiers and solvers of environmental problems. It is at the community level that a great deal of experimentation, innovation and implementation takes place with regard to resource management and stewardship.

The federal government must encourage S&T initiatives that support the move towards sustainability. Their objectives could include reduction of raw materials used in production processes; reduction of energy intensity; shifts to renewable energy sources; and control of environmental contaminants by prevention. A fundamental shift is needed away from narrow scientific specializations and towards multidisciplinary team research, which can evaluate all aspects of ecosystems, including the potential impact of industrial activity on their function.

Recommendations:

Encourage the environmentally responsible exploitation of resources, consistent with long-term sustainability.

Use S&T to create evidence-based regulations.

Work with the private sector to set realistic but high environmental standards and challenge firms to meet them.

2.2.6 A Framework for Federal Support of Industrial S&T Activity

Governments around the world provide various forms of financial support to firms within their borders. There are good reasons for our federal government to give careful consideration to similar industrial S&T support, while avoiding the confusing array of multiple programs of recent years. NABST proposes some general principles that should govern industrial S&T support programs.

The primary goal of federal support of industrial S&T activity should be to increase the innovative capacity of Canadian-based firms and their ability to take good economic advantage of S&T.

Support mechanisms should focus on priorities identified in the federal S&T strategy, including such areas as adding value to natural resources, better sustainable development practices, competing on a level playing field with international competitors, and making more effective use of the best of emerging technologies.

Federal government funding allocated for industrial S&T support should be managed centrally, to allow for reallocation where the federal strategy or the market demands. The terms and conditions governing such programs should be clear and consistent across federal departments and agencies and should require a significant investment in the project on the part of the recipient firm. Project support should be on a matching funds basis, and federal contributions should be repayable when the recipient is a for-profit organization. Actual program delivery, including project selection and management of funds, should be handled locally through qualified project champions who have the authority to apply selection and funding criteria to best suit local conditions.

Supported projects should be those which, for example, address the high level of risk associated with commercialization of a new technology. In addition, they should build up a new technological capability within the participating organizations. All Canadian-based companies and those non-profit technology institutions with solid connections to firms should be eligible for support, provided that the team's expertise already includes the capability both to carry out the project and to commercialize and export products and services based on the results. Good projects should encourage collaboration with SMEs, partnership with international organizations, or commercialization of the S&T results from universities and government laboratories.

Industry should be encouraged to enter into partnerships with laboratory organizations — universities, non-profit organizations, technology centres and government laboratories. This would facilitate the sharing of risks, resources and, more importantly, success. Royalty payments received by laboratories as a share of commercial success could be used to support longer-term research. Such partnerships would help to create strong bonds between industry and the scientific community and a sharing of responsibility for S&T in Canada. The objective should not be to generate income for the laboratory, but rather to create synergy and to optimize the use of Canadian S&T resources, human and facilities, wherever they may be (i.e., a Canada Inc. approach).

Federal support programs should be guided by advisory panels comprising both users and producers of S&T. Such panels would provide direction and priorities (sectors, technologies) to the program managers and assistance as required to local project champions charged with program delivery. The panels would conduct periodic evaluations of the results against targets, and reallocate funds according to market signals.

Recommendations:

Provide funding for selected industrial R&D activity, on a risk-sharing, repayable basis, to increase the innovative capacity of Canadian firms.

Encourage collaboration amongst large companies, SMEs, universities and colleges.

Manage federal funding centrally, with guidance from an independent advisory board.

2.3 FACILITATE THE ENABLERS

2.3.1 Enabling Technologies

Enabling technologies have brought major advances to many sectors of industry. Microprocessors, robotics, related electronic devices and sophisticated control systems have enabled new levels of accuracy and consistency in the control of industrial plant and equipment. Intelligent systems have brought the capabilities of experts to the design, management and oversight of manufacturing systems and industrial processes. Biotechnology applications extend from mining and mineral extraction through plant growth to the development of pharmaceuticals and have contributed to the development of leading-edge products and to the continuing success of the solid pharmaceutical base that thrives in Quebec.

The federal **government must help bring the full value of enabling technologies to the economy and help Canadians adjust to their impact on business and the workforce**. It must co-operate with industry in actively monitoring new developments of such technologies around the world; be quick to recognize their relevance to Canadian capabilities; and be ready to encourage their development and application by the research and industrial communities. It must apply or provide access to these new technologies in its own areas of responsibility.

From St. John's Newfoundland to the shores of British Columbia, this country is a fertile ground for innovative ideas and products. Dynamic Canadian companies, active in areas such as multimedia, parallel processing, object-oriented programming, wireless communications and health care, have been able to transcend regional and provincial boundaries. Biomech Designs Ltd., of Calgary, Alberta, designs software for Canadian biophysics, focusing on areas such as muscle testing and prosthetics development. Quebec-based Alex Informatics Inc., the only Canadian company focused on parallel processing systems, develops leading-edge software for real-time simulation and mutimedia delivery. Sackville, New Brunswick, is the home of Internet Software Technologies, which specializes in the fast- growing field of client/server application software and training materials for the Internet.

Government must help business — both employers and employees — adjust to the impact of new technologies on business processes and learn how to use them successfully. It must help the public understand the changes and benefits these new technologies bring.

Recommendation:

Help Canadian firms to take advantage of new enabling technologies and apply them effectively in new ways of doing business.

2.3.2 The Information Highway

The concept of an Information Highway,[22] which has emerged from the rapid advance and convergence of our capabilities for creation and transmission of voice and data messages, offers enormous opportunities in a broad range of enabling technologies. A telecommunications and information network of enormous potential reach and power, it offers both a vehicle enabling our transition to a knowledge-based society and a key technical component of this society.

The Information Highway will force Canadians to reinvent the way we work, train, service and collaborate, and will bring about a re-engineering of traditional information-accessing practices. Analysts estimate that the size of the worldwide market for information technology products and services currently exceeds US$1 trillion, and will double by the year 2000.

"The Information Highway initiative is essential for Canada's success in a new global economy in which value, jobs and wealth are based on the creation, movement and application of information.

The world is undergoing an information revolution that is transforming how we live, learn, work and play. New Brunswick has developed an edge in this transformation, which it uses for economic and social benefit. A strategic decision by the provincial government has provided every home and business in New Brunswick with access to the same high-speed digital communications network — a level not found in any other Canadian province. Thus, while other parts of the world are still getting infrastructure in place, New Brunswick can concentrate on using that infrastructure to deliver education, health and other services. The New Brunswick government is stimulating private sector development by acting as a model user/customer of the Information Highway.

22 The term "Information Highway" is used to describe the concept of a telecommunications and computer network infrastructure that enables the transmission of any combination of data, voice and images. The concept can be made real by building on and interconnecting existing and planned telephone and data networks to link homes, businesses, governments and institutions to a wide range of interactive services. In this way, Canadians could reach entertainment, education, cultural products and social services, as well as data banks, computers, electronic commerce, banking and business services.

Its enabling effects will be felt in all industry sectors. The information highway will stimulate research and development in leading edge technologies; it will facilitate the diffusion of innovative technologies and information-based services; it will strengthen the competitiveness of Canadian businesses — large and small; it will provide cost-effective access to high quality healthcare, educational and social services." [23]

To take advantage of the opportunities offered by the Information Highway, the government should build on Canada's strengths in communications technologies. It must update its regulatory and policy regime, to provide a competitive and challenging environment for industry. Canada has one of the most advanced, extensive and universally accessible communications infrastructures in the world. However, we need to expand this infrastructure to guarantee its availability to all Canadians who wish to develop new products, services and applications.

In a collaborative effort, Motorola Canada, Industry Canada and the University of Waterloo are attempting to improve the use of data communications over wireless networks. Wireless data networks use radio or infrared transmission and reception for computer-to-computer communication. Their use with portable computers allows users to maintain uninterrupted access to their office data from anywhere in the world, just as cellular telephones enable voice access. Although additional progress in the wireless marketplace is critical, the initiatives of this partnership will help to maintain Canada's high standing as a global centre of communications development and expertise.

New opportunities in geographic information systems, health care and educational delivery systems abound. We must move faster than our competitors; we must create and sustain a competitive edge. Leadership is required so that our society has low-cost, user-friendly access to worldwide sources and uses of information.

Small or remote communities could be encouraged to make use of modern technologies, such as the information highway, to develop new community-based entrepreneurial activities. Examples already exist for remote medical diagnostics, information provision and telemarketing. R-NET in British Columbia is an ATM-based[24] network. It has been used for telemedicine and has been linked via satellite to Germany for trade-show demonstrations by companies using its capabilities. We must upgrade our training programs in parallel with infrastructure enhancements, so that initiatives such as these can be fully available to all Canadians.

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23 Information Highway Advisory Council. *News Release*. (Ottawa: Industry Canada, April 1994).

24 ATM, or Asynchronous Transfer Mode, is a fully integrated, multimedia-transmission, packet-switching protocol designed to interface wide area networks over existing communications lines at the operating speeds of these lines. ATM is a Canadian innovation. It is a fully interactive, multimedia protocol and is currently the world's highest-speed, commercially accepted standard.

Recommendations:

Establish and maintain a sound policy climate and infrastructure for the Information Highway network.

Facilitate ready access to the network for all Canadians.

2.3.3 Education and Training

Canada has been able to benefit economically from its dynamic, flexible and well-educated workforce. More effective use of these skills is needed in development of dynamic new enterprises and industries where S&T are key components and major determinants of the competitive edge. We have an abundant supply of scientists and engineers in many areas. However, we have a distinct shortage of entrepreneurs and technically literate managers working in Canada to lead our industries.

Training in entrepreneurial skills must be a major focus of efforts to increase industry's investment in, and benefits from, S&T. Companies need to acquire, develop and use sophisticated managers of technology. **Entrepreneurs must be encouraged to employ the qualified personnel they need** to successfully adopt and adapt new knowledge and technology. In provinces such as Ontario, Quebec and B.C., programs for SMEs that facilitate the hiring of engineers and technologists on a declining share of salary costs have had a major impact on industrial technological competence. Although the federal government's own plans for a similar, very limited, program are now unclear following the 1995 Budget, it should encourage the national implementation of such initiatives. It could further increase technical capacity in SMEs by seconding federal scientists to these companies.

The shift to a knowledge-based economy in which new skills can lead to new methods in traditional industries is exemplified by Massey Ferguson, the tractor manufacturer. The MF yield mapping system offers farmers the means to optimize yield at every point in every field. A satellite-based Global Positioning System relays data on crop yield in every square metre to the farmer's desktop computer, which generates maps showing where yield is above or below target. The farmer can then improve overall production by investigating and treating only the affected areas. This system, which applies geomatics and converts data into information and knowledge, may become worth more than Massey Ferguson's primary business.

Source:
Harvard Business Review, Sept.-Oct. 1994, p. 166

The return of some manufacturing jobs to Canada and the United States from elsewhere reflects our comparative advantage, where the labour costs of our better-educated workforce are offset by superior product quality. We must build on this by **ensuring that industry plays a major role in the design, implementation and funding of education and training programs** to meet its future needs for an adaptable and innovative workforce. The goals must be early introduction and

regular reinforcement of skills that will drive and deliver increasing value-added products and processes. **The concept of lifelong learning must be applied** to maintain the relevance and competitiveness of our technological skills. Chapter Four develops these ideas further.

It is crucial to the successful adoption and application of any new technology that **workers have the tools they need to learn and operate in the new environment.** Companies must recognize the vital connection between learning and state-of-the-art equipment, and its relevance to their business growth. Employers will benefit themselves and the economy by investing to upgrade the skills of their workforce, whether by training on-the-job or at outside educational establishments. For their part, the latter must be amenable to co-operation with industry. Successful cooperation between industry and community colleges has already been noted in Section 2.2.4 above, and a specific example is cited in Chapter Four.

The federal government must encourage the development of industry-province-local government cooperation to help align training programs to the needs of industry. It should encourage regional alliances to bring telecommunications and other information resources to benefit educational institutions at all levels. In its role as facilitator, the federal government can be proactive in the provision of virtual networks and libraries, which will provide a healthy exchange of information and ideas among communities and regions. The Information Highway will play a crucial role in the advancement of educational and lifelong learning initiatives as we educate our children and ourselves for the 21st century workplace.

Recommendations:

Emphasize the need for training in entrepreneurial and technological skills to be relevant, aimed to help industry compete.

Encourage significant industry involvement in upgrading workforce capabilities.

Ensure that the systems and tools for learning and work are appropriate to industry's needs.

3.0 The Role of the Federal Government in Wealth and Job Creation

3.1 Government, Wealth and Jobs

The government has authorities and facilities beyond the scope of private industry. It must use these to inform, to facilitate and to simplify the business decisions that will ultimately drive the economy forward. Its broad perspective on Canada and the world enable it to add value to the

perspectives of industries and organizations. Its control of the legislative and regulatory framework within Canada, and its related interactions with other nations, provide the means of developing a strategic approach to Canadian competitiveness. Its extensive procurement responsibilities offer opportunities to enhance the capabilities of Canadian suppliers.

3.2 Performance Measures for Wealth and Job Creation

Criteria for evaluation of government S&T policies and programs are listed in Chapter One.

Additional criteria to be used in assessing investments specifically intended to create wealth and jobs should ask:

- Does the program/policy eliminate or reduce existing barriers?
- Does it create new or additional barriers and impediments for industry? Why?
- Does the program/policy create incentives for S&T development, research or industry within Canada?
- Does the program/policy aid the government in its streamlining activities? Is the program, or variations of it, currently being supplied by another level of government?

Government investments in S&T must be subject to regular and critical evaluation if they are to deliver the most effective returns. This is an essential element of the much-needed system of accountability in federal government that will help to ensure that objectives are being met.

4.0 Summary of Wealth and Job Creation Recommendations

4.1 Preamble

In proposing a framework for priority-setting in S&T, NABST makes the strong observation that similar recommendations have been put forward repeatedly over the past thirty years with little response or action. The Auditor General of Canada has attributed some of this lack of progress to *"a lack of overall government-wide leadership, direction, focus on results and accountability for implementing desired changes."* [25]

A fundamental finding of this report is that an effective federal mechanism is needed for identification and achievement of strategic national goals for S&T. In Chapter One, NABST recommends that a senior cabinet minister acting as a champion of S&T be supported by a Chief S&T Advisor, who would operate with the advice of an independent advisory board and a small team of experts, to provide cross-departmental leadership and direction. The specific recommendations which follow assume that such a mechanism will be put in place and that the Chief S&T Advisor would be responsible for providing direction within each recommendation. **A system of governance such as the one described above is a necessary prerequisite for the success of any federal S&T strategy.**

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[25] Auditor General of Canada, p. 9-5.

4.2 SUMMARY OF RECOMMENDATIONS

The dynamics of global competition and technological change demand that businesses continually reposition themselves to produce higher-value-added goods and services for world-wide markets. To promote this change, NABST recommends that the federal government take action towards three major objectives:

1. Refocus Government Investment in S&T

1.1 Establish and maintain an effective and accurate system of S&T data collection and performance measurement to support government decision-making on S&T investments that are intended to create wealth and jobs.

1.2 Evaluate and justify federal laboratory activities against strategic needs.

Establish accountability procedures for federal intramural S&T.

1.3 Government should facilitate, rather than engage in, market-driven S&T.

2. Mobilize Industry

2.1 Improve the business climate and reward system for successful entrepreneurs and innovators, by revising overall tax structures and removing barriers that inhibit business expansion.

2.2 Encourage industry to focus on value-added products and services for export to world-wide markets by sharing the risks of acquisition, development and adaptation of new technologies.

2.3 Provide incentives to support entrepreneurs and new companies that commercialize research results from universities and government laboratories.

2.4 Facilitate and build on successful examples of partnerships, pre-competitive consortia, clusters and networking.

Lever government incentives that fund industrial R&D by requiring involvement of SMEs, universities or colleges.

Use government procurement policies to help elevate the capabilities of Canadian suppliers and their SME and research partners.

2.5 Encourage the environmentally responsible exploitation of resources, consistent with long-term sustainability.

Use S&T to create evidence-based regulations.

Work with the private sector to set realistic but high environmental standards and challenge firms to meet them.

2.6 Provide funding for selected industrial R&D activity, on a risk-sharing, repayable basis, to increase the innovative capacity of Canadian firms.

Encourage collaboration amongst large companies, SMEs, universities and colleges.

Manage federal funding centrally, with guidance from an independent advisory board.

3. Facilitate the Enablers

3.1 Help Canadian firms to take advantage of new technologies and apply them effectively in new ways of doing business.

3.2 Establish and maintain a sound policy climate and infrastructure for the Information Highway.

Facilitate ready access to the network for all Canadians.

3.3 Emphasize the need for training in entrepreneurial and technological skills to be relevant, aimed to help industry compete.

Encourage significant industry involvement in upgrading workforce capabilities.

Ensure that the systems and tools for learning and work are appropriate to industry's needs.

CHAPTER FOUR REPORT OF THE NABST COMMITTEE ON THE ADVANCEMENT OF KNOWLEDGE

1.0 CONTEXT

More than ever before in our history, knowledge is the quickly changing foundation upon which expansion in productive capacity, wealth generation and job creation are based. It is also the basis for continuous improvement in the quality of life for all Canadians. It is essential for the understanding and solution of the problems of today and tomorrow. The advancement of knowledge, therefore, is a fundamental determinant of economic growth and social progress, and must be an essential component of a federal S&T strategy.

> *"Economic activity is increasingly based on knowledge and sustained by new partnerships. Indeed, the distinguishing feature of the new economy is that knowledge has become a factor of production. Lifelong learning and continuous innovation are now seen as critical factors in achieving environmentally sustainable growth and social development."* [1]

Knowledge is by nature international in scope yet incremental in its growth. Canadian researchers must be at the leading edge of priority disciplines, and be conversant with new knowledge emerging from other fields and from around the world. Participation in knowledge networks is a powerful way for Canada to capitalize on new knowledge in the increasingly short time-span between discovery and product development. As a prerequisite for the achievement of these ends, Canada must fully recognize the importance of, and remain committed to, the performance of first-class basic research.[2] If Canada is to be globally competitive in the long run, government needs to ensure that the level of its R&D investments is competitive and that its resources are deployed effectively. Other stakeholders, including industry and the provinces, need to commit to active partnership with the federal government in the investment in R&D in Canada.

The breadth and excellence of our knowledge base in the sciences and technologies have a direct effect on national objectives such as economic growth, health care, national security, and environmental protection. Industries depend on continuous inputs of relevant science and new technologies in order to remain competitive. Wealth and jobs result from industry's use of these inputs to develop innovative products and services for sale in competitive markets. Advances in the quality of life also depend on excellent research in the social sciences and humanities which interprets the impacts of social and technological change on the Canadian population. The free

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1 Association of Universities and Colleges Canada, *Written Submission to the S&T Review* (Ottawa: August 1994), p. 1.

2 In order to clarify NABST's use of the terms research and development (R&D), the OECD and Federal S&T Review definitions are recorded in Appendix III.

flow of knowledge required to enrich all aspects of Canadian society depends on good communication among individuals working in related fields and on strong links between and among government(s), industry and universities and colleges.

Successful advancement of knowledge is contingent upon a variety of mediating social and economic conditions. Accordingly, an S&T strategy must include components that will:

- **Sustain Strength in Discovery**
- **Improve Capacity to Adapt and Apply Knowledge**
- **Foster and Sustain a Strong S&T Culture**
- **Improve Education and Training Standards and Science Literacy**

The degree to which Canadians excel in these four areas will greatly influence the country's future economic and social development.

Common to these components, and integral to the accomplishment of each, is the element of **access**. The dissemination and communication of information among sectors is of vital importance. It is therefore critically important that mechanisms be in place to ensure ease of access to knowledge and information, and effective interaction among the stakeholders, if Canadians are to make significant gains in these four areas of advancement of knowledge.

In this context, S&T must be seen as an enabler, a key that will greatly facilitate access and the speed at which information crosses boundaries and sectors. S&T provides exceptional new opportunities to advance and exchange knowledge in new and exciting ways.

The ability of Canadians to comprehend the relevance and importance of S&T to the social and economic aspects of their lives is shaped by the quality of, and value placed on, science education in Canada, and is affected by the general Canadian culture. Science culture in Canada is both a foundation for, and a result of, the effective use of S&T knowledge by all sectors.

Responsibility for the accomplishment of these components is held in various sectors whose roles have been discussed in Chapter One. The responsibility of the federal government sector, in the context of this chapter, is to nurture a positive environment for the advancement of knowledge, to remove barriers, and to identify priority areas for funding in universities, industry and, consistent with the appropriate role for government, in its own laboratories. The challenge is to respond to changing social and economic dynamics through new and relevant ways of advancing and disseminating knowledge.

2.0 THE KEY COMPONENTS OF AN S&T STRATEGY FOR THE ADVANCEMENT OF KNOWLEDGE

2.1 SUSTAIN STRENGTH IN DISCOVERY

New knowledge from discovery is essential in order that Canadians keep pace in the modern world, and remain active participants in international R&D. Discoveries from basic and applied research are essential components of an innovative environment that makes possible new technologies, applications and products.[3]

The excellence of Canadian researchers and research institutions is widely acknowledged. However, national and international social and economic realities demand a shift from the status quo. Canadians must find new and innovative ways to sustain the current level of research excellence. Some universities and government research institutions are already responding to the need for change and demonstrate new approaches to doing research. Others must rapidly follow their example if they are to remain relevant and be able to maintain a high level of teaching and research excellence.

Canadian research conducted on the international stage is highly regarded. This level of excellence must be maintained in priority areas, as identified in an S&T strategy. Scientific expertise in key areas will enable Canada to have access to, and benefit from, the best of international scientific research, and to collaborate on international projects. Interactions at the highest levels of international R&D ensure that Canadian researchers remain active participants and benchmark against the best performers on the world stage.

While the importance of a strong R&D base is clear, Canadian R&D expenditures both by government and by industry are well below OECD average when measured as a proportion of GDP (Chapter One, Table 1.1). The federal S&T review consultations revealed wide agreement that advancement of knowledge is important in the health sciences, physical sciences, engineering, and, to a greater extent than is often realized, the social sciences and the humanities.

2.1.1 University Research

University research provides a steady stream of new ideas, a trained and well-educated work force, and the transfer of knowledge from professors to students who will become the leaders of the future.

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3 Empirical studies have been conducted in Canada (Bernstein & Nadiri, 1989), (Mohnen & Lepine, 1991), (Bernstein, 1994) and in the United States (Mansfield, 1991) in order to estimate the relationship between R&D and industrial innovation. The most widely cited findings of these studies estimate the rate of return to society of funds invested in R&D at 28 percent. While the rates of return from R&D vary according to each study (the range is generally between 20 and 40 percent), these results indicate that investments in basic and applied research and productivity growth are related.

In the context of global change and fiscal restraints, **Canadian universities** are facing fundamental challenges with respect to their role in a knowledge-based society. To meet these challenges, they **must adapt and change in order to remain effective, while maintaining standards of excellence. They must increase diversification of their funding sources**. Further, in order to develop solutions to complex social and economic problems, **universities should encourage multidisciplinary and collaborative research** where it is appropriate. This could necessitate the establishment of new departmental alignments and administrative structures. Finally, in order to strengthen Canada's competitive advantage in research, **universities must identify and build upon local strengths**. This must be **accompanied by more active partnering among universities, colleges and technical institutes as well as industry and government laboratories,** in order to maintain a strong *collective* strength in R&D.

A significant proportion of university research is increasingly and appropriately dedicated to strategic areas required for Canada's social and economic health. **It is essential, however, that the focus on directed research be balanced by appropriate levels of support for researcher-initiated work.** History offers many examples of the eventual application of unexpected new discoveries. The discovery of the neutron in 1932 led directly to a power reactor patent ten years later; the invention of the laser was largely the result of the intellectual curiosity of C.B. Townes and others; the discovery of penicillin and the development of transistors were the result of curiosity-driven research of unknown application. Michael Smith's basic research in protein engineering led to the development of a technique known as site-directed mutagenesis, which will further expand research into genetic diseases.

Canada's proportion of the world's expenditures in R&D is approximately 3 percent, and it contributes 4 percent of the world's academic literature. A review of the *Citation Index*[4] reveals that Canada ranked seventh of 107 nations in the number of citations per paper.

Canada's Higher Education Expenditure on R&D (HERD)[5] as a percentage of GDP is, on average, equivalent to other OECD countries (Figure 4.1), and produces research that is internationally recognized as meeting high standards of excellence. The quality of output from research investment is clearly high. But Canadians must not be complacent as a result of these figures. **Rather, they should remain vigilant in the search for innovative and cost-effective ways of maintaining this level of achievement.**

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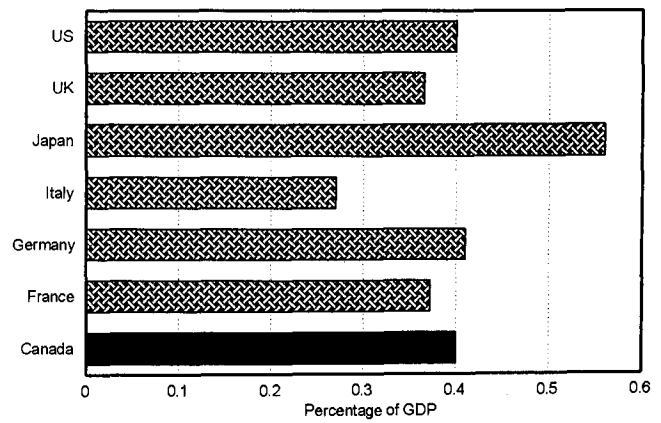
4 Institute for Scientific Information. *Science Citation Index.* (Philadelphia: 1961-1994).

5 HERD represents the portion of Gross Domestic Expenditure on R&D (GERD) that is performed in the Higher Education Sector. This sector is composed of all post-secondary education institutions, whatever their source of finance or legal status. It also includes research institutes, experimental stations and clinics operating under the direct control of, or administered by or associated with, higher education establishments.

The S&T strategy should identify those areas of research in which it is critical to maintain world-class levels of competence in order that we can exploit new advances. **The federal government should benchmark its support for university research with that of other OECD countries, and strive to maintain this funding at competitive levels.**

Figure 4.1 Higher Education Expenditures on R&D as a percentage of GDP, 1992



Source: OECD, Main S&T Indicators, 1994

Funding for University Research

Excellent long-term research requires assurance that funding will continue for the duration of the research project. **An S&T strategy, therefore, must provide a framework for long-term planning that will include long-term funding policies for the granting councils. It must also provide the funding stability required to ensure post-graduate training up to and including the PhD level.**

In the current fiscal climate, the optimum level of funding will not be sustainable if the federal government remains the predominant source of funds for university research. MRC has already made progress in the direction of funding diversification by levering additional funds, in excess of its base budget, through the Network/Partnership Fund, the Technology Transfer Commercialization Fund and Health Research Fund. NSERC has also made some progress in this direction. **All of the granting councils should increase their exploration of new ways of levering funds from other S&T stakeholders.**

The Tri-Council Eco-Research Program, funded through Canada's Green Plan, involves the collaboration of Environment Canada and the three granting councils. In addition to the involvement of these federal agencies, the program encourages the levering of private sector funding for university research. More specifically, the University Research Chairs component of the program requires that universities obtain external, non-federal sponsors in order to be eligible for the Eco-Research grant. For instance, the Chair in Environmental Risk Management at the University of Alberta has levered $1.6 million from various non-federal sponsors, including Gulf Canada Resources Ltd., Alberta Heritage Foundation for Medical Research, and several private consulting firms. In this way, the Eco-Research Program *"encourages the formation of ongoing national and international alliances between universities, private and public sector organizations and public interest groups."* [6]

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6 Eco-Research Tri-Council Secretariat. *Eco-Research: A Tri-Council Green Plan Program — Program Description*. (Ottawa: 1994).

Additional ways must be found to increase partnerships between industry, the provinces and non-governmental organizations in order to sustain and improve the national investment in university research.

Recommendation:

Challenge the granting councils to lever increased funds from research clients and convince the provinces, industry and non-governmental organizations to become partners in the national investment in basic and applied university research.

Limited resources also require that scarce funds be dispersed to maximum advantage, by rewarding the most excellent submissions for granting council funding. It is therefore imperative that the peer review process used to evaluate proposals and to allocate funds continue to be rigorous, fair, effective and, where appropriate, reflect the government's priorities as laid out in an S&T strategy. Although the granting councils' peer review processes are generally highly regarded, **there should be regular formal evaluations of these grant selection processes.**[7]

The New Research Perspective

New approaches to doing research must be fostered and supported. In the past, research has been largely focused on specific disciplines and, in most instances, performed by individual researchers or research groups. Some current problems, however, require a multidisciplinary approach in order to achieve effective resolution. A number of new approaches to multidisciplinary research are being explored that can address these needs. The granting councils collaborate on tri-council projects where appropriate. The Tri-Council Eco-Research program, as mentioned above, aims to address environmental concerns by integrating research expertise from the social sciences and humanities, health sciences and the natural sciences and engineering. Together, researchers from these disciplines are able to develop innovative solutions to current complex environmental problems. The Networks of Centres of Excellence manage multidisciplinary, multisectoral research programs of nationwide scope, which develop partnerships that integrate the R&D priorities of all participants.

In this changing climate, S&T can be an important tool to ensure the most effective use of our resources. The federal government must cooperate with the provinces to seek to **consolidate expensive research equipment in particular locations, in order to preserve critical levels of excellence, while containing expenditures. New information technologies, when effectively used, facilitate access to information and foster interactive partnerships in ways not**

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7 Both SSHRC and NSERC have recently undergone such analyses, the purpose of which was to ensure fair and effective adjudication. See Carroll, 1991, 1994.

possible before. An electronic library system, accessible to all research institutions, would reduce costs in the long term while simultaneously increasing accessibility to library resources.

University Research Infrastructure

Shrinking federal and provincial budgets and increasing enrollments have contributed to severe financial difficulties for Canadian research facilities. Results of this are evident in the deteriorating condition of the university research infrastructure, which involves the indirect costs of doing research.[8] This issue must be resolved, since a strong research infrastructure is essential for the maintenance of an environment conducive to high quality research output. Provincial operating grants[9] have declined dramatically during the past ten years (Figure 4.2a). Over the same period, sponsored research[10] expenditures have increased significantly in most provinces (Figure 4.2b). Consequently there is a deficiency of funds to cover the indirect costs of research.

Unlike the research contracted by either industry or federal departments, funding from the granting councils covers only the direct costs of research. Support for the indirect costs is offset by the funds allocated through the Established Programs Financing - Post-Secondary Education (EPF-PSE) arrangements. These transfer payments represent the federal government's contribution to research infrastructure, thereby eliminating the need to defray further the indirect costs of some federally sponsored research. As these transfers are unconditional, it is not possible to verify or direct the amount of federal money actually used by the provinces to support the university research infrastructure. This fact, together with a reduction in the amount of these transfer payments, is resulting in a serious weakness in the university infrastructure. Research-intensive universities are particularly affected.

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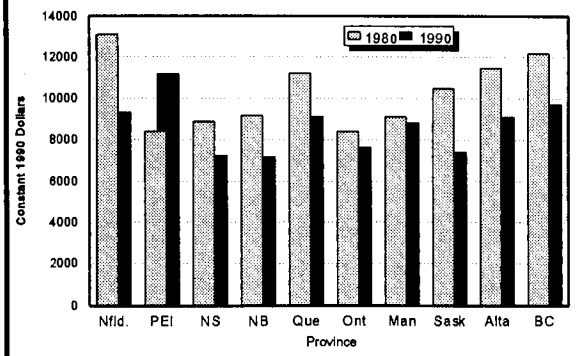
8 Indirect costs refer to the costs incurred by the institution in accepting and conducting sponsored research, including part of the costs of space and basic facilities, libraries, computing facilities, human resource offices, financial services, purchasing, research services, equipment depreciation, legal advice, secretarial services, etc. Infrastructure costs are wider than indirect costs, as they refer to the institutional resources required to develop and nurture an environment conducive to research. In addition to facilities, they include support services required to sustain and promote research, as well as direct financial research assistance, which institutions provide to their academic staff in the form of release time, seed money, top-up funds, etc. (AUCC, *Giving Greater Purpose to Federal Investments in University Research: A Discussion Paper.* June: 1994.)

9 Provincial operating grants, which obtain some funds from EPF-PSE transfers, provide funding to support university infrastructure and the indirect costs of research, as well as to support and facilitate the university mandate to teach and ultimately graduate well-educated people.

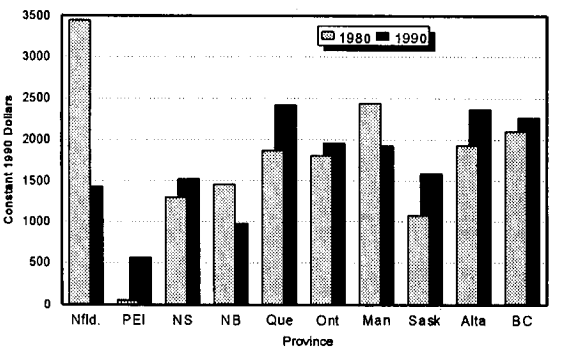
10 Sponsored research is defined as that research which is funded directly through grants and contracts from various agencies. In Canadian universities, the five main sources of funding for sponsored research are: the three granting councils; provincial governments; private foundations and non-profit organizations; federal departments and agencies; and, industry, foreign and miscellaneous sources. [Royal Society of Canada. *A Study of University Research in Canada: The Issues.* (October, 1989)]

Figure 4.2a Provincial Operating Grants per FTE Student By Province, 1980 & 1990



Source: Association of Universities and Colleges Canada, 1994

Figure 4.2b Sponsored Research Expenditures per FTE Student By Province, 1980 & 1990



Source: Statistics Canada, 1980-81, 1990-91

In the social sciences, the real effects of a deteriorating research infrastructure can be seen in fewer and lower-quality library resources[11] — both paper and electronic — and even more constrained technical support such as secretaries and computer technicians. In the health, engineering and natural sciences, a weakened infrastructure is evident in aging computing facilities and outdated equipment, which are not conducive to the performance of leading-edge research. A study conducted for NSERC concluded that 28 percent of Canadian research equipment in 1990 was then obsolete, compared to 17 percent in 1981.[12] The study further noted that:

> *"Impacts on research of not having adequate equipment include not doing certain kinds of research at all (unfortunately, this includes the "hot topics" in the field), doing research on simpler or more limited problems, performing the research on older equipment (with a consequent increase in the time required — often by a factor of ten or so, compared with the time required using new equipment), delaying research until a grant is awarded...and making more group requests for general — as opposed to specialized equipment."* [13]

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11 In the 1980s, spending per FTE student on libraries declined by 13 percent in real terms (AUCC, *Trends,* Ottawa: 1991, p.84). According to the Royal Society, budgets of university libraries have been constrained to such an extent that even the largest collections no longer have any hope of keeping up with the production of new materials. (Royal Society. *Realizing the Potential: A Strategy for University Research in Canada.* Ottawa: 1991).

12 DPA Group Inc. *Final Report for the Evaluation of the Equipment Grants Program of NSERC.* (Ottawa: 1991), p. iii.

13 Ibid, p. iv.

If Canada is to preserve the quality of the research conducted in universities, as well as its international comparative advantage in this area, mechanisms must be found to modernize and maintain Canada's research infrastructure. The government's declared intention to replace the EPF-PSE with new transfer arrangements provides an opportunity to develop these mechanisms and resolve this urgent problem.

> *"Modernizing the university infrastructure for teaching and research will increase the returns on our S&T investments and contribute significantly to the renewal of the national innovation system. Failure to do so will jeopardize Canada's comparative advantage in higher education. It will compromise our ability to develop, import and adapt the knowledge necessary for attaining our economic and social goals."* [14]

To maintain research excellence and to maximize the return on the federal investment in university research, the S&T strategy should include a *process for collaboration* with the provinces to identify and maintain a base level of support for research infrastructure in Canadian universities.

Recommendation:

Include in the S&T strategy, a process for collaboration with the provinces to identify and maintain a base level of support for S&T research infrastructure in Canadian universities.

2.1.2 Government Research Laboratories

Strategic Orientation

Research in government laboratories should be directed to areas of need where only government can and should act.[15] Accordingly, research activity in government laboratories must be strategically oriented to be responsive to priorities identified in an S&T strategy. Where appropriate, analyses should be made of the societal impact of the strategic research undertaken or supported by the government, in order to anticipate both opportunities arising from it and possible adverse consequences of its use.

The government needs to identify areas of current federal research that could more effectively be conducted either in university or industry laboratories, or that could be done collaboratively. It is important to determine those areas in which there may be duplication and those with which the government should no longer be involved. Accordingly, **departments and agencies need to develop mandate-specific criteria consistent with the priorities inherent in an S&T strategy.** Using these criteria, departments must undergo regularly scheduled, rigorous, external

14 Association of Universities and Colleges of Canada, p. 12.

15 A detailed discussion of the federal government's S&T performance role is given in Chapter One.

evaluations of their activities. The purpose of these evaluations would be to determine the need for continuation, re-orientation, transfer to industry or universities, or elimination of federal research programs, and thereby optimize the use of available research funds for essential S&T tasks.

Recommendation:

Require science-based departments and agencies (SBDAs) to carry out regularly scheduled, rigorous, external evaluations of their activities, based upon department-specific criteria consistent with the priorities inherent in a federal S&T strategy.

The identification of duplication or irrelevance, in the context of government spending cuts, must take a systems approach to be applied across all ministries. Coordinated management of government research programs will ensure the cross-departmental synergy necessary to effectively and efficiently achieve the required outputs.

Collaboration and Partnerships

In order to maximize advantages in human expertise and physical resources, and to reduce costs, **government laboratories should seek opportunities for collaboration with university and industry laboratories in cross-sectoral and multidisciplinary partnerships.** Such collaboration could include participation in centres of excellence, consortia or other collaborative activities such as those fostered by IRAP (see inset), instead of operating independently or in competition with other groups.

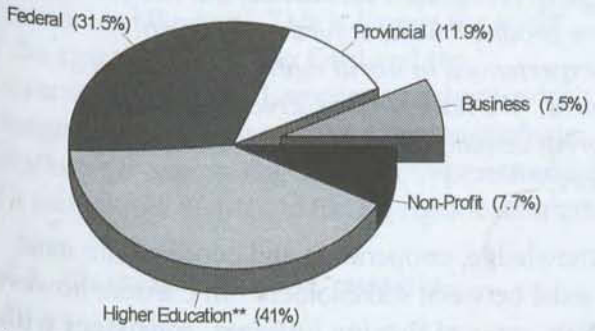
The Industrial Research Assistance Program (IRAP):

IRAP supports and promotes scientific and technological innovation in Canada through strategic partnerships and networking. The program facilitates the transfer of accumulated knowledge found in federal and provincial government laboratories, private sector organizations and colleges and universities for use by small and medium sized Canadian firms. In addition, IRAP provides financial support for R&D activities that will improve a company's performance and competitiveness. IRAP also works with Foreign Affairs and International Trade Canada, to help put Canadian firms in touch with international sources of technology.

2.1.3 Research Conducted by Industry

The relative overall funding of R&D by Canadian industry is far lower than that of the major OECD countries (Table 1.1, Chapter One). In addition, business assumes a very small share of funding support for university research in comparison with other sectors in Canada (Figure 4.3). As was pointed out in Chapter Three, industry needs to increase its share of, and commitment to, R&D. Where it is not feasible to undertake or increase in-house research, **industry should seek opportunities to collaborate with researchers in government and university laboratories**. Combining the technical and commercialization know-how and the R&D dollars of industry, with the expertise and physical resources of government and university scientists will maximize the benefits to all in an economically viable way. Centres of Excellence provide opportunities for industry to participate in, and benefit from, research collaboration.

Figure 4.3 Percentage Share of HERD by Funding Sector, Canada 1992



Source: Statistics Canada

** The Higher Education Sector funding is that which is provided through the General University Funds (GUF), student fees and miscellaneous gifts and donations. GUF is derived from federal and provincial sources, yet is not specifically earmarked for sponsored research. In most cases, the funding that is derived from the federal and provincial funding sectors is intended for sponsored research.

"The research carried out by the Centres builds on the 'basic research' conducted in laboratories of its university partners by concentrating on that part which has strategic potential. "Basic research" builds our stock of knowledge in science and engineering and, through international connections of researchers, provides a window on the worldwide stock of knowledge. The strategic focus assures the development of knowledge in areas with real potential for supporting viable commercial market success in the Canadian context by involving industry users at the very start of the research process. Since such activities are largely 'pre-competitive', they can gain the maximum benefits by being conducted in collaborative ventures such as the Centres." [16]

A key to ensuring that productive interactions take place is to facilitate communication of, and access to, the expertise and resources that reside in various research institutions. Industry can and should play a strong part in facilitating this information flow. This issue is further expanded upon in Section 2.2.1 of this chapter.

16 Ontario Centres of Excellence. *Written Submission to the S&T Review*. (Ottawa: August 1994), p. 4.

Recommendation:

Encourage and strengthen strategic collaborative research arrangements among government, university and industrial laboratories and promote cross-sectoral and multidisciplinary partnerships.

2.2 Improve Capacity to Adapt and Apply Knowledge

Canada's ability to harness the benefits of research should attain a level of excellence that matches our current level of excellence in basic research. Canadians must be developers and exporters of the products of R&D, not just producers of the knowledge itself, if wealth, job creation and a high quality of life are to flow from a strong knowledge base. Effective ways must be found to make this happen.

> *"[Canada] has created pools of knowledge of recognized excellence, but not yet of sufficient maturity to be turned into new products without further financial investments and wise nurturing by those experienced in world markets and in the processes of successful product development. We have, in fact, created a significant 'backlog' of technologies of great commercial potential which, if Canadians do not exploit, will flow offshore."* [17]

In order to facilitate the application and use of knowledge, cooperation and coordination must take place. To this end, effective linkages must exist between stakeholders. In Canada, however, these links are not always strongly connected. **New ways of forging linkages, consistent with the integrated model as described in Figure 1.1 (Chapter One), must be explored, and where successful, should be used as models from which others can learn and adapt.**

2.2.1 Industry/University Linkages

To some degree, weak links between universities and industry arise due to the lack of a science-oriented industrial culture in Canada and to a lack of understanding of the academic sector by business and vice versa. If these links were improved, there would be a greater willingness and ability on the part of industry to adopt scientific innovations and incorporate them into the operation of their activities. In the longer term, industry will be better able to maintain its competitiveness if it acquires a greater understanding of the scientific knowledge that will have an impact on its future. Chapter Three describes various models of partnerships and technology transfer. Where successful, pre-competitive consortia, clusters and networks should be facilitated.

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[17] Canadian Institute for Advanced Research: *Written Submission to the S&T Review (Ottawa: August 1994)*, p. 7.

"The greatest and most serious gap in the spectrum of innovation from fundamental research to product development is the paucity of industry involvement or even interest in research which is more than two years away from producing marketable products...If we fail to bring about a change in this attitude of Canadian industry toward research, foreign companies will be the major beneficiaries of our substantial investments in fundamental inquiry and our most highly-skilled new graduates will migrate towards the challenges offered by those companies." [18]

Where strong links are established, the overall gains are obvious. A good example is Ford Motor Company of Canada which has selected Windsor as the site of the Ford Cast Aluminum Research and Development (CARD) facility. CARD is Ford's world headquarters for R&D for aluminum automotive casting. Ford's decision to locate CARD in Canada was made, in part, due to the availability of highly qualified personnel in Windsor. This is largely the result of the agreement between Ford and the University of Windsor Engineering school, which arranges co-op placements for its undergraduate metallurgical engineering students. These students have played a major role in the development of a technology that could have a significant impact on the automotive and aluminum industries.[19]

"The research projects of PRECARN [Precompetitive Advanced Research Network] provide good examples of a cooperative industry-led approach which involves users and producers of the technologies as well as the very considerable talents of university researchers."

Source: G.M. McNabb & Associates Inc. 1994, p.2

2.2.2 Partnerships and Consortia

Partnerships across sectors and industrial consortia assist small and medium-sized business to tackle large industry-wide problems and take advantage of opportunities. A few promising models are currently being tried which, if successful, should be promoted, and others should be encouraged where appropriate. Telecommunications Research Laboratories (see inset) is one example of an effective research consortium, combining university research with industrial direction.

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18 G.M. McNabb & Associates Inc. *Written Submission to S&T Review*, (Ottawa: August 1994), p. 2.

19 Carrington, John. "R&D Shifts into High Gear." *University of Windsor*, Fall 1993.

Telecommunications Research Laboratories (TR Labs):

TR Labs was founded in 1986 as a research consortium based on industry, university and government collaboration. It operates a research network in Western Canada and represents the largest non-governmental, not-for-profit telecommunications research organization in Canada. Applied research work is focused on five strategic technologies:

- networks and systems research;
- photonics;
- wireless communications;
- network access; and
- data networking and related software.

Affiliated with universities in Western Canada, TR Labs also provides valuable student training at the graduate level.

The Canadian Medical Discoveries Fund (CMDF)[20] is another example. Despite major market opportunities for medical technologies in Canada, there is a large negative trade balance for medical supplies. The CMDF is attempting to rectify this situation. It is a unique partnership of business, government and labour that aims to identify and invest venture capital into commercially viable, promising research projects, which are identified using the peer review system of the MRC. **The federal government should promote such strategic collaborations among other S&T stakeholders in key areas identified by the S&T strategy.**

2.2.3 Access to Information

Efficient and effective access to knowledge and expertise is essential for maximizing the potential for creative use of scientific discoveries. Sector collaboration on the development of a national database of ongoing R&D in Canadian research institutions, together with an interactive database of national and international scientific and technological expertise, would facilitate this access. In addition, there must be a highly effective mechanism to communicate this knowledge to the whole community, together with its importance and its potential applications. The *Canadian Network for the Advancement of Research, Industry and Education* (CANARIE) is a good example of the Information Highway being developed to facilitate the transfer of knowledge (see inset).

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[20] The CMDF, created in December 1994, is a joint venture of MDS Health Ventures Inc., the Medical Research Council (MRC), the Professional Institute of the Public Service of Canada, Talvest Fund Management Inc., CIBC Wood Gundy Capital, and CIBC Wood Gundy. The Fund is managed by the Medical Discoveries Management Corporation.

In the context of globalization and international collaboration, **Canadian communications infrastructures must meet the highest of international standards to allow Canadians to capture the benefits of the Information Highway.**

"The accelerated pace of scientific advances relies on the rapid flow of scientific information made possible by the emerging global information environment. A nation's ability to compete in science and in technology can be reduced severely by deficiencies in communication technology and by national economic or political policies that impede the information flow." [21]

"CANARIE can be seen as a prototype of the large scale public and private sector collaboration that will be required. It will connect researchers and educational communities across Canada by 1999 with a high-speed broadband highway and will upgrade the gateway to the Internet and other international networks."

Source: Industry Canada. *The Canadian Information Highway*, (Ottawa: 1994), p. 17.

Recommendation:

Develop, in collaboration with other sectors, an interactive database of national and international scientific and technological expertise, and a national database of ongoing R&D in Canadian research facilities, as well as the communications infrastructure to make this knowledge accessible.

2.2.4 Intellectual Property Rights and the Information Highway

The advent of the Information Highway has prompted much debate on intellectual property issues such as copyright protection of works disseminated on electronic systems. While the Information Highway is a powerful tool by which to transfer knowledge, the potential for fraud and piracy, and the consequent economic implications, are of great concern.

The Information Highway Advisory Council Copyright Subcommittee was established in August, 1994, to make recommendations on copyright in the context of the Information Highway. The subcommittee concluded that the current copyright legislation is sufficiently flexible to provide adequate protection for new and existing works in an electronic medium.[22] Many of the issues

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21 Government-University-Industry Research Roundtable. *Future National Policies Within Industrialized Nations: Report of a Symposium* (Washington: National Academy Press, 1992), pp. 12-13.

22 Copyright Subcommittee of the Information Highway Advisory Council. *Preliminary Report on Copyright and the Information Highway* (Ottawa: December 1994).

presenting the greatest difficulty were neither legal nor policy related, but rather were administrative or technical in nature. Two such barriers were identified: enforcement difficulties, and clearance of rights difficulties. A list of recommendations, proposed by the Copyright Subcommittee to remove these barriers, is given in Appendix IV. Intellectual property safeguards for Canadian researchers must be established without delay in order to encourage greater use of the Information Highway for the dispersion and use of knowledge in Canada.

Recommendation:

Improve intellectual property safeguards on the information highway, through the removal of any administrative and technical barriers that may limit the effective operation of copyright legislation.

2.2.5 Administrative Barriers

Several **administrative barriers frustrate greater understanding, collaboration and cooperation among industry, government and universities, and must be removed**. For instance, the lack of portability of pensions within and across some sectors inhibits the easy movement of experienced personnel. Similarly, the lack of national standards in education, combined with the lack of recognition of credentials, limits the free transfer of personnel across provincial and sectoral boundaries. Differing treatment of intellectual property rights by different organizations is another example of such an administrative barrier.

2.2.6 Social Policy Development

Social science research requires wider dispersion and innovative application in order that it be used to maximum advantage in the development of social policy.
Government has a responsibility to identify social problems that are not being adequately addressed by current policy. Policy reform should be based on relevant research in the social sciences and humanities. For example, there are high expectations of the advances and advantages that the Information Highway and related technology will bring to the education system. *"However, **to ensure that maximum benefits accrue and that scarce resources are not wasted, responsible research is required into effective use of new technologies in the classroom.**"* [23]

"The rapid growth of breakthroughs in biotechnology — including genetic manipulation of agricultural produce or human reproductive systems — raises a legion of complex legal, ethical and social questions."

Source: Social Sciences Federation of Canada. *Written Submission to the S&T Review*, (Ottawa: August 1994), p. 5.

[23] National Advisory Board on Science and Technology. *National Standards in Education: A Question of Excellence.* (Ottawa: May 1994), p. 13

New models for cooperation and collaboration between research institutions and industry, and creative mechanisms for knowledge dispersion will contribute significantly to the successful application of Canadian and international knowledge. This will greatly facilitate full exploitation, minimize duplication of resources, and lay the basis for strong economic and social development based on knowledge.

2.3 Foster and Sustain a Strong Science and Technology Culture

The promotion of an S&T culture and education are strongly linked, and together are the underpinnings for future social and economic growth. A strong S&T culture in our schools will provide young Canadians with the motivation required for interest and learning in S&T, and will establish S&T as an integral part of the school environment. The value Canadians place on S&T has implications for the transfer and innovative application of knowledge, and for the development of a versatile and scientifically literate workforce. Ultimately, it influences the economic future and social development of Canada.

The development of an informed, motivated population must be seen as a central aspect of both an S&T strategy and of a Canadian human resources strategy. Canadians need to understand the relationships between science, jobs and the quality of life. **An important component of a federal S&T strategy, therefore, must be the creation of a new and shared vision of S&T.**

Despite the importance of a strong S&T culture, the consensus from the federal S&T Review indicates the lack of such a culture in Canada. In general, Canadians tend to be interested in science, yet, in part because of the speed and complexity of change, remain intimidated by it. They do not perceive it as an integral part of, or relevant to, their daily lives, and hence lack the motivation to learn more about S&T and its uses.

Canadians who have neither the talent nor the inclination to make S&T the focus of their education and career goals, nevertheless need to acquire a sense of confidence in the pervasive S&T that shapes their living and working environments. They need to be able to appreciate S&T without being intimidated by it, and to appreciate and comprehend the social and ethical questions that evolve from scientific and technological advances. A greater comprehension of the resulting social changes that affect their families and communities will result in Canadians possessing a deeper understanding and acceptance of their role in a modern knowledge-based society. If current trends are not reversed, Canadian society will polarize into technically literate and illiterate factions, with the risk that a portion of our society may not be able to participate meaningfully in the new economy.

2.3.1 Science Culture Initiatives

Current Canadian science culture initiatives can be categorized into three broad program areas: to help increase Canadians' awareness of the role that S&T plays in their lives; to help provide the skills and resources our schools need to train young people in S&T; and to provide recognition and rewards to outstanding students, teachers and organizations. Within each of these three areas, a number of programs have been successfully implemented. Programs such as Youth

presenting the greatest difficulty were neither legal nor policy related, but rather were administrative or technical in nature. Two such barriers were identified: enforcement difficulties, and clearance of rights difficulties. A list of recommendations, proposed by the Copyright Subcommittee to remove these barriers, is given in Appendix IV. Intellectual property safeguards for Canadian researchers must be established without delay in order to encourage greater use of the Information Highway for the dispersion and use of knowledge in Canada.

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Several **administrative barriers frustrate greater understanding, collaboration and cooperation among industry, government and universities, and must be removed**. For instance, the lack of portability of pensions within and across some sectors inhibits the easy movement of experienced personnel. Similarly, the lack of national standards in education, combined with the lack of recognition of credentials, limits the free transfer of personnel across provincial and sectoral boundaries. Differing treatment of intellectual property rights by different organizations is another example of such an administrative barrier.

2.2.6 Social Policy Development

Social science research requires wider dispersion and innovative application in order that it be used to maximum advantage in the development of social policy. Government has a responsibility to identify social problems that are not being adequately addressed by current policy. Policy reform should be based on relevant research in the social sciences and humanities. For example, there are high expectations of the advances and advantages that the Information Highway and related technology will bring to the education system. *"However, **to ensure that maximum benefits accrue and that scarce resources are not wasted, responsible research is required into effective use of new technologies in the classroom.**"* [23]

> *"The rapid growth of breakthroughs in biotechnology — including genetic manipulation of agricultural produce or human reproductive systems — raises a legion of complex legal, ethical and social questions."*
>
> Source: Social Sciences Federation of Canada. *Written Submission to the S&T Review*, (Ottawa: August 1994), p. 5.

[23] National Advisory Board on Science and Technology. *National Standards in Education: A Question of Excellence*. (Ottawa: May 1994), p. 13

New models for cooperation and collaboration between research institutions and industry, and creative mechanisms for knowledge dispersion will contribute significantly to the successful application of Canadian and international knowledge. This will greatly facilitate full exploitation, minimize duplication of resources, and lay the basis for strong economic and social development based on knowledge.

2.3 Foster and Sustain a Strong Science and Technology Culture

The promotion of an S&T culture and education are strongly linked, and together are the underpinnings for future social and economic growth. A strong S&T culture in our schools will provide young Canadians with the motivation required for interest and learning in S&T, and will establish S&T as an integral part of the school environment. The value Canadians place on S&T has implications for the transfer and innovative application of knowledge, and for the development of a versatile and scientifically literate workforce. Ultimately, it influences the economic future and social development of Canada.

The development of an informed, motivated population must be seen as a central aspect of both an S&T strategy and of a Canadian human resources strategy. Canadians need to understand the relationships between science, jobs and the quality of life. **An important component of a federal S&T strategy, therefore, must be the creation of a new and shared vision of S&T.**

Despite the importance of a strong S&T culture, the consensus from the federal S&T Review indicates the lack of such a culture in Canada. In general, Canadians tend to be interested in science, yet, in part because of the speed and complexity of change, remain intimidated by it. They do not perceive it as an integral part of, or relevant to, their daily lives, and hence lack the motivation to learn more about S&T and its uses.

Canadians who have neither the talent nor the inclination to make S&T the focus of their education and career goals, nevertheless need to acquire a sense of confidence in the pervasive S&T that shapes their living and working environments. They need to be able to appreciate S&T without being intimidated by it, and to appreciate and comprehend the social and ethical questions that evolve from scientific and technological advances. A greater comprehension of the resulting social changes that affect their families and communities will result in Canadians possessing a deeper understanding and acceptance of their role in a modern knowledge-based society. If current trends are not reversed, Canadian society will polarize into technically literate and illiterate factions, with the risk that a portion of our society may not be able to participate meaningfully in the new economy.

2.3.1 Science Culture Initiatives

Current Canadian science culture initiatives can be categorized into three broad program areas: to help increase Canadians' awareness of the role that S&T plays in their lives; to help provide the skills and resources our schools need to train young people in S&T; and to provide recognition and rewards to outstanding students, teachers and organizations. Within each of these three areas, a number of programs have been successfully implemented. Programs such as Youth

Engineering Science Camps of Canada and Shad Valley are examples of successful science promotion initiatives. The Michael Smith Awards for Science Promotion, and the Prime Minister's Awards for Teaching Excellence in Science, Technology and Mathematics, are successful examples, at the federal level, of reward and recognition programs.

2.3.2 Coordinated Approach

> *"The challenge of building a science culture is too complex a task to be left to one profession, one sector of the economy, one interest group, or one level of government — partnerships are required."*
>
> Source: Science Culture Canada. *Written Submission to the S&T Review.* (Ottawa: August 1994).

Despite these apparent successes, science culture initiatives, including many initiatives undertaken by the provincial governments,[24] are limited by their isolation from one another. There is no *cohesive plan* by which the programs could be coordinated in a fashion that builds on best practices and avoids duplication and overlap of resources. A study of programs that have successfully resulted in attitude change, such as the shift in Canadians' attitude to health and fitness (e.g. *Participaction*) in recent years, may reveal some creative new approaches that could be adopted.

Given the significance of science culture as an underpinning for future growth, science culture programs, including those of Science Culture Canada, should be tied together in a cohesive and complementary manner, in order that their effectiveness in motivating the Canadian population with respect to S&T will be fully realized.

In order for a coordinated plan to be developed, there are two necessary precursors. First, **there must be a collaborative effort to compile an inventory of all federal, provincial and independent science culture programs.** This may take the form of an electronic database. Second, **the effectiveness and appropriate targeting of all federal programs should be regularly assessed through rigorous formal evaluations. Program complementarity with provincial and other programs should also be assessed.** If programs are shown to be successful in their mandates, they should be continued and possibly expanded; if not, their expenditures should be redirected.

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[24] Some key provincial organizations currently engaged in science promotion activities include the following: Atlantic Provinces Council on the Sciences; l'Association canadienne-française pour l'avancement des sciences; La société pour la promotion des sciences et de la technologie (Quebec); Science Network Ontario; Science Manitoba; and the Association for the Promotion and Advancement of Science Education (B.C.).

Recommendation:

Create an integrated plan for science culture development, which includes a formal evaluation process for existing federal programs. This plan must include all parties currently involved in science culture initiatives, such as the federal and provincial governments and independent organizations.

2.3.3 Access to Science Culture Resources

A national science culture inventory, coupled with ongoing formal evaluations of federal science culture programs, will facilitate the development of a science culture network for the sharing of resources and best practices. This should result in the creation of a vehicle for effective partnerships and program coordination, and ultimately, more effective and economical delivery of federal science culture activities. **It should facilitate access to science culture information and programs by schools and communities in all parts of the country.**

2.4 Improve Education & Training Standards and Science Literacy

> *"In this information age, the wealth of a nation is measured by the skills, knowledge and abilities of its people. Their cumulative talents stimulate enterprise and allow it to prosper. This in turn provides the wealth that supports our standard of living. Therefore, the quality of education we provide for our citizens reflects the real character of our country."* [25]

Canadians must recognize that to be fully functional in the modern world, a solid knowledge base in science, technology and mathematics is as essential as the ability to read and write. This is the foundation upon which will be built a strong research culture, innovative development activity and progressive social development. In order to achieve the vision for Canada put forth in this report, the education, training and science literacy of Canadians must be viewed as an extension of national social and economic policy, with all sectors taking an active role in its improvement.

Two types of education and training are considered here: the basic education in S&T of the general population and the development of science literacy; and the education and training of highly qualified personnel in S&T.

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[25] National Advisory Board on Science and Technology, *National Standards in Education*, p. 44.

2.4.1 Science Literacy

"Good government requires a citizenry capable of making knowledgeable choices related to S&T..." and "depends on good knowledge based on science and technology to formulate policy and legislation."

Source: Report of the Task Force on Advancement of Knowledge to the Interdepartmental Task Force on S&T Priorities. (Ottawa: November 30 1994), pp. 5-8.

The Royal Society of Canada defines science literacy as having three main components: the general understanding of the scientific process; the understanding of some scientific terms; and the understanding of some of the social impacts of S&T.[26] This general knowledge provides a foundation for continuous learning and an awareness of the place of S&T in our society. It should also provide the basic knowledge and understanding that will enable people to solve the problems that confront society.

> *"There is a significant bias against science, technology and innovation that is rooted in our conservative cultural values and which is, to a larger degree than we wish to admit, reinforced by our formal and informal learning processes."* [27]

Prerequisites to the acquisition of a strong knowledge base in science, technology and mathematics are challenging and exciting curricula which provide the required subject elements, and teachers who are qualified to deliver these curricula effectively.

The Learning Process:

The NABST report, *National Standards in Education: A Question of Excellence* [28], articulated the correlation between levels of education and employment, and the need for national standards if Canadians are to meet and surpass international standards. Progress in this direction has been achieved through the School Achievement Indicators Program (SAIP), instituted by the Council of Ministers of Education, Canada (CMEC). The first national test in mathematics was administered in 1993. A second is scheduled for 1996. CMEC, with support from the federal government, is completing work on a test in science which is scheduled for 1996.

Building upon these examinations, national curricula should evolve for science and mathematics, with mandatory instruction from early childhood to grade 12. However, it must be clear that this does not mean standardization of content organization or of methodology.

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26 Royal Society of Canada. *Science and the Public* (Ottawa: 1988).

27 Ontario Centres of Excellence, p. 4.

28 National Advisory Board on Science and Technology. *National Standards in Education*, p. 46.

Methods of teaching and of achieving learning goals can and should be varied to stimulate interest and satisfy different learning styles. **New methods should be explored, including the use of technology in the classroom. A powerful opportunity is afforded by multi-media instruction and communication to remote sites. Increased directed research in education and the sharing among jurisdictions of successful models will accelerate the rate of development and adoption of new methodologies.** The relevance of S&T to everyday existence should be demonstrated through new and innovative teaching methods. The teaching of history, for instance, should include references to the part that scientific discovery has played in the evolution of social structures and the determination of world events.

Exposure to S&T museum exhibits that invite interactive participation is an excellent device for stimulating interest and achieving comprehension of the basic principles in S&T. It is important also that secondary school students receive an introduction to technological skills. Co-operative or work related experience should be required for high school graduation when and where the economy can support it, as recommended in the NABST report, *National Standards in Education: A Question of Excellence.*

Recommendation:

Encourage the Council of Ministers of Education, Canada (CMEC) to establish a national science and mathematics curriculum.

The Teaching Component

An essential element of a first class education system is first class teacher training. Science prerequisites for admission to education degree programs are inadequate in many institutions, as is the training of science teachers. The Ontario government's Royal Commission on Learning reported that:

> *"Queen's University, for instance, now requires all applicants to its faculty of education to have some background in mathematics and science, but most faculties do not."* [29]

The Commission further noted that:

> *"Very few teacher education programs, here or elsewhere, are evaluated on any basis other than satisfaction of student teachers or the success of graduates in finding teaching positions... There would seem to be no*

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29 Royal Commission on Learning. *For the Love of Learning, Volume III: The Educators.* (Toronto: Queen's Printer for Ontario, 1995), p. 23.

systematic assessment of the knowledge and skills of current Ontario graduates...We suggest that teacher education programs be accredited, in a process similar to that often used with some other professional and graduate university programs, both in Ontario and elsewhere." [30]

This lack of an appropriate background in science and mathematics often results in the poor quality of science education in schools, particularly at the primary level. **Teacher training standards for the sciences must be raised**. As well, in order that teachers remain fully conversant with new knowledge and developments in S&T, periodic recertification should become mandatory, and be contingent upon regular attendance at workshops in science training and education, as recommended in the Ontario Royal Commission Report on Learning.[31]

Recommendation:

Encourage the Council of Ministers of Education, Canada (CMEC) to require that recertification of science teachers become mandatory, and be contingent upon regular attendance at workshops in science training and education.

Access

Not all communities have ready access to S&T museum exhibits or other such useful learning tools. **However, the potential for access improves through the use of an increasing bank of instructional materials on S&T, available through computer networks and by CD-ROM.** SchoolNet and the National Network for Learning are just two examples of the use of computer networks to improve access and enhance the availability of substantive learning materials. **Teachers must have access to this technology and be instructed in the use of technological resources.**

2.4.2 Educating and Training the Experts

Educating and training future generations of scientific and technological experts will ensure that Canada remains at the leading edge of discovery in some fields; will ensure that Canadians have the skills to address social problems and technological needs of a growing economy; will guarantee access to the best of international scientific research; and will enable Canada to participate in important international collaborative projects.

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30 Ibid, pp. 16-17.

31 Ibid, p. 33.

Strategic expertise is required in industry in order to judge the value of technology that should be developed and/or acquired either from our own institutions or from abroad. Expertly trained and innovative personnel are required to ensure that knowledge is applied towards the development of new products and services, and that new products are developed and prepared for the marketplace. Cultural attitudes that present careers in the technologies as inferior to other professions such as law and economics discourage the development and promotion of technologically skilled individuals. The continuing education and training of the scientific and technical workforce are essential to prevent obsolescence of technical skills, and to promote and maintain productivity.

Adequate funding should continue to be available through the granting councils for the training of graduate and post-graduate students, in order to help ensure an adequate supply of highly qualified personnel. At the same time, other sectors, including provincial governments, must acknowledge and accept their responsibility to contribute an appropriate share of required funds. Industry could make significant contributions through scholarship and bursary awards, and through increasing the number and variety of co-operative education opportunities.

Access

Effective use of the Information Highway will greatly enhance access to resource materials. The federal government, for instance, should improve the availability of government held data.[32]

> *"Better data management represents a significant step towards improved knowledge transfer in a democratic society. Furthermore, it contributes to an improved learning culture...A new collaborative approach — one which takes advantage of emerging technologies such as the information highway — is urgently needed... [This] will not only enhance knowledge transfer, but offer a strong educational element for analytical and numeracy skills among Canadian students, two important elements of a sound science and technology strategy."* [33]

Co-operative education experiences increase opportunities for academic-industrial linkages and for access to, and transfer and application of, knowledge from universities to industry, and vice versa.

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[32] This issue has been identified in greater detail in Chapter Two, in the discussion on the Data Liberation Initiative.

[33] Social Science Federation of Canada. *Written Submission to the S&T Review.* (Ottawa: August 1994), p. 7.

2.4.3 Collaboration and Cooperation

Collaboration and cooperation are becoming more and more important given the increasing costs of education and training at all levels. The sharing, for example, of resources, methodologies, and equipment between sectors and among the provinces, together with collaboration on planning for future needs, will allow a greater number of institutions and individuals to profit from the best in the education system.

Partnering with Industry to Create New Educational Programming:

The Edmunston campus of New Brunswick Community College (NBCC) is now collaborating with the Fraser pulp mill to offer an industrial electricity program. The pulp mill contributes funds and equipment and participates in training of NBCC instructors. Among the students are workers from the pulp mill who are updating their skills competency. The program has been extended to include other partners such as McCain Foods Ltd. and the International Brotherhood of Electrical Workers, who are interested in having their workforce benefit from this training program.

> *"The best colleges and institutions can do is to enter into good partnerships with industry, where the finest equipment and the finest teaching can be brought together...We must be able to support training...in industry or working in organized tripartite arrangements with labour and industry."* [34]

In addition to encouraging these partnerships, the federal government should work with the provinces to improve the level of S&T education and training at all levels, to assist them in the establishment of a national science and mathematics curriculum, and to actively promote science literacy and expertise among the population.

3.0 Recommendations for the Advancement of Knowledge

Numerous studies over the years have identified issues similar to those discussed in this chapter, and have proposed similar recommendations. NABST alone has compiled an impressive number of reports on such topics.[35] The Economic Council also identified some of these issues as requiring attention in its 1992 report: *A Lot to Learn, Education and Training in Canada.*

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[34] Study Group on Technicians and Technologists. *Tapping our Potential: Technicians and Technologists of Tomorrow.* (Ottawa: 1993), p. 11.

[35] NABST reports on this issue include: University Committee; Human Resource Development Committee; Committee on Technology Acquisition and Diffusion; Winning with Women in Trades, Technology, Science and Engineering; National Standards in Education: A Question of Excellence; and most recently, the Committee on Federal Science and Technology Priorities: Phase II.

The significant difference today is the recognition that, in order to make significant progress, Canadians must move rapidly from the status quo towards change: in the way learning and research is done, and in the way knowledge is advanced and disseminated.

The time has come to just do it! But there is a major impediment to implementation which the recent federal S&T review process has clearly illustrated: the lack of a mechanism for setting and monitoring S&T priorities and a *federal body* able to make *tough* and *intelligent* choices. **The federal government must provide the leadership and management necessary for the ongoing development, implementation and monitoring of the Canadian S&T strategy, which should include vital components relating to the advancement of knowledge.** Chapter One deals with this governance issue in greater depth.

The final two lines of the NABST report, *Committee on Federal Science and Technology Priorities: Phase II* are no less relevant today than they were in February, 1994:

> *"...two decades' consideration of priorities is long enough. The government should make a decision about a system for establishing priorities and then implement it."* [36]

More than ever before in our history, knowledge is the foundation upon which wealth and job creation and improvements in the quality of life are based. In order to sustain and strengthen this foundation, NABST recommends that the federal government:

Sustain Strength in Discovery:

1. Challenge the granting councils to lever increased funds from research clients and convince the provinces, industry and non-governmental organizations to become partners in the national investment in basic and applied university research.

2. Include in the S&T strategy a process for collaboration with the provinces to identify and maintain a base level of support for S&T research infrastructure in Canadian universities.

3. Require science-based departments and agencies (SBDAs) to carry out regularly scheduled, rigorous, external evaluations of their activities, that are based upon mandate-specific criteria consistent with the priorities inherent in a federal S&T strategy.

Improve Capacity To Adapt and Apply Knowledge:

4. Encourage and strengthen strategic collaborative research arrangements among government, university and industrial laboratories and promote cross-sectoral and multidisciplinary partnerships.

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[36] National Advisory Board on Science and Technology. *Science and Technology Priorities: Phase II*, p. 24.

5. Develop, in collaboration with others, an interactive database of national and international scientific and technological expertise, and a national database of ongoing R&D in Canadian research facilities, as well as the communications infrastructure to make this knowledge accessible.

6. Improve intellectual property safeguards on the information highway, through the removal of any administrative and technical barriers that may limit the effective operation of copyright legislation.

Foster and Sustain a Strong S&T Culture:

7. Create an integrated plan for science culture development, that includes a formal evaluation process for existing federal programs. This plan must include all parties currently involved in science culture initiatives, such as the federal and provincial governments and independent organizations.

Improve Education and Training Standards and Science Literacy:

8. Encourage the Council of Ministers of Education, Canada (CMEC) to establish a national science and mathematics curriculum.

9. Encourage CMEC to require that recertification of science teachers become mandatory, and be contingent upon regular attendance at workshops in science training and education.

APPENDICES

CRITERIA FOR DECISION-MAKING

NABST strongly concurs with the Auditor General who stated, *"the absence of government-wide guidelines and criteria has contributed to departments being involved in activities that we believe they should question."*[1] All federal S&T activities must be subject to rigorous selection criteria, to be applied in an ongoing manner. In their actual application, appropriate weighting should be applied to each criterion, depending upon the type of S&T activity involved. For example, government-sponsored basic research may be weighted in order to give more emphasis to excellence.

Precise criteria would be developed as part of the federal S&T strategy to guide decisions on new or existing activities. NABST proposes that the criteria be divided into two main categories. The first category would be *hurdle* criteria, to determine whether the activity relates to the S&T strategy and if it is appropriate to the federal government's role (criteria 1 and 2 below). If the response is negative to either criterion, the activity does not *clear the hurdle* and should not be pursued. The second category (criteria 3, 4 and 5 below) would act as quality/section screens to help rank the attractiveness of an activity. In addition to these, each department should develop a second tier of criteria to assist in its internal priority-setting among programs.

Selected activities should be regularly monitored and evaluated against stated objectives.

1. **Does the investment clearly and measurably relate to the Federal S&T strategy and goals within the context of the integrated model?**
   - Are the goals of the investment related to the priorities of the S&T strategy?
   - Are there clear targets and milestones?
   - Does the activity and its proponents meet a high standard of excellence?
   - Are the S&T investments contributing to the development of a skilled, flexible and adaptable workforce?
   - Does the activity improve S&T capacity in Canada? Does it add to the private sector's ability to move to higher-value-added products and services and to compete effectively in both domestic and export markets?
   - Does the activity exploit renewable resources in a sustainable way, reduce overall consumption of natural resources, or minimize the negative environmental impact of extraction, manufacturing or other processes?
   - Does the activity reduce the cost or improve the effectiveness of program delivery?

1 Auditor General of Canada, p. 9-17.

2. Is the S&T activity appropriate to the federal role?

- Does the government *need* to be involved? If yes, what role should the government play (e.g., performer, sponsor/partner, regulator/facilitator)?
- Would the activity proceed without government involvement?
- Are the same results available elsewhere at lower cost?
- Does the proposed federal activity facilitate and not drive the technology?

3. Is there a good return on investment?

- Are the S&T investments focused on objectives that maximize the effectiveness of the programs or services addressed, at the least cost?
- Whether performing or supporting S&T performed by others, do the benefits expected justify the costs to the government (e.g., new jobs, recoverable costs, training opportunities, better services)? Are the benefits measurable?
- Do they seek to prevent problems (health, environment, safety), rather than addressing them only after they occur?
- Has adequate and competent risk-assessment been carried out?
- Is the methodology cost-effective?

4. Does it meet or surpass international benchmarks?

- Does the S&T help us meet or surpass international best practices in the activity that it supports?
- Are we building on and building up world-class strengths and capabilities?
- Are we maintaining a solid core of expertise in basic and applied research that is comparable to that of our OECD partners and rivals?

5. Is the S&T activity responsive to client needs?

- Is the activity responding to an expressed client need? Is the client involved in the design and monitoring of the program?
- Where the proposed government investment supports industrial R&D, is it at least matched by investment from the private sector partner in the project?
- Are other partners willing to contribute to or collaborate in the activity?

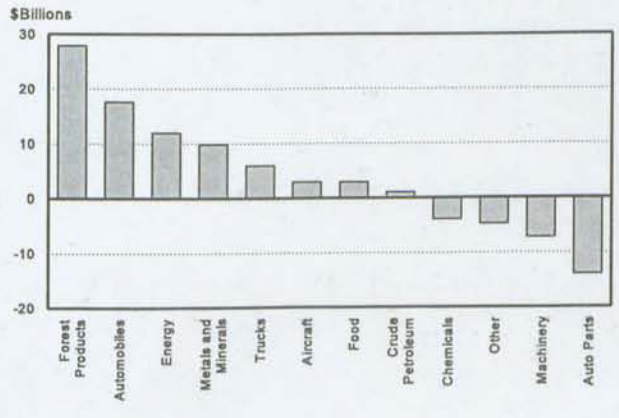
CANADA'S INDUSTRIAL STRENGTHS

Chapter Two emphasizes that wealth is created for a nation only when it sells its products and services outside its own borders. The figure below illustrates the relative strengths of Canada's major industrial sectors in terms of their contribution to the balance of trade; that is, the difference between the dollar value of exports and imports in each sector.

As can be seen, resource industries, led by forest products, are key components of Canada's ability to generate wealth and jobs through trade with the rest of the world. Those sectors usually defined as high technology industries in themselves, for example telecommunications and software, show significantly lower net export earnings. However, in providing products and services to traditional industries, they have played a significant role in helping these sectors maintain their position and move to products of higher value. Today, Canada's resource industries use advanced technology devices, such as sophisticated control systems for heavy machinery; satellite- and laser-based mapping systems (geomatics); and a range of computer-based analytical tools, to keep their products and processes cost-effective and competitive.

New and innovative inputs from science and technology are therefore essential to enable the development and growth of Canada's traditional industries, which will continue to constitute a major proportion of this country's capacity to create wealth and jobs.

Figure II-1 Canadian Merchandise Trade Balance, 1994



Source: Statistics Canada

DEFINITIONS OF R&D

"Research and development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R&D is a term covering three activities: basic research, applied research and experimental development.

> ***Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.*
>
> ***Applied research** is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.*
>
> ***Experimental development** is systematic work, drawing on existing knowledge gained from research and/or practical experience, that is directed to producing new materials, products or devices, or to improve those already produced or installed."* [1]

In the context of the Federal S&T Review, basic research has also been referred to as non-directed[2] or researcher initiated research. **Applied research** corresponds to directed research and **Experimental Development** to the application/dispersion/transfer of knowledge.

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1 Organization for Economic Co-operation and Development. *Frascati Manual*, (Paris: 1994) p. 29.

2 The term "non-directed" does not imply that the research has no specific goal. It does imply that the "direction" of the research is determined by the initiator of the research, and not by an outside influence. Much non-directed research does, in fact, have a clear objective in mind and often a hope for application if the goal is actually achieved.

PRELIMINARY RECOMMENDATIONS OF THE COPYRIGHT SUBCOMMITTEE OF THE INFORMATION HIGHWAY ADVISORY COUNCIL, DECEMBER 1994

Enforcement:

- The federal government should assist in the development and standardization of user-acceptable ways to track use of protected works;
- The federal government should assist in the development and use of 'identifiers' to be included in the distribution of protected works in a digital format to make it easier to trace copyright ownership and unauthorized use of protected materials;
- A joint government/industry public education campaign on copyright and the responsible use of creative works in a digital world should be implemented;
- Government should consider the full range of policy instruments at its disposal to ensure effective copyright protection in order to support the creation of new Canadian works;
- Tampering or bypassing encryption or copyguards of any kind should be made a criminal offense under the Copyright Act.

Clearance of Rights:

- Government should encourage the industry in the creation of administrative systems to streamline the clearance of rights for use of works in a digital medium;
- The subcommittee is not convinced that compulsory licensing need be considered in the commercial marketplace.

SELECTED BIBLIOGRAPHY

This bibliography is not a complete record of all the works consulted. Sources listed are those that have been of particular assistance in the writing of this report. A more extensive bibliography is available from:

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Angus, Douglas, Auer, Ludwig, Cloutier, J. Eden and Albert, Terry. *Sustainable Health Care for Canada: Synthesis Report.* Ottawa: Queen's-University of Ottawa Economic Projects, 1995.

APRO – The Canadian Technology Network. *Overview of Fee-For-Service Industrial R&D and Testing Laboratories in Canada.* Ottawa: Industry, Science and Technology Canada, 1993.

Auditor General of Canada. *Report of the Auditor General of Canada to the House of Commons 1994.* Ottawa: Minister of Supply and Services Canada, 1994.

Baldwin, John. *Strategies for Success.* Ottawa: Industry Canada, 1994.

Baldwin, John and Picot, Garnett. *Employment Generation by Small Producers in the Canadian Manufacturing Sector.* Ottawa: Statistics Canada, 1994.

Battle, Ken and Torjman, Sherri. *Opening the Books on Social Spending.* Ottawa: The Caledon Institute of Social Policy, 1993.

Bernstein, J. and Nadiri, M. "Rates of Return on Physical Capital and R&D Capital Structure of the Production Process: Cross Section and Time-series Evidence," Chapter 11 in Raj, B. (ed.) *Advances in Econometrics and Modelling.* London: Kulwer Academic Publishers, 1989, pp. 169-187.

Bernstein, Jeffrey I. *International R&D Spillovers Between Industries in Canada and the United States.* Ottawa: Industry Canada, 1994.

Brown, George E., Jr. "New Ways of Looking at US Science and Technology," *Physics Today,* September 1993, pp. 31-35.

Canadian Institute for Advanced Research. *Science, Technology, Innovation and Economic Change in Canada.* Toronto: 1994.

Carnegie Commission on Science, Technology and Government. *Enabling the Future: Linking Science and Technology to Societal Goals.* New York: Carnegie Corporation of New York, 1992.

Carrington, John. "R&D Shifts into High Gear," *University of Windsor,* Fall 1993.

Carroll, Barbara and Thorngate, Warren. *Social Sciences and Humanities Research Council: A Case Study in Adjudicated Contests.* Ottawa: 1991.

Carroll, Barbara. *NSERC's Research Grants Adjudications: Analysis and Recommendations for Ensuring Fair, Effective Adjudication Processes.* Ottawa: 1994.

Committee on Science, Engineering and Public Policy. *Science, Technology and the Federal Government: National Goals for a New Era.* Washington D.C.: National Academy Press, 1993.

Congressional Budget Office. *CBO Staff Memorandum: A Review of Edwin Mansfield's Estimate of the Rate of Return from Academic Research and its Relevance to the Federal Budget Process.* Washington D.C.: 1993.

Cyr, J.V. Raymond. *Spending Smarter: Corporate-University Cooperation in Research and Development.* Montreal: Corporate-Higher Education Forum, 1985.

De la Mothe, John and Paquet, Gilles. "Circumstantial Evidence: A Note on Science Policy in Canada," *Science and Public Policy*, Vol. 24, No. 4, August 1994, pp. 261-268.

Department of Finance Canada. *A New Framework for Economic Policy.* Ottawa: Minister of Supply and Services Canada, 1994.

Department of Finance Canada. *Creating a Healthy Fiscal Climate: The Economic and Fiscal Update.* Ottawa: Minister of Supply and Services Canada, 1994.

Department of Finance Canada, The Honourable Paul Martin, P.C., M.P., Minister of Finance. *Budget Plan.* Ottawa: 1995.

Doering, R. and Runnalls, D. "Sustainability: The Key to Competitiveness in the 21st Century," in *Prosperity and Sustainable Development for Canada: Advice to the Prime Minister.* National Round Table on Environment and Economy and Institute for Research on Public Policy, Sustainability and Prosperity Program Working Paper No. 1.

DPA Group, Inc. *Final Report of the Evaluation of the Equipment Grants Program of NSERC.* Ottawa: 1991.

Eco-Research Tri-Council Secretariat. *Eco-Research: A Tri-Council Green Plan Program – Program Description.* Ottawa: 1994.

Eco-Research Tri-Council Secretariat. *Report on the Eco-Research Program Workshop on the Challenges and Opportunities of Cross-Disciplinary Research Programs, January 28-30, 1994.* Ottawa: 1994.

European Commission. *EC-Funded Research and Technological Development.* Luxembourg: Commission of the European Communities, 1994.

Government of Canada. *Networks of Centres of Excellence: Powerful Partnerships.* Ottawa: Minister of Supply and Services Canada, 1992.

Government-University-Industry Research Roundtable. *Perspectives on Financing Academic Research Facilities: A Resource for Policy Formulation.* Washington D.C.: National Academy Press, 1989.

Government-University-Industry Research Roundtable. *Future National Policies Within Industrialized Nations: Report of a Symposium.* Washington: National Academy Press, 1992.

Health Canada. *National Health Expenditures in Canada, 1975-1993.* Ottawa: Minister of Supply and Services Canada, 1994.

Holbrook, J.A.D. "Why Measure Science?" *Science and Public Policy,* October 1992, Vol. 19, No. 5, pp. 262-273.

Howatson, Allan. *Reforming Public Policies for Sustainable Development.* Ottawa: Conference Board of Canada, 1994.

Human Resources Development Canada. *Improving Social Security in Canada: A Discussion Paper.* Ottawa: Minister of Supply and Services Canada, 1994.

Industry Canada. *Building a More Innovative Economy.* Ottawa: Minister of Supply and Services Canada, 1994.

Industry Canada. *The Canadian Information Highway.* Ottawa: Minister of Supply and Services Canada, 1994.

Industry Canada. *Federal Financing of University Research: Options for Funding the Indirect Costs of Federally Funded Research.* Ottawa: 1994.

Industry Commission. *Draft Report: Research and Development.* Government of Australia, 1994.

Industry, Science and Technology Canada. *Industrial Competitiveness: A Sectoral Perspective.* Ottawa: Minister of Supply and Services Canada, 1991.

Information Highway Advisory Council. *Progress Report of the Information Highway Advisory Council: Providing New Dimensions for Learning, Creativity and Entrepreneurship.* Ottawa: Minister of Supply and Services Canada, 1994.

Information Highway Advisory Council. *Access, Affordability and Universal Service on the Canadian Information Highway.* Ottawa: Minister of Supply and Services Canada, 1995.

Information Highway Advisory Council, Copyright Subcommittee. *Preliminary Report on Copyright and the Information Highway.* Ottawa: 1994.

Johnston, Ron. "Designing an Effective Science and Technology Policy Advisory System for the Australian Government," *Science and Public Policy*, April 1993, pp. 87-96.

Kline, Stephen J. and Rosenberg, Nathan. "An Overview of Innovation," in *The Positive Sum Strategy: Harnessing Technology for Economic Growth.* Landau, Ralph and Rosenberg (eds.). Washington D.C.: National Academy Press, 1986, pp. 275-305.

Maioni, Antonia. "Divergent Pasts, Converging Futures? The Politics of Health Care Reform in Canada and the United States," *Canadian-American Public Policy,* Number 18, August 1994.

Manga, Pran. "Health Care in Canada: A Crisis of Affordability or Inefficiency?" *Canadian Business Economics,* Summer 1994, pp. 56-70.

Mansfield, Edwin. "Academic Research and Industrial Innovation," *Research Policy,* No.20, 1991, pp. 1-12.

Martin, B.R. and Irvine, J. "Trends in Government Spending on Academic and Related Research," *Science and Public Policy*, Vol. 19, No. 5, October 1992, pp. 311-319.

Mitchell, Graham R. "Industry's Role in Improving the United States' Economic and Competitive Performance," *Technology In Society,* Vol. 16, No. 4, 1994, pp. 357-371.

Mohnen, P. and Lepine, N. "R&D Spillovers and Payments for Technology: Canadian Evidence," *Structural Change and Economic Dynamics,* Vol. 2, No. 1, 1991, pp. 213-228.

Mustard, J. Fraser, and Frank, John. *The Determinants of Health.* Canadian Institute for Advanced Research Publication No. 5, August 1991.

Mustard, J. Fraser. *Economic Growth, Prosperity and Social Change.* Toronto: Canadian Institute for Advanced Research, 1993.

National Advisory Board on Science and Technology. *Committee on Federal Science and Technology Priorities: Phase II.* Ottawa: 1994.

National Advisory Board on Science and Technology. *National Standards in Education: A Question of Excellence.* Ottawa: 1994.

National Forum of Science and Technology Advisory Councils. *The Halifax Declaration: A Call to Action.* Halifax: 1989.

National Science and Technology Council. *Technology for a Sustainable Future: A Framework for Action.* Washington D.C.: 1994.

Office of Science and Technology. *Realising Our Potential: A Strategy for Science, Engineering and Technology.* London: HMSO, 1993.

Office of Science and Technology Policy. *Science in the National Interest.* Washington D.C.: Executive Office of the President, 1994.

Oregon Progress Board. *Oregon Benchmarks: Standards for Measuring Progress and Government Progress.* Salem: Government of Oregon, 1992.

Organization for Economic Cooperation and Development. *The Changing Role of Government Laboratories.* Paris: OECD, 1989.

Organization for Economic Cooperation and Development. *The Reform of Health Care Systems: A Review of Seventeen OECD Countries.* Health Policy Studies No. 5. Paris: OECD, 1994.

Panel on Information Technology and the Conduct of Research. *Information Technology and the Conduct of Research: The User's View.* Washington, D.C.: National Academy Press, 1989.

Peckham, Michael. "A Scientific Basis for the National Health Service," *Science in Parliament,* Vol. 51, No. 1, February 1994, pp. 10-13.

Picot, G., Baldwin, J. and Dupuy, R. *Have Small Firms Created a Disproportionate Share of New Jobs in Canada? A Reassessment of the Facts.* Ottawa: Statistics Canada, 1994.

Porter, Michael E. *Canada at the Crossroads: The Reality of a New Competitive Environment.* Ottawa: Business Council on National Issues and Minister of Supply and Services Canada, 1991.

Premier's Council on Economic Renewal, Task Force to Review the Ontario Technology Fund in the Context of an Innovation-Based Society. *Ontario 2002.* Toronto: 1993.

Premier's Council on Health, Well-Being and Social Justice. *Health For All Ontarians: A Provincial Dialogue on the Determinants of Health.* Toronto: Queen's Printer for Ontario, 1994.

Premier's Council on Health, Well-Being and Social Justice. *Yours, Mine and Ours: Ontario's Children and Youth, Phase One.* Toronto: Queen's Printer for Ontario, 1994.

President's Council of Advisors on Science and Technology. *Renewing the Promise: Research-Intensive Universities and the Nation.* Washington D.C.: 1992.

Ritchie, C.E., Chairman of the Bank of Nova Scotia. *Putting Canada Back to Work.* Speech to shareholders, Halifax, January 18, 1994.

Roberts, Edward B. "Benchmarking the Strategic Management of Technology," *Research, Technology Management*, January-February, 1995, pp. 44-56.

Roussel, Philip A., Saad, Kamal N., and Erickson, Tamara J. *Third Generation R&D: Managing the Link to Corporate Strategy.* Arthur D. Little, Inc., Harvard Business School Press, 1991.

Royal Commission on Learning. *For the Love of Learning: Report of the Royal Commission on Learning.* Toronto: Queen's Printer for Ontario, 1995.

Royal Society of Canada. *Science and the Public.* Ottawa: 1988.

Royal Society of Canada. *A Study of University Research in Canada: The Issues.* Ottawa: 1989.

Royal Society of Canada. *Realizing the Potential: A Strategy for University Research in Canada.* Ottawa: 1991.

Science Council of Canada. *Reaching for Tomorrow: Science and Technology Policy in Canada 1991.* Ottawa: Minister of Supply and Services Canada, 1992.

Secretariat for Science and Technology Review, Industry Canada. *Resource Book for Science and Technology Consultations, Volumes I and II.* Ottawa: Minister of Supply and Services Canada, 1994.

Senate Special Committee on Science Policy, The Honourable Maurice Lamontagne, P.C. (Chairman). *A Science Policy for Canada Volume 3: A Government Organization for the Seventies.* Ottawa: 1973.

Small Business Working Committee. *Breaking Through Barriers.* Ottawa: Industry Canada, 1994.

Smith, Stuart L. *Report of the Commission of Inquiry on Canadian University Education.* Ottawa: Association of Universities and Colleges of Canada, 1991.

Social Science Federation of Canada. *Data Liberation Initiative: 2nd Draft.* Ottawa: 1994.

Standing Committee on Industry. *Report of the Standing Committee on Industry: Taking Care of Small Business.* Ottawa: Minister of Supply and Services Canada, 1994.

Standing Committee on Industry, Science and Technology, Regional and Northern Development. *Canada Must Compete.* Ottawa: Queen's Printer for Canada, 1990.

Statistics Canada. *Adult Literacy in Canada: Results of a National Study.* Ottawa: Minister of Industry, Science and Technology, 1991.

Statistics Canada Working Group on the Development of Science and Technology Statistics. *An Information System for Science and Technology,* Ottawa: Statistics Canada, 1994.

Study Group on Technicians and Technologists. *Tapping Our Potential: Technicians and Technologists of Tomorrow.* Ottawa: 1993.

Task Force on Challenges in Science, Technology and Related Skills, Prosperity Initiative. *Prosperity Through Innovation.* Ottawa: The Conference Board of Canada, 1992.

Task Force on Federal Policies and Programs for Technology Development. *A Report to the Honourable Edward C. Lumley, Minister of State Science and Technology.* Ottawa: Minister of Supply and Services Canada, 1984.

United Nations Development Programme. *Human Development Report 1994.* New York: Oxford University Press, 1994.

World Economic Forum. *The World Competitiveness Report 1994.* Geneva: 1994.

Written Submissions to the Science and Technology Review (over 350). Ottawa: 1994.

Yoxen, Edward. *Home Care: Competitive Goods and Services for Care in the Community.* London: Centre for Exploitation of Science and Technology, 1992.