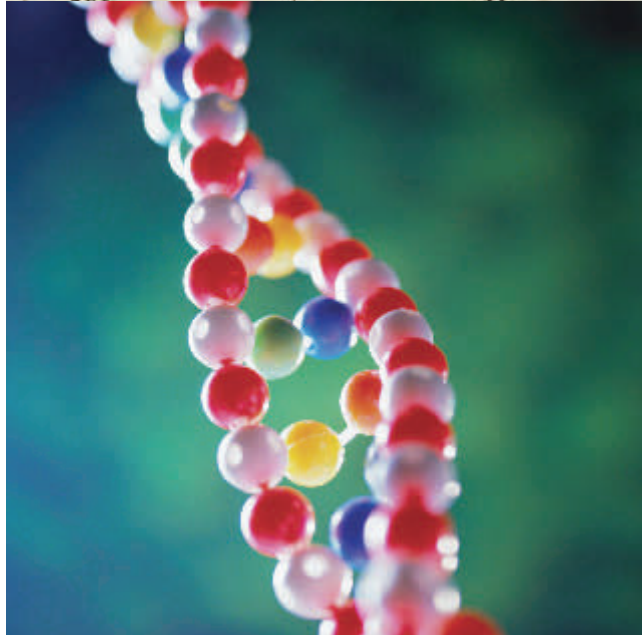


MOVING AT THE SPEED OF DISCOVERY:

FROM BENCH TO BEDSIDE TO BUSINESS



NOVEMBER 2007



ASSOCIATION OF CANADIAN ACADEMIC HEALTHCARE ORGANIZATIONS

WHO WE ARE...

The Association of Canadian Academic Healthcare Organizations (ACAHO) is the national voice of Teaching Hospitals, Academic Regional Health Authorities (RHAs) and their Research Institutes. The Association represents over 45 organizations, with members ranging from single hospitals to multi-site, multi-dimensional regional facilities (also known as "Research Hospitals").

Members of ACAHO are leaders of innovative and transformational organizations who have overall responsibility for the following integrated activities:

- Provision of and timely access to a range of specialized and some primary health care services.
- Provision of all of the principal clinical teaching sites for Canada's health care professionals including partnerships with all 17 Faculties of Medicine and Faculties of Health Sciences.
- Infrastructure to support and conduct health research in its dimensions — medical discovery, knowledge creation, knowledge translation, and innovation and commercialization.

There are no other organizations in the health system that provide the unique combination of health services that our members do. We consider our institutions to be vital "hubs" in the health system — in addition to being a national resource.

OUR MISSION...

The mission of ACAHO is to advance and promote excellence in the delivery of quality health services, the teaching and educational experience, and the health research and innovation enterprise.

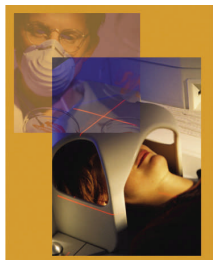
OUR MANDATE...

The mandate of ACAHO is to provide effective national leadership, advocacy, and policy representation in the following three related areas of the:

- Funding, organization, management and delivery of highly specialized tertiary and quaternary, as well as primary health care services.
- Education and training of the next generation of Canada's health care professionals.
- Infrastructure to support and conduct basic and applied health research, medical discovery, innovation and commercialization.

For more information on the activities of the Association, please visit our website at www.acao.org.





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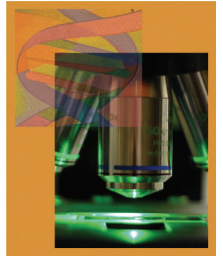


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Over the next few weeks, ACAHO will be releasing two “satellite” reports which will focus on the general themes of world class health research, innovation and commercialization. In particular, the Association will release a review of world-first discoveries and major medical breakthroughs in Canada’s Research Hospitals, and an overview of spin-off companies that have emerged from ACAHO member institutions.

Glenn G. Brimacombe, Chief Executive Officer, ACAHO

Emily C. Gruenwoldt, Senior Advisor, Research & Policy Development, ACAHO

PREFACE

"The empires of the future will be empires of the mind." Sir Winston Churchill, Speech at Harvard University (1943)

In an increasingly interdependent global economy, the creation, dissemination and ownership of knowledge matters. More particularly, where a growing number of countries are competing — and winning — on the basis of new discoveries, speed wins. Understanding these forces suggests that it is to our individual and collective advantage to nurture and support sectors that discover and produce leading-edge innovative products and services that not only benefit Canadians, but the rest of the world.

The mission and mandate of Canada's Teaching Hospitals, Academic Regional Health Authorities (RHAs) and their Research Institutes — also known as "Research Hospitals" — is to provide Canadians with timely access to cutting-edge care, train the next generation of health professionals, and to maintain a strategic focus on the value chain related to health research, innovation and commercialization.

Research Hospitals transfer knowledge in at least three important ways:

1. By giving Canadians access to state-of-the-art information so that they can have a more direct influence on their health status;
2. By driving new evidence into clinical and administrative decision-making processes across the different sectors of the health system; and
3. By discovering, developing and introducing innovative products and services to the marketplace, which contribute to the country's economic prosperity.

In this regard, members of the Association of Canadian Academic Healthcare Organizations (ACAHO) should be considered *engines of innovation*, that contribute to the health and wealth of the country.

We are living in an age where many breakthrough technologies are either under development or in the process of implementation. We are also living in a world where Canadians and funders are demanding increased accountability and transparency in terms of what is being produced in return for our investments in health research.

To better understand the relationship between health research inputs and outputs, ***Moving at the Speed of Discovery*** provides an overview of some of the different ways in which members of ACAHO contribute to and produce a "return-on-investment" for all Canadians — and more largely, the global community.

The document also includes a series of *Calls to Action*, which members of the Association believe need to be carefully considered and addressed if we are to take full advantage of our investments in the country's health research enterprise.

We believe that this report is timely given the country's focus on the future role of science and technology and the public policy discussion concerning the roles of governments, institutions, health charities and the private sector.

Finally, this report is unique in terms of its organization. We are not aware of any other Canadian report that explicitly provides information on the different ways in which health research, innovation and commercialization contribute to the advancement of society. In this context, this report should be viewed as a point of departure, with the understanding that more systematic information will be available in the years to come.





At the end of the day, *we believe that this report can play an important contributing role when it comes to assessing whether we are getting value for money for our investments in health research.* Furthermore, it also asks some penetrating public policy questions about how to move the policy yardsticks forward, in an integrated fashion, to continue to position Canada as a global leader that can take full advantage of the benefits of research and innovation — and share them with the rest of the world.

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EXECUTIVE SUMMARY

In today's fast-paced world, the creation, translation and application of knowledge is the lifeblood of discovery, and the currency of an increasingly information-driven global economy. While the discovery of new knowledge is the forefather of innovation, our future quality of life and overall standard of living depends on our collective ability to harness the many benefits that come from new discoveries.

In a world that is increasingly competitive, inter-connected and rewards speed, it is clear that if Canada is to strengthen its social and economic fabric as well as its international standing – now and well into the future – it must continue to invest in the elements that support and nurture innovation; that is, people, structures, processes and outcomes. Managed within an integrated strategic framework, it is vital that we find ways in which to fully reap the health, social and economic dividends that come from a supportive and dynamic environment that encourages and embraces innovative behavior.

If we as a country do not embrace innovation as a high priority public policy goal, Canada will not be able to attract the great minds and talent needed to discover the ideas that will transform our society from good to great. Any move away from such commitments would result in Canada falling out of step with those countries that place tremendous value on the linkages between creating knowledge and its spin-off effects.

Understanding the relentless competitive pressures that many traditional industries are facing from emerging economies such as Brazil, Russia, India and China, requires that we look to develop and nurture those sectors where Canada has a proven track record and comparative advantage in knowledge. One area that presents a significant opportunity for Canada is the life sciences and biotechnology sectors.

Canada's Teaching Hospitals and Academic Health Regions (also known as "Research Hospitals") – who are the members of the Association of Canadian Academic Healthcare Organizations (ACAHO) – play a critical role in supporting health research, innovation and commercialization in this country. In fact, close to 80% of all publicly funded health research occurs in our members' institutions. In 2006, ACAHO members received a total of over \$3.0 billion in health research funding. Equally important, our members employ more than 20,000 scientists, clinical investigators, other researchers and staff who are involved in health research.

Understanding that the process of innovation is largely about how we *translate and apply* new knowledge, ACAHO has identified three public policy objectives that are mutually reinforcing and complementary in nature. Importantly, these *paths to prosperity* build on the publicly-funded platform of Medicare. They are:

1. Giving individual Canadians access to state-of-the-art information that is both readily available and understandable so that they can have more direct influence on their health status
2. Driving new evidence through the health system so that providers can make cost-effective clinical decisions that improve patient outcomes, and so that administrators and policy makers can apply evidence to improve the overall architecture, functioning and management of the system; and
3. Accelerating the speed at which Canadian-owned leading-edge discoveries are converted into innovative products and services that will compete in an increasingly interdependent and competitive global economy; bringing with it highly skilled jobs, income, wealth creation and a growing public revenue stream.

Combined, and from a public policy perspective, it is about how can we develop and implement a cohesive strategic plan that will maximize our individual and collective *health* and *wealth*. The challenge – which is not insurmountable – is how to do it...

With enhanced accountability, transparency and evaluation being the hallmarks of good governance in health research, ACAHO believes it would be timely to release a report which focuses on the value added role of Canada's Research Hospitals as key drivers of innovation in two fundamental respects:

1. To underscore the critical role that health research has played in identifying leading-edge clinical discoveries, that is "World Firsts" – of which Canada has a legacy to be very proud of, and





2. To review Canada's recent track record through a series of measures (metrics) that largely focus on the economic outputs that come from health research.

Framed this way, this report looks to strengthen the linkages between the organization and funding of the "inputs" of health research with the "outputs" that come from such investments. In seeking to maximize the country's investments in the health research enterprise, the report identifies:

- A framework in which to consider Canada's health research ecosystem;
- "Return-on-Investment" (ROI) in health, social and economic dimensions;
- Over 100 medical "World Firsts" that have occurred in Canada's Research Hospitals;
- Seven benchmarks that measure the performance and outcomes of health research, from 2003 to 2006, including: 4,245 inventions disclosed, 311 patents and 177 provisional patents filed; 411 licenses executed; \$5.5 million in licence income and \$27.0 million in technology transfer revenue; and
- Over 85 Spin-off companies, employing more than 2,000 Canadians, and generating close to \$1.5 Billion in investment capital between 1999 and 2006.

We are not aware of any other Canadian report that explicitly provides information on the different ways in which health research, innovation and commercialization contribute to the advancement of society. In this context, this report should be viewed as a point of departure, with the understanding that more systematic information will be available in the years to come.

The release of ***Moving at the Speed of Discovery*** is also timely given the release of the federal government's science and technology strategy "*Mobilizing Science and Technology to Canada's Advantage*". While the document is an important statement of policy by the federal government – containing close to forty policy announcements – it also identifies a series of policy challenges that need to be addressed if Canada is to truly become an innovative society.

More specifically, the federal government's report is a significant contribution to the public policy discussion about the importance of supporting science and technology in Canada. In this regard, ACAHO members recognize the multiple roles that the government plays in health research – from providing 75 cents of each public dollar invested in health research across the country, to its legislative, regulatory and evaluative roles and responsibilities.

At the same time, however, there remain several important policy issues that need to be more fully considered:

1. How can we develop a more compelling vision and integrated strategic road map for Canada's health research enterprise?
2. How can the federal government work seamlessly with the provinces – who are continuing to invest in health research, in addition to Research Hospitals, health charities and the private sector to advance health research?
3. How can we square the circle between the development of innovative products and services – where the federal government plays such a large role – and their diffusion into the health system – where the provinces play such a large role? It would appear that health expenditures and public and private revenue streams are viewed as two solitudes; much more work needs to be done to better understand the value proposition between innovative goods and products, their impact on the health status of Canadians and the derivative economic effects of investing in innovation in this country.
4. How can we develop the appropriate mix of clinical expertise and business acumen to take research from the bench to the bedside to business? At the same time, what role is there for governments and the private sector to fund early stage research?
5. How can we reach and communicate to the public and decision-makers on a more systematic basis the groundbreaking health research that is taking place in Canada and its many impacts?

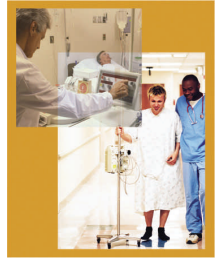
To continue to move the policy yardsticks further, ACAHO has developed **10 Calls to Action**. These Calls to Action are intended to facilitate multi-sectoral dialogue and consensus, focus on improved integration across sectors, promote overall accountability and transparency, and identify concrete results for Canadians.

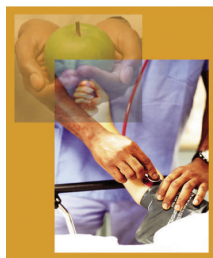
At the end of the day, we need to understand that the process of innovation is a race with no finish line. It is relentless and in perpetual motion. It is also clear that countries that continue to invest significant resources in research and development over the long-term are likely to be the knowledge leaders of tomorrow.

In closing, ACAHO believes that the health research enterprise presents Canada with a unique opportunity to improve the quality of life of Canadians while advancing our standard of living by:

- Creating a nimble and well-educated workforce that can compete on a global scale in attracting talent and resources.
- Developing clusters of knowledge-based industries that support the health sector.
- Providing access to state-of-the-art, world class research infrastructure.
- Ensuring the skills and processes are in place to translate knowledge to Canadians, into the health system, and across the global marketplace.
- Nurturing more effective relationships and programs between the public and private sectors that accelerate technology transfer and commercialization.
- Creating jobs and revenues, owning the factors of production and generating predictable public revenue streams.

What is now required is that we be bold in our vision, focused in our implementation and relentless in our pursuit of excellence. Any country that has not developed integrated systems of innovation that produce “value” – in this case to the health of its citizens, to the health system and to the economy – will have diminished access to the great minds in the global race for talent, and will be relegated to being a country in decline with lower health outcomes, reduced quality of life and a compromised standard of living.





CALLS TO ACTION

Based on the information presented in this first-of-its-kind report, ACAHO has identified a series of ***Calls to Action*** that need to be considered by those who have a direct stake in the future success of Canada's health research enterprise; this includes, federal and provincial governments and their funding agencies, Teaching Hospitals and Academic Regional Health Authorities (RHAs) (and their Research Institutes), Universities, Health Charities and the private sector. Equally, if not more important, is the role of the public, whom we serve and look to enhance their overall health status, quality of life, and contributions to society.

In many ways, the ***Calls to Action*** have been developed with the understanding that the *form* of the country's health research enterprise must follow from its identified *function*. Framed in this manner, ACAHO is of the view that the ***Calls to Action*** must be reflected in any national science and technology strategy.

1. Develop a compelling vision and mission for health research in Canada

It is crucial for Canada to develop a meaningful and compelling vision and mission for the health research enterprise. It is equally crucial that this vision and mission serve as a guidepost or roadmap in developing a more detailed science and technology strategy for the health sector.

2. Develop a national strategic framework for health research in Canada

Following from the development of a vision and mission for health research, it is imperative that a national strategic framework for health research be created. This integrated framework or "ecosystem" — which encompasses the component parts of the health research enterprise — must reflect the "inputs" required to support discovery-based research; the legislative, regulatory and fiscal environment; the technology transfer process; and the process through which we "translate" and convert knowledge into "outputs," such as improved health for Canadians, more cost-effective clinical and administrative decision-making, and greater movement of innovative products and services to the marketplace. It must also be inextricably linked to the policy development process.

3. Develop and communicate more practical methodologies that provide a better understanding of the return-on-investment that come from health research, innovation and commercialization

Given the need for improved accountability and transparency for the manner in which we invest in health research — and the fact that the global landscape for health research is changing in terms of identifying targets and deliverables — we must develop and communicate more practical and user-friendly methodologies that measure the different ways in which health research provides value-for-money; this includes improved health status, the provision of cost-effective health services and the manner in which the system is organized and managed, and an economic return-on-investment.

4. Develop a sustainable, multi-year federal fiscal framework for public investments in health research

To facilitate a more rational policy conversation and planning process that fully leverages our investments in health research across the country, it is vital to develop a sustainable, multi-year federal fiscal framework for health research. In its absence, we continue to run the risk of lurching from year-to-year funding in an environment plagued by uncertainty. This recommendation should be seriously considered in light of the fact that close to 80% of public funding for health research occurs in ACAHO member institutions.

5. Adopt a balanced federal approach to investing in the components that support the health research enterprise in Canada

Given the number of "moving parts" that are integrally involved in supporting health research in Canada and to maximize our collective outputs, it is essential to have an effective structural alignment of federal instruments as well as a balanced approach to investing in highly skilled people, operating grants, infrastructure and indirect costs. At the same time, we need to ensure that we have an appropriate and complementary legislative and regulatory framework (e.g., intellectual property, tax policy) that facilitates innovation in Canada, and accelerates the translation of knowledge.

6. Recognize the full value that Canada's Research Hospitals bring to the health research enterprise

Members of ACAHO — which comprise the overwhelming majority of Canada's Research Hospitals — play a critical role in translating knowledge that comes from health research. Our members have important collaborative relationships and partnerships with governments, Universities and the private sector; however, our members are stand-alone organizations who make strategic contributions to advancing the boundaries of research, knowledge creation and innovation in their own right.

7. Develop a clearer consensus on the relationship between discovery-based and targeted investments health research

While it is understood that new knowledge and innovation can be created in non-linear ways, more clarity is required vis-à-vis the relationship between investments in discovery-based research and those investments that are more targeted in nature (e.g., wait times, public health, mental health). It is important to bear in mind that each form of research has different objectives, and that this should be reflected in our funding priorities.

8. Create additional business acumen capacity to assist in the commercialization of health research

As Canada continues to advance our understanding of the global impact of discoveries that come from the life sciences, we also must ensure that we have the people skills to fully harness the economic benefits that come from new discoveries. While there are established approaches to communicating information to the public, and to clinicians, administrators and policy makers, more must be done when it comes to converting new knowledge into innovative and marketable products and services. We must ask ourselves how we can improve our collective business acumen and implement the “mechanisms” required to successfully commercialize findings from health research.

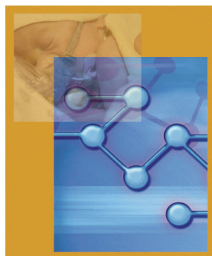
9. Develop an inclusive and ongoing process of consultation that promotes an effective dialogue

While there are ongoing discussions related to Canada's health research enterprise, there is no process that brings together all of the relevant stakeholders to discuss ongoing and emerging issues of importance. Organizations like Research Canada and the Canadian Health Industries Partnership can play vital roles, yet it is important to establish a “meeting place” where all key stakeholders can discuss the future of health research in this country.

10. Develop more robust data instruments that collect comparable health research data

Currently, the publicly available data sets in existence and their respective survey instruments are either incomplete or not as effectively targeted to the health research community as they need to be. In order to more fully understand the breadth of parameters that are involved in the health research enterprise, it is essential to develop relevant and comparable indicators and more rigorous methods of collecting information on a timely and regular basis.





1. THE CHALLENGE BEFORE US

"Science knows no country, because knowledge belongs to humanity, and is the torch which illuminates the world." - As quoted in *Louis Pasteur, Free Lance of Science* (1960)

By the end of the 20th century, the world had witnessed three unprecedented "revolutions" driven by the engine of research, innovation and human ingenuity. The first was the *Industrial Revolution* with the development of industry, the steam engine, internal combustion and flight. The second was the *Information Revolution* with the development of computers and their massive applications. The third — which we are currently in the midst of — is the *Biotechnology Revolution* and its impact on the health and wealth of individuals and their respective communities.

Biotechnology is positioned to have as significant an effect on Canada over the next 15 years as the Internet has had internationally over the previous 15 years.¹ In fact, some have argued that innovations brought about by biotechnology could turn Canada's annual health care trade deficit of approximately \$8 billion into a trade surplus.²

Each wave of innovation has been driven by our innate curiosity of "what if," our desire to improve our collective quality of life, and our ability to think outside the box in terms of "there has to be a better way." Each cycle of discovery driven by research and innovation has allowed the world to take another great leap forward in terms of deepening our understanding of how things work. As a result, this has led to a fundamental reshaping of the world in which we live.

Over time, it is understood that the processes of research and discovery have become increasingly complex. Initially, the care and feeding of great minds was all that was needed, but we now know that many other interlocking elements are required if we are to fully harness the health, social and economic benefits that come from research and innovation — particularly when it comes to the role of science and technology.

In addition to a sound and forward-looking educational system that equips Canadians with the intellectual tools to advance the boundaries of science and exploit emerging technologies, we also require state-of-the-art infrastructure and facilities in which leading-edge research and development take place. Concurrently, we must find ways to attract scientists, retain them and nurture their development so that they can maximize their talents in Canada.

We must also give considerable thought to how we *invest* in and *incentivize* the knowledge discovery process. More clearly, what are the respective roles of the public and private sectors? How can we improve the transfer of new knowledge to Canadians, providers, administrators and policy makers and the market place? Do we have the most effective and efficient legislative, regulatory and tax regimes which are designed to encourage investment, capital formation and discovery, and facilitate the sharing of those benefits in order to improve societal welfare? At the same time, how do we treat the ownership of knowledge and the rewards that go to those who are the discoverers of innovation? Finally, how do we communicate research findings to the public and others, in addition to calculating their impact from a methodological point of view?

While these policy questions are significant and it is (often) difficult to find compatible solutions, they strongly suggest that there is an "ecosystem" of innovation. In other words, there are a number of inter-related policy issues or "moving parts" that must be considered and successfully addressed if Canada is to develop a meaningful long-term national science and technology strategy.

Hence, the challenge that lies before us is how to build an *integrated* value chain that actively supports research, discovery and the innovations that flow from science and technology. There is no doubt that the federal government plays important roles in supporting and nurturing science and technology across the country (e.g., legislator, regulator, performer, funder, user and evaluator). However, there are a number of other important perspectives that must be factored into this equation. This includes the critical roles and perspectives of the private sector and those public sector institutions including Teaching Hospitals, Academic RHAs and their Research Institutes, and Universities and Health Charities that fund, perform, internalize and communicate research findings.

Each wave of innovation has been driven by our innate curiosity of "what if," our desire to improve our collective quality of life, and our ability to think outside the box in terms of "there has to be a better way."

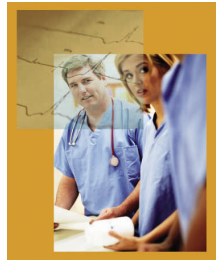
We must also understand that in a world that highly prizes the discovery of new knowledge and its application in the real world, speed wins. Furthermore, if we are to take full advantage of all that science and technology can offer Canada and the rest of the world, it is incumbent upon us to consider how we can accelerate the different processes through which we *translate knowledge and apply that knowledge*.

In the context of health, the Association of Canadian Academic Healthcare Organizations (ACAHO) believes that knowledge translation has at least three objectives:

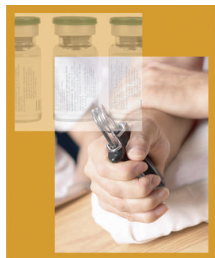
1. Giving individual Canadians access to state-of-the-art information that is both readily available and understandable so they can have more direct influence on their health status;
2. Driving new evidence through the health system so that providers can make cost-effective decisions that improve patient outcomes, and so that administrators and policy makers can apply evidence to improve the overall architecture, functioning and management of the system; and
3. Accelerating the speed at which Canadian-owned leading-edge discoveries are converted into innovative products and services that will compete in an increasingly interdependent and competitive global economy; bringing with it highly skilled jobs, income, wealth creation and a growing public revenue stream.

Importantly, these three public policy objectives need not be viewed as mutually exclusive; rather, they are mutually reinforcing and complementary in nature. These *paths to prosperity* are closely linked and build on the publicly-funded platform of Medicare. Furthermore, each of these objectives is predicated on the value that we, as a society, place on the role of research, medical discovery and knowledge creation.³

In the Association's view, it will be important to consider how embracing the higher order public policy objectives of maximizing our *health and wealth* can be translated into a series of specific science and technology strategies and cohesive policies that will not only continue to improve the quality of life of all Canadians, but contribute to the country's sustained economic prosperity and standard of living.



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apply that
knowledge.***



2. INVESTING IN HEALTH INNOVATION MUST BE OUR FUTURE

"Strength in science and technology is considered to be essential for a modern country's ongoing capacity to innovate and compete in the knowledge-based global economy. The connection between S&T and innovation begins with an innovation — an invention being the practical demonstration of a new idea that may derive from research results, from needs expressed in the market, or from the experience and imagination of individual inventors... There is no linear progression from research through invention to innovations. Instead the process involves false starts, blind alleys and feedback loops, and it includes obstacles that have little to do with the quality of the S&T involved. Above all, it requires talented, highly skilled people with a vision who are also entrepreneurial, energetic and persistent." "The State of Science & Technology in Canada", Council of Canadian Academies (2006)

Over the last century, we have started to discover and develop the tools to begin to unravel life's great mysteries related to health promotion, disease prevention and life expectancy. In many ways, the significant advances of medicine are the result of our ability to extract and apply the knowledge that comes from science and technology. Not only is science and technology the foundation of modern medicine, but it also has a major impact on our quality of life and ability to contribute meaningfully to society in many different ways.⁴

From the perspective of ACAHO members, it is the contribution of health research — applying the tools of science and technology — that has produced some of the most significant discoveries of the 19th and 20th centuries.⁵ These discoveries have manifested themselves in many ways: from basic research that has led to improvements in the health status of individuals and communities; to novel ways in which to deliver a range of cost-effective health services to Canadians in need; to changes in organizing and managing our health delivery system; to discoveries that produce enduring economic benefits — by having a healthy, adaptable and well-trained workforce, to the development of innovative products and services that bring with it jobs, investment, income streams, wealth generation, and a public revenue stream.

At the end of the day, it is to our advantage to create a framework that understands and fully leverages the inter-relationships between our health status, Canada's health system, economic competitiveness, and our future as a nation.

As we enter the third wave of discovery with the beginnings of the biotechnology revolution, we, as a country, must look at how we can sharpen our strategic focus and accelerate the level of investments in health research which contribute to improved socio-economic benefits for Canadians.

The process of care delivery requires many different inputs in addition to maintaining and enhancing our health status. Is this country prepared to simply import the products and services that we need to improve the health of Canadians — with scarce capital flowing out of the country? Or, are we prepared to invest in the people, infrastructure and mechanisms necessary to own the factors of production (i.e., capital, entrepreneurship, land and labour) and capture the economic spin-offs that can accrue from world-class, leading-edge innovations — while improving our quality of life?

This last point carries added weight when one considers the economic opportunities that are before us in terms of the size of the global marketplace for innovative health products and services, which stood at roughly \$1.0 trillion in 2003 and continues to grow. If Canada could increase its market share from its current level of 2% to 3% or 4%, it would attract an additional \$10 to \$20 billion in new revenue. Perhaps more importantly, it would also be a magnet for highly skilled jobs, robust income streams, long-term capital investment, and a significant public revenue stream, while making important inroads on its current trade deficit in the health sector.⁶

From the perspective of ACAHO members, it is the contribution of health research — applying the tools of science and technology — that has produced some of the most significant discoveries of the 19th and 20th centuries.

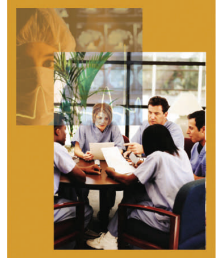
The following quote summarizes the challenges: *"Among the many promising industrial subsectors subsumed within health care are information technology; biotechnology; health care diagnostic, treatment and delivery services; health care management; knowledge/information management systems (including data collection and software development); and imaging systems. These are also leading-edge sectors for employing our high-level human capital and talent, an essential requisite if we wish to become a knowledge-based economy and society. However, there is much more at stake here than merely missing out on a major export platform in the information era: Failure to be in the forefront of these remarkable diagnostic, treatment and service-delivery innovations will mean that we will assuredly fail in our objective to ensure that Canadians will have access to state-of-the-art health care."*⁷

The point that there is much at stake and much potential is underscored in the recent assessment of the state of science and technology in Canada. Stakeholders indicated that the health and related life sciences sector "have the potential to emerge as areas of prominent strength for Canada and generate significant economic and social benefits."⁸ Internationally, Singapore, Stockholm, Austin, Raleigh-Durham, Boston and San Diego are stellar examples of entire economies being built around the health research enterprise. They demonstrate that advanced knowledge-based industries are essential to securing global, long-term economic prosperity.⁹

While many of the country's macro-economic fundamentals *appear* to be sound, there is no guarantee that they will remain so over the medium and longer term in a world that is increasingly driven by innovation. It is particularly important to keep this in mind as other rising economies, such as Brazil, Russia, India, and particularly China are already competitive in some of our well established knowledge-based areas and are placing increasing pressure on our manufacturing sector with cheaper labour and other input costs.¹⁰

This issue is highlighted by The Economist, which states; "...rich nations have already built up big capital stocks. If they are to sustain growth in the years ahead, they must be economic pioneers, pushing out the technological frontier through advances in knowledge"¹¹

In a world characterized by increasing market competition, if we are to continue to grow our economy and improve our quality of life, we must look to those sectors in which Canada has a comparative advantage — which is based less and less on low-skilled input costs and increasingly reliant on the development of a nimble, well-educated workforce that can take full advantage of the creation and ownership of knowledge and the factors of production.¹²



...in the recent assessment of the state of science and technology in Canada Stakeholders indicated that the health and related life sciences sector "have the potential to emerge as areas of prominent strength for Canada and generate significant economic and social benefits.



3. WHERE CANADIANS STAND ON HEALTH RESEARCH

"Polling is merely an instrument for gauging public opinion. When a President (Prime Minister) or any other leader pays attention to poll results, he is, in effect, paying attention to the views of the people." – George H. Gallup (1979)

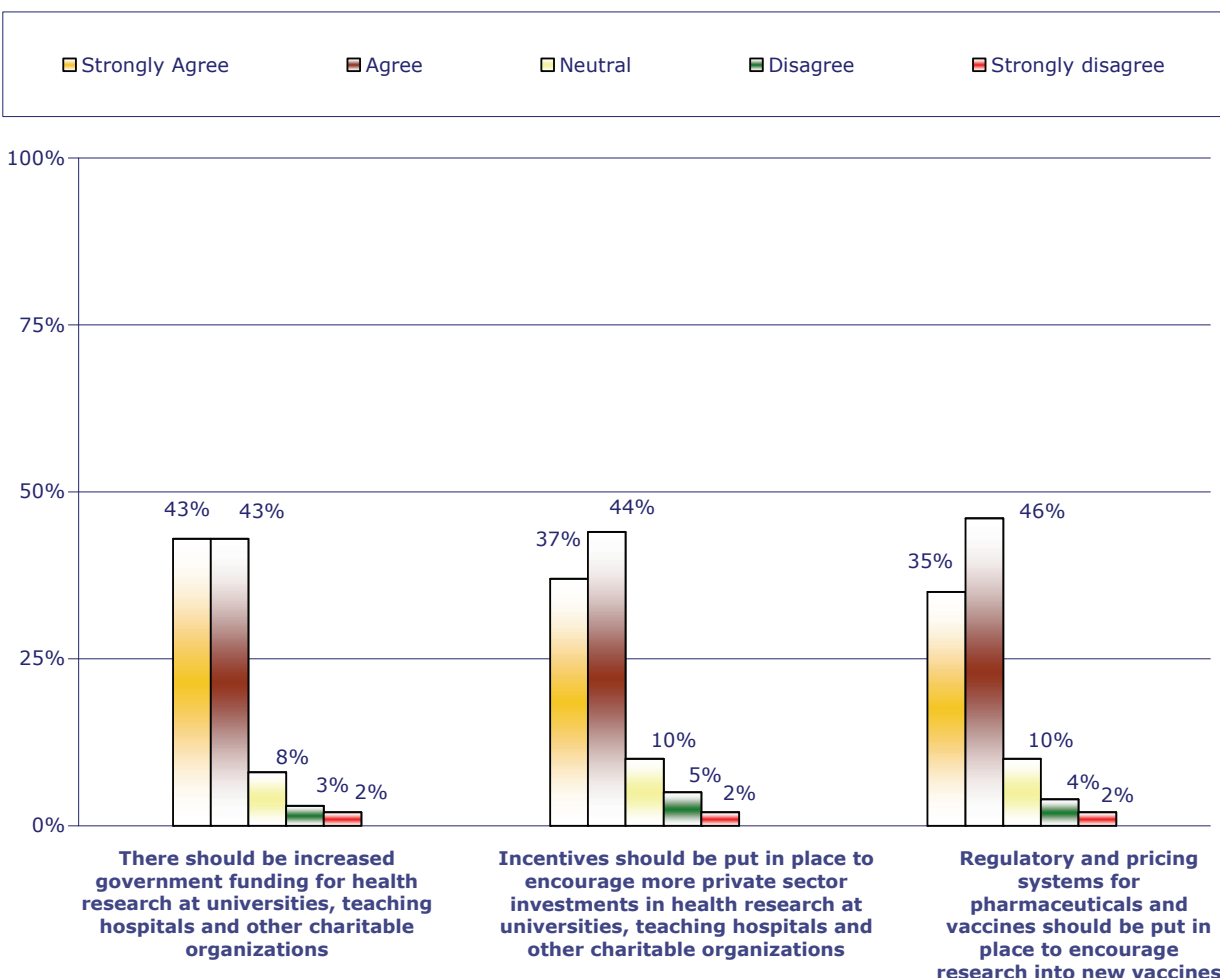
While it is clear where members of ACAHO stand on the need to continue to support health research, less is known about how the public perceives such investments. Generally speaking, the views of the public play an important role in shaping the strategic policy priorities of governments, the health system, and those of the private sector.

Recently, two public opinion surveys were released where Canadians passed judgment on investments in health research. On November 23, 2006, POLLARA released the ninth edition of the Health Care in Canada survey (see Exhibit 1). In that survey, 86% of Canadians agreed that there should be increased government funding for health research at universities, teaching hospitals and other charitable organizations.¹³ This overwhelming support for continued investments was also shared by physicians, pharmacists, nurses and managers.

Exhibit 1

Public Support for Health Research

Q. Health research can include research into treatments, into the best ways to provide care, and into management of the health care system. Would you say that you strongly agree, agree, are neutral, disagree or strongly disagree with each of the following?



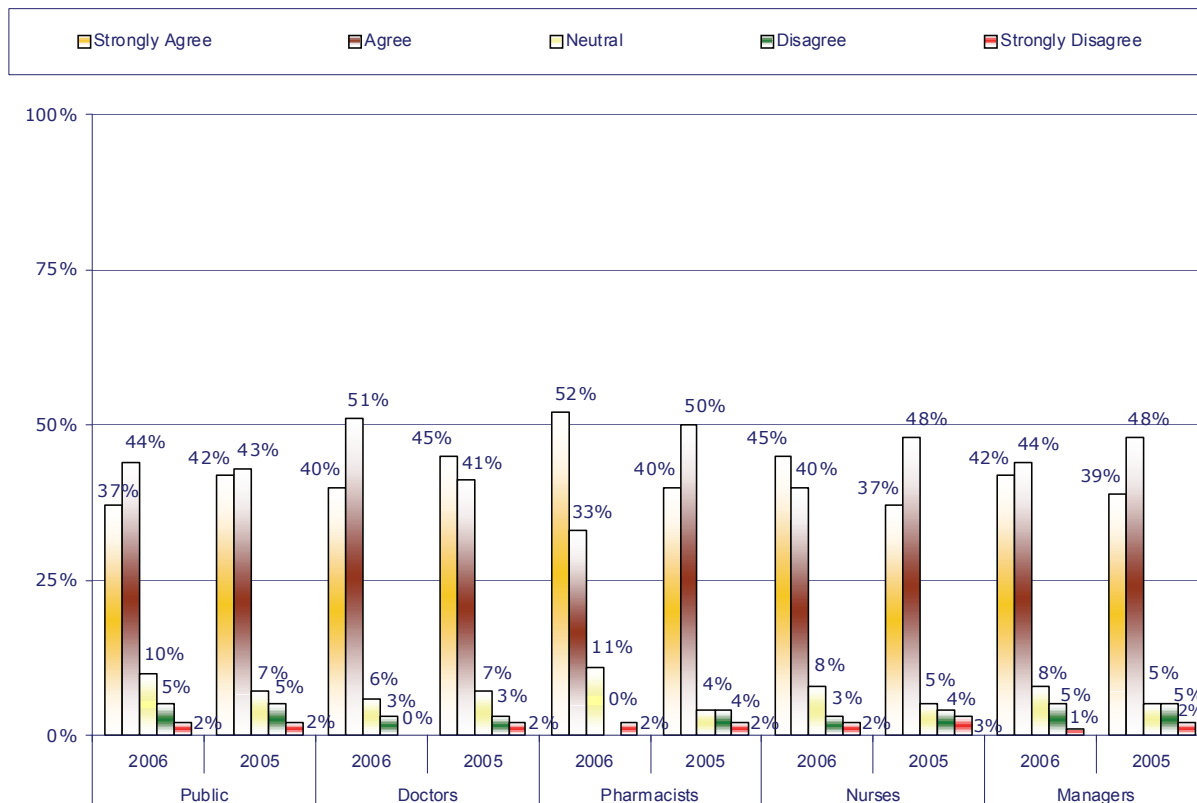
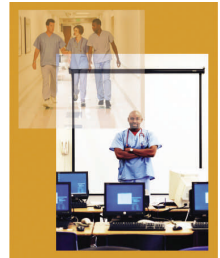
Source: Health Care in Canada Survey, 2006, Pollara.

...86% of Canadians agreed that there should be increased government funding for health research at universities, teaching hospitals and other charitable organizations. This overwhelming support for continued investments was also shared by physicians, pharmacists, nurses and managers.

Exhibit 2

Government Funding for Health Research

Q. Health research can include research into treatments, into the best ways to provide care, and into management of the health care system. Would you say that you strongly agree, agree, are neutral, disagree or strongly disagree with each of the following? ***That incentives should be put in place to encourage more private sector investments in health research at universities, teaching hospitals and other charitable organizations.***



Source: Health Care in Canada Survey, 2006, Pollara.

At the same time, the POLLARA survey also probed Canadians' thinking around the role of the private sector in investing in health research (see Exhibit 2). A full 81% of Canadians were of the view that we need to introduce incentives to encourage additional private sector investments in health research.

The view of Canadians is confirmed by a recent public opinion survey commissioned by Research Canada: An Alliance For Health Discovery where 91% of Canadians see enhanced federal government investments as an important national priority¹⁴ (see Exhibit 3).

The survey also noted that 86% of Canadians believe that Canada should be a global leader in health and medical research, and 80% of Canadians recognize the linkage between health research and economic prosperity.

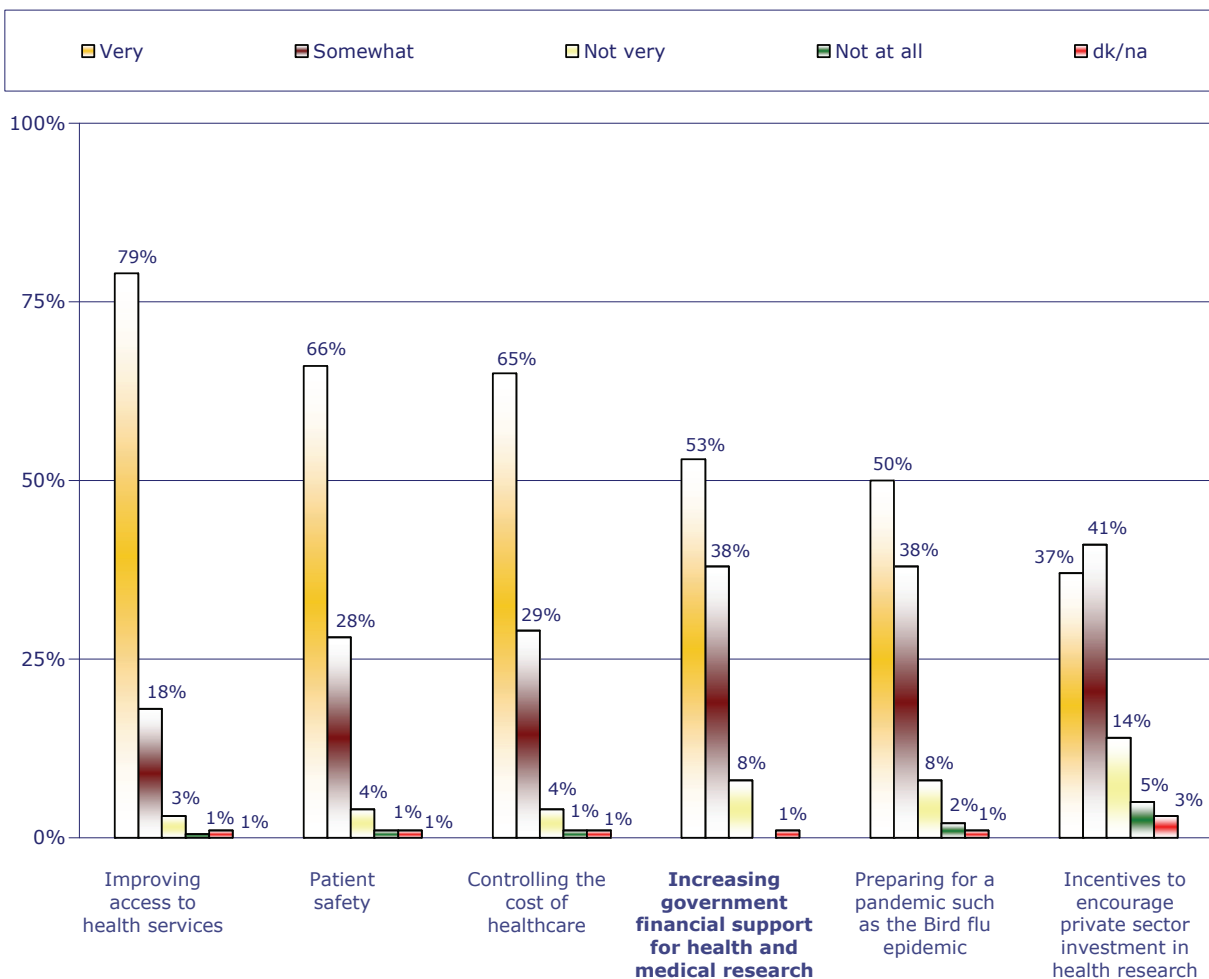
The survey finds that 91% of Canadians want the Federal government to invest in basic research, even if it brings no immediate benefits. At the same time, 87% of Canadians say it is important for both the Federal and Provincial governments to educate and train researchers.

In summary, it would appear that "the public is already there" when it comes to supporting additional investments and incentives in support of health research, innovation and commercialization. Furthermore, they confirm the vital role that governments play in health research. The most important question, however, is how to translate this kind of support into a strategic framework that maximizes what we collectively invest — from both the public and private sectors — in the health research enterprise.

Exhibit 3

Leadership and Priorities

Q. How important would you say each of the following six health-related priorities are in terms of national priorities?



Source: Canada Speaks! 2006
Research Canada: An Alliance For Health Discovery—Environics 2006.

It would appear that "the public is already there" when it comes to supporting additional investments and incentives in support of health research, innovation and commercialization. Furthermore, they confirm the vital role that governments play in health research.

4. LEADERSHIP ROLE OF THE FEDERAL GOVERNMENT

"Men and women make history, and not the other way around. In periods where there is no leadership, society stands still. Progress occurs when courageous, skillful leaders seize the opportunity to change things for the better." – Harry S. Truman, 33rd President of the United States

In a world where managing the rapid pace of change is the rule, and not the exception, Canada has an impressive international record and much to be proud of. However, with the knowledge-based economy increasingly characterized by competition and innovation, and the search for excellence and economic interdependence, we cannot afford to take our current status and quality of life for granted.

Continued investments in research can bring benefits in terms of world-class innovations which drive higher levels of productivity, economic growth and our standard of living.¹⁵ Knowing that Canada's annual productivity growth continues to lag behind other countries, notably the United States, it will be important to find ways in which research continues to drive innovation and our overall level of competitiveness.¹⁶

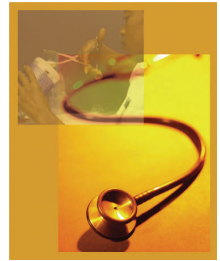
ACAHO's members are focused on: (1) providing quality, specialized health care services, (2) training the next generation of health care professionals, and (3) supporting and conducting the large majority of publicly funded health research. We believe that the federal government can continue to play a significant and complementary role (i.e., a "comparative health innovation policy advantage") in several related areas to improve the health and health care of Canadians, and to continue to position Canada as a global leader when it comes to harnessing the full social and economic dividends that come from supporting research, innovation and commercialization. In fact, the federal government in each of its last two Speeches from The Throne has recognized the critical relationship between innovation and economic development.¹⁷

This view was confirmed by the Kirby Committee: *"The Committee believes that good science is good economics and that the government has a crucial role in maximizing the gains for Canada and its citizens."* The report goes on to say: *"We are convinced that countries with a strong health research network are more capable of translating advances and innovations into cost-effective health services, modern and internationally competitive policy and regulatory frameworks, new or adaptive products, and new health promotion activities. An energetic health research environment contributes to improved health, higher quality of life, and an efficient health care system. This in turn engenders public confidence, a vibrant business environment and a strong economy."*¹⁸

In view of the link between health research and our overall quality of life, it is not surprising that the federal government plays many different roles in supporting science and technology in the context of health research. Of particular importance has been the series of strategic initiatives that have been introduced over the past decade which have had a significant impact on the *capacity* of the country's health research enterprise (see Exhibit 4) as well as on ACAHO members by helping to attract and retain world-class researchers and by advancing the body of scientific knowledge in a number of areas.

It is also important to note that the other two Granting Councils — the National Sciences and Engineering Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC) — also dedicate a portion of their funding to health research activities.

The federal government's investments in the country's health research enterprise have brought important gains, but it is important to remember that up until the mid-1990s, Canada was not regarded as having a dynamic environment that supported health research. Substantial progress has been made, yet we must continue to invest in key elements that support the country's research enterprise if we are to remain internationally competitive, and take full advantage of the multiple benefits that come from health research.¹⁹



... with the knowledge-based economy increasingly characterized by competition and innovation, and the search for excellence and economic interdependence, we cannot afford to take our current status and quality of life for granted.

In view of the link between health research and our overall quality of life, it is not surprising that the federal government plays many different roles in supporting science and technology in the context of health research.



Exhibit 4

OVERVIEW OF SELECT FEDERAL GOVERNMENT INVESTMENTS IN HEALTH RESEARCH

Canadian Institutes of Health Research – As Canada's premiere funding agency for health research, CIHR's budget has increased from \$289 million in 1999–2000 (when it was known as the Medical Research Council of Canada) to \$775.4 million in 2007. CIHR plays a pivotal role in facilitating synergistic and collaborative research within an interdisciplinary model and focuses on four pillars of research (biomedical, clinical, health systems and services, and population and public health).

Canada Foundation for Innovation – Established in 1997, \$3.6 billion was set aside by the federal government to fund leading-edge, world-class research infrastructure. Close to half of all CFI funding has been awarded to build health research infrastructure. Budget 2007 provided an additional \$510 million to CFI.

CFI Research Hospital Fund – In 2004, a \$500 million Research Hospital Fund (RHF) was established under the auspices of CFI to contribute to large-scale, hospital-based research initiatives that take full advantage of state-of-the-art equipment, innovative ways of doing research, and increased research capacity. The RHF is extremely important to the members of ACAHO, and will help address the need for further investment in research hospital infrastructure, especially for new and different space by taking a more integrated and multidisciplinary approach to health research.

Indirect Costs of Federally-Funded Research – Permanently established in 2004 by the federal government, the program is designed to support a portion of the indirect costs of administering and managing world-class (health) research activities funded by the federal government. Current funding stands at \$315 million, as announced in Budget 2007.

Canada Research Chairs – Created in 2000 by the federal government, \$300 million annually is allocated to Universities, Teaching Hospitals, Academic RHAs to support 2,000 research professorships in universities across the country by 2008; This program has helped attract and retain some of the world's most accomplished and promising minds.

Genome Canada – Genome Canada is dedicated to developing and implementing a national strategy in genomics and proteomics research for the benefit of all Canadians. To date, Genome Canada has received \$700 million from the federal government. Almost 60% of the approved projects for funding are in the health sector.

Federal Government Laboratories of Health Canada – Health Canada's Science and Research – A science-based department, Health Canada depends on a strong foundation of science and research to fulfil its legislated mandate and contribute to the health and safety of Canadians. Sound science contributes to risk assessment, risk management and supports evidence-based decision-making within Health Canada.

In 2006-07, Health Canada's overall budget was \$3.01 billion. According to Statistics Canada data for that year, the department spent \$319 million on science and technology (S&T), consisting of \$57 million in research and development (R&D) and \$262 million in related scientific activities (RSA).²⁰ Of the \$319 million spent on S&T, \$293 million were for intramural expenditures (\$51 million on R&D and \$242 million on RSA) and \$26 million for extramural activities. According to the same source (2006-07), the number of personnel within Health Canada engaged in science and technology activities was 2,900, which includes 2,002 scientific and professional personnel.

Networks' Centres of Excellence – Established as a permanent program in 1997, the federal government currently provides \$78 million in annual funding to nurture Networks of Centres of Excellence (NCEs), which are unique partnerships among universities, industry, government and not-for-profit organizations aimed at turning Canadian research and entrepreneurial talent into economic and social benefits for Canadians. Budget 2007 provided an additional \$11 million to NCEs to accelerate the creation of new networks.

Medical and Related Sciences Project (MaRS) – In 2003, the federal government invested \$20 million to support the creation of MaRS, which connects and fosters collaboration among the academic, business and capital Communities. MaRS is having an impact through its catalytic programs and structured networks.

Venture Capital Investments – In the 2004 federal budget, the government invested \$250 million in venture capital via the Business Development Bank of Canada, of which \$100 million was allocated to embryonic technologies such as in the life sciences, biotechnology, and medical technologies.

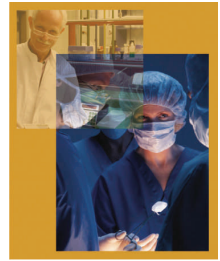
Commercialization Funds Pilot Projects – In the 2004 federal budget, the government allocated \$50 million to develop pilot projects to accelerate the commercialization of University and Research Hospital-based research. Budget 2007 allocated \$350 million to *The Centres of Excellence in Innovation and Research* program. While \$105 million was invested in seven Centres of Excellence, \$165 million will be awarded on a competitive basis.

Industrial Research Assistance Program – Created close to 60 years ago, the Industrial Research Assistance Program (IRAP) of the National Research Council (NRC) provides technical and business assistance to 12,000 small and medium enterprises per year and contributes funds to over 3,300 projects per year. These include a broad range of medical and biotechnology firms, including start-up firms from research hospitals and universities.

Canadian Health Services Research Foundation – Established in 1996, the mission of CHSRF is to support evidence-informed decision-making in the organization, management and delivery of health services by funding research, building capacity and transferring knowledge. CHSRF currently administers approximately \$120 million in total funding, and \$12 to \$14 million annually.

Canadian Partnership Against Cancer – Established in 2006, this not-for-profit organization is designed to serve as a clearinghouse for state-of-the-art information about preventing, diagnosing and treating cancer. It will receive funding of \$250 million over the next five years.

Spinal Cord Injury Translational Research Network – The Network, with an investment of \$30 million over five years, will accelerate the translation of innovative research discoveries into practical benefits for Canadians with spinal cord injuries.



Two reports suggest that concerted action is needed to maintain our ability to compete, particularly in light of the fact that other countries continue to increase their investments in health research.²¹

For example, the United States doubled its National Institutes of Health budget from \$14 billion to \$28 billion. And, as recommended by the American Competitiveness Initiative, the budget of the National Science Foundation will double over the next decade.

Australia is in the process of doubling the budget of its National Health and Medical Research Council. The United Kingdom has more than doubled its science budget in less than a decade, from £1.3 billion to £3.5 billion, and it recently announced that it intends to increase overall funding for research and development from 1.9% of GDP to 2.5% by 2014.

Japan has committed to increasing funding for science and technology by \$32 billion over the next five years, with a particular focus on the life sciences and high-tech sectors. Singapore has invested \$7.5 billion over five years in research & development, which includes a focus on biomedical sciences, and has made a commitment to increase its investment in research and development to 3.0% of GDP by 2010.

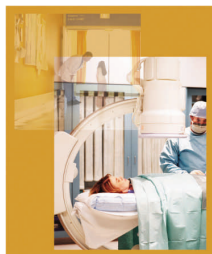
China has committed to increase overall funding in research from 0.9% of GDP to 2.5% by 2020. India increased funding, with a particular focus on biotechnology, nanotechnology and pharmaceuticals, by 16% in 2006.

Based on the most recent information collected by Statistics Canada, 75% of all publicly-funded health research comes from the federal government through a variety of instruments, with the remaining 25% from the provinces.²² As the leader in this area, it is incumbent on the federal government to develop a cohesive national science and technology strategy in relation to the health sector. At the same time, it is essential to recognize that the provinces have taken a number of significant steps in terms of establishing dedicated research organizations that strategically invest in health research, and which complement the initiatives that have occurred at the national level.²³

Furthermore, the importance of this leadership role is reinforced by a recent survey of ACAHO members, where 100% of the Presidents and CEOs indicated that the federal government has either an important or a very important role to play in supporting and nurturing health research in Canada.²⁴

In the Association's view, to continue to move the policy yardsticks forward requires a compelling *vision*, clear *leadership*, strong *stewardship* and collaborative *partnerships*. Given the fact that health research has a significant positive impact on the health and wealth of Canadians, ACAHO firmly believes that the federal government must continue to play a vibrant role in shaping the health research landscape in Canada. As we look to the future, ACAHO members agree that Canada, at a minimum, must strive to have the following fundamentals in place:

...to continue to move the policy yardsticks forward requires a compelling vision, clear leadership, strong stewardship and collaborative partnerships. Given the fact that health research has a strong impact on the health and wealth of Canadians, ACAHO strongly believes that the federal government must continue to play a vibrant role in shaping the health research landscape in Canada.



The reality is that investing in the health and wealth of the country is not an either/or proposition; a balanced and strategic approach to investments in each stream of activity will produce benefits that are greater than their individual contribution.

1. A healthy and well-educated workforce that is nimble and adaptable;
2. A workforce that has the necessary breadth and depth of knowledge and skills to compete and prosper in an increasingly competitive global marketplace; and
3. A commitment to excellence, as demonstrated by strategic investments in processes and structures that will ensure Canada remains at the cutting edge of discovery, knowledge creation, and knowledge dissemination, which in turn will ensure that Canadians bring innovative products and services to international markets.

While there are those who would argue that wealth creation is a precondition to investing in health, others are of the view that without an ongoing commitment to a series of investments in the health of Canadians, there is limited ability to fully harness and leverage our economic performance and potential growth. This is where the *policy intersection* between health research and wealth creation is visible, tangible and substantial.

The reality is that investing in the health and wealth of the country is not an either/or proposition; a balanced and strategic approach to investments in each stream of activity will produce benefits that are greater than their individual contribution.

In this context, if we are to successfully move forward we need a clear and compelling vision of the role of science and technology and its relationship to Canada's health research enterprise. In particular, clarification is needed in a number of critical policy areas:

1. *What are the overarching policy objectives of a science and technology strategy?*
2. *What mix of investments in human capital and physical infrastructure is needed?*
3. *What are the respective roles of the public and private sectors in nurturing research, innovation and commercialization – and how can they be nurtured?*
4. *What legislative and regulatory structures are required?*
5. *What is the most efficient and effective tax regime²⁵ and what is the optimal approach to the protection of intellectual property?*
6. *What metrics will be used to evaluate progress and measure success?*

While many of these issues and challenges are beyond the scope of this report, these are some of the important public policy questions that need to be addressed and resolved. The United Kingdom took an important step forward with the release of *Best Research for Best Health — A New National Health Research Strategy*. The report outlines a vision and mission coupled with a series of strategic goals and objectives to be reached by 2010.²⁶

ACAHO believes that it has a unique perspective and fundamental role to move the national dialogue forward on the future of science and technology in Canada. In this context, Exhibit 5 provides an excerpt of the Association's views, which were recently presented to the House of Commons Standing Committee on Finance.²⁷

The Federal Government Science & Technology Strategy

In May 2007, the federal government released its long-awaited Science and Technology Strategy "*Mobilizing Science and Technology to Canada's Advantage*". As a point of departure, the strategy recognizes that science and technology: (1) improves the overall quality of life and standard of living for Canadians, (2) encourages high-quality, well paying knowledge economy jobs, (3) helps to improve our world through scientific discovery, and (4) contributes to a stronger voice on the world stage.

Building on the government's *Advantage Canada* document released in 2006 and policy announcements contained in Budget 2007, the Science and Technology Strategy focuses on maximizing the country's advantages in four inter-related areas: (1) An Entrepreneurial Advantage, (2) A Knowledge Advantage, (3) A People Advantage, and (4) A Modern Approach to Science & Technology Management.

Of great importance to members of ACAHO, the Strategy also recognizes the health and related life sciences and technologies as one of four strategic areas that will require additional focus and resources from the federal government, and the role of Canada's Research Hospitals.

Through investments in science and technology, Canada's Research Hospitals have made enormous contributions to advancing the health and health care of Canadians. At the same time, members of ACAHO understand the rewards that come from innovation in terms of improved quality of life and sustained economic prosperity – particularly in a global economy that increasingly prizes the creation and ownership of knowledge. As the discussion progresses, ACAHO members look forward to working with the government and our partners to convert this national strategy into a concrete plan of action that is accountable and delivers results for Canadians.

As much as the federal government has a critical leadership role to play in supporting science & technology, it is essential that governments (i.e., federal and provincial) look for opportunities which maximize the alignment of their respective public policy strategies.

In 2006, the province of Québec released its Research and Innovation Strategy "An Innovative, Prosperous Québec".²⁸ As a centrepiece of its economic development strategy, the province commits that by 2010 research spending will reach 3% of GDP – of this amount 1% will be from the public sector and the remaining 2% will come from the private sector. The blueprint also identifies three strategic policy directions: (1) enhance the excellence of public research (2) better support industrial research and innovation in businesses; and (3) round out and strengthen mechanisms to develop and transfer research findings.

To achieve these directions, Québec recognizes that:

1. It must train sufficient numbers of talented researchers and provide them with research facilities of international calibre.
2. Research funding levels in universities and hospital research centers must be competitive.
3. The ability of businesses to innovate must be strengthened.
4. Access to the results of public research must be facilitated, and
5. More research results must be turned to commercial benefit.

As well, the province of Ontario, with the release of its strategic plan for research and innovation in 2006, identified a series of meta-level public policy goals.²⁹



Through investments in science and technology, Canada's Research Hospitals have made enormous contributions to advancing the health and health care of Canadians. At the same time, members of ACAHO understand the rewards that come from innovation in terms of improved quality of life and sustained economic prosperity – particularly in a global economy that increasingly prizes the creation and ownership of knowledge.



A move away from commitments to funding research, innovation and commercialization, would result in Canada falling out of step with those countries that place tremendous value on the linkages between creating knowledge and its spin-off effects, particularly in a global economy that competes on the advancement and translation of knowledge.

Exhibit 5

AN ACAHO PERSPECTIVE ON THE ROLE OF THE FEDERAL GOVERNMENT IN SUPPORTING THE HEALTH RESEARCH ENTERPRISE

"Since, the fruits of research are not borne overnight, it is important to appreciate that a sustained, long-term approach to investing in health research is necessary.

If we are to continue to maximize our health and economic "return-on-investment," we need to ensure that all components of the research equation are funded at appropriate levels. Furthermore, investments in one area should not be viewed as part of a zero-sum game where less funding is subsequently available for other interlocking elements of the research enterprise. What is required is a *balanced* and *strategic* approach to advancing Canada's health innovation agenda.

Given the breadth and depth of health and research investments by the federal government, one might be tempted to say that the time has come to address other important national priorities.

ACAHO maintains that while the "tide has turned" through enhanced investments in Canada's health research enterprise, we must continue to sustain the momentum that we have created so that we can continue to participate in, and derive benefits from, world-class research findings. Understanding that the research and discovery process can take time, we must continue to "till the soil" if we are to fully harvest the fruits of our labour — and remain a world leader.

Knowing that we are on the threshold of a biotechnology revolution, in addition to other advances in health research (e.g., nanotechnology, robotics, population and public health, health services), ACAHO is concerned that any retrenchment in funding the health research enterprise would have serious consequences on our ability to attract and retain world-class researchers — not to mention our ability to advance the process of discovery and innovation. Indeed, we have created an entire biotechnology industry that has spun out of our universities and affiliated teaching hospitals and research institutes. Let's not go backwards.

A move away from commitments to funding research, innovation and commercialization, would result in Canada falling out of step with those countries that place tremendous value on the linkages between creating knowledge and its spin-off effects, particularly in a global economy that competes on the advancement and translation of knowledge.

Importantly, all of the impacts of health research noted above are mutually reinforcing and are built on the publicly funded and administered platform of our health system. This alone presents Canada with a very unique opportunity to continue to harness the multiple benefits that flow from health research and innovation."

5. MEMBERS OF ACAHO — “ENGINES” OF HEALTH INNOVATION

“Members of ACAHO should be considered engines of innovation that contribute to the health and wealth of the country in at least three ways: (1) by giving Canadians access to state-of-the-art information so that they can have a more direct influence on their health status; (2) by driving new evidence into clinical and administrative decision-making processes; and (3) by discovering, developing and introducing innovative products and services to the marketplace which contribute to the country’s economic prosperity.” – Dr. Denis-Richard Roy, President, ACAHO (2007)

ACAHO is the national voice of Teaching Hospitals, Academic RHAs and their Research Institutes — also known as “Research Hospitals” (see Appendices A and B for a complete list of members, and the Vice-Presidents of Health Research). The Association represents over 45 organizations that range from single hospitals to multi-site, multi-dimensional regional facilities. Our members serve a unique and essential role in the health care system (see Exhibit 6):

Exhibit 6

ACAHO FACTS AND FIGURES

Research and Innovation

- In 2006, ACAHO member institutions and their Research Institutes received over \$3.0 billion in total research funding.
- Close to 80% of all public funding for health research in Canada is invested in ACAHO member institutions.
- Canada’s expanding biotechnology industry has been bolstered as a result of the research conducted in ACAHO member Teaching Hospitals, Research Institutes as well as within Universities.
- ACAHO members support more than 20,000 scientists, clinical investigators, other researchers and staff who are involved in health research.
- Over 100 world’s first discoveries and major medical breakthroughs have occurred in ACAHO member institutions including new surgical techniques such as the world’s first heart valve replacement and (double) lung transplant. As well, the genes that cause disease (muscular dystrophy, cystic fibrosis, Crohn’s) and the potential impact of stem cell therapies were discovered in ACAHO member institutions.

Training and Education

- The large majority of the advanced education of new scientists and clinicians originates from scientists within ACAHO member institutions.
- ACAHO member institutions serve as the primary location for educating and training a broad range of health care professionals (e.g., physicians, nurses, pharmacists, dentists, physiotherapists and medical technicians).
- ACAHO member institutions are the only facilities in Canada that offer training in sub-speciality areas (e.g., neonatal intensive care, neurotrauma, paediatric cardiology, transplants).
- Each year, nearly 10,000 medical students are trained in ACAHO member institutions.
- In Ontario, it is estimated that over 90% of Residents and 99% of Fellows are trained in ACAHO members’ institutions.

Health System Delivery

- Teaching Hospitals represent 8% of all hospitals in Canada, however, they account for 70% of all hospital in-patient days.
- In 2006, ACAHO member institutions received \$19 billion or 43% of all public hospital funding in Canada.
- The majority of PET Scanners (83%), Lithotripter machines³⁰ (71%), and MRI machines (58%) are located in ACAHO member Institutions.
- ACAHO members support a workforce totaling more than 200,000 Canadian health providers and other staff who are dedicated to providing a range of health services.



In many respects, the “deliverables” that flow from our members’ mission and mandate are some of the foundational elements that underpin our collective ability to strengthen the fabric of Canadian life and build a truly modern and prosperous 21st century economy.



Canada's expanding biotechnology industry has been bolstered as a result of the research conducted in ACAHO member Teaching Hospitals, Research Institutes as well as within Universities.

Combined, there are no other organizations in the health system that provide this unique range of health services, teaching and education and research and innovation. ACAHO members are a national resource and act as vital "hubs" within the system.

In many respects, the "deliverables" that flow from our members' mission and mandate are some of the foundational elements that underpin our collective ability to strengthen the fabric of Canadian life and build a truly modern and prosperous 21st century economy.

Given our unique set of responsibilities, members of ACAHO strongly believe that we have a critical role to play in improving the linkages between improved health and health care for all Canadians and the country's ability to prosper on a sustained basis. In other words, members of ACAHO have an essential contribution to make when it comes to advancing the *health and wealth* of the nation, from coast to coast to coast.

6. RESEARCH HOSPITAL - UNIVERSITY RELATIONSHIPS

"Academic Health Sciences Centres (AHSCs) consist of a teaching hospital, a university faculty of medicine and other health-related research and health care institutes. Because these centres are responsible for not only patient care but also teaching and research, they are much more complex than community hospitals." – From the Standing Senate Committee on Social Affairs, Science and Technology (2002)

Generally speaking, when we think of support for (publicly-funded) research, it is largely portrayed in the context of university-based research. More specifically, the common view that research takes place wholly within the confines of the university.³¹

While for many disciplines this is the case, it is important to understand that the overwhelming proportion of *health* research in Canada occurs in Teaching Hospitals, Academic RHAs and their Research Institutes, which operate in partnership with the Universities. In specific terms, close to 80% of all publicly-funded health research in the country takes place in ACAHO member institutions.³² It is also important to note that both sectors work in close collaboration with their respective provincial governments.

Given the availability of public information that captures health research funding, more work is required by data gathering institutions – such as Statistics Canada – that do not have the ability to effectively capture order-of-magnitude investments between Research Hospitals and Universities.

This is raised so that the reader appreciates two important points. First, Teaching Hospitals, Academic RHAs and their Research Institutes are stand-alone organizations that set their own strategic priorities in terms of supporting and nurturing health research. A direct corollary of this is that these institutions directly incur the substantive expenses of supporting the infrastructure and indirect costs that supports this research. Second, there are many important collaborative relationships and partnerships between ACAHO members and Universities that support research in this country. For example, a significant proportion of health research is undertaken by investigators from the Faculty of Medicine, housed and supported by ACAHO Member organizations.

Thus, as important as universities are to the creation and dissemination of knowledge that flows from research, members of ACAHO occupy a vital leadership role with these partners when it comes to conducting and directing Canada's *health* research enterprise.

Considering the large proportion of health research that is conducted as a proportion of university-based research funding, it is essential that members of ACAHO continue to have a distinct voice when discussing the future of research, innovation and commercialization in the context of developing a national science and technology strategy.



Thus, as important as universities are to the creation and dissemination of knowledge that flows from research, members of ACAHO occupy a vital leadership role when it comes to conducting and directing Canada's health research enterprise.



7. CANADA'S HEALTH RESEARCH AND INNOVATION VALUE CHAIN

"Innovation is a process through which economic or social value is extracted from knowledge—through the creation, diffusion and transformation of knowledge — to produce new or significantly improved products or processes that are put to use by society." The Conference Board of Canada, How Canada Performs (2007)

As set out in Section 4, it is essential to understand that there are a number of "moving parts" that need to be functioning at an optimal level if we are to fully harness the benefits that come from our investments in Canada's health research enterprise.

In more specific terms, it can be argued that there is a "health research ecosystem" that involves a number of different and complementary areas and programs, which cut across both the public and private sectors in different ways. The fundamental issue is that it is the interaction of these parts and how they are resourced *as a system*. For example, it would be sub-optimal to invest research funding solely into salary support, with no resources for the actual experiments to be performed. Similarly, it would not be effective policy to dedicate all funding to infrastructure or to programs. At the end of the day, there has to be an appropriate strategic balance in the allocation of health research dollars.

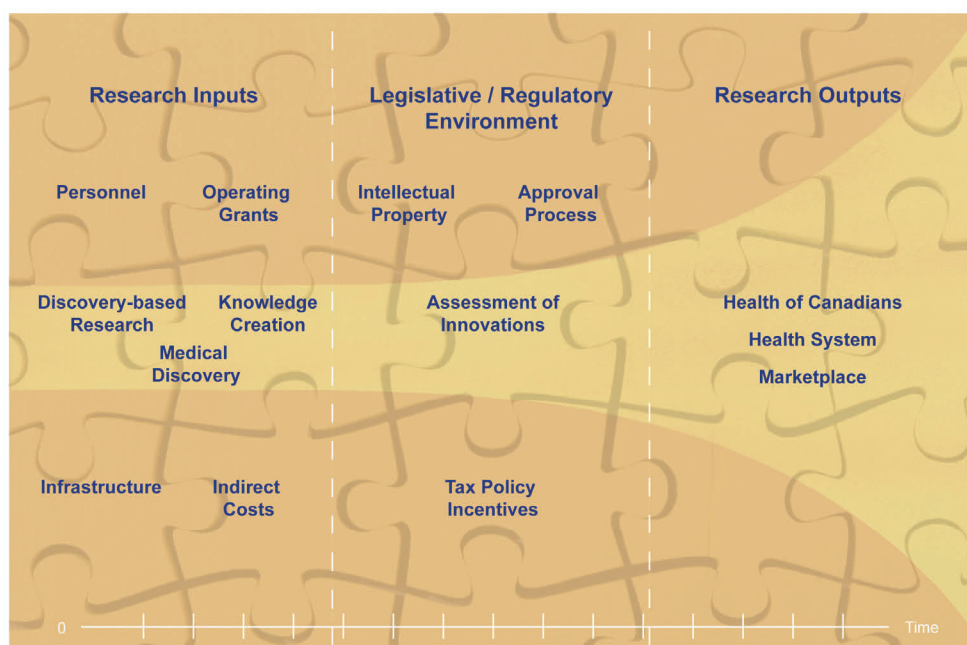
Based on Exhibit 7, ACAHO views the health research enterprise existing across a seamless continuum, and as research moves from its infancy to a mature product or service, there are a number of pieces of the innovation puzzle that must be aligned or in sync.

Specifically, a series of research inputs are required (i.e., personnel, operating grants and infrastructure) to support discovery-based research. Flexible and supportive legislative, regulatory and tax policy regimes are important features that facilitate the accumulation of knowledge and its translation to Canadians, providers and administrators, and the development of goods and services to the marketplace.

It is essential to understand that there are a number of "moving parts" that need to be functioning at an optimal level if we are to fully harness the benefits that come from our investments in Canada's health research enterprise.

Exhibit 7

Canada's Health Research "Ecosystem"

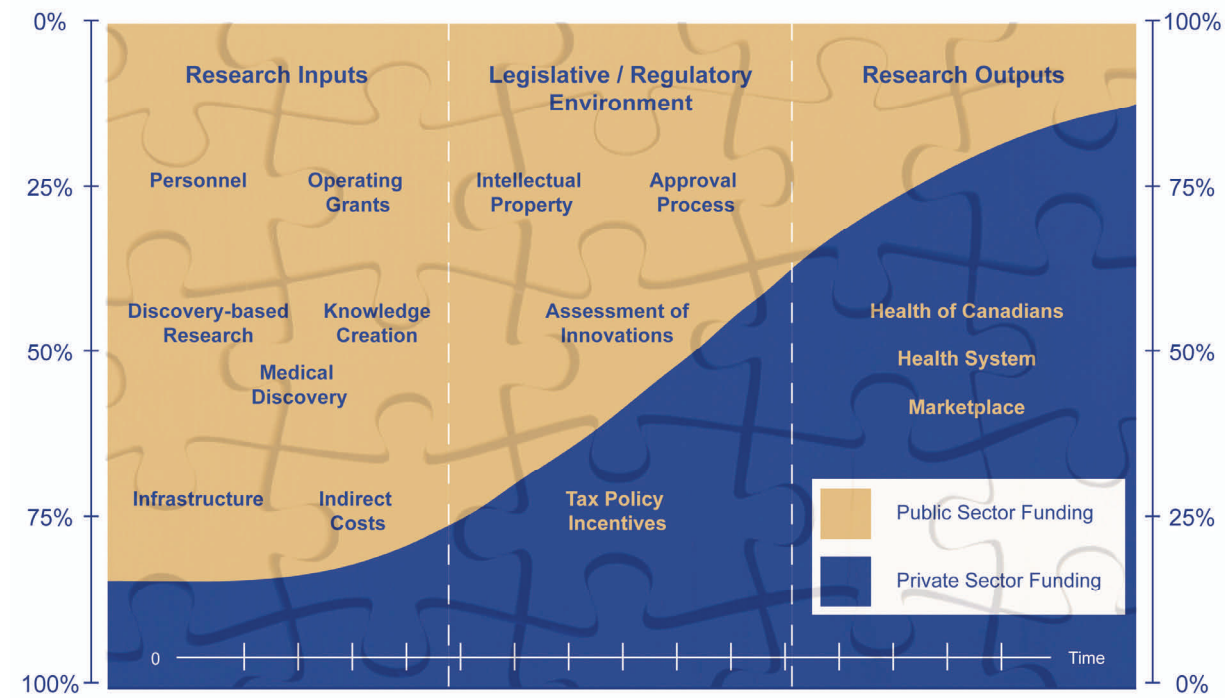


Source: ACAHO

In addition to the overall structure of the health research ecosystem, it is important to acknowledge that the relative roles of the public and private sectors are different depending on the stage of research – which are illustrated in Exhibit 8. Early stage, discovery-based research is almost exclusively funded by the public sector, while almost all end-stage research focused on developing and/or bringing a product or service to the marketplace is funded by the private sector.

Exhibit 8

The Relative Roles of the Public and Private Sectors Funding Health Research

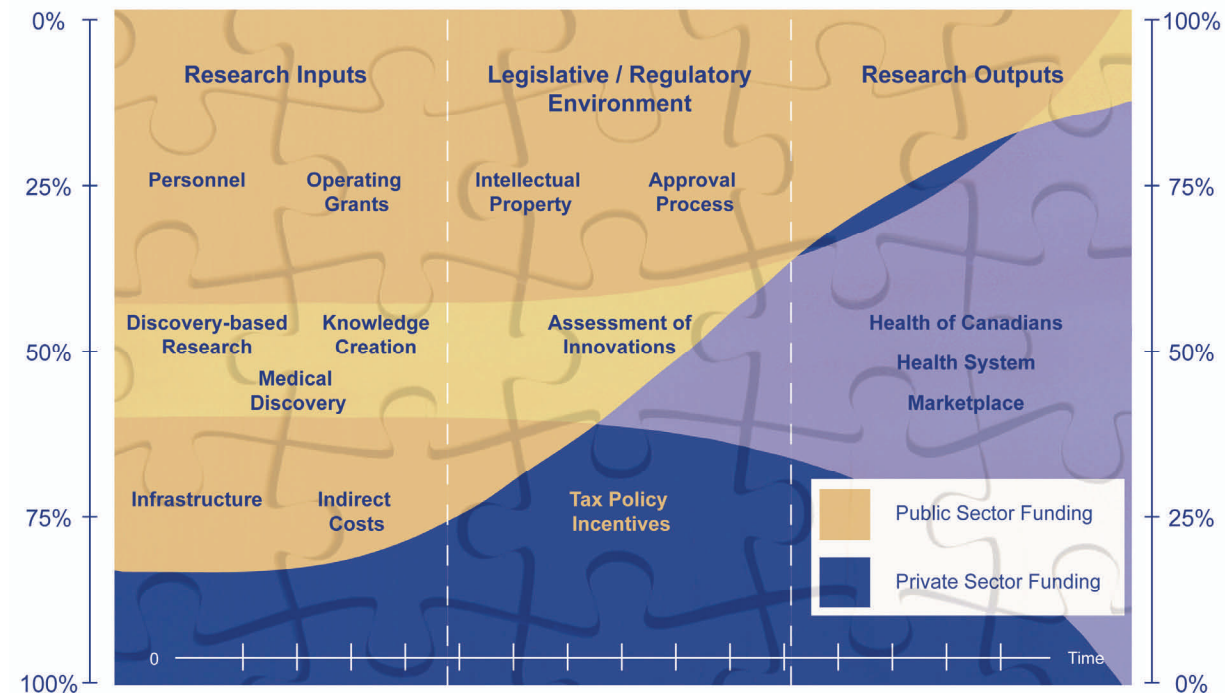


Source: ACAHO

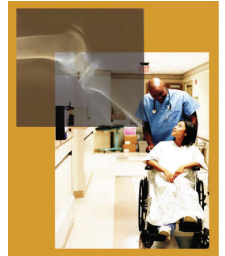
Combining structure with funding, Exhibit 9 presents the mix of relationships that contribute to the health research value chain.

Exhibit 9

The Structure and Funding of Canada's Health Research Ecosystem



Source: ACAHO



Early stage, discovery-based research is almost exclusively funded by the public sector, while almost all end-stage research focused on developing and/or bringing a product or service to the marketplace is funded by the private sector.



As we move forward, it will be important for Canada to maintain a balanced approach to funding health research that will maximize our use of infrastructure and the knowledge and expertise that comes from our research community.

The Association believes that there are four prerequisites for sustaining the early stages of the health research enterprise to take full advantage of the knowledge that is discovered and subsequently translated:

1. **Development, Recruitment and Retention of Scientists** – The development, recruitment and retention of health researchers is a key to our future success. This requires that we carefully consider our training requirements and the programs (e.g., Canada Research Chairs) that develop, retain and attract world-class researchers so that Canada — and the global community — will benefit from their expertise and potential.³³
2. **Operating Grants** – We need to ensure that our granting agencies (e.g., Canadian Institutes of Health Research, Genome Canada) are funded at internationally competitive levels so that we can continue to support research excellence and a growing number of cutting-edge health research projects.
3. **Indirect Costs** – Support for the ongoing costs that are associated with health research, such as through the federal government's Indirect Cost Program, is a critical link in continuing to develop the country's capacity for health research.
4. **Infrastructure** – Appreciating the increasing complexity of infrastructure and technologies that are required to support leading-edge research, such as through the Canada Foundation for Innovation, it is critical that we continue to invest in developing world-class research facilities.

ACAO would like to recognize and applaud the ongoing and substantial commitment that has been made by the federal government since 1997 in these areas through a series of interlocking policy measures. The combination of investments in each of these four areas have served to accelerate the country's advancements in health research.

Clearly, investments in research infrastructure via the Canada Foundation for Innovation and personnel programs, such as the Canada Research Chairs, have revitalized the health research enterprise in this country. At the same time, however, these programs have created new research capacity which has translated into additional demands being placed on the current funding resources of the Canadian Institutes of Health Research, which is the major source of operating funds for health researchers. As we move forward, it will be important for Canada to maintain a balanced approach to funding health research that will maximize our use of infrastructure and the knowledge and expertise that comes from our research community.³⁴

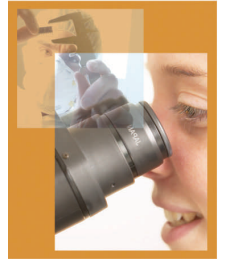
More specifically, public investments in health research focus on a value chain of "inputs," which produce a number of "outputs" in terms of medical discovery, knowledge creation and translation, innovation, and the process of successful commercialization in Canada. *"Investment in public science supports a successful innovation system by providing knowledge assets, infrastructure and trained people that help organizations, whether public or private, seize opportunities... The Government therefore funds this type of research, particularly the more fundamental, long-term research that is unlikely to have immediate application but has the potential for greatest spillover benefit."*³⁵

At the same time, we must also be sensitive to the *environment* in which health research, innovation and commercialization take place. This includes important legislative and regulatory issues such as how we protect intellectual property and the speed at which we assess and approve new products. It also includes the kind of tax regime and incentives that are in place to encourage capital formation and job creation in Canada, which is important when considering the increasingly important role of the private sector in bringing innovative products and services to the marketplace as illustrated in Exhibit 8.

Finally, and most critically, it also involves how we transfer knowledge; be it directly to Canadians, applying new evidence in the process of clinical decision-making and management of the health system, or introducing new products and services into the Canadian economy and global marketplace.³⁶

As we look to develop a compelling vision for health research, it is becoming increasingly evident that we must continue to look at how all of the pieces that are involved in the health research value chain come together. More concretely, we need to develop a holistic framework that reflects the health research ecosystem and its necessary components, and the changing roles of the public and private sectors as one moves along the value chain.

While some constituencies (e.g., Teaching Hospitals, Academic RHAs and their Research Institutes; universities; federal and provincial governments; the private sector, and health charities) will place a different emphasis on separate components of the processes related to research-innovation-commercialization, it is to our collective detriment if we consider these complementary policy areas in an à la carte fashion. We must look for policy solutions which encourage the whole of the health research ecosystem to be greater than the sum of its individual parts.



As we look to develop a compelling vision for health research, it is becoming increasingly evident that we must continue to look at how all of the pieces that are involved in the health research value chain come together.



8. A THREE-DIMENSIONAL APPROACH TO RETURN-ON-INVESTMENT (ROI)

"The health and healthcare sector should be viewed not as a cost to be endured, but as an opportunity to be explored, embracing a vision for Canada to create the most innovative, high quality healthcare system committed to continuous quality improvement... It should be the prime and prized example of innovation around the world. Implementing the vision of the health sector as an engine of economic growth will contribute greatly to a sustainable healthcare system." – Dr. Henry Friesen, Roundtable on Canada's Knowledge Economy, New Models for Health Innovation (2002)

Health research is the *oxygen* of an evidence-based health system. It is the basis on which many sound public policy decisions are based. It is the backbone of a health system upon which cost-effective clinical and/or administrative decisions are taken.

As noted earlier in the report, research is the foundational building block that facilitates innovation in at least the following three dimensions: (1) It contributes to improving the individual and collective health status of Canadians; (2) It impacts on the architecture of the health system and the manner in which we deliver a range of cost-effective health services; and (3) It produces leading-edge, world-class discoveries that provide opportunities to leverage major economic benefit as well as health gains.³⁷

The spirit of these three dimensions was recognized in the text of the 2004 First Ministers' Agreement: "A strong, modern health care system is a cornerstone of a healthy economy. Investments in health system innovation through science, technology and research help to strengthen health care as well as our competitiveness and productivity. Investments in science, technology and research are necessary to develop new, more cost-effective approaches and to facilitate and accelerate the adoption and evaluation of new models of health protection and chronic disease management. Recognizing the progress that has been made, the federal government commits to continued investments to sustain activities in support of health innovation."³⁸

Although there is a growing appreciation of the different ways in which health research contributes to the advancement of Canadian society, there is also an accelerated public discussion about the level of accountability for our investments in research, and a heightened focus on what we are getting for these investments. In other words, what is the return-on-investment that comes from the significant allocation of public and private funds to support the health research enterprise in Canada?

While it is critically important to ensure that we, collectively, are getting value for our investments in health research, the policy question itself is often difficult to answer given the different ways in which health research produces individual and societal returns. ACAHO, in appreciating the dimensions of health research that have been outlined above, would segment the notion of return-on-investment (ROI) into three categories:

Health and Social Dividends – How does health research affect the broader determinants of health (such as physical activity, better eating habits, cleaner air, safer roads, water supply, alternative energy sources) and improve the individual and collective health status of Canadians?

Health System Dividends – How does health research improve the manner in which the health system is organized, managed and is able to deliver a range of cost-effective health services to Canadians in need?

Economic Dividends – What are the direct and indirect economic benefits that flow from investments in health research and how do they contribute to the country's sustained economic prosperity?

Without question, each dividend has a series of potentially important, yet distinctive benefits that accrue to Canadians, both at the individual and collective levels. Given the breadth of variables at play in each category, there is no single metric or uniform methodology that allows us to measure these benefits. As a result, we need to consider a range of different metrics to better understand the linkages between research inputs and their outputs. Furthermore, it is important to realize that the return-on-investment (especially for basic research) can take years or decades to reach fruition.

Investments in science, technology and research are necessary to develop new, more cost-effective approaches and to facilitate and accelerate the adoption and evaluation of new models of health protection and chronic disease management.

9. MEASURING OUR ROI

"Return-on-investment (ROI) measures the value of benefits that flow from a program of investment. In the case of health research, measuring ROI presents special challenges. Research achievements are both cumulative and synergistic. Often it is difficult to foresee the future payoff from health research investments, yet some of the greatest discoveries have been made as the result of curiosity-driven research in areas of basic science...These facts argue for a broad approach to the measurement of ROI in health research." – Canadian Institutes of Health Research, Return-on-Investment Project (2005)

Understanding that there are different ways to measure and calculate the advancements that flow from investments in health research, the Council of Academic Hospitals of Ontario has developed an overarching framework that categorizes the spectrum of returns-on-investment (see Exhibit 10).³⁹ In fact, given the breadth of "returns" that are outlined — and are not considered (primarily) financial in nature — one can make the argument that we should be considering the broader notion of "returns-on-innovation."

Exhibit 10

THE SPECTRUM OF RETURNS-ON-INVESTMENT FROM HEALTH RESEARCH

1. Contribution and Generation of New Knowledge, and the Creation of New Scientific Information

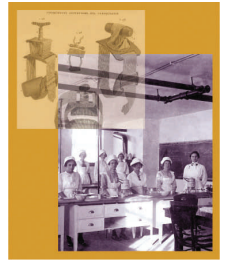
- Basic research findings generate new knowledge that is used by the research community to build on its own research and formulate and confirm new hypotheses of scientific interactions (e.g., mapping the human genome, stem cell therapies, AIDS/HIV research). Over time, a number of these basic discoveries are translated into clinical discoveries including new medications, new technology and new ways of delivering health care.

2. Increasing Research Capacity, Future Research and Innovation Activities

- These activities foster the development of new scientific networks that stimulate interaction and exchange of ideas (Martin, Salter [1996, 2001], Buxton [1999]), such as the creation of the Stem Cell Network in Canada. This is an example of a scientific approach that will take some time before it develops novel therapies that can have a broad impact on health. This form of research may not be successful, however, if it is, it could lead to a new line of therapies with revolutionary implications for the way we treat cardiovascular diseases, neurological diseases, diabetes, etc.
- Government-funded health research grants stimulate additional partnered investment via their cost-sharing formulae. Investments leverage additional public and private investments and innovations (Autant-Bernard, 2001).
- Future research activities can be more precisely defined and targeted, both in scope and methods.
- Enhances our ability to utilize or capture existing research.
- There are important educational benefits through the ongoing training of staff and/or students.
- Industry gains access to unique facilities and researchers (Rappert, Webster, 1999).

3. Policy Making and Managerial Benefits

- Better (clinical, population health, health services, administrative) information is available for decision-making and the capacity for problem-solving is expanded (Martin, Salter [1996, 2001], Buxton [1999]) (e.g., improved chronic disease management).
- Innovations lead to improved and more cost-effective service delivery (e.g., clinical decision rules, such as the Ottawa Ankle and CT Rules).
- Research successes generate momentum towards specific (health and/or policy) outcomes.





...in a world that is driven by enhanced accountability and value for investment in health research, we must look at new ways in which to tell the compelling stories related to the multiple benefits that flow from investing through the different stages of health research.

Broad-based measurement of ROI from publicly-funded health research has landed at rates of return of at least 25% per year.

4. Health Status and Health Care Benefits

- Research can contribute to extended life expectancy and quality of life, as well as reductions in the incidence of disease.
- The development and introduction of new techniques, therapies and technologies can treat and prevent disease (e.g., minimally invasive microsurgery, imaging techniques, new drugs).
- Research can lead to improvements in the quality of service delivery.
- Research contributes to improved equity, accessibility and allocation of scarce resources and health services.

5. Commercial and Economic Benefits

- Successful commercial exploitation of research (i.e. intellectual property rights/licensing) can create highly skilled jobs as well as generates a growing revenue stream.
- Commercialization can increase (private and public sector) investment related to the source of research activity.
- New products can stimulate technology transfer to established firms and the creation and new start-up/spin-off companies and high-skilled jobs affiliated with knowledge industries.
- New products and technologies contribute to productivity gains from a healthier workplace.
- Commercialized products and services have positive impacts on employment, capital formation, productivity, wealth creation, public and private revenue streams, Gross Domestic Product (GDP).
- Focus on commercialization leads to increased economic activity that contributes to a robust public revenue stream for governments.

Some of these benefits reflect the creation and dissemination of new knowledge, some will be related to improvements in patient care and the quality of life of Canadians, while others will be focused on the number of jobs created, revenues generated and patents issued.

Clearly, there are different ways in which the health research value chain requires us to think about metrics to measure the progress that is being made. Furthermore, in a world that is driven by enhanced accountability and value for investment in health research, we must look at new ways in which to tell the compelling stories related to the multiple benefits that flow from investing through the different stages of health research.

THE LITERATURE ON ROI GENERATED FROM HEALTH RESEARCH

The literature on the evaluation of health research outputs has deepened considerably in recent years, and a number of studies have attempted to quantify the ROI. Typically, studies focus on the health benefits via case studies in relation to the generation of new medical knowledge and application of technologies. That said, a number of European studies have focused on the measurement of the strategic value of health research, which is more challenging. While observers agree that the benefits from health research can span and “sum” across all categories in Exhibit 10, very few studies have attempted this measurement in its entirety.

Broad-based measurement of ROI from publicly-funded health research has landed at rates of return of at least 25% per year. For example, the National Institutes of Health in the United States concluded that direct estimates through econometric studies place the economy-wide rate of return on publicly-funded research in the order of 25% to 40% per year.⁴⁰ By way of comparison, the average before-tax profits of non-financial corporations in the United States ranged from 8.5% to 14.3% in the most recent 10 years for which data is available (1988 to 1997), and corporations often use an expected rate of return of 15% per year as the minimum for considering investments.⁴¹

Mansfield⁴² and Beise and Stahl⁴³ determined a rate-of-return of 28% for publicly-funded academic science research. Cockburn and Henderson⁴⁴ conclude a 30% return on publicly-funded pharmaceutical research. In addition, Toole⁴⁵ concluded that a 1% increase in basic research would lead to an increase (via a multiplier effect) of 2.0% to 2.4% in the number of commercially available products.

In *A Wealth of Knowledge*,⁴⁶ the returns on investment from publicly-funded research were assessed through macro and micro-economic methodologies, and found to be in the 39% and 50% range. This study assessed several broad categories of benefit/social rate-of-return (ROR) attribution, concluding that the benefits from building the stock of basic knowledge were 10% with a 10-year lag; benefits from improved access to international research were 7.5% with an eight-year lag; benefits from better informed policy averaged a 6% ROR with an eight-year lag. The largest dimension of ROI was the direct benefits from the improvement to the skill base, averaging a 12.5% ROR with a four-year lag.

A number of important studies have focused on the impact of health research on longevity and the quality of life. In the United States study *Exceptional Returns*,⁴⁷ a group of leading economists tackled the question: "What is the true economic value of U.S. national investment in medical research?" They concluded that: (1) increases in life expectancy in the 1970s and 1980s were worth \$57 trillion to Americans: with the gains associated with prevention and treatment of cardiovascular disease alone totaled \$31 trillion; (2) improvements in health account for almost 50% of the actual gain in living standards in the past 50 years; (3) the returns from medical research are so extraordinarily high that the pay-off from any plausible "portfolio" of investments in research would be enormous. Another U.S. study estimated that major investments in cancer research would yield a nearly 10-fold return to society (Murphy, 2003).

Nordhaus⁴⁸ also studied the research-lifespan linkages, showing that improvements in health status and increases in life expectancy have been a major contributor to economic welfare through the 20th century. He cites impacts of health technology breakthroughs such as the polio vaccine, new drug therapies, surgical procedures, and improvements to health infrastructure. Average life expectancy now stands at 78 years, increasing one year in every five for the past 30 years, and the disability rate of seniors in America dropped by almost 30% in the past 20 years due to scientific advances.⁴⁹

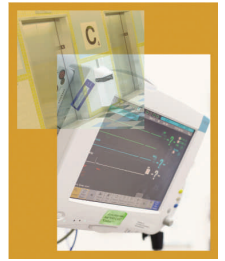
A BRITISH COLUMBIA CASE-STUDY ON THE ROI OF HEALTH RESEARCH

In 1999, KPMG examined the economic and social impacts of research at the University of British Columbia Faculty of Medicine and the affiliated teaching hospitals.⁵⁰ Their analysis concluded that the \$62.8 million invested in health research in 1998-99 had the following short-term benefits:

1. Increased output in the British Columbia Economy in the range of \$94 million to \$118 million.
2. Increased Gross Domestic Product (GDP) in the range of \$57 million to \$71 million.
3. Increased direct employment of 765, leading to increased total employment in the range of 1,113 to 1,371 full-time equivalent positions.
4. Increased household income between \$52.5 million and \$61.0 million.
5. Increased government revenues of up to \$14 million at the federal level, up to \$9 million at the provincial level and up to nearly \$1.0 million at the municipal level. Federal and provincial taxes accrue largely from personal income taxes.
6. The study also pointed out that for every 100 medical research jobs that are directly funded, another 46 to 80 jobs are created elsewhere in the province.

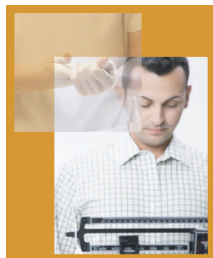
While there continue to be methodological issues related to what is the most appropriate evaluation approach,⁵¹ the synthesis of health research case studies demonstrates that the returns that are generated from investments in health and medical research are substantial.

Furthermore, there are many important dimensions in which ROI is extracted and accounted for that flow from health research. At the same time, the knowledge, networks and investment are generating important social and economic gains — particularly when married with supportive government policies at the researcher, institutional and systemic levels.



The largest dimension of ROI was the direct benefits from the improvement to the skill base, averaging a 12.5% ROR with a four-year lag.

The study also pointed out that for every 100 medical research jobs that are directly funded, another 46 to 80 jobs are created elsewhere in the province.



10. RELATING “INPUTS” TO “OUTPUTS”...

“Everything we know about knowledge-based economies, global competitiveness, productivity and health tells us that investments in research, particularly health research, are one of the wisest, efficient, and most prudent investments any society can make.” Dr. Alan Bernstein, President, Canadian Institutes of Health Research. Appearance before the House of Commons Standing Committee on Finance (2006)

There are a number of different ways in which one can identify the ROI that are the product of health research. Notwithstanding the range of methodologies that can be employed, they speak to the growing importance of effectively *measuring* and *evaluating* the gains that come from investing in the health research enterprise.

At the same time, considering the order-of-magnitude of investments in health research, measuring ROI provides a higher level of *accountability* between early stage “inputs” that are a prerequisite to generating new knowledge and discovery, and the “outputs” that accrue to Canadians in the form of better health, a more cost-effective and responsive health system, and more sustainable economic prosperity.

If there is to be a clearer articulation of what is required to sustain and nurture the country’s health research enterprise, it is incumbent upon all of us to have a better sense of the relationship between *inputs* and *outputs*, the direction in which we want to go, and what is required to bridge the gap for the foreseeable future.

This is an important point, and one in which all of those who are integrally involved in the health research enterprise can and must do a better job of linking inputs to outputs. By developing more effective metrics, there will not only be a more direct way in which to demonstrate a return-on-investment, but there will also be an improved understanding of the significant findings that come from scientific inquiry, and how they have a very real impact on the lives of Canadians.⁵² In this regard, ACAHO looks forward to fully participating in a process led by the Canadian Academy of Health Sciences to define metrics that capture the different ways in which health research produces benefits for Canadians. It is our expectation that this project will not only improve the way in which we effectively communicate the results of health research, but enhance overall accountabilities in terms linking sources of funding with their uses.

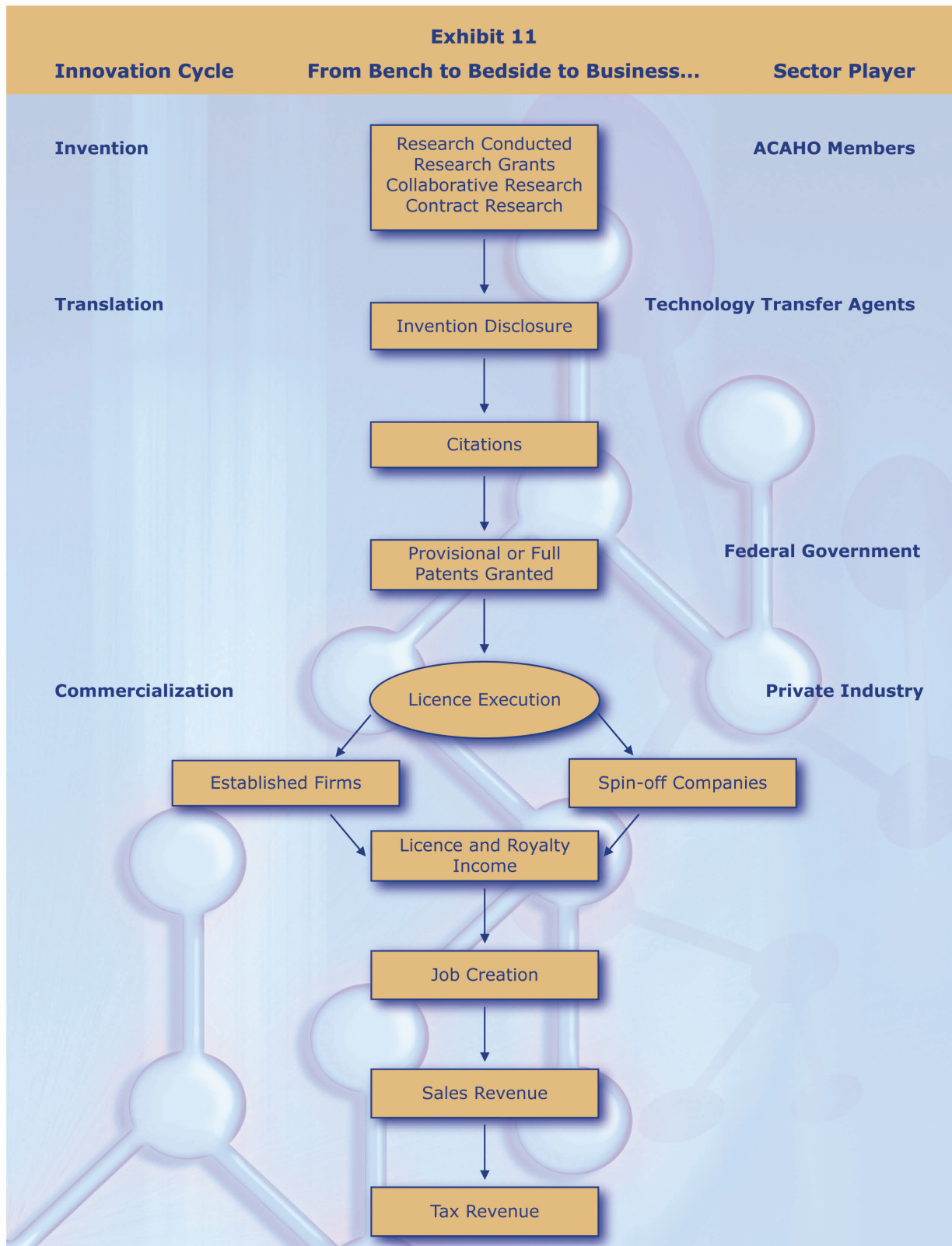
With this in mind, the remainder of this section focuses on a series of quantitative and qualitative metrics that underscore some of the different ways in which members of ACAHO provide not only a return-on-investment, but a “return-on-innovation”. This section focuses on the outputs that are derived from sub-sections 3, 4, and 5 (see Exhibit 10).

In specific terms, the document captures seven different metrics which speak to the outputs that are generated from investments in health research.

- i. World Firsts
- ii. Disclosures
- iii. Citations
- iv. Provisional and Full Patents
- v. Licences Executed
- vi. Licence, Royalty and Technology Transfer Revenue
- vii. Spin-Off Companies

...considering the order-of-magnitude of investments in health research, measuring ROI provides a higher level of accountability between early stage “inputs” that are a prerequisite to generating new knowledge and discovery, and the “outputs” that accrue to Canadians in the form of better health, a more cost-effective and responsive health system, and more sustainable economic prosperity.

Exhibit 11 illustrates the “life cycle” of health research, relating - along a continuum - the early stage “inputs” in terms of discovery-based research conducted via grants and contracts to the ultimate “outputs” which result in knowledge creation, innovation, job creation and revenue generation. To provide context, this continuum is considered in parallel with the stages of the innovation (from invention to translation and commercialization) as well as with respect to the sector players who contribute health research value chain.^{53 54}



By developing more effective metrics, there will not only be a more direct way in which to demonstrate a return-on-investment, but there will also be an improved understanding of the significant findings that come from scientific inquiry, and how they have a very real impact on the lives of Canadians.



Given that close to 80% of all publicly-funded health research in Canada occurs in ACAHO member institutions, a large proportion of extraordinary health research breakthroughs have taken place in the country's Teaching Hospitals, RHAs and their Research Institutes.

OUR "METHOD" ON METRICS

In Canada, there is limited public information on a range of metrics related to health research. This is largely due to the fact that information is collected and reported in an aggregate manner and is not easily separated into its constituent elements. In other cases, the information has not been systematically collected.

ACAHO therefore developed its own Research Funding Flow Survey of members to get a clearer idea of the range of metrics outlined in this section of the report. The survey was administered in 2006, with 75% of members reporting. We believe that the metrics are an important starting point — a floor and not a ceiling — when it comes to relating health research inputs to outputs.

We expect that the dataset will become more robust over time with successive surveys and will continue to highlight the important contributions of health research to Canadian society.

i. WORLD FIRSTS

As *engines of health innovation*, an essential component of the mission and mandate of ACAHO members is to continue to advance the body of scientific knowledge that comes from health research, and to translate this knowledge to the public, clinicians, administrators and policy makers to improve the quality of care provided to Canadians. As a result, Teaching Hospitals, Academic RHAs and their Research Institutes play a crucial role in converting research findings (i.e., "from bench to bedside to business") into innovative products and services.

Without question, research findings play an important role in advancing patient care in each area of focus. At times, the research builds on the initial work of other scientists, and at other times ACAHO members' work has been groundbreaking, if not revolutionary, global in its impact and playing a significant role opening up new avenues of scientific inquiry.

Exhibit 12 provides an overview of a selection of "world firsts" which have occurred in Canada's Teaching Hospitals, RHAs and their Research institutes.⁵⁵ From the discovery of insulin in 1922, to the development of the world's first viral proteins (a powerful new class of anti-inflammatory drugs) to treat heart disease in 2005, Canadians have an impressive track record of achievements in health research.

Given that close to 80% of all publicly-funded health research in Canada occurs in ACAHO member institutions,⁵⁶ a large proportion of extraordinary health research breakthroughs have taken place in the country's Teaching Hospitals, RHAs and their Research Institutes. These institutions play an essential role in the renewal of the health care system. They are dedicated to innovation and best practices in patient care, teaching and education, research, medical discovery, knowledge creation and sharing, and have an established and internationally recognized record of achievement.⁵⁷

It is also important to note that many of the world firsts would not have happened without federal funding administered by the Medical Research Council of Canada and its successor, the Canadian Institutes of Health Research, and other federal agencies (e.g., Canada Foundation for Innovation).

Exhibit 12

SELECT WORLD FIRSTS IN ACAHO MEMBER INSTITUTIONS

1877	Introduction of sterilized cotton wool swabs in test tubes, which reduces contamination. (<i>McGill University Health Centre Research Institute — Montreal, Quebec</i>)
1907	First bronchoscopy performed. (<i>McGill University Health Centre Research Institute — Montreal, Quebec</i>)
1908	Installation of the first milk pasteurization plant in Canada, 30 years before it becomes mandatory. This all but eliminates diseases transmitted by unpasteurized milk like tuberculosis, salmonella, and e.coli. Pasteurization dramatically decreases infant mortality in Canada. (<i>The Hospital for Sick Children — Toronto, Ontario</i>)
1912	First surgical treatment of tuberculosis. (<i>McGill University Health Centre Research Institute — Montreal, Quebec</i>)
1922	First clinical use of insulin for diabetes in human patients. (<i>University Health Network — Toronto, Ontario</i>)

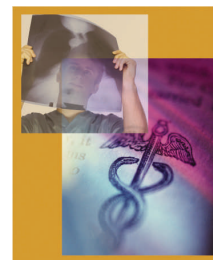
- 1930** Development of a new infant cereal that later becomes famous internationally as “pablum.” This fortified cereal (the first of its kind) significantly reduces death from malnutrition. (*The Hospital for Sick Children — Toronto, Ontario*)
- 1933** First excision of the entire lung performed (pneumonectomy). (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1939** Invention of the corneal splitting knife (still standard in surgery to reduce pressure in glaucoma). (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1948** Development of the first artificial kidney machine. (*Lawson Health Research Institute — London, Ontario*)
- 1948** First 25 million electron-volt beta-tron to be established in any university or hospital — calibration takes nine months. The electron-volt beta-tron is used for cancer research and to improve treatment accuracy. (*Saskatoon Health Region — Saskatoon, Saskatchewan*)
- 1950** Introduction of lumpectomy for treatment of breast cancer. Lumpectomy is a surgical procedure designed to remove a discrete lump (usually a tumour, benign or otherwise) from an affected woman or man’s breast. (*University Health Network — Toronto, Ontario*)
- 1950** Use of total body cooling as a method of making heart surgery safer. (*University Health Network — Toronto, Ontario*)
- 1950** First neuro-surgical treatment of epilepsy performed. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1951** First use worldwide of calibrated cobalt-60 for cancer radiotherapy treatment. (*Saskatoon Health Region — Saskatoon, Saskatchewan*)
- 1951** First “cobalt bomb” in the world used to deliver radiation therapy to cancer patients. (*Lawson Health Research Institute — London, Ontario*)
- 1952** First use of a device that determines whether or not a patient’s thyroid is cancerous through the use of radioactive iodine. (*Saskatoon Health Region — Saskatoon, Saskatchewan*)
- 1956** Major breakthrough in virology by discovering that positive strand Ribonucleic Acid (RNA) could be infectious. (*Capital Health/University of Alberta — Edmonton, Alberta*)
- 1957** Invention of the artificial cell for application in medicine and biotechnology. It was thought that artificial cells could one day be used as a partial substitute for human cells and organs. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1958** World first surgical treatment on cerebral aneurysms. (*Lawson Health Research Institute — London, Ontario*)
- 1960** Implementation of genetic screening programs for hereditary metabolic diseases in newborns. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1960** First implanted mammary artery into the heart wall in order to restore functionality of the heart. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1961** Discovery of blood-forming stem cells enabling bone marrow transplants. (*University Health Network — Toronto, Ontario*)
- 1963** The first widely successful surgery to correct the birth defect known as “Blue Babies” is performed. Before this procedure, this condition used to kill 9 out of 10 patients in their first year. (*The Hospital for Sick Children — Toronto, Ontario*)
- 1965** First artificial knee joint in the world created. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1969** Discovery of a carcino-embryonic antigen, a tumour marker for cancer. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1970** Discovery that hereditary metabolic diseases could be treated with vitamins. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1971** Developed the world’s first paediatric electric prosthetic arm. (*Bloorview Kids Rehab — Toronto, Ontario*)





- 1975** Development of software used worldwide for 20 years to control radiation therapy. (*University Health Network—Toronto, Ontario*)
- 1976** Identification of P-glycoprotein as a major cause of cancer drug resistance. (*University Health Network — Toronto, Ontario*)
- 1978** Developed the internationally-recognized AeroChamber, a medical device used to administer aerosolized medication for patients with asthma. This device continues to be used in practice around the world. (*St. Joseph's Healthcare – Hamilton, Ontario*)
- 1979** Invention of a radically different ventilator (now used worldwide) that gently “shakes” oxygen into the lungs of children with severe lung disease, sparing many of them painful lung bypass procedures. (*The Hospital for Sick Children — Toronto, Ontario*)
- 1979** Development of “Continuous Passive Motion” (CPM), a revolutionary treatment for injured or diseased joints. Before this treatment, patients with damaged cartilage had to be totally immobilized. CPM is such an improvement that it is now being used in 17,500 hospitals in more than 77 countries worldwide. (*The Hospital for Sick Children — Toronto, Ontario*)
- 1980** Initial studies using real time ultrasounds and detailing biological factors affecting human fetal behavioral activity and breathing movements. (*Lawson Health Research Institute — London, Ontario*)
- 1981** World-first heart operation to correct a life-threatening heart condition known as right ventricular dysphasia. (*Lawson Health Research Institute — London, Ontario*)
- 1983** Successful single lung transplant. Lung transplants extend life expectancy and enhance the quality of life for end-stage pulmonary patients. (*University Health Network — Toronto, Ontario*)
- 1983** The Department of Nuclear Medicine becomes first to use a special imaging agent to diagnose Parkinson's disease. Called [18] F6-fluorodopa PET, the chemical was produced by Hamilton Health Sciences and is now used worldwide. (*Hamilton Health Sciences/McMaster University – Hamilton, Ontario*)
- 1984** Discovery and cloning of the T-Cell receptor genes, significant in the field of immunology. (*University Health Network — Toronto, Ontario*)
- 1986** Discovery of the SH2 domain, which controls the ability of proteins to interact with other SH2 containing proteins and thereby direct the function of enzymes involved in transmitting cellular signals. This finding has revolutionized our understanding of how proteins form, signaling pathways inside cells. It is already informing research to control these pathways in diseased cells — the basis for novel therapies. (*Mount Sinai Hospital — Toronto, Ontario*)
- 1986** Developed first predictive testing for late onset genetic diseases (Huntington Disease). (*Provincial Health Services Authority – Vancouver, British Columbia*)
- 1987** First aortic valve replacement in the world using the Toronto Heart Valve, which is now used worldwide. (*University Health Network — Toronto, Ontario*)
- 1987** World's first pacemaker cardioverter defibrillator is implanted. (*Lawson Health Research Institute — London, Ontario*)
- 1988** Researchers solve the structure of rennin, a key enzyme in the kidney that plays a role in the development of high blood pressure. (*Capital Health/University of Alberta — Edmonton, Alberta*)
- 1988** World's first successful liver/small bowel transplant is performed. (*Lawson Health Research Institute — London, Ontario*)
- 1989** Researchers develop sputum induction techniques and sputum cell analysis. Research on nasal mucosa suggested ways in which the cellular response to antigen challenge might be studied in bronchial mucosa and sputum. (*Firestone Institute for Respiratory at St. Joseph's Healthcare – Hamilton, Ontario*)
- 1989** Development of the first oral treatment for hepatitis B, resulting in the drug Lamivudine. (*Capital Health/University of Alberta — Edmonton, Alberta*)
- 1989** Discovery of the gene which, when defective, causes cystic fibrosis, the most fatal genetic disease of Canadian children today. (*The Hospital for Sick Children — Toronto, Ontario*)

- 1990** First measure of neurotransmitter concentration in schizophrenics by Magnetic Resonance Spectroscopy (MRS). MRS allows scientists and doctors to measure chemicals within the body and brain without removing tissue or blood samples and without using dangerous radioactive “tracers.” It is therefore safe and can be used repeatedly on the patient without any ill effects. (*Lawson Health Research Institute — London, Ontario*)
- 1991** Publication of the first paper demonstrating that treatment of obstructive sleep apnea by nasal continuous positive airway pressure (CPAP) in patients with congestive heart failure improves cardiac function and symptoms of heart failure. This discovery has major implications because it suggests that obstructive sleep apnea contributes to the development and progression of congestive heart failure. (*Toronto Rehabilitation Institute — Toronto, Ontario*)
- 1992** Discovery of the first gene responsible for Fanconi anemia. Fanconi anemia (FA) is a rare genetic disease that affects children and adults from all ethnic backgrounds. FA is characterized by short stature, skeletal anomalies, increased incidence of solid tumors and leukemias, bone marrow failure (aplastic anemia), and cellular sensitivity to DNA-damaging agents such as mitomycin C. (*Hospital for Sick Children — Toronto, Ontario*)
- 1993** Researchers demonstrate that mouse embryonic stem cells are capable of supporting the entire embryonic development and in fact creating completely cell cultured derived mice. (*Mount Sinai Hospital — Toronto, Ontario*)
- 1993** Discovery of a novel gene associated with Lou-Gehrig’s disease. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1994** World’s first three-dimensional (3-D) ultrasound-guided cryosurgery. (*Lawson Health Research Institute — London, Ontario*)
- 1994** Solved the 30-year old puzzle of why so many people suffer an allergic reaction when they receive a blood transfusion. (*Hamilton Health Sciences/McMaster University — Hamilton, Ontario*)
- 1995** First physical map of the human genome created. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1995** Discovery of the gene associated with localized muscular dystrophy. (*McGill University Health Centre Research Institute — Montreal, Quebec*)
- 1996** Identification of a human blood cell that regenerates the entire blood system. This discovery enabled the development of new treatments for blood diseases such as leukemia, thalassemia and sickle cell anemia. (*Hospital for Sick Children — Toronto, Ontario*)
- 1996** Identification of a gene that causes colon cancer. Colorectal cancer is the second leading cause of cancer-related deaths among Canadians. (*Hospital for Sick Children — Toronto, Ontario*)
- 1998** Developed the first trophoblast stem cells – the precursors of cells that form the placenta. Since the placenta is critical for a successful pregnancy, this discovery will have a major impact on research to understand and ultimately prevent pregnancy complications resulting from a failure in normal placental function. (*Mount Sinai Hospital — Toronto, Ontario*)
- 1998** Discovery of the first gene that causes Lafora disease, one of the most severe forms of teenage-onset epilepsy. (*Hospital for Sick Children — Toronto, Ontario*)
- 1999** First islet transplant under the Edmonton protocol for Type I diabetes. Islet transplantation had been performed under other protocols; however, the Edmonton protocol produced unprecedented levels of success in the field of islet transplantation. (*Capital Health/University of Alberta — Edmonton, Alberta*)
- 1999** World’s first closed chest robotic-assisted beating heart coronary artery bypass graft conducted. (*Lawson Health Research Institute — London, Ontario*)
- 1999** Identification of ABCA-1 gene – key regulator of HDL concentrations in humans. (*Provincial Health Services Authority/BC Children’s Hospital — Vancouver, British Columbia*)
- 2000** Discovery of the mechanism of formation of amyloid, the basis of Alzheimer’s and other diseases, and the subsequent development of drugs to treat this. (*Kingston General Hospital — Kingston, Ontario*)
- 2001** Discovery of a clinical rule that may reduce use of unnecessary x-rays for low-risk neck injuries and could aid in reducing use of imaging tests in alert and stable patients. (*Ottawa Health Research Institute — Ottawa, Ontario*)

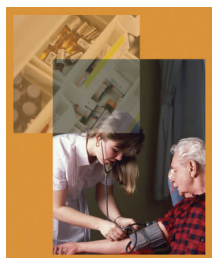




- 2001** Development of the first animal model for Hepatitis C in mice, using transplanted human cells, providing a convenient way to test new treatments for Hepatitis C. (*Capital Health/University of Alberta — Edmonton, Alberta*)
- 2001** Tissue factor is a cell surface membrane protein involved in the initiation of blood clotting. Overexpression or increased activation of tissue factor can increase the risk of cardiovascular disease. The research group demonstrated that overexpression of GRP78 (a protein), can block the coagulant activity of tissue factor in human cells. These studies are important because they have identified a relevant cellular factor that can mediate tissue factor activity. (*Hamilton Health Sciences Centre — Hamilton, Ontario*)
- 2001** Identified the emerging role that albuminuria as an important risk factor for both kidney and heart disease. (*Hamilton Health Sciences/McMaster University — Hamilton, Ontario*)
- 2002** Introduction of revolutionary medication doses for depression and schizophrenia through positron emission tomography (PET) technology. (*Centre for Addiction and Mental Health — Toronto, Ontario*)
- 2002** Creation of a simple system to generate T-cells in a Petri dish. T-cells are a vital component of the immune system that orchestrate, regulate and coordinate the overall immune response. This discovery provided a method to create model systems to study the genetics and molecular biology of T-cell development and points to future clinical therapies for people whose immune systems have been destroyed, for example, by HIV or toxic cancer therapies. (*Sunnybrook & Women's Research Institute — Toronto, Ontario*)
- 2002** Discovery that a type of self-destructing "suicide cell" activity, previously believed to only be detrimental, is in fact necessary for the proper formation of muscle tissue. (*Ottawa Health Research Institute — Ottawa, Ontario*)
- 2002** Pioneered the use of Botulinum Toxin A to reduce upper limb spasticity in children with cerebral palsy. (*Bloorview Kids Rehab — Toronto, Ontario*)
- 2003** Discovery of a molecular marker to diagnose hepatocellular carcinoma (HCC), the most common type of liver cancer. HCC is usually asymptomatic at early stages, and has great propensity for invasion, making it difficult to treat. A test was developed for the early diagnosis of HCC, which could also be useful for the screening of individuals that are at high risk for developing this disease, such as people chronically infected with Hepatitis B and C. (*Sunnybrook & Women's Research Institute — Toronto, Ontario*)
- 2003** Researchers discover a way to make the immune system specifically recognize infectious prions, proteins that cause brain-wasting diseases like mad cow disease and Creutzfeldt-Jakob disease, its human equivalent. This discovery paves the way for the development of diagnostic tools, immunotherapy and a vaccine. (*Sunnybrook & Women's Research Institute — Toronto, Ontario*)
- 2003** Major international clinical trial provides first alternative treatment to taxol for preventing breast cancer recurrence in survivors five years post diagnosis. (*University Health Network — Toronto, Ontario*)
- 2003** Compilation of the complete DNA sequence of chromosome 7. Researchers decode nearly all of the genes on this medically important portion of the human genome. Chromosome 7 contains 1,455 genes, some of which, when altered, cause diseases such as cystic fibrosis, leukemia and autism. (*Hospital for Sick Children — Toronto, Ontario*)
- 2003** Study makes it easier to identify patients with deep vein thrombosis (DVT), providing faster diagnosis and significant savings to the health care system. (*Ottawa Health Research Institute — Ottawa, Ontario*)
- 2003** Performed the world's first deep brain stimulation for depression, causing depression that was previously treatment-resistant to go into remission. (*University Health Network — Toronto, Ontario*)
- 2003** Identification of a cancer stem cell responsible for brain tumors. This discovery may change how this deadly condition is studied and treated in the future. (*Hospital for Sick Children — Toronto, Ontario*)
- 2003** Linkage of maternal folic acid intake to a decrease in neuroblastoma, a deadly childhood cancer. (*Hospital for Sick Children — Toronto, Ontario*)
- 2003** Performed the world's first hospital-to-hospital telerobotic assisted surgery on a patient more than 400 kilometres away. During the procedure, they completed a Nissen Fundoplication on a 66-year old patient located at North Bay General Hospital from St. Joseph's telerobotics suite in Hamilton, Ontario. (*St. Joseph's Healthcare — Hamilton, Ontario*).

- 2003** Developed a genetically modified vaccine that can completely prevent the recurrence of metastatic breast cancer through genetically altered cells that only destroy cancer cells. (*Hamilton Health Sciences/McMaster University – Hamilton, Ontario*)
- 2003** Developed first draft DNA sequence for coronavirus implicated as cause of SARS (*Provincial Health Services Authority/BC Cancer Agency, Genome Sciences Centre – Vancouver, British Columbia*)
- 2003** Found that the vast majority of heart attacks can be predicted by nine easily measurable factors that are the same in virtually every region and ethnic group worldwide. (*Hamilton Health Sciences/McMaster University – Hamilton, Ontario*)
- 2004** Performed the world's first simulated underwater surgery during the NASA Extreme Environment Mission Operation (NEEMO 7). During the 10-day NEEMO 7 Mission, they successfully telementored the NEEMO7 crew through various surgical simulations from their base in the underwater Aquarius habitat located 19 metres below the surface off the coast of Key Largo, Florida. (*St. Joseph's Healthcare – Hamilton, Ontario*)
- 2004** Development of StemBase, a database of gene expression data from DNA micro array experiments on samples from human and mouse stem cells and their derivatives. This growing resource is used to find genes whose activity is related to stem cells. (*Ottawa Health Research Institute – Ottawa, Ontario*)
- 2004** Discovery of the apelin receptor and design of an analogue that can interfere with and block the actions of apelin, in order to decipher its role in the brain. (*Centre for Addiction and Mental Health – Toronto, Ontario*)
- 2004** Discovery of over 70 novel human receptor genes; many of which, together with their chemical activators, mediate unique functions in the brain and are being targeted for drug design. (*Centre for Addiction and Mental Health – Toronto, Ontario*)
- 2004** In the first large, multi-centre clinical trial of its kind, researchers provided evidence to suggest that artery grafts from the forearm should be used in place of vein grafts from the leg in heart bypass surgery because radial arteries have significantly higher graft patency over one year. Graft patency, a measure of whether the bypass remains open enough to permit efficient blood flow, is critical to success after surgery. (*Sunnybrook & Women's Research Institute – Toronto, Ontario*)
- 2004** A research team finds magnetic resonance imaging detects more breast cancer tumors, earlier, compared with mammography, ultrasound or clinical examination in women with the BRCA1 and BRCA2 genes. This finding offers hope to genetically at-risk women, and gives them an alternative to removing both breasts. (*Sunnybrook & Women's Research Institute – Toronto, Ontario*)
- 2004** World's first use of beads of palladium, a low-dose radioactive material, to treat women with breast cancer on an outpatient basis. This therapy holds the promise of eliminating anguishing side effects and considerably enhancing the women's quality of life. (*Sunnybrook & Women's Research Institute – Toronto, Ontario*)
- 2004** Demonstration of an association between pediatric multiple sclerosis (MS) and the Epstein-Barr virus, indicating that exposure to the virus at a certain time in childhood may be an important environmental trigger for the development of MS. (*Hospital for Sick Children – Toronto, Ontario*)
- 2004** Developed a virtual instrument that allows children with physical disabilities to make music (both therapeutic and recreational applications of the software – which is licensed in 7 countries around the world). (*Bloorview Kids Rehab – Toronto, Ontario*)
- 2005** Developed the world's first upper respiratory viral panel test that can accurately identify all respiratory viruses including various flu strains including H5N1 and the SARS Coronavirus. (*St. Joseph's Healthcare – Hamilton, Ontario*)
- 2005** In the first trial of its kind in the world, researchers begin treating prostate cancer using a 3-D image-guided radiation therapy device that was developed in Canada. This non-surgical technique allows oncologists to visualize the exact position of the target and deliver precise external beam radiation therapy. (*Sunnybrook & Women's Research Institute – Toronto, Ontario*)
- 2005** Key discovery in Type-1 Diabetes proves the repair process is present within the pancreas during disease development. Understanding the repair process could be the key to successful treatment. (*Ottawa Health Research Institute – Ottawa, Ontario*)
- 2005** Study determines that a specific enzyme, known as pro-protein convertase 4 (PC4) may be responsible for fetal growth restriction, the second leading cause of infant mortality in the developed world. Knowledge may lead to screening for the defective enzyme early in the pregnancy and provide the ability to monitor the pregnancy more closely. (*Ottawa Health Research Institute – Ottawa, Ontario*)





CIHR funds a spectrum of strategic research initiatives in ACAHO member institutions that cover a broad range of disciplines and cut across the full range of health challenges faced by Canadians...

- 2005** Scientists show that early surgical removal of the spleen combined with antiangiogenic therapy, which arrests the growth of tumour-feeding blood vessels, may stop the progression of leukemia. (*Sunnybrook & Women's Research Institute — Toronto, Ontario*)
- 2005** Using neuropsychological testing, researchers accurately predict which study participants will develop Alzheimer's disease within five and 10 years. Previous studies were able to predict Alzheimer's only for shorter periods of time; other studies showed predictions for 10 and even 15 years, but these did not indicate the predictive accuracy of the tests. (*Sunnybrook & Women's Research Institute — Toronto, Ontario*)
- 2005** Identified novel mutations in the gene that causes Rett Syndrome. The discovery is now licenced as a test for the disorder and is available to the public. (*Centre for Addiction and Mental Health — Toronto, Ontario*)
- 2005** Initiation of first human clinical gene therapy trials for lipoprotein lipase deficiency. (*Provincial Health Services Authority/BC Children's Hospital – Vancouver, British Columbia*)
- 2006** Discovery of the precise molecular chain of events that initiates the wide-scale immune destruction of "super bug" infections such as flesh-eating disease, toxic shock syndrome and severe food poisoning. (*Robarts Research Institute — London, Ontario*)
- 2006** Implantation of an antibody-coated stent into the first human patient. The invention of the antibody-coated stent reduces restenosis and prevents blood clots from occurring. (*St. Michael's Hospital — Toronto, Ontario*)
- 2006** World's first clinical trial to combine gene and cell therapy to treat a cardiovascular disorder. The PHACeT (Pulmonary Hypertension: Assessment of Cell Therapy) trial will assess the use of adult stem-like cells called endothelial progenitor cells (EPC) for the treatment of pulmonary hypertension. (*St. Michael's Hospital — Toronto, Ontario*)
- 2006** First demonstration that children with cystic fibrosis have choline deficiency. Provision of choline improves redox balance and methyl transfer capacity in humans. (*Provincial Health Services Authority/BC Children's Hospital – Vancouver, British Columbia*)
- 2006** First demonstration that dietary omega-3 fatty acid deficiency impairs neurogenesis in vivo (*Provincial Health Services Authority/BC Children's Hospital – Vancouver, British Columbia*)
- 2006** First curative therapy for Huntington Disease in a mouse model (*Provincial Health Services Authority/BC Children's Hospital, Vancouver, British Columbia*)

THE CANADIAN INSTITUTES OF HEALTH RESEARCH

The Canadian Institutes of Health Research (CIHR) is the federal government's agency for health research. CIHR's mission is to create new scientific knowledge and to catalyze its translation into improved health, more effective health services and products, and a strengthened Canadian health system. Comprised of 13 Institutes, CIHR provides leadership and support to nearly 10,000 health researchers and trainees across the country.

CIHR funds a spectrum of strategic research initiatives in ACAHO member institutions that cover a broad range of disciplines and cut across the full range of health challenges faced by Canadians, including: chronic diseases such as diabetes and Alzheimer's disease, to obesity and the threat of infectious diseases (like SARS). CIHR also conducts health system research (such as more effective management of wait times) to ensure that state-of-the-art knowledge is in the hands of clinicians, administrators, policy-makers and the public.

CIHR consists of thirteen Institutes. They work together to shape a national health research agenda for Canada. The Institutes bring together researchers, health professionals and policy-makers from voluntary health organizations, provincial government agencies, international research organizations and industry and patient groups from across the country with a shared interest in improving the health of Canadians.

Several publications outline many of the important contributions funded by CIHR.⁵⁸ Exhibit 13 highlights some of the leading-edge research that has been conducted by members of ACAHO and supported by CIHR.⁵⁹

Exhibit 13

SELECT WORLD FIRSTS IN ACAHO MEMBER INSTITUTIONS FUNDED BY CIHR

A researcher at the IWK Health Centre is making genetically modified tilapia fish that produce human insulin. If the researcher is successful, tilapia could become a **source of islet cells for transplantation**. At present, islet cell transplantation is limited in part, by a small supply of human islet cells. (*IWK Health Centre — Halifax, Nova Scotia*)

A researcher at the University Health Network discovered that **treating SARS** with a combination of interferon alfacon-1 and corticosteroids was more effective than treating with the corticosteroids alone. (*University Health Network — Toronto, Ontario*)

A new diagnostic test can tell couples if they carry a gene called *cirhin* that is responsible for **North American Indian childhood cirrhosis**. This serious liver disease occurs only in certain Aboriginal communities in Quebec. Fewer than half of the children born with the condition since 1970 are still alive. Couples who both carry *cirhin* have a one-in-four chance of passing the disease to each of their children. The gene was found and the diagnostic test developed by a CIHR-funded team from Sainte-Justine Hospital. (*Sainte-Justine Hospital, Montréal, Québec*)

Researchers at the Child & Family Research Institute were the first to show that **dietary omega-3 fatty acid deficiency impairs neurogenesis in vivo**. They also demonstrated exceedingly low and inadequate levels of omega-3 fatty acids among Canadian women and were the first to draw attention to the transfer of high amounts of trans fat across the placenta. (*BC Children's Hospital/Provincial Health Services Authority — Vancouver, British Columbia*)

Women with **Alzheimer's disease** show less loss in brain mass than men with the disease at the same stage of decline in mental function, according to research at Sunnybrook and Women's College Health Sciences Centre. The study is the first to examine sex differences in the area of the brain believed to handle emotions and memory. The study findings could have impacts on diagnosis and treatment of the disease. (*Sunnybrook and Women's College Health Sciences Centre — Toronto, Ontario*)

A team of researchers at The Hospital for Sick Children have **isolated brain cancer stem cells in humans**. With support from CIHR, they have also demonstrated in mice that as few as 100 of these stem cells can trigger tumour growth. Their discovery could lead to new treatments to prevent tumours from growing, as well as lead to a better understanding of the mechanisms of brain tumour growth. (*The Hospital for Sick Children — Toronto, Ontario*)

Infants under a year of age are able to receive heart transplants from donors with different blood types—a procedure that would kill older recipients. The reason, according to research by CIHR- supported research at The Hospital for Sick Children, is that they have not yet developed the antibodies that cause them to reject other blood types. This knowledge could **make the wait shorter for infants on waiting lists for heart transplants**, and perhaps even save their lives. (*The Hospital for Sick Children — Toronto, Ontario*)

The strain of **C. difficile** that plagued some Quebec hospitals was 20 times more toxic than many other strains of the infection, according to research at the Centre Hospitalier Universitaire de Sherbrooke. (*Centre Hospitalier Universitaire de Sherbrooke — Sherbrooke, Québec*)

Patients admitted to hospital on the weekend are more likely to die within 48 hours, compared to those admitted with the same diseases on a weekday, according to Sunnybrook and Women's College Health Sciences Centre. Its research suggests the problems may be related to reduced staff and fewer supervisors with less seniority and experience on the weekends. The findings should **help hospitals examine their staffing patterns to improve quality of care**. (*Sunnybrook and Women's College Health Sciences Centre — Toronto, Ontario*).

ii. DISCLOSURES

Often, basic and applied research will result in discoveries that have “value,” be it knowledge that has clinical application and/or commercial potential. When it comes to the process of discovery and innovation, disclosures are an important metric to define new findings that stem from original research, or alternatively, new research that builds on the work of others.

The disclosure of an invention or discovery to the host institution of the primary researcher may include biotechnology, genetic engineering or any other product of research which may be ultimately licensable. Disclosures serve to inform the host institution of all dimensions of the new discovery.



The average annual number of publications per researcher in Canada was highest in the health sciences (2.55) when compared to the natural sciences and engineering (1.18), social sciences (0.22) and humanities (0.19).



Based on the activities of ACAHO members, more than 4,245 inventions have been disclosed over the past three years.

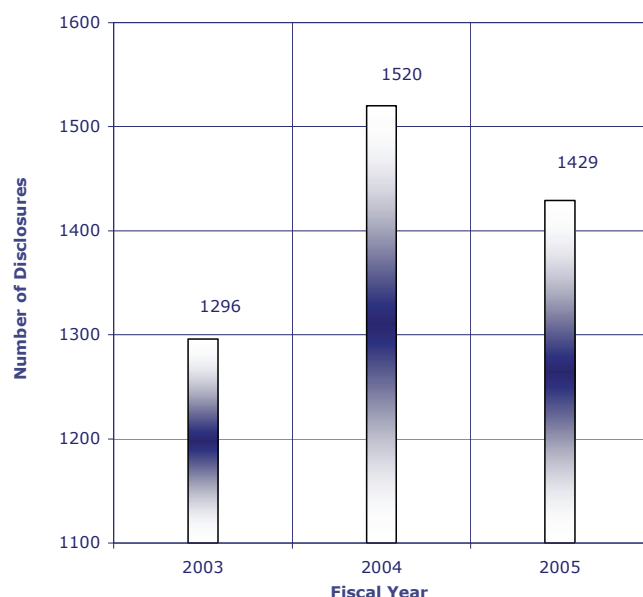
Based on the most recent available information, Canada ranks sixth internationally in terms of the number of publications in health sciences (biomedical research and clinical medicine) over the 1999–2004 period.

At the same time, disclosures are the genesis or building blocks of innovations to come, be they improvements in how we prevent, diagnose and/or treat illness, or how we transform these disclosures into viable products and services that will compete in the international marketplace.⁶⁰

Based on the activities of ACAHO members, more than 4,245 inventions have been disclosed over the past three years.⁶¹ Not unexpectedly, the number of discoveries, and subsequent disclosures, fluctuate from year to year, demonstrating the cyclical nature of innovation. Disclosures reported by ACAHO members rose markedly between fiscal year 2003 and 2004 (from 1296 to 1520, a 17% increase), and then tapered off somewhat in 2005 (to 1,429 disclosures). See Exhibit 14.

Exhibit 14

Total Number of Disclosures Recorded by Research Offices in Fiscal Year



Source: ACAHO Research Funding Flow Survey, 2006.

iii. CITATIONS

Citations refer to the number of peer-reviewed papers that have been published in leading international journals. Based on the most recent available information, Canada ranks sixth internationally in terms of the number of publications in health sciences (biomedical research and clinical medicine) over the 1999–2004 period. Interestingly, the field of health sciences accounts for the largest proportion of publications in Canada, at 46% over the same time frame.⁶²

Exhibit 15 demonstrates Canada's relative strengths in research.⁶³ The bibliometric portrait illustrates the relative intensity (or level of activity) of research occurring in Canada, in comparison to similar research occurring internationally in two dimensions, specialization and impact.

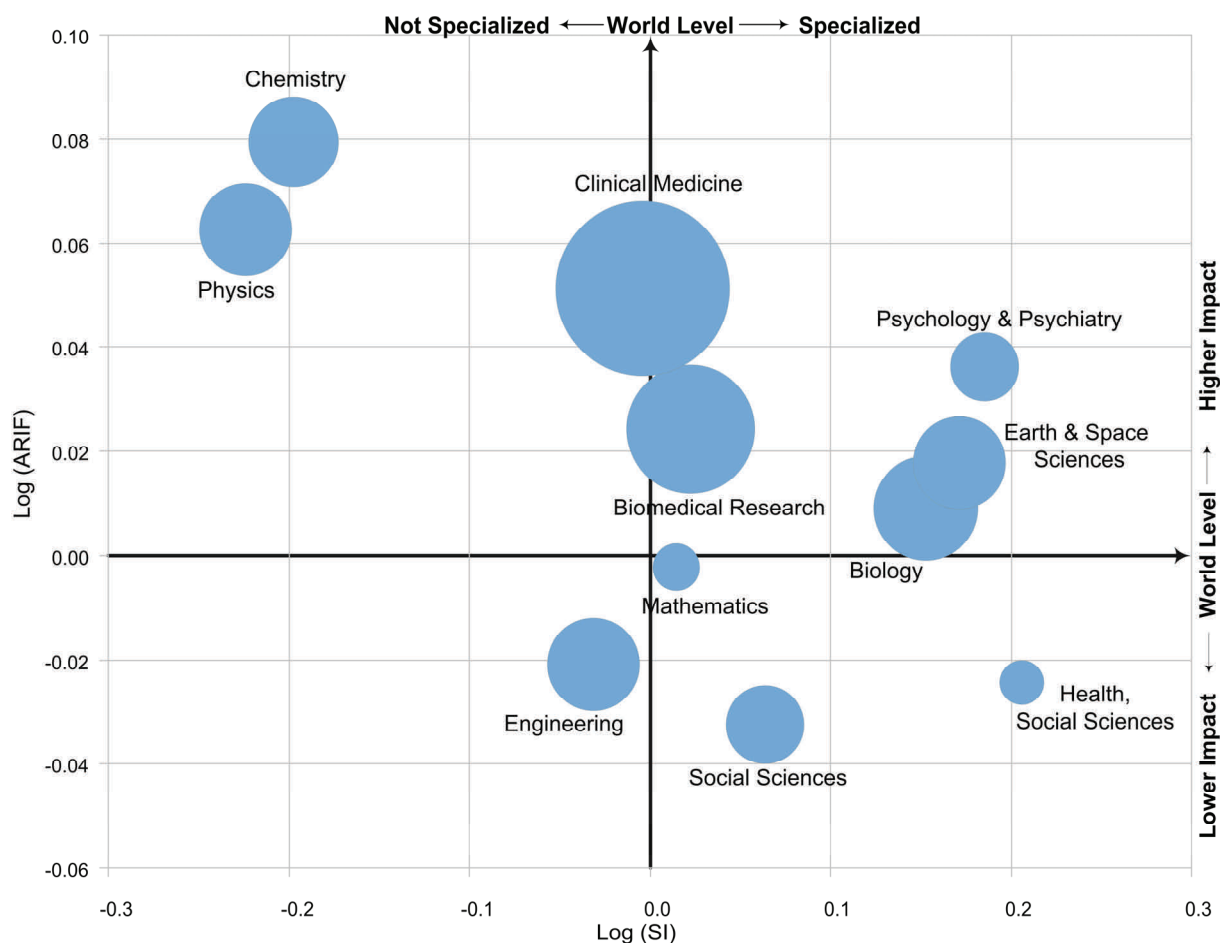
"Impact" is a proxy for the quality of the journals in which the research results are published, where "specialization" is an indicator for the intensity of research in Canada compared to international activity.

Research efforts in clinical medicine and biomedical research according to this portrait are expressed to be the largest focus of research in Canada (as indicated by the relative size of the circular marker). Both clinical medicine and biomedical research occurring in Canada are shown to have "high impact" compared to similar research internationally. That is to say, results of the Canadian research are published in highly respected journals internationally. However, with regard to focus on research in biomedical and clinical medicine, Canada is on par with efforts at the world level.

In the field of health sciences, Canada ranked fourth in the world. It is behind the United States, Switzerland and the Netherlands in terms of specialization, and 9% above the overall world average from 1999 to 2004. The average annual number of publications per researcher in Canada was highest in the health sciences (2.55) when compared to the natural sciences and engineering (1.18), social sciences (0.22) and humanities (0.19).⁶⁴

Exhibit 15

A Bibliometric Portrait of Canada's Relative Research Strengths



Source: Council of Canadian Academies, 2006



IV. PROVISIONAL AND FULL PATENTS

Notwithstanding the critical role in terms of creating new knowledge, it is also important to consider who has ownership over new discoveries. The granting of provisional and full patents is important for two reasons. First, it recognizes those who have exclusive control over the application of new knowledge. Second, it recognizes the ownership opportunities in terms of controlling the factors of production that are required to convert knowledge into useful products and services. These have a positive impact on our health status and/or the health system, and having ownership of them allows Canada to retain the income stream that may come from their commercial viability.⁶⁵

By definition, a patent is granted by a national government, upon application and in exchange for a complete disclosure of an invention.⁶⁶ The disclosure is initially a confidential disclosure to the patent office, which later becomes a non-confidential disclosure to the public at large. A patent gives the applicant the right to prevent others from making, using, or selling the claimed invention for a limited period of time. Subject to the payment of the prescribed annual fees, patents generally have a life of 20 years, depending on the jurisdiction. In order for an invention to be patentable, it must be novel, useful and not obvious to a person skilled in the field of the invention.⁶⁷

Provisional patent applications are logistically much simpler patents that can be filed in the United States. The purpose of a provisional patent is to provide protection for an inventor who wants to publish while still developing the idea. A full patent must be filed within 12 months of the granting of a provisional patent.⁶⁸



According to recent survey data (see Exhibit 17), ACAHO members reported filing 52 provisional patents in 2003, 38 in 2004, and 87 provisional patents in 2005, for a total of 177 over a three-year period. ACAHO members filed 86 full patents in each of 2003 and 2004, and 139 full patents in 2005, for a total of 311 over a three-year period.

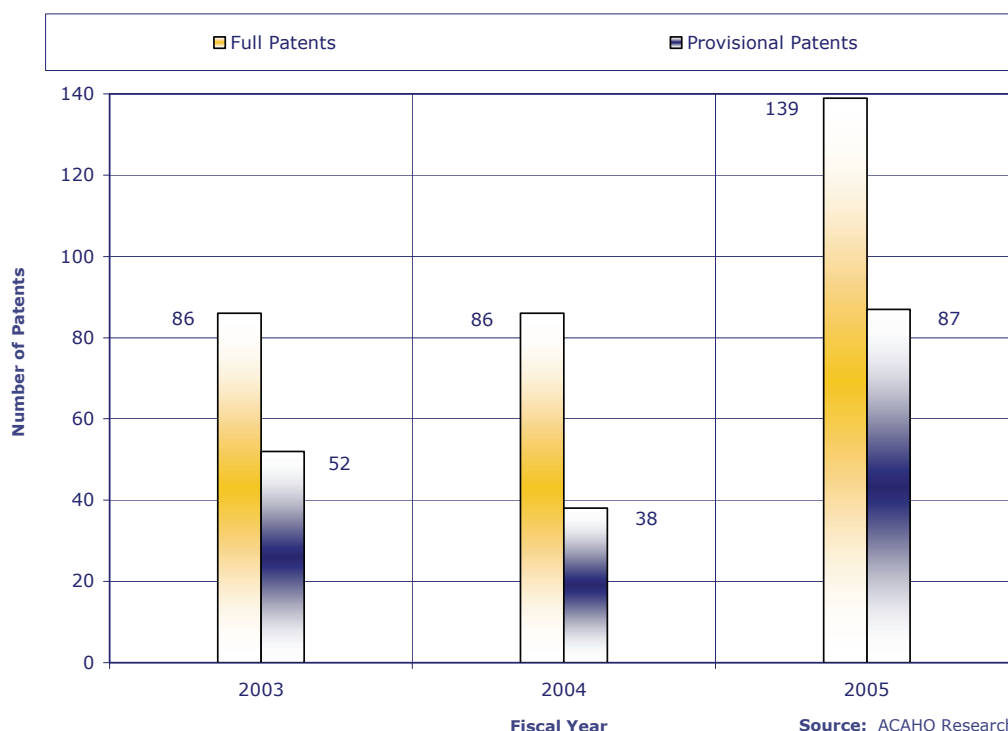
In a world increasingly driven by intense competition for knowledge creation and its ownership, having the ability to produce patents is not only an important potential contributor to the health of Canadians, but also to the future wealth of the nation.

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In a world increasingly driven by intense competition for knowledge creation and its ownership, having the ability to produce patents is not only an important potential contributor to the health of Canadians, but also to the future wealth of the nation.⁷⁰

Exhibit 16

Total Number of Provisional and Full Patents filed by the Research Offices



Source: ACAHO Research Funding Flow Survey, 2006

V. NUMBER OF LICENCES EXECUTED

The next stage of the commercialization process occurs when a new technology or invention is licenced to an existing business or to the creation of a new Teaching Hospital, Academic RHAs or Research Institute spin-off company. The objective of licensure is to allow a business or individual to manufacture and sell an invention, usually in exchange for royalties. In the case where the technology or invention is licenced to a new spin-off company, employment opportunities are also created, and in time, successful spin-off companies will ultimately generate sales revenue.

Licence agreements formalize the transfer of the right to use a technology (intellectual property) from the Teaching Hospital, Academic RHA or Research Institute to the licensee. Different types of inventions lead to different licensing strategies: a basic scientific tool which could be used by everyone in the field is typically licenced on a non-exclusive basis, whereas an invention that requires extensive investment by the licensee may be licenced exclusively.⁷¹ As an increasing number of licensing agreements are expected, it will be important to identify ways in which a growing proportion of these licences remain with Canadian companies, and are not "exported" to the United States or other countries. Currently, a large proportion of Canadian licensure revenue is from international sources.

Generally speaking, licensing negotiations do not follow a set timetable. For many promising inventions, it may be years before a window of opportunity to commercial development opens. This can be explained in part by the length of time involved in regulatory approval, or in conducting cost-effectiveness analyses. It follows then, that the technology transfer process is complex and highly interactive, involving numerous stakeholders. Often, 7–12 years can pass before significant returns on an invention are realized.⁷²

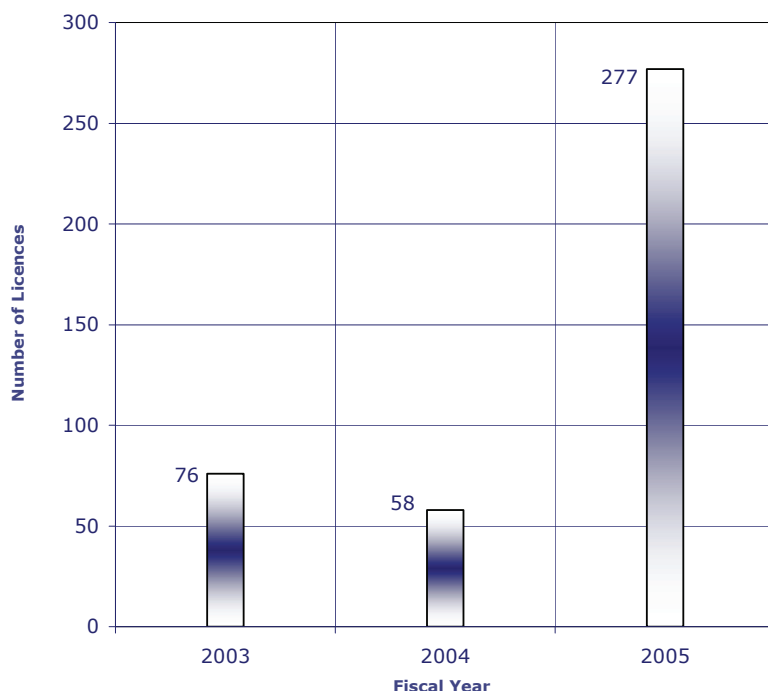
Over the past three years, ACAHO members have licenced a number of new discoveries (see Exhibit 17). In 2003, 76 licences were executed by Teaching Hospitals, RHAs or Research Institutes across the country; in 2004, the number fell slightly to 58 but in 2005, 277 licences were executed, for a total of 411 over a three-year period.

One might speculate that the increase from 2003 to 2005 indicates the applied value of research within ACAHO member organizations and the importance of working with other organizations and private sector companies.⁷³



Exhibit 17

Total Number of Licences Executed by Research Offices



Source: ACAHO Research Funding Flow Survey, 2006

As an increasing number of licensing agreements are expected, it will be important to identify ways in which a growing proportion of these licences remain with Canadian companies, and are not "exported" to the United States or other countries.

vi. LICENCE, ROYALTY AND TECHNOLOGY TRANSFER REVENUE

a. Licence and Royalty Income

Licence agreements continue to be monitored following their conclusion in order to ensure that royalty payments are collected and properly distributed at the end of each fiscal year. After the recovery of direct licensing costs (which may include patent, consulting, prototype development and legal fees), the royalties are typically divided between the researcher(s), and the researcher's institution(s).

According to recent survey data,⁷⁴ in 2005, ACAHO members received over 2,500 contracts, valued at over \$128 million. Moreover, the value of licence and royalty income as reported by ACAHO members is in the magnitude of \$5.5 million. This represents over 277 licences executed in fiscal year 2005, as reported by the research offices.

b. Technology Transfer Revenue

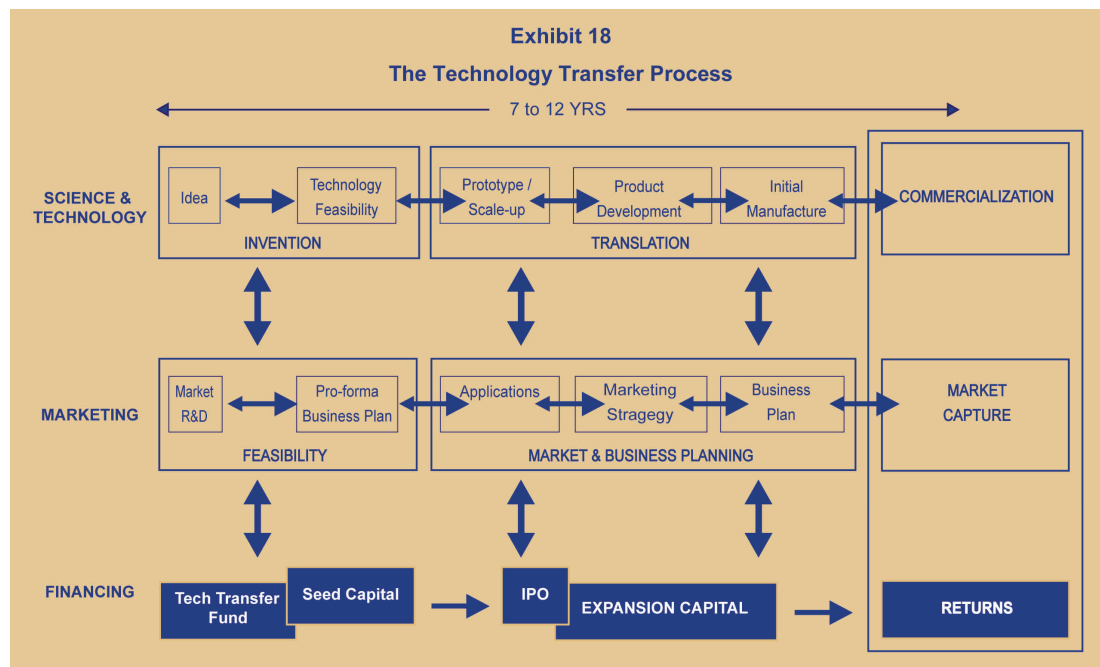
In the case where the discovery or innovation is being licenced as a "technology," the return which accrues from licensing is often referred to as *technology transfer revenue*.⁷⁵ Technology (a concrete expression of scientific enquiry such as an invention, software, or trade secret) can be transferred via a licence, sold outright, or transferred via a more informal mechanism such as consulting (whereby consultants are paid for their time and expertise, but not specifically for the particular ideas transferred) or through individuals who impart knowledge to an employment venue (popularly referred to as "technology transfer on two feet").⁷⁶



From an economic standpoint, licence or royalty income and technology transfer revenue measure returns that flow from the process of research and discovery.

Over the past three years, ACAHO members reported that technology transfer revenue (including licence revenue) was \$7.5 million (2003), \$7.5 million (2004), and \$12.0 million (2005), for a three-year total of \$27.0 million.

Exhibit 18 provides a broad context for understanding the technology transfer process. While each technology transfer is unique, some of the key steps involved in moving technology to market are presented. The diagram illustrates the three parallel processes that take place during the technology transfer process. The first relates to the science and technology discovery process where a particular discovery or invention is assessed for technological feasibility, then translated into a marketable product for commercialization. The second process focuses on or around assessing market conditions and developing a business plan. Finally, the financing stage identifies and procures funds for seed capital, expansion, market penetration etc. in order to make sure that the return-on-investments is in order. ⁷⁷



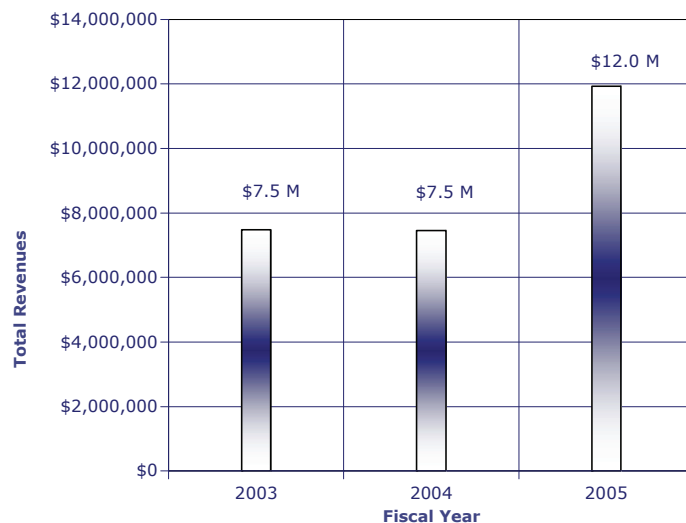
Source: Adapted from the University of British Columbia ⁷⁸

From an economic standpoint, licence or royalty income and technology transfer revenue measure returns that flow from the process of research and discovery. More specifically, it is also one measure of return-on-investment.

Over the past three years, ACAHO members reported that technology transfer revenue (including licence revenue) was \$7.5 million (2003), \$7.5 million (2004), and \$12.0 million (2005), for a three-year total of \$27.0 million. (See Exhibit 19.) ^{79 80}

Exhibit 19

Total Technology Transfer Revenue



Source: ACAHO Research Funding Flow Survey, 2006

vii. SPIN-OFF COMPANIES

Spin-off companies play a revolutionary role generating new products and services, creating dynamic employment opportunities, and in some cases, developing significant economic returns in the form of employment revenues, earnings, capital formation and new public revenue streams.⁸¹ As a result, viable and successful spin-off companies provide a very tangible and measurable metric when it comes to demonstrating the economic and social value of health research.

The final metric of this report focuses on the creation of spin-off companies to commercialize intellectual property owned by an ACAHO member (in its entirety or shared in part with the affiliated University), and/or an ACAHO researcher (independently or shared with the affiliated University).⁸²

Based on our review, since 1985, Canada's Teaching Hospitals, Academic RHAs and their Research Institutes have created a minimum of 81 new companies, originating as spin-off ventures (see Exhibit 20).⁸³

Available data suggests that in 2006, over 2,000 Canadians are employed by ACAHO member spin-off companies.⁸⁴ Importantly, these spin-offs have generated close to \$1.5 billion in investment capital between 1999 and 2006, and have recorded sales well above \$160 million in 2006 alone.⁸⁵

Relative to their university counterparts, hospital spin-off companies are generally smaller in size. The smaller size of hospital spin-offs is most likely attributed to the fact that a higher proportion (71%) of hospital spin-offs were formed in the last 10 years (i.e., 1996 and onwards), whereas 65% of university spin-offs are over 10 years old and have therefore had the chance to more fully develop and mature.⁸⁶

Significantly, it is estimated that 20% of Canadian hospital spin-offs listed are considered public companies; that is, they trade on a public stock exchange such as the Toronto Stock Exchange, the American Stock and Options Exchange or the NASDAQ. The remaining 80% of Canadian hospital spin-off companies listed are privately held.⁸⁷ Statistics reveal that hospital spin-off companies are more likely to establish public entities compared to other sectors, including universities; this is especially remarkable given hospital spin-offs are relatively "young" companies, and as a result they tend to have fewer employees.⁸⁸

That said, a number of hospital spin-off companies are experiencing rapid growth in their early years. Spin-off companies that achieve a doubling of employment in five years or less are considered "gazelles". Gazelles exemplify responsible growth and economic viability. A healthy 19% of hospital spin-off companies have doubled employment within five years to a minimum of 20 employees.⁸⁹ Comparatively, only 1% to 4% of all spin-off companies in Canada achieve "gazelle" status, according to a Statistics Canada and Industrial Research Assistant Program (IRAP) study of over two million firms.⁹⁰

Exhibit 20 highlights a number of successful companies which have spun-off from Teaching Hospitals, RHAs and their Research Institutes across Canada.

Finally, it is important to note that not all research ultimately results in the creation of a spin-off company. Indeed, often technology is licenced to well-established firms to produce new products and services. The result is further growth and maturation of the existing firm, including expanded opportunities for employment, higher sales and therefore the generation of tax revenue.



Spin-off companies play a revolutionary role generating new products and services, creating dynamic employment opportunities, and in some cases, developing significant economic returns in the form of employment revenues, earnings, capital formation and new public revenue streams.

...in 2006, over 2,000 Canadians are employed by ACAHO member spin-off companies. Importantly, these spin-offs have generated close to \$1.5 billion in investment capital between 1999 and 2006, and have recorded sales well above \$160 million in 2006 alone.



Exhibit 20

SELECTION OF SPIN-OFFS COMPANIES FROM ACAHO MEMBERS

1. **AB Biopharma (Calgary Health Region — Calgary, Alberta):** Founded in 2001, AB BioPharma is a nutraceutical company that develops products to help sufferers of gastrointestinal problems. The term “nutraceutical” refers to foods believed to have a medicinal effect on human health.
2. **AdapCS Canada Corporation (Kingston General Hospital — Kingston, Ontario):** Founded in 2003, AdapCS develops information technologies and services for the Canadian health care market that focus on current areas of concern, including clinical and financial outcomes, accountability and access. (www.adapcscanada.com)
3. **Adherex Technologies Inc. (McGill University Health Centre Research Institute — Montreal, Quebec):** Founded in 1998, Adherex Technologies Inc. is a biopharmaceutical company dedicated to the discovery and development of novel cancer therapeutics. Adherex has multiple oncology products in the clinical stage of development. (www.adherex.com)
4. **Advanced Molecular Imagine (AMI) Inc. (Centre Hospitalier de Sherbrooke — Sherbrooke, Québec):** AMI was founded in 2004 to design, develop and manufacture next-generation imaging systems for both clinical and preclinical applications. The company invented MicroSPECT® and its X-SPECT® system is the market leader in the small animal SPECT category. (www.advanced-mi.com)
5. **Advitech (Les Produits Lactotech) (Hôpital Laval — Sainte-Foy, Québec):** Founded in 1995, Advitech is a nutraceutical company specializing in the development of new therapies for health conditions and diseases of the immune system. The term “nutraceutical” refers to foods believed to have a medicinal effect on human health. (<http://advitech.com/>)
6. **Aegera Therapeutics (Children’s Hospital of Eastern Ontario — Ottawa, Ontario):** Aegera Therapeutics, founded in 1995, is a clinical stage biotechnology company focused on developing drugs that control apoptosis (programmed cell death) to address major unmet medical needs. Lead programs are in development to induce apoptosis to kill cancer cells and to prevent apoptosis to save injured neuronal cells. (www.aegera.com)
7. **Affinity Biologicals Inc. (Hamilton Health Sciences/McMaster University — Hamilton, Ontario):** Founded in 1987, the company’s initial focus was the production of reagents for research into disorders of thrombosis and hemostasis (blood clotting disorders). Products include affinity-purified antibodies, matched-pair antibody sets for ELISA, as well as a line of artificially prepared coagulation factor-deficient plasmas. (www.affinitybiologicals.com)
8. **Affinium Pharmaceuticals (University Health Network — Toronto, Ontario):** Founded in 2002, Affinium is a pharmaceutical company focused on the clinical development of antibacterials (used to kill or prevent the growth of bacteria). Affinium’s lead development program encompasses a potent, orally available, novel antibiotic class for the treatment of antibiotic resistant infections. (www.afnm.com)
9. **Amorfix (Sunnybrook Health Sciences Centre — Toronto, Ontario):** Founded in 2004, Amorfix is focused on the diagnosis and treatment of neurodegenerative diseases, where aggregated misfolded proteins (AMP) are prevalent. These include degenerative diseases such as Alzheimer’s, Amyotrophic Lateral Sclerosis (ALS) and Parkinson’s. (www.amorfix.com)
10. **ARIUS Research (University Health Network — Toronto, Ontario):** Since its inception in 1999, ARIUS has been engaged in the research and development of novel anti-cancer monoclonal antibodies (antibodies that are identical because they were produced by one type of immune cell). ARIUS’ proprietary FunctionFIRST™ technology platform uniquely creates functional anti-cancer monoclonal antibodies that belong to a class of revolutionary cancer drugs. (www.ariusresearch.com)
11. **Aspreva Pharmaceuticals (Provincial Health Services Authority/Centre for Molecular Medicine and Therapeutics — Victoria, British Columbia):** Founded in 2003, Aspreva specializes in the search for innovative treatments for less common diseases through the identification, development, and commercialization of late-stage and approved medicines that show potential for high therapeutic impact. (www.aspreva.com)
12. **Atamai Interactive Visualization (Robarts Research Institute — London, Ontario):** Founded in 2000, Atamai is specialized in real time three-dimensional medical image visualization. Atamai operates a growing repository of software components that can be modified and assembled quickly into functioning applications by those who prefer to focus on their problem domain rather than software engineering. The vast majority of this code base is available under a non-restrictive licence, making it attractive for academic environments to use and contribute code. (www.atamai.com)

- 13. Atherochem Inc. (Kingston General Hospital — Kingston, Ontario):** AtheroChem Inc. is developing novel compounds for the treatment of coronary heart disease caused by atherosclerosis, an accumulation of fatty deposits within the artery walls. (www.atherochem.com)
- 14. BioAxe Therapeutic Inc. (Centre Hospitalier de l'Université de Montréal — Montréal, Québec):** BioAxe's strategy is to target the Rho factor protein in RNA transcription and Rho-related pathways with the purpose of developing drugs that meet large unmet medical needs. Rho is a signaling pathway which plays a key role in many disease indications. BioAxe was founded in 2000. (www.bioaxone.com)
- 15. Biomark Imaging Inc. (Robarts Research Institute — London, Ontario):** Founded in 2004, Biomark Imaging Inc. specializes in imaging technology. Imaging technologies, which are varied in their application, can assist in diagnosing and treating conditions such as cardiovascular disease, asthma and mental illness. Imaging technologies are helping to better define clinical trials, and are even changing the way surgery is performed. More recently, imaging technologies are being used to bridge vast geographical expanses.
- 16. Biomira Inc. (Capital Health / University of Alberta — Edmonton, Alberta):** Biomira is a biotechnology company founded in 1985, specializing in the development of innovative therapeutic products for the treatment of cancer. Biomira's goal is to develop and commercialize novel synthetic vaccines and targeted small molecules that have the potential to improve the lives and outcomes of cancer patients. (www.biomira.com)
- 17. BioMS Medical (Capital Health / University of Alberta — Edmonton, Alberta):** BioMS Medical is a biotechnology company engaged in the development and commercialization of novel therapeutic technologies with emphasis on the treatment of multiple sclerosis. BioMS was founded in 2000. (www.biomsmedical.com)
- 18. Biorthex Inc. (Hôpital Sainte-Justine — Montréal, Québec):** In 1994, Biorthex Inc. was established as a biotechnology company that designs, develops, manufactures and markets innovative and proprietary surgical products for the treatment of spinal disorders. The company is dedicated to providing the surgical community with safe, technologically proven and innovative spinal implants for use in the treatment of spinal disorders, diseases and injuries. (www.biorthex.com)
- 19. Cardiovascular Solutions Inc. (Winnipeg Regional Health Authority — Winnipeg, Manitoba)** CSI is developing and commercializing new treatments for restenosis – the blockage of arteries as a result of atherosclerosis. CSI has developed a proprietary product to coat stents which are used to prevent re-blockage of arteries. Successful pre-clinical trials in animal models are being used to prepare an application to be used in clinical trials.
- 20. Cevena Bioproducts Inc. (Capital Health / University of Alberta — Edmonton, Alberta):** Cevena is a science-based manufacturer and supplier of technologically superior oat and barley-based ingredients for the dietary supplement and functional food markets. Cevena was founded in 2002. (www.cevena.com)
- 21. Chenomx Inc. (Capital Health / University of Alberta — Edmonton, Alberta):** Chenomx offers a platform for generating, classifying and interpreting metabolic information obtained from biological fluids. Metabolic profiling allows researchers to link biochemicals to corresponding genes or proteins with relative ease. From these linkages, the detection and validation of potential drug targets can be accelerated. (www.chenomx.com)
- 22. Critical Outcome Technologies Inc. (Robarts Research Institute — London, Ontario):** Founded in 1996, Critical Outcome Technologies' mission is to apply computer technologies to profile, identify and optimize commercially viable drug candidates at the early stage of preclinical drug development and thereby dramatically reduce the time line and cost of getting new drugs to market. (www.criticaloutcome.com)
- 23. CV Technologies (Capital Health / University of Alberta — Edmonton, Alberta):** Founded in 1992, CV Technologies develops and manufactures evidence-based natural health products for disease prevention and health maintenance. CV Technologies' most successful product is Cold-fX, a leading cold and flu product in Canada. CVT trades on the Toronto Stock Exchange. (www.cvtechnologies.com)
- 24. Dementia Guide Inc. (Capital District Health Authority — Halifax, Nova Scotia):** Founded in 2000, Dementia Guide Inc. conducts research and development to create SymptomGuide, a tool to provide simple and comprehensive management of the symptoms of dementia. (www.dementiaguide.ca)





- 25. Diabetogen Biosciences Inc. (Robarts Research Institute — London, Ontario):** Diabetogen is a biotechnology company that discovers and develops new drugs for autoimmune diseases (such as diabetes or lupus). Diabetogen's initial programs focus on the development of novel therapeutics for the treatment, prevention and cure of Type 1 (insulin-dependent) diabetes. (www.diabetogen.com)
- 26. DNA Genotek (The Ottawa Hospital):** Founded in 2003, the DNA Genotek technology "Oragene•DNA" is the easiest, most reliable and cost-effective way to collect, transport, store and process large amounts of human DNA. Oragene•DNA is non-invasive, dependable, and easy-to-use. DNA Genotek markets its products worldwide and has established a global customer base, with more than 1,500 labs in 58 countries currently testing and using its products. (www.dnagenotek.com)
- 27. DriveABLE Assessment Centres Inc. (Capital Health / University of Alberta — Edmonton, Alberta):** DriveABLE provides a scientifically based driving evaluation procedure to identify persons who have become unsafe to drive due to cognitive impairment. Its technology is internationally recognized and can be delivered on a worldwide basis. (www.driveable.com)
- 28. Dynastream Innovations Inc. (Capital Health / University of Alberta — Edmonton, Alberta):** Dynastream's patented SpeedMax technology is the platform on which several personal monitoring devices currently on the market are based. Dynastream is a developer and manufacturer of motion-sensing and communication technologies to large companies worldwide. (www.dynastream.com)
- 29. Emerillon Therapeutics (McGill University Health Centre Research Institute — Montreal, Quebec):** Emerillon Therapeutics is a genomics-based drug discovery company founded in 2003, dedicated to the discovery of novel drug targets in complex human diseases. Emerillon is a spin-off of its parent company Xenon Pharmaceuticals. (www.emerillon.ca)
- 30. GEMMA Biotechnology Ltd. (University Health Network — Toronto, Ontario):** GEMMA BioTechnology, founded in 1996, has developed an immune-boosting nutraceutical ingredient which could find a place in meal-replacement products and food supplements. The company's lead technology is Lactation-Associated ImmunoTrophic Protein (LAIT).
- 31. GlycoDesign Inc. (Mount Sinai Hospital — Toronto, Ontario):** GLYCODesign is a world leader in the field of glycobiology (carbohydrate containing molecules and their role in the body). The company focuses on the discovery and early stage clinical development of novel glycotherapeutics for the treatment of cancer, cardiovascular diseases, inflammation and infectious diseases.
- 32. Iaculor Injection Inc (Centre Hospitalier Universitaire de Sherbrooke — Sherbrooke, Québec):** Iaculor is focusing on the development and commercialization of new generation needle-free medical devices for the delivery of liquid or powder form drugs or vaccines. The company's short-term goal is to complete the development of its medical devices and establish strategic partnerships for their production and commercialization.
- 33. Innovotech (University of Calgary — Calgary, Alberta):** Founded in 1995, MBEC Biofilm Technologies was taken over by Innovotech, a product development company with three core businesses: contract research, commercial sale and product development. (www.innovotech.ca)
- 34. Inception Biosciences (Mount Sinai Hospital — Toronto, Ontario):** Founded in 1996, Inception is the largest cord blood program in Canada, with more than 21,000 samples banked. The Inception Cord Blood Program is able to provide every family with the ability to collect and store their baby's cord blood, while the company's biosciences division focuses on developing new and improved applications for stem cells. (www.biomsmedical.com)
- 35. ISM Biopolymer Inc. (Centre Hospitalier Universitaire de Sherbrooke — Sherbrooke, Québec):** ISM BioPolymer Inc. was founded in 1997. Its mission is to discover, develop and transform natural biopolymers (such as proteins and peptides, DNA, RNA, etc.) into unique, scientifically supported, high commercial-quality active ingredients that will improve human, animal and plant health in targeted indications. (www.ismbiopolymer.com)
- 36. Isotechnika Inc. (Capital Health / University of Alberta — Edmonton, Alberta):** Isotechnika Inc. is an international biopharmaceutical company dedicated to the discovery, development and commercialization of novel immunosuppressive therapeutics (to reduce the activation or efficacy of the immune system) for the treatment of autoimmune diseases (e.g., Type 1 diabetes, lupus, rheumatoid arthritis) and for use in the prevention of organ rejection in transplantation. (www.isotechnika.com)

- 37. Jennerex Biotherapeutics Inc. (The Ottawa Hospital — Ottawa, Ontario):** Founded in 2006, Jennerex Biotherapeutics Inc. is a development stage company working to discover, develop and commercialize novel oncolytic virotherapy products. Virotherapy is an experimental form of cancer treatment using biotechnology to convert viruses into cancer-fighting agents by reprogramming viruses to attack only cancerous cells, leaving healthy cells undamaged. The lead product candidate has completed one Phase I/II clinical trial and is currently in expanded Phase I/II clinical testing. The pipeline product candidates are completing preclinical evaluation and are expected to enter Phase I clinical trials in early 2007. (www.jennerex.com)
- 38. Kinexus (Vancouver Coastal Health Authority — Vancouver, British Columbia):** Founded in 1999, Kinexus is harnessing the powerful synergies of genomics, proteomics (the study of protein) and bioinformatics to understand cell signaling for the advancement of drug discovery, disease diagnosis, and global biomedical research. (www.kinexus.ca)
- 39. KMT Hepatech Inc. (Capital Health / University of Alberta — Edmonton, Alberta):** Founded in 2001, KMT Hepatech, Inc. provides collaborative research services to companies that are in preclinical development of hepatitis C therapeutics and vaccines, utilizing proprietary platform technology. (www.kmthepatech.com)
- 40. Life Imaging Systems Inc. (London Health Sciences Centre — London, Ontario):** The company began operations in 1995 to commercialize medical imaging technologies pioneered at the London Health Sciences Centre. Life Imaging Systems' primary focus is in developing three-dimensional ultrasound imaging technologies to overcome the limitations of conventional two-dimensional ultrasound imaging and increase ultrasound's overall clinical efficacy. (<http://www.imaging.robarts.ca/irlspin.htm>)
- 41. Liponex Inc. (Ottawa Heart Institute — Ottawa, Ontario):** Founded in 2000, Liponex is a biopharmaceutical company moving into Phase II trials with CRD5, its lead candidate. CRD5 raises High Density Lipoprotein (HDL), often called "good cholesterol." Novel HDL therapies, such as CRD5, are an area of significant interest for pharmaceutical companies worldwide. Liponex also has a broad pipeline of products with drug candidates in areas such as atherosclerosis, cancer and infectious disease. (www.liponex.ca)
- 42. LMS Medical Systems (McGill University Health Centre Research Institute — Montreal, Quebec):** LMS is a health care technology company founded in 1993 that develops innovative tools for obstetrical decision support, risk management and clinical information systems. LMS is a leader in the application of advanced mathematical modeling and neural networks for medical use. (<http://www.lmsmedical.com>)
- 43. Lymphosign Inc. (The Hospital for Sick Children — Toronto, Ontario):** LymphoSign Inc. is a private biopharmaceutical company developing drugs acting on signaling pathways involved in the progression of acute leukemias, lymphomas and solid tumours. LymphoSign is developing a number of novel compounds to inhibit abnormal cellular signaling specific to the growth of cancer cells. LymphoSign's lead drug candidate is nearing completion of preclinical testing and has shown great promise as a potential treatment of acute leukemias as well as other cancers. (www.lymphosign.com)
- 44. MDS OCATA (Mount Sinai Hospital — Toronto, Ontario):** MDS Ocata Inc. is a new company using mass spectrometry to identify interacting proteins (www.mdsinc.com).
- 45. Medicure Inc. (Winnipeg Regional Health Authority — Winnipeg, Manitoba):** Founded in 1997, Medicure Inc. is a publicly traded biotechnology company focused on becoming an internationally recognized leader in the development of therapies for unmet cardiovascular needs. (<http://www.dfait-maeci.gc.ca/canada-europa/france/espace/pdf/Medicure-ENG.pdf>)
- 46. MedPharmGene Inc. (Centre Hospitalier de l'Université de Montréal) :** Founded in 2001, MedPharmGene Inc is focused on clinical research in the fields of diabetes and hypertension. Current research aims to verify if more intensive management of blood pressure and glucose levels in diabetic patients is reducing the risk of major complications such as heart attack, stroke, blindness and kidney failure.
- 47. Micralyne Inc (Capital Health / University of Alberta — Edmonton, Alberta):** With core competencies in micromachining, thin film deposition, and micro-electromechanical systems assembly and test capabilities, Micralyne develops and manufactures devices for the communications, energy, life sciences, and transportation markets. Micralyne was founded in 1982. (<http://www.micralyne.com/>)
- 48. MIGENIX (Vancouver Coastal Health Authority — Vancouver, British Columbia):** MIGENIX is focused on the development of drugs to treat or prevent infectious, degenerative and metabolic diseases or disorders. MIGENIX was founded in 1988. (www.migenix.com)





- 49. MJ Laboratory Services Limited (Hamilton Health Sciences/McMaster University – Hamilton, Ontario):** Established in 1990, the company offers a complete range of testing for clinical trials, research projects and product evaluation to pharmaceutical companies, diagnostic manufacturers and researchers. Areas of expertise include the measurement of routine and esoteric hemostasis testing, cytokine testing and DNA analysis. (www.hemostasislab.com)
- 50. Molecular Templates Inc. (University Health Network – Toronto, Ontario):** Founded in 2000, Molecular Templates Inc. aims to advance the preclinical and clinical development of novel treatments for melanoma, prostate and other cancers and move rapidly into clinical trials. (<http://www.moleculartemplates.com/home.htm>)
- 51. MOXXI Medical Inc. (McGill University Health Centre Research Institute – Montreal, Quebec):** Founded in 2003, MOXXI Medical is an integrated delivery system for prescription drug management for physicians, pharmacists, payers and their respective patients. MOXXI Medical will commercialize an electronic prescription and drug-tracking transaction-based solution that directly links physicians prescribing medications, pharmacists fulfilling the prescriptions, and payers (public and private). (www.moxximedical.com)
- 52. NAEJA Pharmaceuticals Inc. (Capital Health / University of Alberta – Edmonton, Alberta):** NAEJA specializes in preclinical drug discovery and contract research in multiple therapeutic areas. NAEJA employs scientific researchers with expertise in all aspects of drug development, including lead optimization, biopharmaceutical profiling, microbiology and custom synthesis. (www.naeja.com)
- 53. Neptune Technologies and Bioresources Inc. (Centre Hospitalier Universitaire de Sherbrooke – Sherbrooke, Québec):** Neptune Technologies and Bioresources Inc. extracts, scientifically validates, and markets natural health products from marine biomasses and currently provides the world's only FDA-approved oil from krill. (www.neptunebiotech.com)
- 54. Neurochem Inc. (Kingston General Hospital – Kingston, Ontario):** Neurochem is a publicly traded pharmaceutical company with product candidates in clinical development for amyloid-related diseases and disorders of the central nervous system (such as Huntington's disease, Parkinson's disease, etc). Neurochem was founded in 1994. (www.neurochem.com)
- 55. Neuromed Pharmaceuticals (Vancouver Coastal Health – Vancouver, British Columbia):** Formed in 1998, Neuromed Pharmaceuticals develops drugs to target chronic pain, including neuropathic pain and inflammatory conditions such as arthritis. In March 2006, Neuromed and Merck & Co. signed a research collaboration and licence agreement to research, develop and commercialize novel compounds for the treatment of pain and other neurological disorders, including Neuromed's lead compound NMED-160 for the treatment of pain, which is currently in Phase 2 development. (www.neuromed.com)
- 56. NovaNeuron (Capital District Health Authority – Halifax, Nova Scotia):** By studying Huntington's disease (HD) mouse models and post-mortem brains of HD patients, NovaNeuron scientists discovered a drug target for HD. Research is ongoing to demonstrate the link between this target and the pathogenesis of HD.
- 57. OncoGeneX (Vancouver Coastal Health – Vancouver, British Columbia):** Founded in 2000, OncoGeneX is a biopharmaceutical company committed to the development and commercialization of new cancer therapies that address treatment resistance in cancer patients. OncoGeneX currently has three product candidates in development. These product candidates are designed to selectively inhibit the production of proteins that are associated with treatment resistance and that are over-produced in response to a variety of cancer treatments. (www.oncogenex.ca)
- 58. Oncolytics Biotech Inc. (Calgary Health Region – Calgary, Alberta):** Founded in 1998, Oncolytics is a Calgary-based biotechnology company focused on the development of oncolytic viruses as potential cancer therapeutics. Oncolytics' clinical program includes a variety of Phase I and Phase I/II human trials. (www.oncolyticsbiotech.com)
- 59. Osteokine Inc. (Hamilton Health Sciences/McMaster University – Hamilton, Ontario):** Osteokine Inc. is a small biotechnology company that has as its main focus the development of novel therapeutics for the treatment and prevention of postmenopausal bone loss. Osteokine investigators have made exciting observations in animal models, enabling the identification of the molecular mechanisms responsible for bone loss leading to the development of specific agents to reverse these mechanisms.
- 60. Plantigen Inc. (London Health Sciences Centre – London, Ontario):** Plantigen Inc. is a novel therapeutics discovery company focused on the identification and development of biopharmaceuticals in genetically enhanced plants to prevent and treat disease. (www.lhsc.on.ca/plantigen)

- 61. Prognomix Inc. (Centre Hospitalier de l'Université de Montréal) :** Founded in 2006, Prognomix aims to develop new prognostic genomic biomarkers for the early identification of subset of type 2 diabetes patients at risk of developing renal, cardiovascular, nervous or ocular complications.
- 62. Quillsoft Ltd (Bloorview Kids Rehab – Toronto, Ontario):** Founded in 2000, Quillsoft manufactures and distributes specialized writing software (WordQ and SpeakQ software) for individuals with learning disabilities. Distribution includes Canada, USA, UK, Germany, Australia and New Zealand. WordQ is available in English, French, German, and Spanish. There are currently more than 100,000 WordQ users, with gross revenues in excess of \$1.5 million. (www.wordq.com)
- 63. Resonant Medical (McGill University Health Centre Research Institute – Montreal, Quebec):** A privately-held company founded in 2000 by industry experts, Resonant Medical develops, manufactures and commercializes 3-D ultrasound image-guided adaptive radiotherapy products. Radiotherapy is the use of radiation as part of cancer treatment to control malignant cells. The goal is to help cancer centres make significant improvements in radiation therapy planning, verification and delivery in order to advance patient care. (www.resonantmedical.com)
- 64. Resverlogix Corp. (Calgary Health Region – Calgary, Alberta):** Resverlogix Corp. is a publicly traded biotechnology company focused on groundbreaking research in the areas of cardiovascular disease, cancer, and fibrotic diseases. Resverlogix was founded in 2003. (www.resverlogix.com)
- 65. Saga Tech Electronics Inc. (Calgary Health Region – Calgary, Alberta):** SagaTech focuses on creating innovative medical devices for the diagnosis and management of sleep apnea. SagaTech develops and manufactures convenient, scientifically valid devices that provide cost-effective solutions to diagnostic and therapeutic challenges in the field of sleep-disordered breathing. (www.sagatech.ca)
- 66. Sembiosys (Calgary Health Region – Calgary, Alberta):** Sembiosys develops products using its proprietary oilbody-oleosin technology to treat cardiovascular and metabolic diseases, while harvesting the investments that have been made in non-pharmaceutical products. Sembiosys employs nearly 50 researchers in its Calgary headquarters. (www.sembiosys.com)
- 67. Sentinelle Medical (Sunnybrook Health Sciences Centre – Toronto, Ontario):** Sentinelle Medical, which has grown out of leading-edge research at Sunnybrook and Women's Health Sciences Centre, is dedicated to furthering breast MRI and interventional technology. (www.sentinellemedical.com)
- 68. Sirius Genomics (Vancouver Coastal Health – Vancouver, British Columbia):** Sirius Genomics is a life sciences company that uses pharmacogenomics in the research, development and commercialization of genetic-based diagnostic products for the treatment of critical illnesses and severe infections. The company identifies important genetic variations in the biological pathways that are important in critical illness and severe infection and then uses this information to select the appropriate treatment for each patient. These discoveries will make possible dramatic improvements in the design and results of the efficacy of clinical trials and clinical care through the selection of appropriate patients. (www.siriusgenomics.com)
- 69. Solution YD3 (Centre Hospitalier de l'Université de Montréal) :** Founded in 1999, YD3 is commercializing a 3D evaluation tool of knee kinematics comprised of a harness and data analysis software. The method provides quantitative data for the 3 main knee movements. Real-time data is obtained by harnessing sensors to the knee thus producing the personalized signature of the patient's knee (BIOKNEE™).
- 70. Spectral Diagnostics (University Health Network – Toronto, Ontario):** Spectral is a developer of innovative technologies for comprehensive disease management. It provides accurate and timely information to clinicians enabling the early initiation of appropriate and targeted therapy. (<http://www.spectraldx.com/>)
- 71. Stem Cell Therapeutics (Calgary Health Region – Calgary, Alberta):** Stem Cell Therapies is developing a pipeline of CNS-regenerative drugs to treat traumatic brain injury. (www.stemcellthera.com)
- 72. Stempath Inc. (The Ottawa Hospital – Ottawa, Ontario):** Founded in 2002, Stempath Inc. aims to become the first pharmaceutical company specializing in therapeutic solutions that modulate the body's natural regenerative capacity. Currently at the discovery stage, StemPath is engaged in *in vivo* proof-of-concept experiments and anticipates entering into preclinical testing by early 2007. (www.stempath.com)
- 73. Strida Pharma Inc. (McGill University Health Centre Research Institute – Montreal, Quebec):** Strida Pharma Inc. is a biopharmaceutical company dedicated to improving the survival and quality of life of cancer patients by developing targeted therapeutics focused on a proprietary strategic anti-cancer target. Strida Pharma Inc was founded in 2002. (www.stridapharma.com)



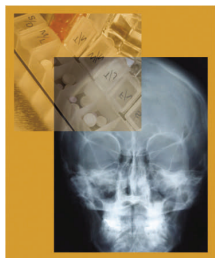


- 74. Topigen Pharmaceuticals Inc (Centre Hospitalier de l'Université de Montréal) :** Founded in 2005, Topigen is developing several new classes of drugs and is actively progressing two drug candidates in Phase II trials for Chronic Obstructive Pulmonary Disease and asthma. These drugs are uniquely focused on inhibiting multiple inflammation targets underlying chronic pulmonary diseases. (www.topigen.com)
- 75. Transition Therapeutics Inc (Mount Sinai Hospital — Toronto, Ontario):** Founded in 1998, Transition Therapeutics is a fully integrated biopharmaceutical company with a proprietary state-of-the-art drug discovery engine and extensive drug development program exploring novel therapeutics in multiple disease indications. (www.transitiontherapeutics.com)
- 76. TrialStat (Children's Hospital of Eastern Ontario — Ottawa, Ontario):** TrialStat is an Ottawa based technology and services company, founded in 2002, providing powerful, cost-effective turn-key data capture and management tools for researchers and investigators in health care. TrialStat provides proven, industrial-strength data management software solutions to the clinical research community. Focused specifically on clinical trials, systematic reviews and patient registries, TrialStat's comprehensive, intuitive products are helping hundreds of clinicians to manage their data and their entire studies efficiently, securely and cost effectively. (www.trialstat.com)
- 77. Trillium Technologies (Robarts Research Institute — London, Ontario):** Founded in 1996, Trillium Technologies is a research-driven biopharmaceutical company with a strong immunology focus, specializing in the discovery and development of innovative therapies for the treatment of immune-mediated disorders. The company's therapeutic approaches are aimed at restoring balance to the immune system in conditions associated with aberrant and harmful immune responses, such as autoimmune and inflammatory disorders, graft rejection, cancer and chronic viral diseases. (<http://www.trilliumtherapeutics.com/>)
- 78. Unleashed Informatics Ltd. (Mount Sinai Hospital — Toronto, Ontario):** Founded in 2004, Unleashed Informatics is targeted to the general life sciences market, including biotechnology and pharmaceutical firms, with a focus on bioinformatics, genomics, proteomics, and cheminformatics applications. (www.unleashedinformatics.com)
- 79. Variation Biotechnologies Inc. (Children's Hospital of Eastern Ontario — Ottawa, Ontario):** Variation Biotechnologies Inc. was founded in 2001 to commercialize pioneering research in the bioinformatic design of vaccines. Variosite technology addresses the issue of "antigenic variation," which allows viral pathogens to escape detection by the human immune system; the technology can be applied to viruses such as HIV, hepatitis C, influenza, SARS and dengue. In 2006, Variation was named one of the top 10 life science companies in Canada. (www.variationbiotech.com)
- 80. Vascular Therapeutics Incorporated (Hamilton Health Sciences/McMaster University — Hamilton, Ontario):** Since acquired by GlycodeSIGN in 1999, Vascular Therapeutics Incorporated (VTI) was funded to the level of one million USD per year, in return for 10 years of first rights of refusal of discoveries in the treatment of thrombosis. (www.hemostasislab.com)
- 81. ViRexx (Capital Health / University of Alberta — Edmonton, Alberta):** ViRexx is an Edmonton, Alberta-based biotechnology company focused on the development of novel therapeutic products for the treatment of cancer and chronic viral infections. ViRexx's most advanced clinical programs include drug candidates for the treatment of ovarian cancer, chronic hepatitis B&C and solid tumours. (www.virexx.com)
- 82. Viron Therapeutics Inc. (Robarts Research Institute — London, Ontario):** Founded in 1997, Viron Therapeutics Inc. is a biopharmaceutical company dedicated to becoming a market leader in the treatment of inflammatory disorders. By harnessing the evolutionary power of viruses that have evolved over millennia, the company is developing powerful protein therapeutics that will block the human body's inflammatory attack. (www.vironinc.com)
- 83. VisualSonics Inc. (Sunnybrook Health Sciences Centre — Toronto, Ontario):** VisualSonics is the leading developer of high-resolution, *in-vivo* micro-imaging systems devised specifically for non-invasive, small animal research. High-resolution imaging allows the small animal researcher to derive results in ways that were previously possible to imagine, but extremely difficult to achieve. (www.visualsonics.com)
- 84. World Heart Corporation (The Ottawa Hospital — Ottawa, Ontario):** Founded in 1996, World Heart is a global technology leader in mechanical circulatory support systems. World Heart provides long-term mechanical circulatory support to the population of heart failure patients. World Heart is developing both pulsatile ventricular assist devices (VADs), which mimic the action of the natural heart, as well as the continuous flow rotary VAD, which is smaller and more easily implanted. (www.worldheart.com)

- 85. Xenon Pharmaceuticals (Vancouver Coastal Health Authority/Provincial Health Services Authority – Vancouver, British Columbia):** Xenon is a privately held company located in Vancouver with just over 70 employees. Xenon is a leader in clinical genetic-based drug discovery and development and has built a worldwide network of over 40 clinical collaborators to find and access the rare families with diseases of relevance to drug discovery. (www.xenon-pharma.com)
- 86. Xillix Technologies (Provincial Health Services Authority – Vancouver, British Columbia):** Founded in 1988, Xillix focuses on the research, development and commercialization of medical imaging technologies which aid in the early detection and localization of cancer. (www.xillix.com)
- 87. XLR Imaging (Robarts Research Institute – London, Ontario):** Founded in 2003, XLR develops and manufactures MRI imaging products and solutions. (www.xlrimaging.com)



In developing a science and technology strategy for Canada, the critical question is what combination of policy levers should be implemented that will maximize our collective investments in Canada's health research enterprise?



11. LOOKING TO THE FUTURE...

In closing, *Moving at the Speed of Discovery* is about Canada and how science and technology can and must constructively shape our collective future. It is about understanding the issues and challenges that are before us and the important public policy choices that need to be made if Canada is to thrive and not simply survive in a world that increasingly competes for knowledge on a global scale. Finally, it is about providing Canadians with the highest quality of life possible.

To do so, however, requires a compelling vision of where we want to go, and a committed plan of action that is achievable and measurable.

In this context, ACAHO believes that *Moving at the Speed of Discovery* can make an important contribution to better understanding the relationships between: (1) science and technology — which is the building block of modern medicine and the discovery and knowledge creation process, and (2) research inputs and outputs — which can provide Canadians with unparalleled health, health care and unlimited opportunities for the future. As we have stated in this report, ACAHO views these public policy objectives as being mutually reinforcing rather than competitive in nature.

In developing a science and technology strategy for Canada, the critical question is what *combination* of policy levers should be implemented that will maximize our collective investments in Canada's health research enterprise?

Knowing that we are at the beginning of a biotechnology revolution, and that we are pursuing other advances in health research (e.g., nanotechnology, robotics, population and public health, health services), ACAHO firmly believes that any retrenchment in funding the health research enterprise would have serious consequences for Canada's ability to attract and retain world-class researchers — not to mention our ability to continue to advance the process of discovery and innovation.

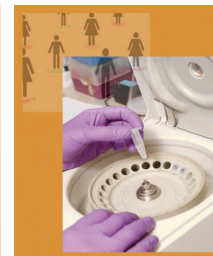
In our view, any move away from our commitments to health research, innovation and successful commercialization would result in Canada falling out of step with those countries that place tremendous value on the linkages between creating knowledge and its spin-off effects — particularly in a global economy that competes — and wins — on the advancement and translation of knowledge.

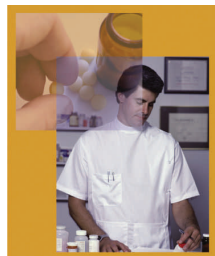
Finally, in a world that demands of all public and private institutions increased accountability and transparency for what we do, *Moving at the Speed of Discovery* takes an important step forward by making the link between what is invested in the health research enterprise and the range of products and services that are the offspring of innovation.

This report should be considered a starting point in terms of available data on a range of metrics. ACAHO looks forward to continuing to build a robust set of information that tells the compelling stories that come from health research, medical discovery, knowledge creation and innovation.

END NOTES

1. The Conference Board of Canada, *Biotechnology in Canada: A Technology Platform for Growth*, (Ottawa: The Conference Board of Canada, 2005).
2. Dr. Henry Friesen, "Lifetime of Leadership," *BioScience World*. March 2005.
3. In an interesting series of presentation and discussions about how to improve the convergence of health, health care and economic prosperity is contained in the following publication: *Advancing Health, Science and the Economy - Innovative Thinking on the Future of Canadian Health Care*, November 2000 – as part of the "Directions for Canadian Health Care" published by Merck Frosst.
4. In the report *"The State of Science & Technology in Canada"* (Council of Canadian Academies, 2006), science and technology is defined as one joint entity, of which the *health sciences* is identified as one discipline.
5. A more in-depth review of "world firsts" produced by ACAHO members is listed in section 10 of the report. As well, ACAHO will be releasing a separate report entitled "Eureka! World's First and Other Major Medical Breakthroughs in ACAHO Member Institutions".
6. Health Innovation Canada Factsheet, December 2003.
7. T.J. Courchene, *Medicare as a Moral Enterprise: The Romanow and Kirby Perspectives*. Institute for Research on Public Policy, 2003, p. 12.
8. The Committee on the State of Science & Technology in Canada, Council of Canadian Academies, *The State of Science & Technology in Canada*, September 2006.
9. A cross-city comparison was recently conducted and released by the Toronto Regional Research Alliance in November 2006: *At a Crossroads — Strengthening the Toronto Region's Research and Innovation Economy*.
10. The Conference Board of Canada, *Mission Possible: Stellar Canadian Performance in the Global Economy*. (Ottawa: The Conference Board of Canada, 2007).
11. The Economist. *Innovation and the Economy. The Good, The Bad and The Ugly*. August 2007.
12. In 2003, Secor presented a ten point strategy to improve Canada's performance in health innovation. Source: *Health Care and the Innovation Agenda: Assuring Canada's Growth in the Life Sciences Century* – report from the Conference on Health Innovation, Wealth Creation and System Renewal, November 2003 – as part of the "Directions for Canadian Health Care" published by Merck Frosst
13. *Health Care in Canada Survey 2006* – A National Survey of Health Care Providers, Managers and the Public. Conducted by POLLARA Research, November 2006.
14. *Canada Speaks! 2006*. Research Canada's First Public Opinion Survey on Health Research in Canada. Conducted by Environics, November 2006.
15. The Conference Board of Canada, *Mission Possible: Stellar Canadian Performance in the Global Economy*, Chapter 4.
16. J-P Cotis, "Benchmarking Canada's Economic Performance," *International Productivity Monitor*. Number 13, Fall 2006.
17. In the 2004 Speech From the Throne, the federal government recognized the relationship between innovation and economic development: "*Canada must now elevate its economic performance to the next level. Advancing technology and pervasive global competition demand of Canada a commitment to excellence, the pursuit of greater productivity, and a vision directed outward to the challenges and opportunities the world presents... The next challenge is to turn more of Canadians' bright ideas into dynamic businesses, great jobs and growing export earnings.*" The 2006 Speech from the Throne addressed the relationship between innovation and economic prosperity: "*Over the course of its mandate...the Government will work diligently to build a record of results. It will promote a more competitive, productive Canadian economy.*"
18. *The Health of Canadians — The Federal Role*. Final Report on the State of the Health Care System in Canada. Standing Committee on Social Affairs, Science and Technology. Volume Six: Recommendations for Reform, October 2002, p. 207.





19. *The progress that Canada has made in funding health research is reflected in data that has been released by the OECD. Using the measure of government budget appropriations or outlays for research and development (GBAORD). In 2004, Canada ranked 4th amongst health-related R&D in government budgets as a percentage of GDP. As well, over the 2000-2004 period, Canada's average annual growth rate was 17.5%, placing it 4th amongst OECD countries. Source: OECD Science, Technology and Industry Scoreboard 2005 – ISBN 92-64-01055-6. OECD 2005, p. 29.*
20. Statistics Canada defines RSA as activities that complement and reinforce R&D efforts by contributing to the generation, dissemination, and application of scientific and technological knowledge. For the purposes of calculating federal S&T expenditures, Statistics Canada includes activities such as scientific data collection; testing and standards development (work directed toward the establishment of national and international standards for materials, devices, products and processes, the calibration of secondary standards, and non-routine quality testing); and scientific information and museum services (e.g. the operation of scientific and technical libraries, publication of scientific journals and monographs, and S&T consulting and advisory services). RSA is central to the government's ability to monitor and regulate risks and health and environmental effects in the public interest. Many of the important S&T-based services that the public expects the government to deliver are supported by RSA, such as weather forecasting, the regulation of new drugs and medical devices, and the monitoring of activities and impacts related to environmental hazards and risks.
21. *The Global Technology Revolution 2020, Technology Trends and Cross-Country Variation.* Rand Research Brief, National Security Research Division, Rand Corporation, 2006. *The Global Technology Revolution 2020 — In-Depth Analyses: Bio/Nano/Materials/Information Trends, Drivers, Barriers and Social Implications.* Technical Report, National Security Research Division, Rand Corporation, 2006.
22. Statistics Canada. Science Statistics – Science, Innovation and Electronic Information Division. Catalogue Number 88-001-XIE/ISSN1209-1278, March 2007.
23. In particular, most provinces, with the notable exception of Ontario, have established a medical research organization that invests in health research: Michael J. Smith Foundation for Health Research (British Columbia); The Alberta Heritage Foundation for Medical Research (Alberta); Saskatchewan Health Research Foundation (Saskatchewan); Manitoba Health Research Council (Manitoba); Fonds de recherche en santé Québec (Québec); Medical Research Fund of New Brunswick (New Brunswick); Nova Scotia Health Research Foundation (Nova Scotia); Newfoundland and Labrador Centre for Applied Health Research (Newfoundland and Labrador).
24. Association of Canadian Academic Healthcare Organizations, *A View from the Top: A Survey of ACAHO's Presidents & Chief Executive Officers* (Ottawa: Association of Canadian Academic Healthcare Organizations. 2006).
25. For example, BIOTECANADA has recommended changes to Canada's Scientific Research & Experimental Development (SR&ED) Program. Its recommendations are intended to ensure that all small and medium-sized enterprises (SMEs) conducting R&D in Canada have immediate access to refundable tax credits. Specifically, it recommends that the SR&ED annual R&D expenditure limit increase from \$2 million to \$10 million; that the current Canadian Controlled Private Corporation (CCPC) restriction on SR&ED be removed, while maintaining eligibility requirements (taxable income and taxable capital thresholds); and that the taxable income and taxable capital gains thresholds that are used to determine entitlement for refundability be reviewed and adjusted. See *Investing in Canada's Future — BIOTECANADA's Proposed SR&ED Policy Amendments*, February 2007.
26. United Kingdom Department of Health, *Best Research for Best Health — A New National Health Research Strategy.* (London: U.K. Department of Health, January 2006).
27. Association of Canadian Academic Healthcare Organizations. *Leveraging our Investments in Health & Health Research...Drivers of Sustained Prosperity.* Submission to the House of Commons Standing Committee on Finance, September 2006.
28. *An Innovative, Prosperous Québec.* Québec Research and Innovation Strategy. 2006
29. *Ministry of Research and Innovation. Strategic Plan. November 2006. The goals are as follows: (1) Ontario will be the preferred location to grow knowledge-based businesses because of its innovation culture, commerce-friendly environment, highly qualified workforce, support for business and entrepreneurship, access to investment capital and competitive tax policies; (2) Ontario will be the preferred location for the best and brightest scientists and innovators from around the world because of its globally recognized R&D excellence and the efficient transition of ideas from the laboratory bench to the marketplace; (3) Ontario will attract increased private-sector investment in R&D, becoming a leader in the rapid introduction of innovative products; (4) Ontario will generate the highly qualified workforce needed by an innovation-based economy through greater awareness of the key role played by careers in science, engineering, business and entrepreneurship; and (5) Ontario's government will lead by example, with integrated and coordinated innovation initiatives across all ministries and a culture of innovation in its own operations.*

30. A device that pulverizes kidney stones by passing shock waves through a water-filled tub in which the patient sits. The procedure creates stone fragments small enough to be expelled in the urine.
31. Association of Universities and Colleges of Canada, *Momentum — The 2005 Report on University Research and Knowledge Transfer*. (Ottawa: Association of Universities and Colleges of Canada, 2005).
32. Association of Canadian Academic Healthcare Organizations, *ACAHO Research Funding Flow Survey of Members*. 2006.. As there is little comprehensive information that captures all funding dimensions of the health research enterprise in Canada, ACAHO administered a comprehensive survey of its members in 2006.
33. A recent report by the Ottawa Centre for Research and Innovation (OCRI) noted the shortage of critical talent in the life sciences and biotechnology sectors (*Trends, Opportunities and Priorities (TOP) Report*, prepared by Talentworks, a program of OCRI, January 2007). As well, *The Economist* recently called highly trained scientists and engineers “the hottest commodity on the planet.”
34. Canadian Institutes of Health Research, *Balance of Funding in Canadian Health Research and Future Funding Requirements*. (Ottawa: Canadian Institutes of Health Research, September 2006).
35. United Kingdom Department for Education and Skills, *Science & Innovation Investment Framework, 2004–2014*. July 2004, p. 154.
36. A series of compelling stories that focus on the *translation* of research are contained in the publication *Discovery. Innovation. Our Future*” by the Council of Academic Hospitals of Ontario. 2006.
37. Glenn Brimacombe, “Health, Healthcare and Nation-Building: A Three-Dimensional Approach to Innovation in Canada.”. *Healthcare Quarterly*, Vol. 8, No. 3, 2005.
38. *A 10-Year Plan to Strengthen Health Care*, First Ministers, September 14, 2004.
39. Adapted from Buxton and Hanney, 1997, as well as the Council of Academic Hospitals of Ontario *Discovery. Innovation. Our Future. A Profile of Health Research from Ontario’s Academic Hospitals & Health Research Institutes*. Council of Academic Hospitals of Ontario. 2006, p. 3.
40. Council of Academic Hospitals of Ontario, *Discovery. Innovation. Our Future. A Profile of Health Research from Ontario’s Academic Hospitals & Health Research Institutes*. 2006, p. 4.
41. United States Senate, *The Benefits of Medical Research and the Role of the NIH* (Washington, D.C.: United States Senate. May 2000), p. 16.
42. E. Mansfield, “Academic research and industrial innovation: An update of empirical findings.” *Research Policy* 26 (1998), pp. 773–776.
43. M. Beise and H. Stahl, “Public research and industrial innovation in Germany,” *Research Policy* 28: (1999), pp. 397–422.
44. I.M. Cockburn and R. M. Henderson, “Publicly Funded Science and the Productivity of the Pharmaceutical Industry,” NBER Conference on Science and Public Policy, Washington, D.C., 2000.
45. A.A. Toole, *The impact of public basic research on industrial innovation: evidence from the pharmaceutical industry*. SIEPR Discussion Paper No. 00-07. Stanford, California, 2000.
46. The Allen Consulting Group, *A Wealth of Knowledge: The Return on Investment from ARC-Funded Research*. 2003.
47. Mary Woodward Lasker Charitable Trust/Funding First, *Exceptional Returns — The Economic Value of Americans Investment in Medical Research*,. 2000.
48. William D. Nordhaus, *The Health of Nations: The Contribution of Improved Health to Living Standards*. (New Haven: Yale University, 1999).
49. Dr. Elias Zerhouni, *NIH Fiscal Year 2007 Budget Report* (2006).
50. KPMG, *Economic and Social Impacts of Research at the UBC Faculty of Medicine and the Affiliated Teaching Hospitals*. October 1999.





51. The debate about which is the most appropriate application of evaluation methodologies can be broadly categorized into bibliometric analyses; cost-benefit and economic analyses; case studies; retrospective analyses; surveys; and benchmarking comparisons. Buxton et al. (*Assessing the Payback from Health R&D: From Ad Hoc Studies to Regular Monitoring*. HERG Research Report, No. 27, December 1999) indicated that qualitative and quantitative approaches can be used to assess payback but that immense problems exist with time lags and attribution of outcomes to specific items of research funding. He also noted that commercial benefits can “spill over” into other sectors and that research generates non-commercial benefits that require a departure from traditional economic measurement tools. Meltzer (*Can Medical Cost-Effectiveness Analysis Identify the Value of Research?* University of Chicago, 1999) indicated that calculations based on the tools of cost-effectiveness may help assess the value of research in a range of clinical contexts, but may not provide much insight into the value of basic research. SPRU (*The Economic Returns to Basic Research and the Benefits of University-Industry Relationships. A Literature Review and Update of Findings*, 2001, SPRU — Science and Technology Policy Research, University of Sussex, United Kingdom) observed that debate about measuring comprehensive returns to public research and development has encouraged researchers to adopt a “modest” approach, focusing on measuring the relationship between public funding and specific desirable outcomes. Academics have concluded that there is no one best method of evaluating research, but methods can be complementary. There is a good deal of literature available on evaluation methodologies, most notably from the United Kingdom.
52. For instance, in addition to the reporting activities of members of ACAHO, the Innovation Institute of Ontario (www.Iio.on.ca) has developed a methodology (called “Factorial”) for the efficient collection, management and reporting of academic activities and research results that can be used for impact assessment and performance management.
53. A similar framework depicting the different phases of the commercialization process has been developed by The Ontario Centres of Excellence (An Introductory Guide for Researchers, The Intellectual Property Management Offices of Ontario’s Universities and Hospitals and OCE Inc, March 2005).
54. *Complementing this framework, an interesting overview of commercialization best practices for health research in relation to University Health Network, The Hospital for Sick Children and Mount Sinai has been undertaken by Dr. Chris Riddle “Commercialization Best Practices: Performance and Resources of Toronto Research Hospitals – Supplement to Commercialization Best Practices Study”, May 2004.*
55. *Eureka! World First Discoveries and Other Major Medical Breakthroughs in ACAHO Member Institutions...* A comprehensive publication of world-first discoveries as they have occurred in ACAHO member institutions will be available in the Fall of 2007.
56. *Follow the Funding*, ACAHO Research Funding Flow Survey, 2006.
57. Council of Academic Hospitals of Ontario, *World Class Achievements and Major Medical Breakthroughs*. 2004.
58. Canadian Institute of Health Research, *Evidence in Action, Acting on Evidence – A Casebook of Health Services and Policy Research Knowledge Translation Stories*, (Ottawa: Canadian Institutes of Health Research, 2006) and Canadian Institutes of Health Research, *Your Health Research Dollars at Work*. (Ottawa: Canadian Institutes of Health Research, 2005–06).
59. Many of the world-first discoveries listed in Exhibit 13 resulted from research funded by CIHR.
60. Mr. Brad Wheeler, Technology Transfer Manager, University-Industry Liaison Office, University of British Columbia.
61. *Follow the Funding*, ACAHO Research Funding Flow Survey, 2006. Member research offices were asked how many disclosures were recorded over the past three fiscal years.
62. *Canadian University Publications 2006*. Re\$earch Infosource Inc. June 2006.
63. *State of Science & Technology in Canada*. The Committee on the State of Science & Technology in Canada. September 2006, p 79.
64. *Canadian University Publications 2006*. Re\$earch Infosource Inc. June 2006.
65. The “factors of production” are defined as: capital, entrepreneurship, land and labour.
66. University of British Columbia, UILO webpage. www.uilo.ubc.ca
67. Ibid. University of British Columbia, UILO webpage. www.uilo.ubc.ca

68. Mr. Brad Wheeler, Technology Transfer Manager, University-Industry Liaison Office, University of British Columbia.
69. It is important to make the distinction between (provisional or full) patents filed and patents issued. At the University of British Columbia, for example, approximately 25% of patents filed are ultimately issued.
70. *Follow the Funding, ACAHO Research Funding Flow Survey, 2006.* Member research offices were asked how many provisional and full patents were filed over the past three fiscal years.
71. Mr. Brad Wheeler, Technology Transfer Manager, University-Industry Liaison Office, University of British Columbia.
72. Ibid.
73. *Follow the Funding, ACAHO Research Funding Flow Survey, 2006.* Member research offices were asked how many licences were executed over the past three fiscal years.
74. Ibid.
75. Mr. Brad Wheeler
76. Dr. Jean Farall, PhD. Jean Farall & Associates. Technology Transfer Consultant at the Children's Hospital for Eastern Ontario Research Institute. February 2007.
77. Global Development Research Centre. www.gdrc.org
78. Technology Transfer Process adapted from the University of British Columbia. www.uilo.ubc.ca
79. *Follow the Funding, ACAHO Research Funding Flow Survey, 2006.* Member research offices were asked what their technology transfer revenue was over the past three fiscal years.
80. It is important to understand that technology transfer revenue will not be captured if the Technology Transfer Office (TTO) is not engaged in the commercialization process. Therefore, technology transfer revenue is often under-reported (as in this case), and the three-year total of \$27.0 million represents only the revenue that was captured through engagement of the TTO.
81. *The Health of Canadians – The Federal Role.* Final Report on the State of the Health Care System in Canada. Standing Senate Committee on Social Affairs, Science and Technology. Volume Six: Recommendations for Reform, October 2002, page 218.
82. Dr. Denys Cooper. National Research Council. 2006
83. Dr. Denys Cooper. National Research Council. January 3, 2007.
84. Ibid.
85. Ibid.
86. Ibid.
87. Ibid.
88. Ibid.
89. Ibid.
90. Ibid.





APPENDIX A

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While members of the Association are the institutions or regional health authorities, they are represented by the President and CEO of that organization.

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APPENDIX B

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