2015 10 YEARS ANNÉES

The Henry G. Friesen
INTERNATIONAL PRIZE
in Health Research

LE PRIX INTERNATIONAL
de la Recherche en Santé Henry G. Friesen

2015 Friesen International Prize Program

1."The Role of Discovery Research in the Health of Canadians"

2."Does Canada Have Too many PhDs?"

Proceedings of Policy Roundtables

Amis des instituts de recherche en santé du Canada
FCIHR/AIRSC
Friends of Canadian Institutes of Health Research

RCIS
Royal Canadian Institute for Science

BANTING
RESEARCH FOUNDATION

www.fcihr.ca www.rciscience.ca www.bantingresearchfoundation.ca

December 7-8, 2015
University of Ottawa
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The Henry G. Friesen International Prize in Health Research is awarded in recognition of the distinguished leadership, vision and innovative contributions of Dr. Henry G. Friesen. The prize supports an annual Public Forum and address to the Canadian Academy of Health Sciences (CAHS). Through the partnership of CBC Radio One Ideas, the lecturer is interviewed for broadcast to reach a national audience. Over the past decade a variety of activities have been added including institutional visits and high level roundtables on major health research topics. Please Visit http://www.fcihr.ca/prize/ for more information and a history of the Henry G. Friesen International Prize.

Messages from the Presenting Organizations

Dr. Aubie Angel, President, Friends of CIHR.

Dr. Aubie Angel

Friends of CIHR is celebrating its 15th anniversary in Ottawa on December 7th-8th, 2015, coincident with the 10th anniversary of the Henry G. Friesen International Prize in Health Research. To commemorate these milestones, FCIHR partnered with two venerable organizations – The Royal Canadian Institute for Science (RCIS) and The Banting Research Foundation (BRF) to develop major Roundtables on critical issues in Canadian Biomedical Science. Senior scholars, institutional leaders and educators were assembled to exchange views, highlight challenges and obstacles and also provide insights and priorities worthy of consideration. Roundtable 1 is entitled, "The Role of Discovery Research in the Health of Canadians", and Roundtable 2 will address the challenging question: "Does Canada have too many PhDs?" We are grateful to participants featured in this booklet for their commitment to advance Canadian Science and graduate education. Their views and vision will be of interest to policy-makers and leaders responsible for the future health and social well-being of all Canadians.

Ms. Helle Tosine, President of the Royal Canadian Institute for Science.


Ms. Helle Tosine

I have the honour of being the 113th President of the Royal Canadian Institute for Science. The oldest scientific society in Canada, our mission is simple – we provide a platform for public engagement with prominent Canadian and international scientists through free live lectures, events and webcasts. As Canada's oldest scientific society, we are pleased to partner on this important forum on research in Canada.

RCIS
Royal Canadian Institute for Science

Dr. John S. Floras, Immediate Past Chair of the Board of Trustees of the Banting Research Foundation.


Dr. John Floras

BANTING
RESEARCH FOUNDATION

Established to commemorate the discovery of insulin and to provide opportunity for other Canadian investigators to make discoveries "which, like insulin, will bring alleviation to human suffering", the Banting Research Foundation has fostered medical research across Canada for over 90 years. Once the country's only such granting agency, the Foundation's present focus is to support innovative projects proposed by outstanding investigators within the first three years of their initial appointment to a Canadian University or Research Institute. It is in this spirit that the Banting Research Foundation has partnered with the Royal Canadian Institute for Science and the Friends of the CIHR to support the 2015 Henry G. Friesen International Prize Program and its expert roundtable discussions informing the contribution of discovery science and graduate programs to the health of all Canadians.

Organizational Overview and Shared Purpose

Proceedings of Roundtables – 2015 Friesen Prize Program

Dr. Aubie Angel CM., MD, MSc, FRCPC, FCAHS,
President of Friends of CIHR

Dr. Aubie Angel

Brief Bio: Professor Emeritus, University of Manitoba, President, Friends of Canadian Institutes of Health Research, Senior Fellow, Massey College, University of Toronto. Dr. Angel is an Endocrinologist with research interests in adipose tissue and lipid/lipoprotein metabolism. He was Professor and Head, Deptartment of Internal Medicine, University of Manitoba and Head of Medicine at the Health Sciences Centre in Winnipeg. Prior to that, he served as Director of the Institute of Medical Science and Director of the Clinical Sciences Division at the University of Toronto. He was founding member of a number of academic and advocacy organizations and established Friends of CIHR, a national organization that promotes the goals and ideals of CIHR and under its auspices founded the Friesen International Prize in Health Research (2005) and the Video History of Medicine in Canada Project. He has had a lifelong interest in health research promotion and guiding young scholars in academic careers.

Perspective and Introductory Remarks

I am privileged as President of Friends of CIHR to provide introductory comments for this document, which records the Proceedings of two special Roundtables that were featured in the 2015 Henry G. Friesen International Prize in Health Research Program in Ottawa on December 7th-8th, 2015.

2015 was a milestone year in that it marked the 15th anniversary of Friends of CIHR and the 10th anniversary of the Henry G. Friesen International Prize. To commemorate these milestones, Friends of CIHR enhanced the usual annual gathering by adding high-level Roundtable discussions involving key leaders in Science and Higher Education to address significant issues in our Research Agenda and draw attention to concerns about the future of Health Research in Canada. It is our good fortune that Friends of CIHR partnered with two venerable Canadian organizations – The Royal Canadian Institute for the Advancement of Science (RCIS) and The Banting Research Foundation (BRF) – orrganizations known for their longstanding commitment to support early-phase scientists and to explain Science to society. This collaboration was most fruitful in enhancing the Friesen Prize Program and attracted a wider participation of interested scholars, students and policy people who attended the Friesen Prize Lecture by Professor Paul Nurse, Director & Chief Executive, The Francis Crick Institute (UK) and Past President, The Royal Society of London.

The Roundtable themes, each lasting about 2 hours, are entitled:

I. "*The Role of Discovery Research in the Health of Canadians"*

II. *"Does Canada have too many PhDs?*"

These themes were chosen after wide consultation and reflect current concerns that creative research is not enjoying the support it deserves and that targeted research with perceived economic return is favoured. The question of graduate training and employment is relevant today because the job market in the Academy is thin. This is important and much has been written recently to suggest (without substantiation) that we are training too many PhDs at the time of vanishing opportunities. Each presenter's address was supplemented with a brief essay that helped focus their views with reference to the Institution they represented. In this way, opinions were presented and not aimed specifically for consensus. Instead, a spectrum of thoughts worthy of further consultation were tabled.

Both Sir Paul Nurse and Dr. Henry Friesen participated as observers and offered their thoughts on an informal basis. There was considerable support for continuing the Roundtable discussion (a format that engaged many knowledgeable people) and the need to revisit these and other questions at our next gathering.

Friends of CIHR is grateful to the University of Ottawa for its dedicated support of the Friesen Prize Program and particularly, the major role it has served in fostering the Friesen Prize Program over the years and hosting the Roundtable. FCIHR is also delighted with the new collaborations with RCIS through Ms. Helle Tosine (President) and BRF through Dr. John Floras (Past President), for their sponsorship and active organizational role in developing the Roundtables.

-Dr. Aubie Angel

Executive Summary Roundtable 1

"The Role of Discovery Research in the Health of Canadians"

Co-chaired by **Dr. Alan Bernstein,** President of the Canadian Institute for Advanced Research and **Dr. Lorne Tyrrell,** Director of the Li Ka Shing Institute of Virology of the University of Alberta, focused on "The role of discovery research in the health of Canadians." The aim was to solicit ideas and opinions on the topic from different quarters, rather than drive a consensus on the questions posed.

General Comments

There was acceptance of the premise that discovery research represents the heart of scientific endeavour and that Canada has the capacity to conduct transformational discovery research, the forerunner of innovation and advanced care. The recent contributions by Canadian scientists in presenting therapies for diabetes, HIV/AIDS, hepatitis C, and the Ebola virus are evidence of this. These examples also illustrate the value of decades'-long investments in discovery research and for patience when pursuing important questions.

An overarching paradox emerged in that the capacity for conceptual innovation has never been greater while impediments inhibiting knowledge generation abound.

Over the past decade, funding lagged behind the increasing infrastructure and human resource cost of research. Further, funding was often re-directed from investigator-initiated research towards strategic targets. This created a cohort of well-trained early career scientists, who struggle through many granting competitions, each awarding insufficient funds to establish or maintain a successful independent research program.

Canadian research culture is risk averse

Participants felt that the Canadian research culture, as evidenced by funding choices and the peer-review process, was averse to bold science and scientists. This results in support for safe proposals, and fewer opportunities for productive investigators to access the large sums required to compete with their international peers.

Governments recognize the value of health research, but there are still obstacles

Governments appreciate the impact of science and medical research on the nation's economic health. However, regulatory friction occurs frequently and may have broader unintended consequences with greater negative impact on discovery and clinical research and on innovation in Canada than in other nations.

There is too strong a demarcation between disciplines and funding. NSERC funds biomedical engineering and biochemistry, but not health sciences, though they are clearly related. A "blurring of lines" between discipline funding would promote interdisciplinary research.

Barriers in translating Discovery Science to Innovation.

The potential of discovery research to improve the health of Canadians is much greater now than in the past but the time required is becoming frustratingly longer. All aspects of the continuum from hypothesis to product require functional re-examination. Barriers include the difficulty of funding clinical trials, institutions holding onto research ethics approvals, academic institutions lacking the resources required to attract external investors to discoveries, and a lack of Canadian entities willing or able to bridge the 'valley of death' between product and prescription.

The Academy and industry were perceived as not taking full advantage of potential synergies to their work and interests. Although Canada has some examples, such as in the development of vaccines, other nations have created successful models for mutually beneficial productive collaborations and balanced bidirectional partnerships that could be considered and adapted to our context.

There has never been a better opportunity to pursue a career in discovery science. The country's scientific, academic, and industrial leadership must voice a positive message, propose pragmatic solutions, and communicate these to our political colleagues and to the Canadian public. Further, it is our scientific, academic, industrial, and governmental leadership's responsibility to design and establish effective means of funding and facilitating the entire continuum from discovery to therapy.

Tensions among the various sectors and stages of this continuum should be minimized by discouraging rigidities in the mandates, structures, perspectives, and

operations of academic institutions, research institutes and governmental and non-governmental funding agencies.

Policy makers, individuals with authority over granting agencies, and industrial leaders all must appreciate that funding discovery science is a long-term social investment, not a cost and that returns from such investments are rarely immediate. The ‘war on cancer’ was not won in 5 or 10 years, but has been ongoing for 45 years or more.

Recommendations

Focus more on people and the culture fostering interrelationships among people, rather than on specific projects or initiatives. Direct energy towards increasing the permeability between scientific, commercial, governmental, legal, artistic, sociological, and philanthropic cultures. Enabling more effective mechanisms of capturing knowledge generated within one domain for use in others could have major benefits for health, societal welfare, economic growth, and for the professional and career development of graduate and post-doctoral trainees who elect to pursue creative careers outside of academy.

Transform the present culture of peer review to invest preferentially in people who consistently create and execute exceptional science. Peer-review should also not be the final arbiter of funding but rather one of several elements of the evaluative process. Weighting should be given to bold, innovative research proposals embedded with clear thinking regarding potential risk management.

Conclusions

To move forward, Canada should follow the example of nations whose scientific leadership has captured the imagination of government decision makers as well as the public by setting forth bold, audacious, and exciting visions for discovery science as fundamental to improving population health.

With many ideas and organizations clamouring for public funds, it is critical that there be effective and sustained communication concerning the importance of scientific discoveries that impact the health and well-being of Canadians.

The Roundtable ended on an optimistic note and acknowledged that the conversation was a starting point. It was agreed that the Roundtable discussions should be summarized, supported by participants’ submitted position papers, then circulated for comment. The resulting document could then serve as a platform for future exchanges focused on advancing discovery science for the future health of Canadians.

Massey College, University of Toronto

Home of F.C.I.H.R.

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Mr. Allan Rock, O.C., BA, LLB
President of the University of Ottawa

Welcoming Remarks

Mr. Allan Rock

Brief Bio: President of the University of Ottawa, one of Canada's most research-intensive universities. A trial lawyer by profession, Mr. Allan Rock practised in Toronto for 20 years before being elected as a member of the House of Commons. During his decade in Parliament, he occupied a number of senior cabinet positions including Minister of Justice and Attorney General of Canada, Minister of Health and Minister of Industry. He then served a term as Canadian Ambassador to the United Nations in New York before joining the University in 2008.

University of Ottawa Hosts 2015 Friesen Prize Program

Aubie, thank you very much, and Sir Paul Nurse, and distinguished guests, ladies and gentlemen, it is a great pleasure for me on behalf of the University of Ottawa to welcome this distinguished group to our campus, congratulations on finding the room.

You have to understand that it's for security purposes that we've arranged things like that. So we're now all secure and where we should be. Je voudrais aussi remercier nos partenaires dans cette entreprise, Les Amis des Instituts de Recherche en Santé du Canada, ainsi que L'Académie Canadienne des Sciences de la Santé. C'est toujours un grand plaisir et un honneur de travailler avec vous. I would like to especially extend my warmest welcome and sincere congratulations to Sir Paul Nurse, our guest of honour today and recipient of the 2015 Henry Friesen International Prize in Health Research.

Sir Paul's extraordinary work in the fields of genetics, cell biology, and the cell cycle have of course already been recognized through the award of the Nobel Prize and the Albert Einstein World Award of Science. But we wish also to draw attention too, to acknowledge and to celebrate, Sir Paul's deep dedication to science education and his tireless effort to promote and to foster greater understanding of the scientific process. What is more, his consistent and his conspicuous contributions to major scientific organizations, culminating in his election as President of the Royal Society, demonstrate so clearly his preparedness to give up himself in serving shared interests and advancing the common cause. I very much hope that you will feel at home on the campus, Sir Paul. A campus that takes pride in the intensity of its research in health, in science, in engineering, for which we are ranked second in all of Canada behind only the University of Toronto. And we've put them on notice.

Nous sommes ici à l'Université d'Ottawa, un établissement reconnu pour ses travaux de recherche sur la santé et en politique de santé. À ce titre, nous sommes fiers d'être non seulement partenaires du prix Henry Friesen, mais aussi de partager entièrement l'esprit de découverte et de collaboration mis en relief dans la série de conférences qui l'accompagne. As a centre of learning we aspire to achieve that which Sir Paul so fully embodies, to fulfill our educational and research mandates, and in so doing, to advance the public interest. And may I say what a very great honour it is for us to be associated with the prize that bears the name of Henry Friesen. Henry's contributions to the cause of research and learning in Canada have been truly remarkable, what a difference he has made to our country and how delighted we are to see him back on campus today. And so I say to all of you, a sincere welcome to the University of Ottawa. Thank you, Aubie.

Tabaret Hall, University of Ottawa

The Role of Discovery Research in the Health of Canadians

Roundtable 1

The Honourable Dr. Reza Moridi, PhD
Minister of Research and Innovation, Government of Ontario

Honorary Chair

The Hon.
Dr. Reza Moridi

Brief Bio: Minister of Research and Innovation, Minister of Training, Colleges and Universities. The Hon. Dr. Reza Moridi has served as the Parliamentary Assistant to the Minister of Training, Colleges and Universities, the Minister of Research and Innovation and the Minister of Energy. He is an award-winning scientist, engineer, educator, business leader and community activist. Minister Moridi worked as a CEO and Chair in the electrical industry and his career in academia included serving as the Dean of the School of Sciences, Chair of the Physics Department, University Chief Librarian and member of the Senate at Alzahra University in Tehran. Dr. Moridi was the Vice-President and Chief Scientist at the Radiation Safety Institute of Canada. He received the Education and Communication Award from the Canadian Nuclear Society and the Fellow Award from the US Health Physics Society. He was elected as a Fellow of the UK Institute of Physics and the UK Institution of Engineering and Technology for his original contribution to physics and engineering.

A View from the Top

It is a pleasure to join you this morning as honorary chair of this roundtable.

I want to thank the Friends of Canadian Institutes of Health Research for inviting me today and acknowledge Dr. Friesen, one of Canada's most prominent scientists. And welcome Sir Paul Nurse: It is an honour to join you here today.

Before I entered politics, I was a nuclear researcher and scientist, so I know how much dedication and drive it takes to succeed.So, on behalf of Premier Wynne and all Ontarians,

I want to thank everyone in this room —and your teams —for the great work you do every day.

You know the challenges we face—and they are not new —but we have made tremendous progress with remarkable breakthroughs in many areas, including regenerative medicine, cancer and stem cell research.

In fact, just last month we learned that researchers at the University of Ottawa and Ottawa Hospital discovered that Duchenne Muscular Dystrophy is a stem cell disease. This is hopeful news for people with this debilitating disease and their families.

Discoveries like this are helping make our province a strong economic force and our government is there to continue to support that enterprise.

Over the past 10 years we have made significant investments in research and innovation and we are seeing positive results.

Our life sciences community has already generated more than 61,000 high value jobs and Canada ranks 6th in the world in quality and impact of research with nearly half of the national research enterprise happening right here in this province.

I am proud that many Ontario ventures owe their success to partnerships between universities, hospitals, research groups, businesses and government. That collaborative spirit—from research through to commercialization—makes Ontario stand out in a highly competitive global economy.

But to stay in the lead we must continue to turn challenges into opportunities and we know one critical opportunity is through research excellence.

Ontario's future prosperity depends on attracting the brightest people and keeping home grown talent here. Our Early Researcher Awards program does that. It helps promising Ontario researchers build their teams and train the next generation of innovators.

And through our flagship initiative —the Ontario Research Fund—we have committed more than $1.3 billion to research that has generated more than 150 spin-off companies.

We want to continue to be an innovation leader by harnessing our research, innovation and entrepreneurship strengths that bring new Ontario - made technologies to our hospitals and clinics faster and provide better care for Ontarians.

That is why we created the Ontario Health Innovation Council two years ago.The Council presented us with a clear vision on how to enhance Ontario's health technology sector and we embraced it.

We want to continue to create the right environment where new ideas, discoveries and innovations make it to the marketplace faster.

An environment where our researchers have the resources to have eureka moments and where the next generation of researchers and entrepreneurs can flourish—and make history.

We look to everyone in this room to help us as we work to strengthen Ontario's position. I know today's discussion will form a foundation for great things to come that will benefit everyone in this great province and the world.

Thank you.

Trillium The Flower of Ontario

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Lorne Tyrrell, O.C., AOE, MD, PhD, FRCPC, FRSC
Director, Li Ka Shing Institute of Virology, University of Alberta

Co-Chair

Dr. Lorne Tyrell

Brief Bio: Distinguished University Professor at the University of Alberta. Dr. Tyrell is the Founding Director of the Li Ka Shing Institute of Virology and has focused his research since 1986 on viral hepatitis. Dr. Tyrrell was the Dean of the Faculty of Medicine and Dentistry from 1994-2004. He is an Officer of the Order of Canada, Fellow of the Royal Society of Canada, and he won the Killam Prize in Health.

"The Best Topic for the Time"

Lorne Tyrrell: Alan Bernstein and I are very pleased to be here and we thank the Friends of the CIHR for the invitation to co-chair this Roundtable.

There is not a more important topic for scientists in Canada than refocusing on the importance of discovery research – for people who have made careers in basic science research and people more broadly involved in health research. We have seen some dramatic examples of transformation in our healthcare system and these transformations are solidly rooted in discovery research.

As a clinician-scientist with a practice in Infectious Diseases, I have seen these dramatic transformations first hand. I began seeing patients with AIDS in 1983. At that time, I knew that every AIDS patient would die in one or two years, and they did. That continued until basic science researchers solved the structure of key enzymes and the development of new antivirals targeting three key enzymes. Since these first new antivirals were discovered in 1996, I have not lost a patient with AIDS. AIDS patients now can lead normal lives with normal life expectancy. This transformation is directly attributable to solid discovery research. Infectious diseases has been a home for a number of examples of discovery research transforming the management of major diseases.

Hepatitis C was the major culprit of "tainted blood" in Canada – investigated through the Krever Inquiry. The virus was discovered in 1989 through persistent discovery research efforts led by Dr. Michael Houghton. Shortly after the discovery, blood and blood products were safe, targets for antivirals were identified, and now this disease is curable – possibly with three weeks of combination antiviral therapy. This is the first persistent viral infection to be cured – unbelievable progress in a relatively short time, and led by discovery research.

Today we do less than one per cent of the ulcer surgery we did in the late 1970s – based on the discovery of a bacteria by Barry Marshall as the cause of ulcers. Antibiotics rather than surgery are used to treat ulcers – another dramatic example of how discovery research transformed management of a major disease. Many scientists in Canada do not feel there is adequate recognition of discovery research. The funding of discovery research has stagnated and scientists, particularly young scientists, have invested heavily in their careers, but are very concerned for their future. The convergence of the sciences – biology, chemistry, physics, bio-informatics, cell biology, biochemistry, and physiology can identify key targets in disease processes and develop solutions. The sequencing of the human genome and the new technologies leading to gene editing are exciting new areas that deserve strong support.

Thank you for choosing "The Role of Discovery Research in the Health of Canadians" as the topic. It couldn't have been a better topic for this time.

Dr. Alan Bernstein

Co-Chair

President & CEO of CIFAR (Canadian Institute for Advanced Research) and served as the inaugural president of the Canadian Institutes of Health Research (CIHR). Dr. Bernstein is a Senior Fellow of both Massey College and the Munk School of Global Affairs. His is an Officer of the Order of Canada and was inducted into the Canadian Medical Hall of Fame in 2015.

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Daniel J. Drucker O.C., MD, FRCPC, FRS, FRSC
Lunenfeld-Tanenbaum Research Institute, Mount Sinai Hospital

Presenter

Dr. Daniel Drucker

Brief Bio: Dr. Drucker received his M.D. from the University of Toronto in 1980, and is currently Professor of Medicine. He holds a Canada Research Chair in Regulatory Peptides and the Banting and Best Diabetes Centre-Novo Nordisk Chair in Incretin Biology. His laboratory is based in the Lunenfeld Tanenbaum Research Institute at Mt. Sinai Hospital in Toronto and studies the molecular biology and physiology of the glucagon-like peptides. Dr. Drucker has 33 issued US patents, and his work in discovery science has been recognized by receipt of the Prix Galien Canada, the Banting Award from the American Diabetes Association, the Claude Bernard Medal from the European Association for the Study of Diabetes and election to the Royal Society (Canada and London).

"Discovery Research has Multiple Benefits"

Support of discovery research has multiple benefits for Canadian Society. Our economy is transforming from more traditional resource-based, manufacturing and agriculture-focused activities to a rapidly evolving knowledge-and technology-based economy. Many of the technologies, materials, and innovations we take for granted today, have been developed through discoveries in the physical, chemical, biological and materials sciences. Entire traditional industries have been upended and even the most talented 'futurists' have been unable to foresee the extent, scope, and pace of technological innovation. The spectacular technical advances in physical and telecommunications sciences have been further enabled by breakthroughs in miniaturization and nanotechnology, and computational biology.

Complementary advances in discovery biology have led to the development of hundreds of new drugs for the treatment of human diseases and the alleviation of human suffering. Underlying the power of science to disrupt, transform and improve the lives of Canadians is the inherent unpredictability of scientific discovery.

Most applied discoveries have their roots in fundamental basic science, often within scientific areas seemingly tangential to or even unrelated to subsequent adaptation and ultinmate commercialization. Hence support of basic science discovery, spanning basic biological, chemical, mathematical and physical science research, is fundamental and essential for the subsequent success of applied science and technology.

The health of Canadians (and the ability to support a sustained economic enterprise with good paying jobs) will be safeguarded through scientific efforts directed at improving our environment, the safety and quality of our food supply, the sophistication, quality and safety of our transportation vehicles and infrastructure, and through development of novel vaccines, genetic and diagnostic testing methodologies and new pharmaceutical agents to treat current unmet medical needs. Investment in discovery science, ideally in a non-targeted manner, is the best approach to foster often unpredictable ingenuity, allowing curiosity-driven lines of inquiry to bubble, and enabling unanticipated discoveries to spring forth. A second component of a successful platform for discovery research is support and establishment of the optimal economic and investment conditions for a scientific ecosystem to thrive, allowing Canadians to further develop and commercialize their discoveries in Canada, with leadership from fellow Canadians.

A strong basic science sector, supported by an expanded solid foundation of substantial grants from our agencies such as CIHR and NSERC, will increasingly attract the attention of globally-oriented companies with complementary skills in technological adaptation, encompassing generation of new chemical agents with industrial applications, innovative software, devices, tools, instruments, appliances and next generation drug development. Forward-thinking economic policies (taxation credits, favorable taxation rates on corporate investment for research, scientific equipment and infrastructure, royalty streams, and both business and personal income) will attract and competitively foster the necessary complementary investment from skilled private sector partners. Together an eco-

system ripe with talent in basic and applied science will become an ideal environment for discovery research and enable creation of a scientific and commercial enterprise that spans multiple sectors and accelerates translation of basic science discovery into applications that can improve the health, productivity and economic well-being of Canadians. It is extremely difficult for even the most talented forward-looking seers to pick champions and winners in specific sectors, geographic regions and areas of basic and applied science. Unrestricted recurring predictable tangible investment in basic science is the best policy for ensuring that recurring generations of Canadians play repeatedly leading roles in the generation and discovery of the next generation scientific breakthroughs and their applications that will improve the lives of not only Canadians, but all of our fellow human beings worldwide.

Sir Paul Nurse Hon. Dr. Reza Moridi Mr. Allan Rock

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Roderick R. McInnes C.M., MD, PhD, FRSC
Director, Lady Davis Research Institute

Presenter

Dr. Roderick McInnes

Brief Bio: Director of the Lady Davis Institute of the Jewish General Hospital, Alva Chair in Human Genetics, Canada Research Chair in Neurogenetics and Professor of Human Genetics and of Biochemistry at McGill University. Dr. McInnes was a University Professor of the University of Toronto and previously the Head of the Program in Developmental Biology at the Research Institute of the Hospital for Sick Children, an International Research Scholar of the Howard Hughes Medical Institute and the inaugural Scientific Director of the Institute of Genetics of the Canadian Institutes of Health Research. He has made important contributions to the understanding of the molecular basis of retinal and eye development, the identification of genes and processes associated with inherited retinal degeneration and to our knowledge of synaptic accessory proteins that modulate the activity of ion channels in the nervous system. He was appointed to the Order of Ontario and is a member of the Order of Canada.

"Canadian Biomedical Research is Risk Averse"

I believe that Canadian biomedical research is indeed risk-averse, and that there are three principal causes, for which I will suggest three solutions.

The first cause of our risk aversion in research is that Canadian culture in general is anti-elite. We have a widespread epidemic of the tall poppy syndrome. You don't often hear Canadians saying "We're #1!" (which is a virtual mantra in the USA), except perhaps when a Canadian team is on the podium at the Olympics. As David Naylor is fond of saying, and I think I'm quoting him correctly, the tendency in Canada, and in Canadian research investment, is to use the "peanut butter solution", to spread the resources around, and thus thinly, rather than maintaining a strong emphasis on outstanding performance. In contrast, as we all know, scientific research is one of the most elite of all human activities, and the competition is international. Canadians are uncomfortable with the concept of any elite, in anything perhaps excepting hockey. We have to divest ourselves of this discomfort. It's not just a matter of being the best in Canada, the elite researchers have to be better than the world.

The second cause of our Canadian tendency to avoid research with risk arises from the fact that grants panels, understandably, want to fund excellent researchers who are asking important questions, questions that are significant to science, medicine and Canadians. But this focus leaves little or no room for a grant that is equally good scientifically, except that it is more risky; the idea might not pan out. Thus, if you have two equally great grant applications, but sufficient funds for only one, the less risky one is more likely to be funded, even if the reviewers agree that the potential benefit of the riskier grant is greater. And of course we know that to do brilliant novel research, you often have to take substantial risks. A funding culture that is risk averse is therefore less likely to facilitate novel transformative discoveries.

The third cause of risk aversion in Canadian research is that there is too little unencumbered funding available to most investigators in this country. If a Canadian researcher makes a discovery with great transformative potential, she will ideally want to exploit the potential of this discovery quickly. But in our current system, her research budget will not have the flexibility to allow her to pursue opportunities of this type; one can't redirect funds currently supporting a graduate student's research, for example, and use them to take advantage of a new discovery. In contrast, in the US, a Howard Hughes Medical Institute Investigator or someone in one of the wealthy US universities, will have access to discretionary funds for new projects of this type. Canadian researchers, and research institutions, have very little "free change" at their disposal. One of the cancer researchers at the Lady Davis Institute has just discovered a truly remarkable gene that has nothing to do with cancer. Fortunately we've been able to give him funds to pursue this project, which is quite outside his mainstream research. But in Canada in general, the resources for funding new research directions such as this one simply do not exist, or are insufficient. An admirable exception to this gap in the Canadian funding land-

scape is the new Innovation Grant program at the Canadian Cancer Society Research Institute.

I propose three solutions to overcome Canada's risk aversion in research. First, we must establish unencumbered career awards for the most brilliant young researchers. A superb model for this type of program is the Career Awards in Medical Sciences (CAMS) program of the Burroughs Wellcome Fund (http://www.bwfund.org/grant-programs/biomedical-sciences/career-awards-medical-scientists). These awards are given to the very best physician scientists (American or Canadian) in the last year of their post-doc. Canadian candidates have done well in this competition (although not enough apply). The total award is $700,000 over the first 5 years of the new researcher's career. However, the researchers are not obliged to spend the funds during the first 5 years - they can keep the funds as a no-cost extension, thus allowing them to carry over any balance past the original 5 year term. The BWF has a very liberal policy regarding no-cost extensions and most CAMS awardees hold balances well past the original end date. The funds are unencumbered, and so can be used by the scientist to supplement their general research program, to address exciting new findings, to undertake pilot projects, and so on. These funds allow the awardees to take risks and compete at the highest international level.

The European Research Council (ERC) also has a program that encourages research on novel ideas that have a risk component. There three programs, depending on the career level of the applicant: ERC Starting, ERC Consolidator, and ERC Advanced grants https://erc.europa.eu/funding-and-grants.

A second solution would be to increase the level of funding to a degree that would allow at least our very best researchers, our elite, to compete with the generously funded scientists of the Howard Hughes Medical Institute or the Wellcome Trust. This would seem a shockingly un-Canadian initiative, but it would be the right thing to do.

The third solution is more speculative, but would be worth a trial run. One could ask all grant applicants to include two pages at the end of each grant, in which they would propose a high-risk high-benefit addition or extension to their research program (i.e. "If I had an additional $100K/year for three years, I would…"). One could then take the top three or four grants from each panel, and ask a separate multidisciplinary advisory committee (a MAC, to imitate CFI's multidisciplinary advisory committees) to identify the most attractive of these high-risk high-benefit proposals. One could then fund the top 5 or 10. Alternatively, one could adopt, at the level of CIHR, the Innovation Grants program of the Canadian Cancer Society Research Institute. As with any risky investment, there might be more losses than gains, but the gains that succeed will sometimes be of unpredictable and unexpectedly high benefit. They would justify the whole enterprise.

In conclusion, should Canadian scientific leadership fail to address the issues reviewed here, our research will be at high risk of not making transformative discoveries in the future.

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Rob Van Exan, PhD
Director of Immunization Policy Sanofi Pasteur

Presenter

Dr. Rob Van Exan

Brief Bio: Director of Immunization Policy at Sanofi Pasteur Limited, the Canadian Vaccine division of Sanofi Group. Robert Van Exan completed his graduate research as a developmental cell biologist at the University of Guelph (Ontario Veterinary College) and was a Killam Postdoctoral Fellow at Dalhousie before joining Connaught Laboratories in 1981. He has 34 years of experience in the vaccine industry and has served in multiple capacities including vaccine research, development, manufacturing, marketing, sales & policy.

"Humanitarian and Societal Needs Through Science"

Discovery Science is a continuum of science from the most basic, scientific research associated with the academic institutions, through research which is broadly directed to solving a humanitarian or societal need as is frequently directed through an NGO or medical institution, to government based research which has a fundamental societal perspective or direction to the research generally associated with industry (SME's and Multinationals) which is usually very mission oriented and focused on innovation which will translate into a product or process which has societal value.

All of these endeavors share some elements in common. They usually share the same basic values and drivers – good scientific rigor (ie a systematic investigation to establish facts or principals), some form of societal or humanitarian objective (ie for the advancement of human knowledge, for the betterment of mankind, to meet an unmet medical need etc.) All require funding support and all require a high degree of intellectual capacity. In my view, they are all interdependent to a greater or lesser degree.

From the industry perspective, the vast majority of the basic research is conducted in the academic communities and institutional settings and it is largely funded by NGO's and Government. Most of the heavy lifting for innovation lies in the small, medium and large industrial settings and it is generally funded through government, the investment community and ultimately through revenues generated from successful products which are valued by society in the market place. All of these segments of discovery science play a role in building intellectual capacity through education and training.

Industry relies heavily on discoveries made external to its own R&D. Only 15% of industrial R&D is directed towards discovery research in the pharma industry – the vast majority of industry investment is spent on development. This expenditure is growing far more rapidly than our economic growth as regulatory requirements increase and expensive technologies become integrated into the development of new products. This leaves Government and NGO's as the primary funders of basic research.

But industry contributes to the health and wellness of society not only through the products it develops but through the wealth it generates for investors, employees and other stakeholders. Ultimately, economic prosperity of a society is linked to its health and wellness. The generation of money through marketing of industry developed products, is not only reinvested in its own targeted R&D but also finds its way back into government coffers through direct (Academic chairs, through external R&D contracts and partnerships) and indirect (corporate taxes, employee wages/taxes etc). A Canadian example – the vaccine Pentacel which was researched developed and is manufactured in Canada. Only 6% of this vaccine is used in Canada – 93% is exported. The corporate tax revenue and the tax revenue derived from the 1100 employees and R&D investments in Canada far exceeded the gross sales of the company in Canada.

Industry also contributes to the intellectual capacity. It provides a training ground for graduate students that could not be found in any other setting. Sanofi Pasteur has over 80 graduate coop students at any point in time and funds a number of post-doctoral research positions. In addition, scientific and medical employ-

ees are frequently cross appointed to academic institutions and/or are guest lecturers supporting undergraduate and graduate training agendas.

The impact of a healthy Discovery Science continuum is fundamental to the health and wellness of society. The impact is maximized when the right balance of funding and intellectual capacity is brought to bear to create an optimal environment for all players to be successful within the continuum of Discovery Science.

Mr. Allan Rock Dr. Alan Bernstein Dr. Lorne Tyrrell

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Mario Pinto, PhD, FRS
President, NSERC

Presenter

Dr. Mario Pinto

Brief Bio: President of NSERC. Dr. Pinto received his B.Sc. and Ph.D. in Chemistry from Queen's University. He served as Professor and Chair of Chemistry and Vice-President, Research at Simon Fraser University, President of the Canadian Society for Chemistry and Vice-Chair of the Chemical Institute of Canada. A Fellow of the Royal Society of Canada, Dr. Pinto has received numerous awards for his research. At NSERC, Dr. Pinto has promoted the discovery-innovation dynamic.

"The Future Begins Now"

My opinions are informed by a consultation process over the past year with our academic and industrial stakeholders. NSERC currently works with 12,000 professors, 30,500 students and postdoctoral fellows, and 3,500 companies. Their collective input has resulted in the formulation of a strategic plan, NSERC 2020, which outlines five clear goals that NSERC will pursue to position Canada for the future (www.nserc-crsng.gc.ca).

1. Fostering a science and engineering culture in Canada
2. Launching the new generation
3. Building a diversified and competitive research base
4. Strengthening the dynamic between discovery and innovation
5. Going global

With these goals, we feel strongly that NSERC will play an important leadership role as it works to fulfill its mandate and its vision for Canada.

We are at a time where an exciting, dynamic, and prosperous future is possible for Canada. Science and technology can be a driving force in this narrative, but only with a clear plan and only if we fully mobilize the discovery and innovation ecosystem that exists in Canada. NSERC 2020 provides this plan. It sets out a vision for the organization: to make Canada a country of discoverers and innovators for the benefit of all Canadians. The plan provides a supporting mission: to be the focal point for discovery and innovation in natural sciences and engineering for Canada. NSERC 2020 is rooted in the rich foundation of discovery research. NSERC provides value by investing in and fuelling a brain trust focused on fundamental research to explore the unexplained and unknown. This focus ensures that Canada is producing major discoveries, world-firsts in cutting-edge, high-impact domains that will shape the world we live in. NSERC also plays a critical role in bridging the gap between discovery research and industry. For small and medium-sized enterprises, access to intellectual capital to inform and refine R&D can be a significant rate-enhancing factor in their growth. We are focused on building industry-researcher partnerships to help these companies. These partnerships validate and de-risk opportunities stemming from discovery research for future investment or further development via business-led R&D.

Given the time constraints, I will focus only on two topics before addressing the point raised by Alan Bernstein. The first concerns the preoccupation of discovery versus applied research or innovation. Treating these two areas as two solitudes is not only counterproductive and disingenuous but it does not reflect reality. Invention sometimes does arise from discovery research whether it is through conception, misconception, or accident. It is recognizing the invention under each of these scenarios that is the key. Once realized, it takes many complex events to turn invention into innovation, but one thing is certain---one needs to apply the same level of rigor when developing innovation as in scholarly inquiry. One needs to apply business and industrial measures of success in routine go/no go decisions---one needs to "kill it quickly". This art form can be practised most effectively when industry is intimately involved from the outset. I use as a metaphor a Möbius strip which has no beginning and no end and has only one side. It is best to work in an informed way with all players on the same side and absent the preoccupation with the origin of the trigger. Accordingly, NSERC 2020 advocates a dy-

namic exchange between discovery and innovation where information flow is bi-directional. Fundamental research informs R&D and industrial research triggers new questions to be addressed by basic research.

I will use three examples to illustrate the point. New materials are exploited very quickly but very often fail. Understanding why they fail and mitigating the failure often require going back to discovery research. A second example involves stem cell research which will prove to be extremely expensive if personalized medicine requires cell differentiation in vitro followed by transfer to the patient. A preferred route would be cell differentiation in vivo, which will require considerable discovery research (in vitro) to deduce which stimuli, perhaps using small molecule candidates, will lead to such cell differentiation. A third example is that of HIV-AIDS treatment using anti-retroviral therapy. Resistance to the first drug candidates led to increased efforts to compromise the critical enzyme activity using other candidates. A study of the molecular interactions between these drug candidates and the enzyme by chemists quickly led to the conclusion that the virus could be "snookered" because avoiding susceptibility to one candidate through mutation would render it susceptible to another. Hence, a cocktail of drug candidates was found to be very effective in treatment of HIV-AIDS, rendering an infectious disease almost "chronic" in nature.

Overall, NSERC's efforts at partnership building across the discovery and innovation ecosystem have given us the ability and the line-of-sight to build consensus, convene other partners, and mobilize resources.

My second point is on risk aversion and the conservative nature of peer review. It is true that, with limited resources, evaluation panels err on the side of caution and seek precedent upon which to base funding decisions. Bold, edgy ideas may not receive just investment. This issue is of concern because if one were truly innovative, one would have no peers. At NSERC, we have decided to give panel members the comfort of "cautious" peer review in the main individual discovery grant evaluation process but to superimpose on that system another based on "accelerator" supplements that reward bold, frontier ideas which may not have precedent but, if successful, would advance knowledge in a quantum and not incremental fashion. At the team level, NSERC has established the Discovery Frontiers Program for the same purpose of pushing the boundaries.

Let me turn now to Alan Bernstein's point of funding interdisciplinary research between NSERC and CIHR through joint programs. Science has evolved naturally to require interdisciplinary approaches to problem solving. It is therefore, unfortunate that the historical boundaries imposed by the mandates of the granting councils may impede progress. At NSERC, 22% of the candidates funded are now in the area of biomedical research. We prefer, therefore, to continue this practice, admitting that science has evolved, and assessing the applications based on excellence through informed peer review with interdisciplinary panels in a conference model for evaluation.

In summary, I feel that as we move towards 2020, there are many strengths on which to build. Federal and provincial investments across Canada in knowledge networks, incubator and accelerator spaces, and co-location facilities have provided infrastructure for enabling innovation. Reorganization internally has erased artificial divisions between discovery and innovation programs and has given us the agility to pursue change. However, significant investment is necessary to take full advantage of this new structure. Finally, support and refinement of peer review systems have given us a highly efficient quality assurance system for NSERC investments.

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Duncan Stewart, MD, FRCPC, FRSC
President & CEO, Ottawa Hospital Research Institute

Presenter

Dr. Duncan Stewart

Breif Bio: CEO and Scientific Director, Ottawa Hospital Research Institute. Dr. Duncan Stewart is a pioneering Canadian cardiovascular researcher recognized for his discoveries in blood vessel biology and his dedication to translating these into benefits for patients and society. Dr. Stewart received the Dexter Man Chair of Cardiology and Research Achievement Award of the University of Toronto and the Research Achievement Award of the Canadian Cardiovascular Society. Dr. Stewart is a leader in bringing diverse groups of clinicians and scientists together to put Canada on the world stage for translational cardiovascular and regenerative medicine research. Dr. Stewart is also a senior scientist in OHRI's Regenerative Medicine Program and holds the Evelyne and Rowell Laishley Chair. He is Vice-President of Research at the Ottawa Hospital and a Professor in the Department of Medicine at the University of Ottawa.

"Discovery Research is the Forerunner of Clinical Innovation"

Discovery is the very bedrock on which transformational improvements in health will be based. And we are now in a time when discovery research has never held more promise. Those of us that have had the privilege of participating in basic research during the rise of the modern era molecular and cell biology, can't help but to have had a glimpse of this exciting future. The veritable explosion of knowledge about the fundamental workings of the cell, has led to the development of an ever increasing array tools that can be used to manipulate nearly every component of the cell machinery, offering a potential armamentarium to accomplish diagnostic and therapeutic feats that could not even be imagined when I began my clinical training. Yet, by and large, the day to day practice of medicine is much the same, with some notable and rare exceptions. As well, the experience of our patients who suffer from debilitating and incurable disease is little different.

Why is this? When we can produce a pluripotent stem cell from any cell in the body – when we can sequence an entire genome in days, not years, at cost of hundreds, not millions, of dollars? The real roadblock in my view is not in the pace of discovery (which I believe will continue to increase exponentially if adequately supported), but in the length of time it takes to move discovery into meaningful impact on health and health care. And, there are a number reasons for this, first and foremost being the complexity of this translational journey – as well as the need to balance potential benefits with risks both at an individual and societal level. It is absolutely essential that at the same time as we are pursuing brilliant discoveries in the laboratory, we are also exploring how these can be applied to tackle important clinical problems. This may be far less glamorous, often dealing with mundane issues about how best to deliver a stem cell therapy – how to we make the cells stay where they're supposed to stay or do what we want them to do? But it is these mundane issues that will determine the success or failure of a clinical trial. Unless we get everything right in the proof-of-principle stage, down to the tiniest detail, the tremendous promise that these approaches may hold will be lost in translation!

In Canada, we have benefited immeasurably from the Canadian Stem Cell network which, over its 14 year mandate, has ushered in major advances in this field. But now that the is sun setting, we may be losing the opportunity to move these advances into clinical application. This has recently been compounded by reforms to the Canadian Institutes of Health Research (or CIHR) that have resulted loss of the "Randomized Clinical Trial" program so that now there is no specific mechanism to fund such trials, in fact any clinical trial! Without a way of taking Canadian discoveries forward to the clinic, we may be forced to watch as others take advantage of these and reap their potential benefits!

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Trevor Young, MD, PhD, FRCPC, FCAHS Dean of Medicine, University of Toronto

Presenter

Dr. Trevor Young

Brief Bio: Dean, Faculty of Medicine and Vice Provost, Relations with Health Care Institutions University of Toronto.Trevor Young is a clinician-scientist who studies themolecular basis of bipolar disorder and its treatment.He was a research fellow at Johns Hopkins School of Medicine, Professor of Psychiatry and Behavioural Neurosciences at McMaster University, Head of theDepartment of Psychiatry at the University of British-Columbia and Chair of the Department of Psychiatryat the University of Toronto. He was Physician-in-Chief and Executive VicePresident Programs at the Centre for Addiction and Mental Health in Toronto..He received the 2015 Colvin Prize for Outstanding Achievement in MoodDisorders Research from the Brain and Behaviour Research Foundation, the Douglas Utting Award for outstanding contributions in the field of mood disorders, and the Canadian College of Neuropsychopharmacology Heinz Lehmann Award. He is a Distinguished Fellow of the American Psychiatric Association.

"Striving for Higher Levels of Acheivement"

It's a great pleasure to be here today and part of this panel. It's also hard to imagine that being the sixth or seventh speaker I have very much to add that would be unique. So, I would like to highlight that I agree with the three principles I've heard so far. Firstly, we must continue to support our best scientists and strive for even higher levels of achievement than ever before.

Secondly, the need for funding discovery research is certainly very important, and will continue to be important. Investing in our young scientists and the model of the Crick Institute we heard from Sir Paul earlier was really remarkable.

So if I think about my 25 years in research, I went from mental health into looking molecular basis of bipolar disorder and its treatment and now in being responsible as Dean for a big medical school. In psychiatry we never would have imagined that something like optogenetics, a technology that uses light to control the activity of specific cell types in the brain, would completely change the field. So Karl Deisseroth, who pioneered optogenetics, comes around, no one could see the value of that methodology, and now in mental health research, if you don't have a molecular or behavioural model and not using tools like optogentics you're just out of the game. It's completely changed the way we're looking at mental health and that's in a period of less than a decade.

The things that I'm so excited about -- again as others have mentioned, stem cells and regenerative medicine, incredible advances but there is clearly a lot to do on so many different levels. CRISPR/Cas we've just mentioned that, how that came out from left field and now is a mainstay. Now we're looking at taking somatic cells and change gene expression with this tool. And then Brendan Frey is a great example of the investment in the interdisciplinary space between computer sciences, engineering, medicine to see the great advances in the field of computational genome biology. We don't even know, in our Donnelly Centre for instance, where the primary activity, be it molecular medicine, computer science or engineering – it doesn't matter – there's a whole crew of folk working in that interdisciplinary space.

And then finally, the bright students that we see, certainly in medical school and the keen competition that is there. Then, to imagine that many of them are very interested in pursuing an MD-PhD, many of them want to get into fields – very far from clinical medicine and we need to definitely encourage and support these students.

So, I am very optimistic about where we are. There's so much talent in our universities, and so much talent in our students coming along. There seems to be some pretty obvious things that we need to do. It is not easy to find the large scale funding that we need but I think we have a pretty clear path forward. So thank you for allowing me to be a part of this conversation.

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Professor Sir Paul Nurse, PRS, PhD,
President of the Royal Society (London, UK) and Chief Executive,
The Francis Crick Institute

Honoured Guest

Sir Paul Nurse

Brief Bio: Sir Paul Nurse is a geneticist and cell biologist who has worked out, using yeast as a model organism, how the eukaryotic cell cycle is controlled and how cell shape and cell dimensions are determined. His major work has been on the cyclin dependent protein kinases and how they regulate the cell cycle. In 2001 he shared the Nobel Prize in Physiology or Medicine and has received the Albert Lasker Award, the Gairdner Award and the Royal Society's Royal and Copley Medals. He is immediate past President of the Royal Society and Director of the Francis Crick Institute in London. The Francis Crick Institute is a consortium of six of the UK's most successful scientific and academic organisations, including the Medical Research Council, Cancer Research UK, the Wellcome Trust, University College London, Imperial College London and King's College London. Sir Paul, as Director and Chief Executive, isresponsible for implementing its scientific vision and research strategy.

"Invest in Young Scientists"

I'm going to cover quite a number of the topics in my talk a little later in a more coherent way, so I thought I would just make some incoherent remarks now.

So in no particular order, I'd like to start with the point Rob said, there is indeed a continuum of activities (which involves discovery at all stages of basic translation and application research, and I think we need to recognize and accept that. The reason I mention it is that we need to ensure that the tensions that can arise sometimes between sectors should be kept minimal and sometimes we can encourage tensions, and I think that's dangerous for the whole agenda.

Second thing I'd like to say about the way in which this works is that we have to focus on people, relationships, permeabilities and culture, and think about those things as much as projects. We tend to always talk about projects and specific initiatives but equally and perhaps even more important are these other more sociological aspects to the whole endeavour. People really matter, high quality people, that's very important, permeability matters, permeability across all sectors not only between basic translation applied research but between commerce, academia, healthcare delivery, between politicians and scientists, between different funders. Often there are quite a lot of barriers in all those places and I think that just simply gets in the way. So we have to focus on permeability and the ability for the different cultures that those tend to give rise to, and to focus on how those cultures can actually work well together. In the car coming over here, we were discussing how clinicians are trained differently from scientists. Scientists sit on the fence about any decision until they get extra data, and if you are treated by a clinician you don't want to be told 'Well, come back in nine months when I have more data,' you have to make decisions. These are different cultures and we need to work on getting those cultures to work together. And sometimes I think the barriers between application, commerce and academia can be much enhanced by meeting and by talking.

In terms of making decisions, peer review was mentioned. I'm a trustee of the Howard Hughes, which was mentioned, and of course Hughes focuses on people. And I have to say, I think this is the most effective way to proceed, you invest in people until they are no longer effective. And because -- I put it this way, you don't want to invest in people who write good projects, you want to invest in people who do good projects, and that means you need to invest in people. I'm not a great fan in saying we should do risky research. I'd rather do bold research. I prefer to do research that had no risk at all. What we really should be doing is bold and innovative work and if possible, trying to keep the risks under control. I know it's a little counter to what other people present, but I think it's worth just thinking about because particularly for the general public if you just say 'Well we want to publish risky research' actually it doesn't sound quite right.

So I would think about the language there. Peer review is so interesting, isn't it? I obviously spend a lot of my life reviewing research and people and usually the specialist reviews about individuals which 30-40 years ago would have

been the gold standard by which you are judged, seem to be getting increasingly irrelevant to good decision making. The way I view it is you need to have those expert views but they should not be determining the outcome, they should be a factor in the outcome. And what is crucial in making the overall decision is having wise people making it and that isn't the same thing as ancient people making it. And there aren't so many about them, so that is actually quite tricky. And I think it's worse thinking about how we make these decisions because we overload the people who are good at this and -- as a consequence they say no and then it trickles down to people who are no good at it and who will make a decision on whether something should be funded on the concentration of the magnesium in a solution which was wrong in an application rather than anything to do with an idea.

Two more things, one thing about discovery research which I think is the most effective engine for knowledge, because it relies on creativity of the individual, but we also have to have that hand in hand with very effective mechanisms of capturing that knowledge and using that knowledge elsewhere. And I am not sure we do that in the most effective ways at this moment. So let discovery lead but make sure we have ways of capturing it for a potential societal and economic growth.

Finally, I wanted to say something about careers and youth. We have a dilemma, the engine room of research are graduate students and post-docs. The pyramid of careers is such that many of those will never become senior researchers. Yet we continue to act as if they would. We continue to have the myth that we are training them for a career in research and this is not only unfair on that community it's actually deeply wrong in my view and so we have to face this. We cannot solve this by saying we will make the careers better because the structure is wrong. It can only work when you have an expanding system which happened in the '60s and '70s but it doesn't happen now. So we have to face that. Now, what's the solution? Well, the only solutions are either research groups become very small, and there is actually some advantages in that because a large group never gets run properly and they are ineffective. Now, the fact is we need to train our younger graduate students or post-docs in such a way that they are not only trained for research but they are open to other alternatives and trained for other alternatives outside research. What it does is, exports the skills that you see in science to elsewhere in the community, you export not only the ability to think logically, and to analysis data, we hope in an objective way, but in addition there is a culture of science that is exported to other parts of community and society which are important. Then we can be more honest with our junior colleagues. Come and work for a while as a researcher, it is exciting, it's a good five or ten years, you will end up possibly being a researcher but also possibly doing something else. And I don't think we present anything like this to them. Other industries do it, if you're a policeman, you're policeman for a while, if you are in the military, you're in the military for a while. We just have to get more honest with them because we want the best people but we have to recognize they're not all going to stay. So those are my incoherent observations. Henry.

The London Eye, United Kingdom

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Henry G. Friesen, C.C., FRSC, FCAHS Distinguished Professor Emeritus, University of Manitoba

Honoured Guest

Dr. Henry Friesen

Brief Bio: A renowned and visionary medical scientist, Dr. Henry Friesen is a Canadian endocrinologist credited with the discovery of human prolactin, and for redefining medical research in Canada. Now a Distinguished Professor Emeritus of the University of Manitoba, Dr. Friesen was a Professor and Head of the Department of Physiology and Professor of Medicine. As President of the former Medical Research Council of Canada, he brought together scholars, scientists, practitioners, governments, industry and patient groups, and inspired the creation of the Canadian Institutes of Health Research. His integrity and selfless idealism attracted the support of thousands of advocates and admirers, both nationally and internationally. He fostered and nurtured the creation of Friends of CIHR.

"Delivering the Right Message"

Henry Friesen: Thank you very much. As I listened to the discussions there seemed to be a contradiction. On the one hand there is the assertion with which I agree entirely that there has never been a better time to be a scientist. But on the other hand following that optimistic claim I heard a litany of complaints. If I were a potential student listening to the opportunities that are available to me in the face of all the expressions of doom and gloom about the current research funding support I would immediately find another door seeking better opportunities going forward. So I think it's very important that we get the message that we really want to deliver right. I think it's important we don't carry all the pessimism outside this room as it will surely discourage young people from pursuing a career in science.

I didn't hear a proposal for a coherent plan going forward. I didn't hear an approach to developing a plan that's exciting and attractive. I remind us all that fairly recently we've as a country we have experienced the greatest investments in research and science ever in the history of Canada-- from about '96-'97 until 2004, massive investments probably 12- 14 billion dollars were made. The GOLDEN ERA OF RESEARCH FUNDING IN CANADA. We became conditioned to imagine that's the new normal and that it would go on forever. The truth is it hasn't and it won't but there is an opportunity now in my judgment with a new government to begin to look at how to proceed, given our history. The issue we are discussing is "discovery research". I find narrowly focusing on defining the language around the topic is divisive and unnecessary. In my own career I never spent a lot of time thinking whether I was doing basic science, discovery or applied research, I just did research and tried to discover things as I went along, I think all of us when we're doing science discover things that we hadn't anticipated.

Alan Bernstein: Maybe not everybody proactively but we all try to discover something ---

Henry Friesen: Right. So I think it's important that we use the language to make our case very carefully. Words like "elite scientist", I know it's something that we see as important but I think if we're communicating those words to decision makers, they're probably not helpful. Another pair of words—"unencumbered funding" immediately brings to mind unaccountable funding which is an anathema to decision makers that hold the public purse. So I would say I agree wholeheartedly with those who believe as I do, that there never was a better time to do science in this country, indeed in the world, with all the tools that are now available.

But it also then puts the challenge back to us all---how are we going to persuade the larger public to recognize the importance of what we do because in the end it's the public that provides the funding and we need to remind ourselves and them that research really is about hope, a better future, and a healthier population. Perhaps nothing is more compelling than to offer concrete examples where research has led to profound differences in the health of individuals and populations

The examples of the impact of health research on Hepatitis mentioned by Dr. Lorne Tyrrell that led to the discovery and introduction of new drugs to cure

hepatitis illustrate so well how research has transformed the lives of whole populations around the world.

Similarly in the area of HIV/Aids, Dr. Julio Montaner, a Canadian championed the view that the application of highly effective antiretroviral therapy HAART could if applied universally, virtually wipe out the epidemic of HIV globally. Initially his suggestion was much criticized but I think the evidence now is pretty clear that if you use anti-retroviral therapy effectively, the HIV levels in blood fall to very low levels such that HIV transmission rates drop to close to zero. Incidentally the UN/WHO has recently recommended that the treatment regimen first proposed by Montaner be applied globally.

I think using concrete examples is most effective when speaking to decision makers in government to make the case for the importance of research and discovery research. A further example I would cite is vaccine research, and specifically the development of the Ebola vaccine in the National Microbiology Laboratory in Winnipeg. It has been proven to be a most effective vaccine, virtually 100% effective, even one week after exposure to the Ebola virus. Really quite extraordinary. The availability of this vaccine would really transform the threat of Ebola if properly applied. So with a few examples one can make a powerful case for the value and impact of research---whether it be basic, applied or discovery type research really is secondary.

So I say we are in a very privileged position. We should recognize that we need to communicate very effectively the opportunity and advantage we have. I remain optimistic that if a well-constructed plan that's exciting is proposed there may well be a favourable response by decision makers. I take my cue from Sir Paul Nurse who has a reputation for not thinking in incremental terms, but in bold, audacious ways, presented an ambitious plan to create the Crick Institute in London to decision makers several years ago and now soon will see it open as the largest biomedical research institute in Europe. It is that kind of approach that is persuasive.

Lorne Tyrrell:Thank you very much Henry.

Prarie Crocus, The Flower of Manitoba

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Alex MacKenzie, MD, PhD
Senior Scientist, CHEO Research Institute

Discussant

Dr. Alex MacKenzie

Brief Bio: Attending pediatrician at the Children's Hospital of Eastern Ontario (CHEO), Dr. Alex MacKenzie has served as the CEO and Science Director of the CHEO Research Institute as well as Vice President of Research for both CHEO and Genome Canada in addition to being founding scientist of the AeGera biotech company. Dr. MacKenzie's laboratory has conducted translational research on the rare pediatric disorder spinal muscular atrophy over the past 25 years; in recent years has broadened its focus with its involvement in the enhance Care for Rare project to search for therapies for a larger number of rare diseases.

"Thoughts on Discovery Research"

Paul sit back and watch a master. We need to find something for our graduate students to aim for-- I think you're absolutely right that it's not going to be academia and I think actually a lot of graduate students in Canada confront that grim reality sooner than in the UK; defining that something else, reconfiguring our training programs so that were not maintaining the canard of them becoming professors, getting them ready for the industry, in health policy, public service, et cetera; we absolutely need to do a better job of that.

Just briefly, you also mentioned the peer reviewer that talks about the magnesium buffer concentration en route to rejecting a grant.. the small mindedness of our culture. In this regard, and this is a bit of a ugly truth perhaps, we have a lot of very ordinary research occurring in Canadian labs-- if you look at the papers being published, and ultimately their relevance it is not always an uplifting experience. Whether we need to get more ruthless in monitoring the science that is progressing within the research institutes, universities, government labs is a question which might be asked, whether our devotion to the minimal publishable unit now accepted as the norm is the best policy. This is a difficult discussion, but if we're truly all about excellence, we need to scrutinize the opportunity cost of less than stellar research occurring. And I'm not sure we do that as well as we should in Canada.

Similarly, the real blue sky stuff -- and just parenthetically 50 years ago it was the Boyer/Berg study of bacterial immunity which led to the identification of restriction enzymes and the molecular biology revolution, and now, half a century later, basic blue sky research once again into bacterial immunity that has led to CRISPR and I'd say it's not going to be ten or 20 years for CRISPR to make a translation but in the next year or two there will be somatic bone marrow transplants based upon CRISPR, it's really going to revolutionize the therapy of, among other things, rare diseases. But just to finish my incoherence, as far as blue sky science goes, looking at rare diseases therapy as my lab does, some of the most exciting innovation that's taking place is in industry..for example Pfizer and Novartis, I think this is a level we don't attain as much in academia. And critically, perhaps counterintuitively, much of the exciting preclinical work, is IP free research.

I think if you look at innovation, there is real sand in the wheels in the form of intellectual property, patents, MTAs..these have been and are becoming increasingly a net drag on the enterprise. And interestingly enough it's these big pharmas who recognize this and have in some places institutes what Aled Edwards in Toronto advocates… a form of open access research which should take place I think really everywhere.

Looking further down the pipeline as one gets closer to clinical translation, the process which exists there now in ethics board approval and regulatory issues is a significant problem that we face in Canada less so in the UK but I think it's an issue there. And if we're going to talk about true innovation all the way as Rod says it's a spectrum, we need to look at those regulatory processes as well. So just some stream of conscious thoughts.

Rosie: Yes, thank you

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. Rosie Goldstein, MD, FRCPC
Vice-Principal (Research & Innovation), McGill University

Discussant

Dr. Rosie Goldstein

Brief Bio: Vice-Principal of Research and Innovation at McGill University. Previously, she was Vice-President of Research at the University of Calgary and the Vice-Dean of Academic Affairs in the Faculty of Medicine at the University of Ottawa. Dr. Goldstein was the Founding Director of the Ottawa Academic Health Sciences Leadership Program. Her research in general rheumatology and medical education, including the exploration of gender and health topics in the training of medical students and the study of conflict resolution in health care and medical education, has been supported by a number of national and international grants. She is a Fellow of the Royal College of Physicians and Surgeons of Canada and was the recipient of the first annual Canadian Medical Association (CMA) May Cohen Award for Women Mentors, among other honours.

"Bridging the Gap: McGill's Commitments to Ideas and Innovation."

Basic, curiosity-driven research is the lifeblood of all research-intensive universities. Therefore, McGill's Strategic Research Plan includes several strong statements about how we will seek out and support excellent, curiosity-driven research wherever it is found. One of our "core commitments" is to what we call "ideas." We say, "Wherever research may ultimately lead, all advancements begin with ideas." At the same time, we also value "innovation", including bringing research discoveries to market and connecting research to the people and groups who will benefit most.

For example, McGill has recently (September 2015) accepted a proposal for the creation of the McGill Cystic Fibrosis Translational Research Centre (CFTRc). The CFTRc will provide the many researchers working on Cystic Fibrosis at McGill with an administrative structure to coordinate their activities, seek funds for shared projects and obtain shared resources. This will enhance McGill's basic research activities in Cystic Fibrosis, and help respond to the growing need for translational research in the field.

McGill also announced in November 2015 that a treatment for major eye disease based on research conducted at the Lady Davis Institute will be commercialized by Allergan, a leading global pharmaceutical company. The new treatment promises to bring relief to over a 100 million people worldwide who suffer from chronic dry eye disease. This discovery is beating the odds, which are stacked against any scientific discovery making the long journey from lab bench to clinic. As many of you will be well aware, only one in 100 pharmaceutical discoveries make it to a phase 3 trial, and only one in ten of those actually get to market, where they can help patients.

In an effort to prevent so many research discoveries from languishing in the 'valley of death' – the chasm between biomedical researchers and the patients who need their discoveries – we must build capacity both in research institutes and universities, and among industry partners and investors for true collaboration, a process characterized by mutual respect, listening, and breaking down of barriers. Research institutes and universities have the obligation to simultaneously facilitate cross fertilization across disciplines, for example through initiatives which include computer science, engineering, management and medicine. By bridging these disciplines, as an example, we can anticipate an overall enhancement in health care research: in the creation of biomedical devices to assist with the physical limitations of aging populations and in the development of the best IT systems to support health care. This collaborative and interdisciplinary approach should be extended to the training of students.

Finally, together we must advocate for balance in research and innovation funding. An increase in funds for the commercialization of research should not divert funds from basic research. As I mentioned at the outset, while it is essential that universities fully appreciate the importance of innovation and applied research and make these integral parts of their research missions, basic, curiosity-driven research often reveals unanticipated applications and is therefore important to society in the near, medium and long term.

The Role of Discovery Research in the Health of Canadians

Roundtable 1

Dr. John Floras, MD, DPHIL, FRCPC, FCAHS
Banting Research Foundation

Presider

Dr. John Floras

Brief Bio: Director of Research for the University Health Network and Mount Sinai Hospital Division of Cardiology Deputy Physician-in-Chief for Research of the Mount Sinai Hospital Department of Medicine. Dr. John Floras pursues patient-oriented research into circulatory and cardiac control mechanisms in health and disease. He established the first human cardiovascular laboratory in Canada with the capacity to record efferent sympathetic nervous discharge to resistance vessels and integrated this program with a cardiac catheterization and a sleep laboratory, both dedicated exclusively to human cardiovascular investigation. He is Tier 1 Canada Research Chair in Integrative Cardiovascular Biology. In 2014, he was elected to the Canadian Academy of Health Sciences and served on the Canadian Hypertension Society Board, including as its President. From 2009- 2015 he was Chair of the Board of Trustees of The Banting Research Foundation, Canada's oldest medical granting Foundation.

Presider's Synthesis

Two Roundtable discussions were held in conjunction with the 2015 2015 Henry G. Friesen International Prize Program and the 2015 Henry G. Friesen International Prize Lecture by Sir Paul Nurse, Nobel Laureate, Past President of the Royal Society and Director of the Francis Crick Institute in London, entitled "The Fundamental Significance of Discovery Science in the Creative Process."

For each Roundtable, an outstanding group of science, academic, and governmental leaders was invited to provide the scholarly, business, and policy development communities their specific insights and considered recommendations with respect to two important issues concerning the health and social well-being of Canadians with the intent of assembling the fruits of their discussion for publication and dissemination across a broader audience.

Invited participants and discussants included the Honourable Allan Rock, President of the University of Ottawa and federal Minister of Health at the inception of the Canadian Institutes of Health Research, the Honorable Dr. Reza Moridi, Minister of Research and Innovation for the Province of Ontario. The full list of participants and discussants appears in the 2015 Friesen International Prize Program Booklet.

Roundtable participants and discussants were invited in advance to consider three general questions:

1. Is Canada too risk-averse in its approach to Discovery Research?

2. Bridging the gap between federal and provincial support for health research and its translation: what are the obstacles?

3. Compare incentives vs. barriers in translating Discovery Science to Innovation.

Participants affirmed that discovery research represents the 'heart' or 'engine' of scientific endeavour and expressed no doubt as to Canada's capacity to conduct transformational discovery research, to translate findings rapidly into the clinical arena, and to demonstrate clear and compelling improvements in both the burdens of disease and longevity. Illustrations of recent successes exampled included the contributions of our scientists to present therapies for diabetes, HIV/AIDS, hepatitis C, and the Ebola virus.

Importantly, each of these successes represents the product of decades'-long investments in discovery and applied research, underscoring the critical value of secure long term stable sources of funding of creative scientists given wide latitude to experiment and the importance of patience when pursuing important questions.

The overarching paradox articulated by all participants when framing their responses to these roundtable questions was that at the present time methodologi-

cal capacity and conceptual opportunities to perform revolutionary and exciting discovery science in Canada were never greater, yet also were the encumbrances and impediments inhibiting knowledge generation, knowledge translation and innovation.

Is Canada too risk-averse in its approach to Discovery Research?

It was observed that this behaviour may be one reason as to why the productivity of Canada's unencumbered discovery research enterprise has fallen behind that of other nations. It was acknowledged that great benefit had accrued from a significant $13 billion new national and provincial investment between 1998 and 2004 in research infrastructure, in financial support for graduate and post-graduate training, and in support of scientific and medical endeavour. However, perhaps conditioned to believe that such expansion would continue indefinitely, over the subsequent decade the scientific community became obliged to temper its expectations.

Important issues raised by several participants were that subsequent growth in funding sources lagged the increasing technical and human cost of research and that of the total funds available, a greater proportion often had been directed purposefully from investigator-initiated research towards centrally determined strategic targets. One legacy of this redistribution is a cohort of exceedingly well-trained early career Canadian scientists capable of pursing internationally-competitive independent programs of unencumbered discovery research but to be productive are obliged to struggle through many often capricious competitions each awarding insufficient funds to establish or maintain a successful independent research program.

There was consensus amongst participants that the Canadian research culture and in particular peer-review was adverse to both risk and to any perception of favouring an elite, resulting in agency support of 'safe' or 'incremental' protocols rather than 'bold' or 'audacious' proposals, with relatively few opportunities for outstandingly productive investigators or groups to access the large sums required to advance relative to their international peers and competitors.

A number of changes were perceived necessary to alter this culture, including:

- Developing undergraduate, medical and graduate educational opportunities for diverse and inter-disciplinary training;
- Sufficient investment in scientists commencing their careers to assure a reasonable probability of a successful initial trajectory;
- A willingness by government and national charitable agencies to allocate more funding to unencumbered (also called 'unfettered') long term early career salary and operating grant support of unencumbered research (a practice of charitable and governmental agencies in other jurisdictions);
- Promotion by academic, scientific, governmental, and agency leaders of a culture of preference for challenging and potentially transformational over 'safe' research;
- Promotion of a culture of peer-review that does not simply represent 'quality assurance' by commissioning a cadre of peer-reviewers to judge specifically bold proposals without safe precedent but with the argued promise and potential to open or accelerate entirely new fields of knowledge, scientific endeavour and innovation;
- Questioning whether, in an environment where funding is constrained, we 'not enable less than stellar research'
- Acceptance by those entrusted with research budgets, and those auditing and reporting on budgetary expenditures that to support 'risk' or 'unfettered research' does not imply abrogating 'accountability', and that focusing a greater proportion of support on the top-tier of scientists, regardless of their geographical distribution does not constitute 'elitism';
- Acknowledge that within a 'feedback system' failure that focuses minds and teams on developing new pathways to success should be considered not a subject of criticism but fundamental to progress;
- The creation of new pools of risk capital, that could be accessed by those ranked highest in conventional competitions, that would enable the parallel pursuit of novel and bold additional concepts;
- Rapid recognition of and rapid deployment of resources to support involving revolutionary technologies capable of addressing definitively important research questions individually or through inter-disciplinary teams or networks (recent examples provided were opto-genetics; CRISPR/Cas9 and deep learning);

- Greater weighting to prior creativity, innovative discipline-changing discovery, and innovation when evaluating specific proposals from established investigators;

- Greater weighting to training, the demonstrated capacity to conduct and complete projects, and the novelty and imaginative elements of the proposed hypotheses and plan of research plan when evaluating specific proposals from early career investigators;

- Create a specific pool of funds, analogous to the Howard Hughes programs in the United States, to which the top tier of Canadian scientists could apply for large and stable grant support;

- Encourage the development, through funding mechanisms, of small groups, not large groups, which "are rarely run properly"; monitor recipients of group funding for effectiveness as one aspect of accountability process.

- Ensure greater public recognition of the value governmental agencies place on discovery research and innovation;

- Establish new public awards for success in discovery research and innovation with demonstrated benefit for the health of Canadians

<u>Bridging the gap between federal and provincial support for health research and its translation: what are the obstacles?</u>

Governments, as emphasized by Minister Moridi appreciate the impact of science and medical research on the nation's economic health. In Ontario, the life sciences generate approximately 60,000 high-valued jobs and at $37 billion per year, contribute more to the gross domestic product than the automotive sector, and generate approximately $8 billion per year of exports. Thus all levels of government acknowledge the critical importance for the future of present investment not exclusively in applied research and the development of products and services, but across the entire spectrum of research and innovation.

Such investments can take many forms. The Government of Ontario has created a Ministry of Research and Innovation, established the Ontario Research Fund that has led to over $1.5 billion disbursed in levered partnership with other governments and industry, and has invested extensively in graduate studies and the capacity of research institutions.

From the Minister's perspective, research and innovation is a journey that may end with a product or a service, but which requires at its inception creativity, imagination, and a dream. However, the latter attributes are not sufficient; society and government cannot hope for a future stream of propitious accidental discovery. The probability of future success is enhanced by present planning.

The Minister assured the attendees that his Provincial government recognizes science funding as an investment, not as a cost, and that it is particularly committed to the graduate training and the opening of opportunities for well-trained scientists with creativity and imagination.

The panel participant from industry highlighted the importance to the Canadian research environment of: federal and provincial departments conducting basic and regulatory research; fundamental research conducted by small and medium, as well as large corporations; and the research efforts of non-governmental organizations, and emphasized the critical importance to the entire Canadian research continuum "from esoteric to direct or product-focused" of access to a high degree of intellectual capacity and a broad range of funding sources. It was acknowledged that access to and need for funds by academia, small businesses and large corporations differ greatly. This diversity mandates the growth and support of a range of funding mechanisms and funding sources.

Concerning obstacles that could be bridged, one example provided was our national output of graduate programs, with Canada producing approximately half, per capita, of the doctoral students graduated by our competitor countries.

Another was the concept of 'regulatory friction'. Due to our unique confederal structure, this may occur more frequently and may have broader unintended consequences with greater negative impact on discovery and clinical research and on innovation in Canada than in other nations.

Dr. Pinto, the Director of NSERC, informed the roundtable that this afternoon his agency was to release formally their 5 year strategic plan, which would place great value on discovery research and the concept of unfettered investment.

Although the act establishing NSERC states specifically that the agency would not fund health research, Dr. Pinto noted that approximately 22% of all fundamental health research in Canada is presently funded by NSERC, which supports programs, for example, in biomedical engineering and cell biology. He advocated for greater interaction between all national councils to foster and support interdisciplinary research and to identify those proposals represented a continuum of activity across several disciplines. He recommended 'blurring' of the lines presently content demarcation between disciplines. Dean Young supported this recommendation, noting that the primary appointment of his faculty does not constrain their scientific research direction. National and provincial funding agencies should remove any similar barriers.

It was proposed that projects that engaged themes and scientists across a range of disciplines could be earmarked for informed review and adjudication by a panel of expert delegates from several granting agencies empowered to bring to bear their specific content expertise on the relevant elements of the proposal and to recommend joint funding.

Compare incentives vs. barriers in translating Discovery Science to Innovation.

It was acknowledged that the potential of discovery research to transform clinical medicine and improve the health of Canadians is so much greater than in the past but rather than such knowledge being translated imminently into practice the time required to realize these benefits is becoming frustratingly longer, in some cases up to 20 years. Thus, all aspects of the continuum from hypothesis to product require functional re-examination.

A series of issues and questions were tabled:

Several rate-limiting barriers were identified as opportunities for improvement, e.g., a paucity of funds to support investigator-initiated randomized clinical trials; regulatory barriers, such as inefficient duplication of efforts by single institutions unwilling to relinquish research ethics approval to over-arching independent boards; academic institutions lacking the resources and mechanisms required to advance discoveries to the point of attractiveness to external investors; and, few Canadian entities willing or able financially to bridge this 'valley of death' between product and prescription.

The financial return generated from new products by the Canadian market alone is often insufficient to assure that reinvestment will indeed advance the line of discovery research to generate a new entity, or overcome an inhibiting technical challenge, or support the development and manufacture of the next new industrial product. How might this funding gap be remedied?

Academia and industry were perceived not be taking full advantage of the potential synergies to their work and interests. Although Canada has some examples, such as in the development of vaccines, other nations have created successful models for mutually beneficial productive collaborations and balanced bidirectional partnerships that could be considered and adapted to our context.

Participants were invited to reflect upon the three potential scenarios from which discoveries arise: by design or conception; from misconception; or by accident, and how those discoveries then lead to innovation. An important step to the latter is the development of a constructive feedback loop, such as one created through partnership between academia and industry, that could can identify and mitigate initial causes of failure, propose improvements in, for example, experimental design or materials, and thus increase the probability of successful translating of a discovery to an innovation.

Summary Conclusion and Recommendations

With the advent of powerful new technologies to investigate important questions and complex problems concerning health, disease and disease therapies, and with the convergence of a range of scientific disciplines seeking to address conditions fundamental to the health and well-being of Canadians, there has never been a better opportunity to pursue a career in discovery science. How might Canada best capitalize such opportunities?

All acknowledged that at the same time our medical researchers and researchers in training face many new and long-standing impediments to success.

It nevertheless falls upon the country's scientific, academic, and industrial leadership to articulate a positive message, to propose pragmatic solutions, and to communicate this positive message convincingly to our political colleagues and to the Canadian public. Further, it is our scientific, academic, industrial, and governmental leadership's responsibility to design and establish effective and efficient means of funding and facilitating the entire continuum from discovery to therapy.

It is critical for Canada that we develop an effective strategy to retain young well trained individuals in science-related careers. It is difficult to dispel the perception that it has never been more difficult than now for a young scientist to begin a new career as an independent investigator.

Across the landscape, those presently most vulnerable to attrition are the PhD scientists. MD-PhD scientists have the security of clinical practice should they elect to abandon their pursuit of discovery research but PhD scientists do not. There are many issues that must be addressed for doctoral studies to be perceived as an attractive pursuit and for those graduating with doctoral degrees to become more optimistic when considering their career opportunities. If not addressed, PhD-based disciplines risk losing a generation of scientists who are the very assets in whom we must invest if Canada is to compete in the future on the world stage.

Policy makers, individuals with authority over granting agencies, and industrial leaders all must appreciate that the funding of discovery science is a long-term societal investment, not a cost. At the same time, it should also be understood that returns that accrue from such investments are rarely immediate. The therapy of many diseases is presently being transformed by the clinical application of monoclonal antibodies, but the progression from their discovery to their clinical application represents the culmination of a 30 year process. The 'war on cancer' was not won in 5 our 10 years, but 45 years later the returns on such investment have been extensive, with fuller understanding of what makes a cancer cell behave differently from a normal cells, and with new therapies that come much closer to a cure. CRISPR/Cas 9 technology, the culmination of a 50 year process, may soon revolutionize clinical bone marrow transplantation. Similar time lines should be accepted, and hence, a similar degree of patience exercised, by those now seeking similar successes in the understanding and treatment of highly prevalent conditions with a heavy societal burden, such as mental health and chronic degenerative diseases.

There is a continuum of research of research across all stages that must be accepted by all who participate. Tensions inevitably arise between sectors; these tensions must be minimized, not encouraged, whether by rigidities in the mandates, structures, perspectives, and operations of academic institutions, research institutes and governmental and non-governmental funding agencies. Emphasized was the importance of eschewing all potentially divisive commentary concerning the perceived value of discovery versus other domains of research, and the careful selection of language and tone with sensitivity to Canadian nuances when communicating any message advocating for preferential funding for certain individuals or groups.

One means of reducing such tension is to focus present and future initiatives more on people, their inter-relationships, and the culture fostering such inter-relationships, rather than on specific projects or initiatives. With the scope of discovery science evolving so rapidly, and its potential fruits so diverse and unpredictable, energy should be directed at increasing, through frequent meeting, conversation, interaction, and collaborative efforts, the 'permeability' between the solitudes exhibited by present scientific, commercial, governmental, legal, artistic and sociological and philanthropic cultures. More effective mechanisms of capturing knowledge generated within one domain and enabling its use in these others could have major benefits for health, the societal welfare, economic growth, and for the professional and career development of graduate and post-doctoral trainees who elect to pursue creative careers outside of academe.

Another means is to transform the present culture of peer review such that research enterprises invest less in individuals who express good projects on paper but whose output is weak and ineffective and invest preferentially in those who consistently create and execute exceptional science until such time as they are no longer effective innovators. Peer-review, particularly if the project proposed has no safe precedent, should not be the final arbiter of funding but rather one of several elements of the evaluative process. Weighting also should be given bold innovative research proposals embedded with clear thinking that potential risk is anticipated and managed effectively. Universities must come to acknowledge peer review as an important academic activity that merits recognition and reward.

By their nature, academic and governmental institutions are risk-averse, and scientists themselves seek to compete for funding within a reliable, stable and risk-averse structured environment. However, to move forward, Canada must follow the example of other nations whose scientific leadership has captured the imagination of government decision makers as well as the lay public by setting forth bold, audacious, and exciting visions for discovery science as fundamental to improving population health. Government and the public would likely be most receptive to proposals that engage and recruit several agencies such that the resources of all are allocated to an important common purpose. (Sir Paul Nurse has proposed for the United Kingdom an overarching UK Research supervisory body.) It is important that the public is convinced their funds are well spent and that

mechanisms are established to assured that its recipients are accountable for their disposition.

With many ideas and organizations clamouring for public funds, it is critical that there be effective and sustained communication concerning the importance of such science, its discoveries, and their impact on the health and well-being of Canadians. This message should be animated by compelling examples of past and present successes and should project optimism that similar life-transforming advances will accrue in the future from investment today in discovery science. It was noted that the community of science teachers in high school and elementary school are positioned ideally to communicate the importance of this message and to inspire their pupils to consider a future career in discovery science.

The Roundtable ended on an optimistic note—Science is back in Canada. However, it was acknowledged that the Roundtable's conversation was too brief to result in any distilled focused message concerning actions that could be taken to advance discovery science in Canada or to even to develop a consensus as to how a plan to achieve this goal might be developed. It was agreed that the Roundtable discussions should be summarized, supported by participants' submitted position papers, then circulated for comment and as a platform for future exchanges focused on advancing discovery science for the future health of Canadians.

Ottawa Ontario, Canada

Executive Summary Roundtable 2

"Does Canada have too many PhDs?"

Co-chaired by **Ms. Helle Tosine** of the Royal Canadian Institute for Science and **Dr. Mona Nemer**, Vice President Research, University of Ottawa, this Roundtable focused on the question, "Does Canada have too many PhDs?"

General Comments

There was wide agreement that Canada is not producing too many PhDs. In fact, there is evidence we are graduating too few. There is a correlation between the number of PhDs and a country's economic performance, as well as the personal benefit realised through higher salaries that PhDs enjoy. Canada lags its main competitors, with fewer than 1% of the population with a PhD, below levels found in the United States and Europe. We rank 22nd in the world in PhD production, with slightly higher numbers in science and engineering (17th and 15th respectively).

It is estimated by the Conference Board of Canada that Canada needs 100,000 more PhDs to match our competitor nations and achieving this would allow for more discovery and growth, ensuring a more robust economic future.

The point was also emphasized that we should continue to graduate PhDs, but with a shift in direction in order to accommodate the diverse needs of the workplace as fewer than 20% of PhDs will ultimately move into an academic career.

Where do PhDs Go?

Many participants referred to the lack of outcome data about where PhD graduates end up. There is no systematic tracking of PhD graduates and those who move out of academic careers can become lost to their former faculty advisors. This information is therefore not easily available to current graduate students who are seeking non-academic mentors and role models. Some attempts have been made to track PhDs, but more data in this area is needed to feed back into the training of current PhDs.

Need to shift training to reflect non-academic careers

Nearly every participant noted the need to update PhD training programs to include the soft or transferable skills, such as communication and network building. Though training in these areas are more commonly found now than in the past, such professional development activities are often recommended as optional add-ons to the rigorous scientific training, rather than embedded into training programs. Should they become embedded into programs, it was noted that they should be tailored as much as possible to the specific needs of the individual student.

A few participants noted that PhDs are trained on an apprenticeship model, in which an advisor molds their students to create a "copy of themselves." This sits in contrast to MD and some other professional training, in which students are also required to adhere to standards and certifications of a rigorous educational program that builds their core competencies. An MD trains in an environment where he or she is less dependant on the "one on one" relationship of the PhD model. Though each have their merits, it was acknowledged that a re-examination of how the traditional PhD training works would perhaps reveal some better model.

There were some observations about how to ensure the quality of graduate students entering PhD programs remained high and consistent. It was noted that some institutions tended to attract higher quality students and that the reasons for this should, perhaps, be examined.

The transition from training to the workforce

It was noted that, to better prepare PhD students for work in industry, they need to learn skills often acquired through experiential learning. While common at the undergraduate level, these are uncommon at the PhD level. In addition, experiential learning programs help connect non-academic entities to doctoral programs. In some countries, industrial PhDs are offered in which industry and universities collaborate, often with co-supervision. MITACS was referred to as a setting a good example in this area.

Funding and Increasing Private Sector Involvement

A few participants noted that Canada's business sector has decreased its investment in R&D, creating a lack of research jobs in the private sector. Our OECD ranking dropped from 3rd to 8th in higher education R&D expenditure between 2006 and 2013 and we spend less of our GDP on this than comparable nations. It was also noted that the private sector may not recognize the values that

PhDs bring to the workplace in terms of creativity and critical thinking gained through shepherding a research project from inception to completion and reporting on its findings.

Suggestions

Several suggestions were put forth by participants, including modifying PhD programs to better prepare students for non-academic careers, building better relationships with the private sector during the PhD process (e.g. experiential learning opportunities) and the possibility of more industrial or professional PhDs. Additionally, there was a suggestion that PhD programs should become more multi-disciplinary.

Conclusions

Canada shuld continue to increase its production of PhDs, but should examine different methods of achieving this. Generally, it was agreed that there needed to be more interaction between the academic and private sectors, including an education program directed towards the private sector to help them understand the value of a PhD. This, it was hoped, might help both with the absorption of PhDs into the private sector and with the value placed on R&D, thus increasing the investment from the private sector in this area.

Iris Versicolor The Provincial Flower of Quebec

Does Canada have too many PhDs?

Roundtable 2

Dr. Mona Nemer, C.M., C.Q., PhD, FRSC
Vice- President Research, University of Ottawa

Co-Chair

Dr. Mona Nemer

Brief Bio: Professor and Vice President, Research at the University of Ottawa since 2006. A renowned heart researcher with pioneering contributions to the genetics of heart development and function, Mona Nemer has a distinguished record of training and community service in the health sector. As VP, Research, she has guided the University through unprecedented research growth. Her achievements have been recognized at the highest levels nationally and internationally.

Pre-amble and Introduction

It amazes me that when discussing the issue of the number and the quality of PhDs, how little data we actually have. Suddenly, there came "the problem" that only 15% to 20% of PhDs are going into academia. I looked into all the studies and I didn't see any historical perspective. So I went and discussed this with some historians. Apparently, the last time we saw a majority of PhDs go into academia was in the 1960s, when we had the expansion of Higher Education. I think it will be very important to look if there is truly a shift between, maybe, 1970 and 1980 and 2000. And I think that when we reflect on the colleagues that trained with us that we are not surprised to know that 20% are in academia and that all the others actually have very fulfilling and great jobs. Which gets me to my second point – recognizing that the quality is very unequal. I think that is something we definitely need to target because even within the same university and the same department, the quality is not equal. Nonetheless, you know, the people who were trained the same way, apparently, are now very successful. There is no question that the skills that we are trying to have in our PhDs, and they were amply repeated – creativity, analytical skills, problem-solving, adaptability. And as a matter of fact, I would say that all PhDs are risk-taking because they trust someone with their career for the next several years. So, we need to equip them with communication and team-working skills. We need to train them to teach as well. We are graduating people and hiring them in universities to do research and to teach and they have never been in front of a classroom. Communication: if we do our job properly and have the students present in Departments, go to present in front of their peers at national and international meetings – is this not equipping them a little bit with communication? Team-working skills: I don't know of any grad students who are working alone. They often have to mentor undergrads or interns and so on, and maybe we can do more of that. Don't get me wrong – I'm not trying to suggest that we don't do anything. I'm just saying that maybe the system that we have can actually offer a lot of what we want and it's how to do it and how to control the quality.

So, I think one unquestionable problem is the private sector R&D. And as Canadians, I think we need to be very concerned when we see three of the major Pharma research centres in Montreal close within 18 months and nobody is in the street and no politician made any fuss about it. A lot of PhDs were employed in those centres. And this is the knowledge-economy not going quite right here. So, I would just like to put a question on the table here: "How do we go about getting data, historical data?" Asking the question, "Why is the post-doc necessary?" Because, some industries will actually not hire a PhD if they don't have a post-doc. So, is it because they are not stepping up to the plate and doing their own in-house training, as well? And that could be the government and the private sector, as well. So, the question of "shared training" between the various sectors should also maybe be discussed.

If I can again have a plea, your message is actually not as prominent out there, as the message that there are too many PhDs and they are not employed. And I am worrying that this is actually discouraging further quality PhDs from entering the system.

No. I think we are addressing the issue of "quality control", in an evidence-based manner, and avoiding the disparities between people, even from the same institution. In relation to the examples that you and Henry have given to the medical profession, I think we also need an assessment of the diversity of the different skills. We don't all need to become surgeons. Do we know what percentage we want to equip with specific skills? We have diversity and again, not an obligatory mold for people.

Does Canada have too many PhDs?

Roundtable 2

Dr. Michael Bloom BA, MA, DPhil
Vice-President, Industry and Business Strategy, Conference Board of Canada

Presenter

Dr. Michael Bloom

Brief Bio: Vice-President, Industry and Business Strategy at The Conference Board of Canada. Dr. Michael Bloom is responsible for managing the Education, Skills and Immigration; Business Innovation; Industry and Business Strategy; Organizational Excellence; Governance, Compliance and Risk; Corporate Responsibility, Sustainability and Stakeholder Relations research groups, and the Saskatchewan Institute. He oversees funded research projects and executive networks and has management responsibility for nineteen executive networks. Corporately, Michael is executive lead for the Centre on Skills and Post-Secondary Education, a major five-year initiative which is developing a Skills and PSE Strategy for Canada, based on a program of 52 research projects, and creating pathways tools for learners to navigate through education and training to jobs and careers across Canada. He also leads the National Immigration Centre, which is developing a National Immigration Action Plan for Canada; the Centre for Business Innovation, whose goal is to improve firm-level business innovation in Canada as a cornerstone of improved national competitiveness and prosperity.

Does Canada Have Too Many PhDs? Framing the Challenge.

I reframe the question slightly to ask: does Canada today have a sufficiency of PhDs? Sufficiency can be defined as an adequate amount of something, especially of something essential. To determine whether we have an adequate amount, we need to address two connected questions about the role and value of PhDs.

The first question (in two parts) concerns PhDs within the post-secondary education (PSE) world—which in Canada today means 40 per cent of PhDs, just under half of whom hold tenure-track professorial positions. How many PhDs will be required to deliver outstanding educational experiences to graduate and undergraduate PSE students? How many will be needed, and in what roles, to sustain Canada's post-secondary research performance at a very high level in the face of the rising capacity of universities in China, India and other emerging economies to conduct advanced research and their growing ability to develop and attract advanced researchers?

Here, a significant related issue is ensuring that we have enough PhD advanced researchers inside the academy to partner on sufficient scale globally in disciplines where international collaboration is crucial to maintaining a position at the forefront of discovery research.

The second question concerns PhDs in the economy and society beyond the PSE world—where about 60 per cent of Canada's PhDs work today. Today, the largest numbers work in:

- natural and applied sciences (17 per cent),
- health and health-related occupations (11 per cent), and
- business management (9.5 per cent).

How many PhDs will we need to supply our broader economy and society with enough advanced researchers, entrepreneurs and innovators, business managers and professionals to generate and bring to market the products and services we require for citizens and customers, create large numbers of satisfying and well-paid jobs, and establish firms that can compete globally?

We Do Need More PhDs

The answer is that we will need more PhDs—about 100,000 more to match our chief competitor nations. This would allow us to enhance discovery, fuel growth, and ensure our future standard of living and quality of life.

Canada's key research and economic challenges will require significantly more PhDs to solve—inside and outside the academy in order to:

- Improve productivity to keep competitive with global exporter nations—advanced economies that are seeking to export to rapidly growing international markets;

- Enhance discover research and use-inspired basic research as well as applied research, in part to fuel higher levels of innovation and commercialization that will improve business performance; and

- Create high-value products and services that meet the increasingly diverse needs of citizens and consumers.

The importance of PhDs to national economies is well attested by the strong correlations between doctoral levels in national populations and economic performance indicators, including GDP growth and innovation performance, across the developed economies, especially up to the 1.5 per cent level in the adult workforce. The value of PhDs in the economy is demonstrated by the private returns to a doctoral education. PhDs earn a significant premium to bachelors and masters degree holders and on average exceed all other levels of education in lifetime earnings. Indications are that private returns relative to masters degree holders have been growing in recent years, a trend that is likely to continue as our knowledge economy focused sectors of the economy grow in importance.

Achieving PhD levels comparable to the United States and Europe will not happen soon. Even after having grown our PhD graduation level by 68 per cent between 2002 and 2011, to reach a total of 161 thousand PhDs, Canada lags well behind its major competitors, the United States and Europe, in the number of PhDs it has in its adult population and workforce. Top economic performers Switzerland, Germany and Finland have about 2 per cent PhD holders in their 25-64 age cohorts.

In order for Canada to come up to the average of the U.S. and the larger group of advanced European economies—about 1.5 per cent PhDs in the adult population aged 25-64—we need to increase the number of PhDs by approximately 100,000. We have a considerable way to go to reach this level given our current graduation rate of about 7 thousand PhDs annually, supplemented by several thousand PhDs arriving as immigrants each year, less retirements and deaths of working-age doctoral degree holders.

Numbers are Not Enough—Transitions are Critical

Of course, numbers alone are not enough. The key is to ensure that our PhDs, whether developed and graduated in Canada or brought to Canada as immigrants or returning Canadian-born citizens, are able to find jobs and careers that make the most of their high-order talents—both their advanced knowledge and their skills.

The main challenge lies outside the academy not inside. Currently, the 60 per cent of the PhD population who work outside of PSE (a proportion that is unlikely to change in the foreseeable future), are experiencing some problems in making timely transitions from academic training in their PhD programs to career-track jobs in non-academic workplaces.

The Conference Board of Canada's recent study, *Inside and Outside the Academy: Valuing and Preparing PhDs for Careers*, identifies four main issues facing doctoral candidates and recent PhDs in making a successful transition to non-academic employment: [1]

1. Students are graduating with underdeveloped professional skills and networks—which they need to find meaningful work and career opportunities.

2. Candidates are trained in the traditional doctoral training model, with mentorship and direction from professors who tend to focus on preparing doctoral students for academic careers (although this is starting to change), not on opportunities beyond the walls of the academy.

3. Experiential workplace learning opportunities for doctoral students are limited. As a result, many students do not gain practical experience of work and first-hand knowledge of career options. This reduces their awareness of the full range of skills they possess and limits their ability to 'market' their talents to employers following graduation.

4. Private sector receptor capacity is limited— employers are not making optimal use of the full range of knowledge and skills that PhDs bring to the workplace. Often employers, outside of research laboratory operators, have limited awareness or misperceptions about what PhD hires offer to productivity growth, innovation and commercialization, project management, and performance gains.

Policy and Program Solutions

University administrators and educators can undertake a range of actions to help PhDs successfully transition into a wide range of productive and rewarding careers:

1. **Create comprehensive professional development initiatives** for candidates to take throughout their doctoral programs, including modularized on-line programs. This will improve their knowledge of career pathways outside the academy and help hone their skills. MyGradSkills.ca is a good example of an initiative offered by a consortium of universities.

2. I**ncrease opportunities for experiential work place learning** in environments where candidates can use and develop their knowledge and skills.

3. **Offer multi-institutional or national internship pro-grams** such as Mitacs' Accelerate Program.

4. **Create a communications campaign backed by all PhD granting universities** in Canada to promote the value of PhDs as highly knowledgeable and skilled people who offer great benefits to private and public sector workplaces.

5. **Offer industrial PhD programs in science and engineering.** Such programs engage candidates in research involving collaboration between a company and a university, often with co-supervision. Denmark has been offering this type of PhD since 1970. Since 1981, France has awarded 10,000 industrial PhDs.

More than ever, PhDs are vital to our economic, social and cultural well-being. If we embrace the twin challenges of catching up with our leading competitors by producing more PhDs, and ensuring that all our PhDs can make the most of their talents both inside and outside the academy we will reap great benefits.

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Does Canada have too many PhDs?

Roundtable 2

Dr. Brenda Brouwer, PhD
President, Canadian Association for Graduate Studies &
Dean, SGS Queens University

Presenter

Dr. Brenda Brouwer

Brief Bio: Queen's University's Vice-Provost and Dean, Dr. Brenda Brouwer has been appointed president of the Canadian Association for Graduate Studies for the 2015-2016 term. She takes up the position as the organization works to foster a national dialogue on the role and impact of graduate education. She is recognized for her innovative work representing the needs of graduate programs and students and for her collaborative style. Dr. Brouwer joined Queen's after completing her PhD in Neuroscience at the University of Toronto. She holds a BSc. in Kinesiology (University of Waterloo) and an MSc in Biomechanics (McGill University). She served as an Associate Dean in the School of Graduate Studies then moved into the role of Vice-Provost and Dean. She maintains an externally funded research program focused on the biomechanical, neuromuscular and metabolic demands of mobility in healthy aging and stroke. She has supervised over 32 research master's and doctoral students and post-doctoral fellows.

Canada Needs More PhDs!

There's a disturbing subtext to this question. It second-guesses two of the greatest assets our country has – our education system and our citizens. And, it undermines the value of the PhD in preparing for a better future in a global economy. From my perspective the answer is a resounding no. But that doesn't belie the pressing responsibilities to adapt and grow.

It would be more to the point to ask if we have set in place policies, practices, and attitudes that maximize the potential of both graduate schools and students as well as the receptiveness of employers. If not, why not? And if not yet, then when? This is not an exclusively academic issue. It encompasses economic development, social innovation, global responsibility, bold vision and political will. Leadership on this issue can help transform the raw assets of brains, curiosity and ambition into an intellectual infrastructure essential to a 21st century Canada.

In comparison to our neighbours and competitors, Canada's tentativeness is startling. Fewer than one per cent of our population holds a PhD. That is low in comparison to other developed countries despite being substantially bolstered by a sizable number of foreign-trained PhD holders who have immigrated to Canada. Indeed, the number of Canadian PhD degrees granted lags behind all but one country in our 15 nation international peer group.[1]

The diversity and global experience that our PhD holders bring to society and our labour market should be celebrated and held as an example. Given the growing complexity of global issues and an increasingly competitive knowledge-based economy, we need a robust supply of highly trained talent infiltrating all sectors and amongst our political and business leaders to drive growth. But there's the rub. Leveraging that talent requires a strategy and assertive investment.

Intellectual infrastructure and the talent of those with strong disciplinary, technical and cultural knowledge is fundamental to research, innovation and creativity. In turn it can drive productivity, economic and social well-being. However, it is not the sole driver. Economic and societal prosperity and growth relies on good policy and political will. A recent report on Canada's innovation challenges and opportunities[2] indicates that Canada's performance has continued to decline since 2006, attributable to low investments in research, development and business enterprise (ranking 26th in the OECD). The report emphasizes the urgent need for businesses and organizations to embrace and manage innovation as a strategy for growth and competitiveness. It highlights the corresponding need to support this through government funding. Such action will drive the demand for a highly trained and educated workforce as research capacity is incorporated into the operation. PhD trained individuals have the ability and experience to guide projects through ideation to execution/implementation of solutions. They are an obvious source of top talent and leadership.

Canadians holding PhDs have expertise in a particular field and are skilled communicators, problem solvers, critical thinkers and lifelong learners who are highly motivated, comfortable with uncertainty and ambiguity and are increasingly globally connected. These are highly desirable attributes in all sectors and enable those with PhDs to succeed in a variety of work settings. Indeed it is the case that PhD graduates have well-paying and satisfying careers in multiple sectors including the academy. The labour outcomes for earned doctorates, including the frequently stated 20% employment in the professoriate, have remained stable over the past 15 years despite a 72% increase in Canadian PhD degrees granted (2002 to 2012) indicative of the continued absorption of research and creative talent into diverse careers. The PhD process trains individuals to be adaptive and resilient; important characteristics in a rapidly changing world.

Professional skills or soft skill development programs are now commonplace in graduate education, though often supplementary to academic requirements. Experiential learning opportunities beyond the dissertation research, which is by its very nature experiential, are also increasing in order to provide 'real world' experience by engaging external partners. The MITACS Accelerate program is an oft-cited example from which we can learn. But the time has come to integrate those 'real world' opportunities within the PhD program of study in order to mitigate prolonging degree completion time.

Whether it is global or technological challenges or working within communities, success is more likely to come from the efforts of a team with complementary skills and expertise. Corporate culture, and Canada's new government, understands this and form teams with combined relevant expertise (e.g. cultural knowledge, engineering design and biomedical expertise) to improve outcome, implementation and acceptance. Universities, and students themselves, recognize the importance of cultivating team skills. This was a main message from students at the conclusion of the CAGS/SSHRC "Imagining Canada's Future" project. Also striking was the responsibility they felt to authentically engage with colleagues, communities and their world. Yet most PhD programs have not been structured to provide opportunities for multi-disciplinary collaboration and shared learning. Our responsibility is to improve on that in short order.

Education is never an individual or solely an institutional endeavour. More than ever, we need to consider it a communal undertaking built on partnerships and shared values that planned well, reaps both individual and societal returns. PhD holders raise that bar in our communities, businesses, schools and seats of government. Let's make sure we do all we can to get them there.

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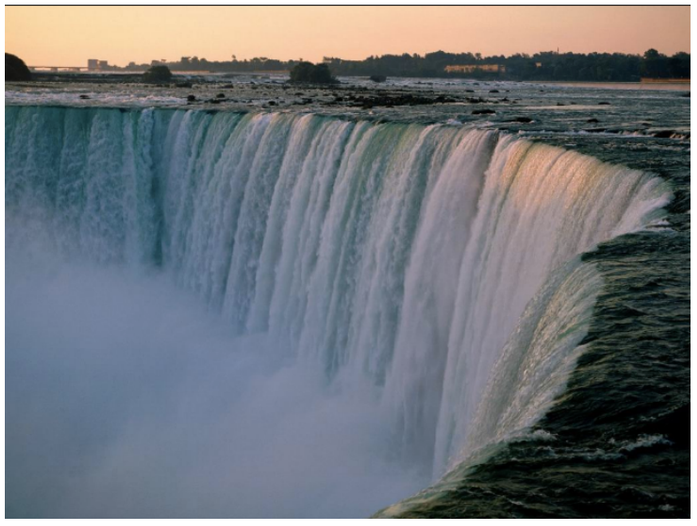

Niagara Falls Canada

Does Canada have too many PhDs?

Roundtable 2

Mr. Paul Davidson, BA, MA,
President Universities Canada

Presenter

Mr. Paul Davidson

Brief Bio: President, Universities Canada. Paul Davidson has played leadership roles in government, the private sector and the voluntary sector for over 25 years. At Universities Canada, he has led a process of organizational renewal and greater member engagement, achieving increases in research funding, resources for campus internationalization and increased attention to issues of access and success for aboriginal students. Named both a “top lobbyist” in Ottawa and a “top foreign policy influencer,” prior to joining Universities Canada, Mr. Davidson was the executive director of World University Service of Canada (WUSC) a leading international development agency active across Canada overseas. Mr. Davidson also held senior positions in Canadian book publishing and led the Toronto office of a prominent government relations firm. Mr. Davidson holds an MA from Queen’s University and a BA from Trent University.

"Now is the Time to Raise Ambition"

We have seen Canada’s research capacity grow and flourish over the last 20 years with the growth in funding of the granting councils, the creation of CFI, CIHR, and the establishment of the Canada Research Chairs, the Canada Research Excellence Chairs, and the Canada First Research Excellence Fund (CFREF). We are starting to see the results of these ambitious investments in university research.

To give three recent examples:

- The Canadian vaccine that stops the spread of Ebola in its tracks, saving tens of thousands of lives.
- The Nobel Prize in Physics to Art McDonald for his ground-breaking research at SNOLAB into the nature of neutrinos over the last 25 years.
- The response to the first call for CFREF funding which saw $2.6 billion in research proposals compete for $350 million – demonstrating our capacity to do world leading research if resources are available.

But we still have a long way to go. In 2014, Canada invested 1.55% of its GDP in research and development (GERD). But the OECD average for GERD as a share of GDP is 2.4%. To reach the OECD average would require an incremental investment of $81 billion over five years, assuming our competitors stood still.

Now is the time to raise our ambition.

In the last few years, from 2006 to 2013, we’ve gone from third position to eighth among OECD countries in higher education expenditures on R&D (HERD). For university attainment, Canada used to be a leader among OECD countries. But the latest OECD data shows that Canada is only in 18th spot for university degrees – and we fall to 21st when considering university degrees among 25- to 34-year-olds. For university degrees beyond the bachelor’s level (MA and PhD), Canada ranks 25th out of 34 countries. We say we are a knowledge-based economy, but we are being outperformed by our peers on the world stage when it comes to higher education.

Do we have too many PhDs? The answer is an emphatic no. We are only 22nd in the world for overall PhD production: 15th in science, 17th in engineering and 23rd in the social sciences. We need more PhDs and we need to help them transition into good jobs that utilize their valuable, specialized skills. Canada’s overall prosperity and innovation depend on it.

Universities are working hard to prepare their doctoral graduates for jobs outside academia. Institutions like the University of British Columbia, Concordia University, the University of Alberta, the University of Toronto and many more are prioritizing professional development for their PhD students. New programs, work-

shops and resources are supporting doctoral students to find and succeed at the careers they want, and these programs are becoming more and more common at universities across the country.

But for Canada to fully benefit from the expertise and skills of our PhDs, the business sector needs to step up. Over the last eight years, Canada has fallen from 18th to 26th in BERD (R&D investment by businesses). And between 2008 and 2012, Canada's R&D workforce in the business sector decreased by 24% – that's more than 40,000 jobs lost. These are not forestry jobs or oil patch jobs; these are knowledge jobs.

When the Lamontagne Committee of the Senate did a review of Canadian science policy, it heard evidence that Canada would soon produce "twice as many PhD graduates as we need" which would result in an "undesirable market situation." That was in 1968. If government had heeded their advice back then, how many of our leaders in research, innovation and the public service today might not have obtained their PhD?

PhDs are essential to Canada's innovation, future prosperity and international standing. We need more PhDs, not fewer. And we need the Canadian private sector to invest in these talented graduates to produce world-leading business innovation.

Dr. Paul Davidson Dr. Reinhart Reithmeier

Ms. Helle Tosine

Sir Paul Nurse. Dr. Michael Bloom

Does Canada have too many PhDs?

Roundtable 2

Dr. David Eidelman, MDCM, FRCPC
Dean of Medicine, McGill University

Presenter

Dr David Eidelman

Brief Bio: Vice-Principal (Health Affairs) and Dean of the McGill Faculty of Medicine. Dr David Eidelman received his MDCM from McGill University in 1979 and has been a practicing Respirologist for over 30 years. After completing his residency in internal medicine in Toronto he returned to McGill to complete his training in respiratory medicine. He has since held several administrative positions including, Chair of the McGill Department of Medicine and Physician-in-Chief at the McGill University Health Centre and Director of McGill's renowned Division of Respiratory Diseases.

"Improve the Quality of Doctoral Training"

To directly answer the question, compared to other leading industrial countries, Canada does not have too many PhDs. Nevertheless, Canada can do a lot to improve the quality of doctoral training so as to better meet the needs of our students and the economy.

Of course, as Dean of a Faculty of Medicine I am in an obvious conflict of interest in regard to this question. At any one time, my Faculty alone has about 1000 PhD students registered in its many programs, along with a similar number of MSc students. Of note, we have more PhD students than medical students. PhD students are a major part of the educational activity of the McGill Faculty of Medicine and critical to its success.

But are we ensuring the success of the students we have? To the extent that we can rely on surveys, 5 years from graduation 62% of our PhD graduates are employed and 30% are in post-docs. Of those employed, 61% are in university settings and 24% in government. 88% report considering themselves somewhat or very successful. Of note, McGill PhD graduates in Science and Engineering report higher employment rates than those from Medicine (78% and 90% respectively), with higher rates of employment in industry than our graduates. Thus, while our students are finding some success and satisfaction, the high rate of post-doc employment at 5 years suggest that we are not successfully preparing them for the job market. Post-docs are meant as preparation for an academic career, yet most post-docs will not get the tenure track job they are being prepared for.

How can we do better? In this regard, it may be of interest to compare the way we teach medical students to the functioning our doctoral programs. Of course, the comparison is not entirely straightforward. Medical school is intended to prepare students for a professional career and is predicated on the idea that students will receive additional training as residents before they go out into the "real world". Nevertheless, in both cases, an enormous investment in time and resources is made in preparing students for an eventual career.

A key change in medical education occurred toward the end of the 19th century as medical education moved from an apprenticeship model to one of a well structured educational program. In contrast, doctoral candidates are still largely trained on an apprenticeship model, supervised by someone who has the responsibility of training the student to be just like them. For students who aspire to become professors this can be very successful. However, as only about 20% of Canadian PhD graduates eventually go on to a tenure-track career, this is not realistic. PhD programs need to go beyond simply preparing a student for an academic career that most will never have.

Ideally, doctoral programs need to establish formal learning objectives that include traditional expectations of scholarship but go beyond this to consider the receptor capacity of the Canadian economy. Without sacrificing scholarship, students need to have the opportunity to master skills needed in the private and public sectors outside of the university. Moreover, appropriate assessment tools and evaluation methods are needed to ensure that students acquire the skills that they need. Comprehensive exams and thesis defenses may be effective tools to dem-

onstrate doctoral level scholarship, but do they guarantee that students have acquired the additional skills that make them attractive to employers.

In contrast to what happens with doctoral candidates, the training of health professionals is highly regulated. Supervision of medical students for example is subject to rigorous accreditation standards that aim to ensure, among other things, that supervisors are effective, supportive and fair. This is not the case for many or even most doctoral programs in Canada. The right to supervise doctoral students is often nearly automatic upon appointment as a professor. Once that right is granted, it is rarely taken away even if there is a record of poor supervision. Supervisors are not usually subjected to oversight and the outcomes of their supervision are not typically reviewed systematically. When students are unproductive or fail to complete their projects on time, this is almost always ascribed to a failure on the part of the student. While this approach is arguably acceptable under a traditional apprenticeship model, it is not the best way to prepare Canada's next generation of PhDs most of whom will work outside of academia.

Canada needs more PhDs. But we need to be more deliberate in establishing how we want to educate them, combining traditional scholarship with the acquisition of critical competencies necessary for success in the non-academic world. We need to be more rigorous in the design of our programs, in our assessment of outcomes and in the selection and oversight of supervisors. Given the excellence of Canada's universities and the large pool of highly qualified candidates, Canada has the opportunity to be a leader in graduate training but to do so requires a more structured approach aligned with the needs of the Canadian economy and society.

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Does Canada have too many PhDs?

Roundtable 2

Dr. Danika Goosney, PhD
Director General, Science CIHR

Presenter

Dr. Danika Goosney

Brief Bio: Director General, Science, Knowledge Translation and Ethics at the Canadian Institutes of Health Research. Dr. Goosney's doctoral dissertation garnered the Governor General's Gold Medal and the Cangene Canadian Graduate Student Microbiologist of the Year. She conducted her postdoctoral training as a CIHR Postdoctoral Fellow in the Department of Immunology at the Scripps Research Institute in La Jolla, California. Following her postdoctoral research, she pursued a career as a research scientist at two Vancouver-based biotechnology companies. She has held several key Director positions within the Research, Knowledge Translation and Ethics Portfolio at CIHR. In 2015, she was named one of Canada's emerging leaders as a member of the Governor General's Canadian Leadership Conference. She currently serves as a member of CIHR's Science Council and the Standing Committee on Ethics, and is co-chair of the Subcommittee on Implementation and Oversight. She is a passionate mentor for graduate students and postdoctoral fellows looking to pursue academic and non-academic careers.

Building and Broadening Capacity

Annually, CIHR invests $65M in direct training awards and approximately another $135M in supporting trainees indirectly through stipends on grants.

Reflecting on these investments and the changing health research landscape, it is critical that we ensure the quality and relevance of training to maximize return on our training investments… not just for CIHR, but also for trainees and institutions.

Collectively, we need to broaden our vision of research training to position Canada's PhDs as scientific, professional, and organizational leaders within and beyond the health research enterprise.

Following much consultation, we identified three main challenges that are driving the need for change:

I. The way we do research is evolving.

- The questions we're trying to address are more complex and require expertise from multiple disciplines and sectors.
- Technology and communication are advancing at a fast pace and changing the research environment.
- Global expertise is increasingly needed, as reflected in OECD stats that show that internationally co-authored papers have more than doubled in the past 2 decades.

II. We are lacking capacity in critical areas, including:

- **Data-Intensive Research:** A solid cadre of trainees must be equipped with data scholarship and analytical skills to take advantage of digital technologies to capture of the full value of research
- **Research Conducted with/by Aboriginal Peoples:** Relevant research and effective knowledge translation to improve the health and wellness of Aboriginal peoples requires the integration of Aboriginal peoples as research leaders
- **Health Professional Scientists:** There is a need to increase the number and diversity of health professionals involved in multidisciplinary research to build their research skills
- **Patient-Oriented Research:** To improve patient health outcomes through evidence-informed care, trainees must be effectively supported through training and career development in patient-oriented research
- **Entrepreneurial Skills in the Health Research Enterprise:** Canada needs researchers with entrepreneurial / business skills to support innovation in Canada

III. The career paths of health research trainees have shifted.

- According to a recent report published by the Conference Board of Canada (2015), only 18.6% of employed PhDs in Canada become full-time professors.

- Because the pool of PhDs is increasingly outpacing the # of available tenure-track academic positions, many believe that Canada is producing too many PhDs; however, OECD reports (2012) that Canada ranks second to last in terms of producing PhDs per capita compared to 16 of its peers (European countries, Scandinavian countries, Japan, Australia, USA, etc.)

Does Canada produce too many PhDs?

I would argue that Canada needs highly educated employees across the breadth of our knowledge sector, but we need to arm these trainees with the right skills and experiences to be successful within and outside of academia, and we need to work with employers to help them see the valuable skill set a PhD can bring to a job.

Many PhD graduates face challenging initial transitions to careers outside academia due to underdeveloped professional skills and networks, difficulty articulating the value of the skills gained through PhD studies to non-academic employers, and limited employer awareness or misperceptions about the potential value of PhD hires.

How do we position PhDs for successful careers?

The crucial importance of research training should remain at the heart of doctoral training, because various transferrable skills are acquired through this type of training; however, there are many things that could be done to empower trainees to take charge of their training and careers, including:

- Encouraging professional skills development;

- Increasing career awareness of trainees and their supervisors, including the skills required for those careers, and the employer expectations in different sectors; and

- Providing trainees with opportunities for critical hands-on experience and mentorship opportunities across different disciplines and sectors.

Dr. Maryse Lassonde Dr. Mona Nemer

Dr. David Eidelman

Dr. Rosie Goldstein Dr. Bruce McManus Dr. John Floras

Does Canada have too many PhDs?

Roundtable 2

Dr. Mehrdad Hariri, D.V.M., M.Sc.
CEO and President, Canadian Science Policy Centre

Presenter

Dr. Mehrdad Hariri

Brief Bio: Founder and CEO of the Canadian Science Policy Centre (www.sciencepolicy.ca), a not-profit virtual HUB for science technology and innovation policy in the Canada. Dr. Mehrdad Hariri founded the national annual Canadian Science Policy Conference (CSPC), a national multidisciplinary forum dedicated to the Canadian Science Technology and Innovation (STI) Policy discussions, engaging hundreds of organizations from various sectors and across the country to discuss the most pressing issues in Canadian Science and Innovation Policy. Mehrdad has numerous publications and opinion pieces in various media outlets, and regularly appears in media as a commentator on science policy issues. He studied in the fields of Veterinary Medicine, Cell Biology and Functional Genomes, in Tehran, Montréal and Toronto universities, and performed a post-doctoral research fellowship at the McLaughlin-Rotman Centre for Global Health.

Do we produce too many PhDs? My answer to this question is a BIG NO.

The 2012 State of the Nation report produced by Science Innovation Council, shows that in comparison with other nations and in particular with OECD countries, trend of PhD production is slow in Canada and we are not over producing PhDs. On the other hand the Conference Board of Canada report indicates that only 19% of PhD graduates can secure a full time academic position, almost one in five. This data suggest that it is time to review the PhD training comprehensively to ensure the PhDs graduates have the knowledge and skills to encounter realties of today's market and to be relevant to the position of science in society.

The world and the position of science in society has dramatically changed in the past three decades. Science has increasingly become integrated into all societal affairs - from policy making, to communication and public affairs to international affairs and diplomacy, to politics, social innovation and entrepreurship. Science is everywhere therefore science enterprise need to build its systematic channels of interactions with many of these areas.

Therefore the PhD training method need to be revised to provide better opportunities and training for candidates to expand their scope and see the challenges beyond lab and see the world differently, and find their ways of contributions at the frontiers of science in society. In other words, PhD training needs to be multidisciplinary and include comprehensive suite of trainings to impart multiple skills. In addition to traditional workshops and sessions, training opportunities are also required to interact with the real market, in particular soft science skills.

Through this we build capacities for ambassadors of science in many areas and find career paths for those PhD graduates who have the talent and the interest to work outside of the lab. Similar to MD PhDs, the training can be coupled with minors in business, public policy, international affairs, communications, management, entrepreneurship and many others.

In the past few years there have been efforts to provide entrepreneurship training for graduate students. While an excellent step forward, however this is far from variation and continuity. Training must go beyond just entrepreneurship and expands to many other skills.

Tomorrow's jobs market requires scientists as journalists, communicators, policy experts, diplomats, politicians, entrepreneurs, project managers, and many more. One may ask, but you don't need to have a PhD to serve as diplomat. The answer is that increasingly you do indeed. You must understand the science and innovation of the country of your mission, to report back to your ministry. Who would deny that science is increasingly part of the international affairs as the countries have immense global challenges such as climate change, global health, trade and IP matters, nuclear proliferations, GMO etc.

A comprehensive suite of professional training for PhD candidates is needed now.

Does Canada have too many PhDs?

Roundtable 2

Mr. Rob Henderson, BSc (Honours)
President and CEO, Bio Talent

Presenter

Mr. Rob Henderson

Brief Bio: President and CEO of BioTalent Canada. BioTalent Canada has reinvented itself over the past few years, and in the process has built one of Canada's largest networks of biotech companies and associations, including no less than 5 national and 10 provincial industry associations. BioTalent Canada's Mission as a national non-profit association is ensuring that Canada's bio-economy has access to the most skilled people available. Along with producing high-quality biotech Labour Market research, BioTalent Canada works to link the BioEconomy with key employment markets, including newcomers to Canada as well as young people.

The Business of Science

Dr. Goosney and Dr. Hariri echoed a lot of what I'm going to say. BioTalent Canada is a non-profit, national association that does, essentially, identifies skills gaps within the biotech sector and then works with various governments and our partners to address them. We can find national and provincial biotechnology associations through which we represent around 3,400 companies across Canada. 80% of the companies in the biotech industry, small to medium-sized enterprises, have less than 50 employees. They are also the greatest sector that represents the employment factor. So in terms of are we churning out PhDs, from a practical perspective, theoretically, no, absolutely not. Nor would I ever state that we should stop. Actually, we are doing a bad job on that point.

I should say the largest need right now within the bioeconomy is capital investment. Right next to it, is skill shortages. 53% of the companies across Canada report skill shortages. And in Ontario alone, which represents about 50% of the industry, in terms of the biotechnology cluster, the rate among new graduates is 19.5% within the biotechnology sector. Why is this? I agree totally with your commentary about entrepreneurship. The problem is sometimes we equate "innovation" with "entrepreneurship" and they are vastly different skill sets.

The biotechnology sector is a vastly unregulated sector and the employment positions are not regulated. Obviously, what we produce is highly regulated. However, we are using the title of "PhD" often as only an accreditation, which is sometimes an error because some of the skills that they are lacking are largely skills gaps. The 3 largest skills gaps, right now in the bioeconomy that are reported by small to medium-sized enterprises are sales, marketing, and leadership. A PhD doesn't necessarily give you these things.

We forget at times that as much as we are looking at research, the industry is governed by people – it is governed by "soft skills". This is where a lot of these new graduates and PhDs are failing or I should say, struggling, in terms of being able to get a foothold within a small to medium-sized enterprise, which is the flatstone of the organization. And the more critical these skills are, because the last thing that defines you as a small to medium-sized enterprise is your job title. And so one of the things that we have done is, and I think another indicator of this is in the last month, we placed 165 new graduates, biotechnology graduates, within their first career position within Canada's bioeconomy. 85% of the companies stated that employees, through a weighted assessment, state that they would not have employed these graduates had it not been for their assessment. Why is that? The vast number of CEOs state that they would not touch the graduate until they have 2 to 3 years of industry experience. It is simply too risky. So, that being said, there are lots of jobs out there for them. I do believe that there has to be a culture change, in terms that they have to understand the theory of Science, when talking about the biotechnology sector, and it is absolutely fundamental, however, we have to do a better job at teaching them "the Business of Science".

Does Canada have too many PhDs?

Roundtable 2

Dr. Ted Hewitt, PhD
President SSHRC

Presenter

Dr. Ted Hewitt

Brief Bio: President of the Social Sciences and Humanities Research Council (SSHRC). Dr. Ted Hewitt was Vice-President, Research and International Relations, at Western University in London, Ontario. Ted was also public policy scholar at the Brazil Institute at the Woodrow Wilson International Center for Scholars, and has been a professor of sociology since 1989. A leading authority on Brazil, his work is widely published. In 2002, Brazil's Ministry of Foreign Relations named him commander of the Order of Rio Branco. Ted's research has focused on national and international innovation systems, with emphasis on the roles of universities, industry and government in promoting economic prosperity in the 21st-century. Ted holds a PhD in sociology from McMaster University.

The Inherent Value of the PhD

Background

• SSHRC funds research and training in social sciences and humanities; we do not tend to fund research that touches on human health outcomes, but do fund considerable research on the implications of health for social well-being and prosperity

• About 45% of SSHRC's annual budget of $350M or so is allocated to student training; of that $75M on doctoral fellowships and $14M on postdoctoral fellowships

Does Canada Have Too Many Ph.Ds?

Depends how you look at it, but I would say definitely not, for a couple of reasons; there is an inherent value in the Ph.D itself, regardless of discipline, just as there is inherent value in education; it's about enlightenment, citizenship and creativity and about creating the kind of society in which we all want to live.

From the talent perspective, things get a bit more tricky; there is a long debate about the inherent contribution to higher education to economic development that dates to the human capital theories of the 1960s and 1970s. On the one hand, in graduating Ph.Ds Canada is producing its next generation of highly motivated, creative thinkers that would logically think would spur innovation and start-up activity. On the other hand, that's not an outcome that describes all Ph.D graduates, and to the extent that opportunities are not available for them at home, they will look elsewhere.

The challenge then is to create those opportunities, or more likely, to train Ph.Ds in such a way that they are better equipped to take advantages of the ones that exist—and more often than not these are outside the walls of academia and that certainly describes where we are with Ph.D grads in social sciences and humanities currently.

• Data pattern is clear; number of graduates is increasing markedly (now at well over 2000 per year), and the number of university vacancies is falling (to well under 1000)

• At SSHRC, we've responded to this challenge in a couple of ways; we have produced new guidelines for effective research training (for both supervisors and graduates) that apply to both academic and non-academic settings.

We are opening the doors to new training opportunities through Mitacs and through existing grants that involve partners in the community and in industry

• And we are funding research into the very question of Ph.D training itself

• Just before I leave this, I wanted to mention a critical element in the Ph.D equation that is often forgotten; it's not just a question of whether or not there are too many or too few Ph.Ds in general, but the rates of graduation in particular communities; this brings its own challenges

• This would include the representation of women in some disciplines, as well as graduation rates overall for aboriginal people; in both regards we have some distance to go

Does Canada have too many PhDs?

Roundtable 2

Dr. Reinhart Reithmeier, PhD Special Advisor to Dean of Graduate Studies, University of Toronto

Presenter

Dr. Reinhart Reithmeier

Brief Bio: Professor, Department of Biochemistry, University of Toronto. Dr. Reithmeier is known internationally for his research on anion transport membrane proteins in human health and disease. An award-winning lecturer, Dr. Reithmeier enjoys teaching introductory biochemistry to over 1,000 undergraduate students every year, as well as upper level and graduate courses. As former Chair of Biochemistry and a Special Advisor to the Dean of Graduate Studies on Graduate Skills Development and Engagement, Dr. Reithmeier is dedicated to ensuring that graduate students have the skill set and network to be fully prepared to succeed in graduate school and take advantage of the diverse job opportunities available to them in today's global marketplace. His leadership was recognized in 2012 by election to the Canadian Academy of Health Sciences.

The Case for Graduate Professional Development

When I completed my 11 years as Chair of Biochemistry at the University of Toronto, the Department completed a major self-study to demonstrate the excellence of our standing nationally and internationally.

I realized that we did not track our MSc or PhD graduates and so had no outcome data. To address this issue I hired a graduate student to locate all of our recent graduates to find out where they went upon graduation and where they are now. I was surprised to learn that only 15% of our PhD graduates become university professors. Since we use an apprenticeship model focused on training the next generation of professors, I found this number startlingly low.

I wondered about the 85% -are they working as baristas or driving taxis? The answer was a resounding no! The majority of our PhDs have found their unique pathways to success in diverse careers -scientific publishing, university administration, science policy, patent law, biotechnology and of course, medicine and dentistry.

What can you do with a PhD in biochemistry? Lots it turns out. The problem was that I didn't know, faculty members didn't know, and most significantly, graduate students didn't know. This knowledge gap highlights the importance of tracking graduates and generating robust outcome data. The realization that most PhD graduates don't become professors but find meaningful employment in different sectors is actually a good news story. We just need to tell it, to show the value of a PhD to funders, employers and especially prospective graduate students.

Graduates told us that they found the transition from school to the workplace difficult. To ease this transition, Biochemistry created a course in Graduate Professional Development featured in Science Careers: (http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2013_10_01/caredit.a1300216)

This for-credit course is designed to help graduate students develop the essential skills to succeed in graduate school and beyond and to build their professional network. They learn to communicate to the non-expert, write compelling cover letters and resumés, and perform cold calls and informational interviews. We also engage alumni. They are happy to return and tell their life story and how they met their challenges on the road to success. Many continue to serve as mentors.

Our graduates are "market-ready". Graduates of our course are moving directly from their PhD to exciting positions in many different sectors. A postdoctoral position is now becoming the plan B instead of the default pathway –a necessary pathway to an academic or research position, but little else. Universities need to re-imagine the PhD. It is much more than a credential to teach and research in one's discipline. It provides the opportunity for our highly-qualified personnel to be the thought-leaders, innovators and problem-solvers that our world need now more than ever.

Does Canada have too many PhDs?

Roundtable 2

Dr. Janet Rossant, C.C., PhD, FRS, FRSC
Immediate Past Chief of Research, Sick Kids Hospital

Presenter

Dr. Janet Rossant

Breif Bio: Senior scientist in the Developmental and Stem Cell Biology Program at the Hospital for Sick Children and University Professor in the Department of Molecular Genetics at the University of Toronto. She received her undergraduate degree from the University of Oxford and her PhD from the University of Cambridge. Her research interests are focussed on understanding the development of the early mammalian embryo and its derived stem cells. She is immediate past Chief of Research at the Hospital for Sick Children, a research enterprise with over 800 research trainees at various levels.

Why we need to change PhD training programs, not the number of PhDs.

"Graduates of advanced research and professional programs in the province develop skills that are not only required in the current marketplace, but are also necessary to innovate and create future enterprises in the fields of business, science, arts and culture. Graduate students of today will become leading innovators of tomorrow."

Council of Ontario Universities, Feb 2012

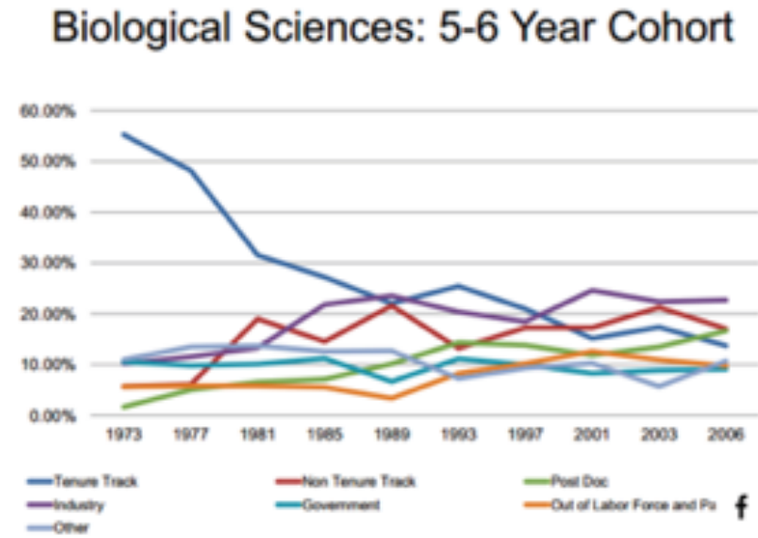
In response to the Ontario Government's plan to increase graduate training spaces in Ontario.

"A graduate education in the sciences produces individuals with broadly applicable skills in critical thinking and problem-solving, whose expertise could be invaluable in fields such as science policy and administration, the commerce of science, science writing, the law, and science education at all levels."

Bruce Alberts, Marc W. Kirschner, Shirley Tilghman and Harold Varmus. PNAS (2014), 111; 5773.

While also calling for a reduction in numbers of graduate students enrolled.

"*There is no definitive evidence that Ph.D. production exceeds current employment opportunities. We are aware, however, that training currently offered may be too narrow to promote full consideration of all of those opportunities. In that regard, we have recently announced the BEST award program to encourage institutions to offer training experiences that better prepare students for the existing array of research and research-related careers."* Sally Rockey and Francis Collins, NIH blog, September 2013



Jordan Weissman, (2013) The Atlantic.

Tenure stream jobs in academia have dropped with only some compensatory rise in other employment opportunities.

These contrasting views on the current state of graduate training programs and the job market for PhD students, reflect divergent views on the meaning and value of the PhD in our current global economy. The outdated view of the PhD as an automatic stepping stone to a career in academia seems still to linger on, despite all the evidence that shows that only a minority of PhDs end up in tenure stream positions today. Graduate training is still provided by academics, who often have little understanding of the broader job market and, it must be said, often little sympathy for those who chose to take their quantitative and analytical skills gained in graduate research and use them outside of the academic womb. And yet, PhDs gained in STEM subjects can open doors to careers in industry, government, business and the financial sector, health charities and not-for-profit foundations, venture capital, communications and education, to mention only a few.

So how must graduate training programs change to respond to the changing market? First, we are not necessarily training too many PhDs, but we keep them in training too long. In many N.American universities, it takes between 5-7 years to complete a PhD in the life sciences. This is largely driven by the need to complete complex experiments to the level expected for publication in a top journal. However, that length of time at a salary close to the poverty line, does not seem appropriate for those not intending to pursue an academic career. Many PhD programs talk about reducing the timeline but few take any drastic action to change this equation.

Second, we must broaden the training opportunities available to PhD students to include soft skills, such as communication, leadership training, people management, and more specific opportunities to intern in related job areas during their training programs. Many universities and funding agencies are putting such programs in place, in collaboration with the trainees themselves. At the Hospital for Sick Children, for example, through the Research Training Centre, we have put in place a comprehensive series of career development modules to support the broad training needs of our students, post-docs, research associates and faculty members, at the different stages of their careers. We take pride in sending our trainees around the world into a variety of different careers, and we learn from their experiences to better train the next generation.

Third, more consideration should be given to interdisciplinary programs beyond the MD/PhD stream, such as PhD/MBA, PhD/Law, PhD/Governmental affairs.

The critical skills and problem-solving capacities gained from intensive scientific research will provide PhD graduates not only with transferable skills in the workforce, but also the means to rationally assess complex global issues, such as climate change, economic disparities, global security, and contribute meaningfully to the needed public and political debates.

Supreme Court of Canada, Ottawa

Does Canada have too many PhDs?

Roundtable 2

Dr. Henry G. Friesen, C.C., FRSC, FCAHS Distinguished Professor Emeritus, University of Manitoba

Dr. Henry Friesen

Discussant

Bigraphical excerpt see page 22

Emerging Themes

Some themes have emerged during the discussion. A general consensus expressed was that the current approach to education of PhD's fails to recognize the diversity and range of employment opportunities for graduates in today's society.

I am reminded of the study by the Council of Canadian Academies (2009) ""Why Canada Falls Short"– that highlighted the shortfall in investments in industrial R&D in Canada. I am not sure where Canada ranks in R&D investments by the private sector relative to other countries, but it is much lower than ranking for Canada's R&D investments by the public sector. Given the decline in oil prices, there is likely to be a further loss of industrial R&D, on top of the major reduction in R&D that took place with the collapse of Nortel earlier.

I am particularly interested in the comment about a study that concluded 15% and 85% of PH. D's graduates from the U of T find employment in academia and the private sector respectively. I would be particularly interested to have a more detailed account of the variety of opportunities that exist for the 85%, It would provide guidance to PH.D programs to assist in designing their programs.

I couldn't help but reflect on current MD programs and professional development. Certainly in my era, many if not most entered Medicine imagining themselves to be a family physician, as the only possible career path.

Today when we look at the range of career opportunities available to MD graduates it's absolutely mind-boggling. Today the number of specialty programs approved by the Royal College alone number in the 40s.. And that is just one category of many career paths available to MD's. both in the public and private sector.

Blue Jay The Provincial Bird of Prince Edward Island

Does Canada have too many PhDs?

Roundtable 2

Professor Sir Paul Nurse, PRS, PhD,
President of the Royal Society (London, UK) and Chief Executive,
The Francis Crick Institute

Sir Paul Nurse

Discussant

Biographical excerpt see page 20

PhDs and the Knowledge Economy

There has been a lot of agreement already and I am not going to say anything new. I would like to start with this issue of the overall vision of what we are trying to achieve and how we can drive that into the political agenda. I think central to this is the development of a knowledge-driven economy. The problem with that sentence is that it just trips off the tongue and everybody says then they move on to something else. I think that more analysis is needed, and the point is how we deliver that. And the whole PhD issue is critical to it and we have to put it in that context. But the first thing we have to do is to sell the concept of the knowledge-economy properly, sell it to our political masters and sell them what the consequences of that are – which is, of course, investment in the generation of knowledge, not only in the universities, but across the whole endeavour. And that's crucial because I think it was Henry who commented on the poor investment not only in Canada, but in many other countries around the world in privately, commercially-based research as well. But first of all, we have to establish the vision and sell it. That is our starting point.

First, are we really attracting (and this is not really a Canadian problem, but a worldwide problem), are we really attracting the highest quality PhD candidates? I am not sure we are to be honest with you. There are various reasons for this, which I will get back to in a moment. But we need to look critically at the standards we apply to our graduate students. I've worked in different places and I have seen that there are some institutions that attract the very highest quality and there are others who do not, and there is very little discussion about why and I think if we need to dig into that rather painful subject.

Second, there is a tension because graduate students are the engine of research and they are often thought of as cheap labour that produces the results that academics can build their careers on. And bluntly, that can be the main driving force in the laboratory for some group leaders and that is quite wrong.

Also other skill sets are required. But what are we to do about this? The pyramid of employment is such that most students cannot get into an academic career, although we pretend they can. It was true when higher education was expanding perhaps, but that is no longer the case. I do think that the "apprenticeship model" is not a bad one for PhD activity, but I may be getting too ancient and might need reconstruction. But the "apprenticeship model" needs to be complemented and supplemented by other professional skills development.

Now, the question mark I put there is, let us not retreat into a sort of tick-box approach to that, which is, I think, another danger. Professional skills, tick. Understanding entrepreneurship, tick. And I have looked at some of these courses and they are not appropriate. And not only that, they are time-consuming and our students know that they are not useful and that doesn't do us any good at all. So, I think we need to invest in really decent and tailored activities that would allow student development.

The statistics are that 85% of students will leave academia and they can contribute, as many have said, greatly to society. They bring a new way of thinking elsewhere if they've been trained properly. They bring a respect for evidence; they bring a respect for data, intersecting with society where we need it. And in addition, they can act as the bridge between other activities, like Law, Finance and Policy-making into Science, which we also desperately need. Unfortunately, most

supervisors have little idea about other career alternatives and indeed, look upon them as failure. So that means we have a cultural issue too that if you should dare to leave this profession, you are a failure. So that's another issue I think we have to pick up on.

I have almost said everything I was going to comment on. But I am struck by the difference in quality of graduate students going into different institutions. Having worked in different places in my life, on both sides of the Atlantic, the figure is 85%:15%, perhaps in the UK, closer to 80%:20%. There are institutions where it is utterly the reverse. In fact, both the institutes that I ran in the UK and in the US the figures are 20%: 80%, the reverse! 80% went into an academic career. Why is there such a disparity?

So, to sum it all up, everything said around this table was all very sensible, but I think two things are clear. First, somebody said, "data". We don't have enough data about all of this stuff. We just rumble along with the same old model for half a century. We haven't really thought about this enough and we need the data to understand what is happening. Also, we have not conceptually thought about what we are trying to deliver. Second, is back to where I began. It has to be seen as part of an overall vision for society and the role of research in a knowledge-economy and the key part that PhD students should play in that.

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European Robin, The National Bird of The U.K.

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