

# 2017 Pre-Budget Submission from the Canadian Institute for Advanced Research (CIFAR)

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## Executive Summary

The Government of Canada recognizes the important role that research plays in supporting a sustainable, innovative economy and competitive businesses. By ensuring that Canada has a vibrant and forward-looking research community, it supports the idea generation and talent development necessary to help Canada's businesses meet their innovation and prosperity goals. Budget 2016 announced new funding for Canada's granting councils, regional innovation clusters, and clean tech research, among other programs for research and innovation.

In order to support the creation of the cutting edge knowledge and top-tier talent necessary for Canada's businesses to succeed and prosper in a sustainable manner, CIFAR recommends that as the Government of Canada develops Budget 2017, it ensures that its evaluation of investments in research and innovation consider four critical lenses:

- 1) **Global Collaboration:** Canada continues to punch above its weight in scientific research, and as a small nation, much of its scientific success comes from its ability to collaborate outside of its borders. To become more innovative, Canada must accelerate its ability to collaborate globally.
- 2) **Supporting Young Researchers:** Young people bring fresh perspectives, energy, passion, curiosity and intelligence, all of which are essential for great science. As the global competition for talent becomes more intense, Canada must ensure that it is a destination of choice for the best young minds.
- 3) **Problem-Based Research:** The most pressing challenges facing the world can only be solved by focusing on problems, as opposed to single disciplines. Issues like climate change are not just engineering or economics problems, they must be addressed by a multidisciplinary approach.
- 4) **Research Excellence:** Canada must maintain both a broad research capacity as well as the capability for top-tier, world-leading discovery in important, selected areas.

## Introduction

Budget 2016 emphasized “the central role of science in a thriving, clean economy” and the importance of “the creation of knowledge and development of highly qualified people [for] Canada’s prosperity in the global economy.” Cutting edge research is critical for creating the new ideas that fuel the long-term prosperity and innovation of Canadian businesses. Maintaining Canada’s advantage in an increasingly competitive global research environment requires investment, but those investments must be made intelligently. CIFAR recommends the that following four lenses be considered when evaluating investments in Budget 2017.

## Global Research Collaboration

The era of the lone scientist developing research breakthroughs is long past. Today, major discoveries increasingly arise from collaboration within large research teams, frequently based in multiple countries. In 1981, over 30% of significant scientific papers had a single author, but by 2012 this had dropped to just 11%. Today, scientific papers regularly include authorship groups of over 50, and even number in the hundreds.

As research becomes more collaborative and interdisciplinary, it also has become more global. Worldwide, the proportion of science and engineering papers with multinational authors almost tripled from 1988 to 2011. Being part of these international collaborations is critical: according to a 2011 study published in *Nature*, “institutions that do not form international collaborations risk progressive disenfranchisement and countries that do not nurture their talent will lose out entirely.”

International collaboration also improves the results of domestic research: A 2013 study found that international research had greater impact than domestic research, which could not be explained by the quality of the individual researchers. The study concluded that international collaboration provides new insights more readily than purely domestic research.

CIFAR has seen first-hand the power of global collaboration. Since its inception in 1982, CIFAR’s mission has been to bring together extraordinary researchers from around the world to address questions of global importance. With 14 research programs in its portfolio, CIFAR is now comprised of over 360 fellows and advisors, from 17 countries. The work of our fellows in these programs has transformed our understanding of population health, the Earth’s evolution, artificial intelligence, early brain development, the effect of institutions on prosperity, and much more.

As a smaller nation, global collaboration has been critical to Canada’s success: in 2014, a full 45% of Canadian papers were co-published with international authors. Global connectivity is also critical to Canada’s ability to recruit top-tier researchers to Canada. However, Canada has room to improve, as it ranked just 12<sup>th</sup> out of 30 countries in international co-publication. Canada must be proactive in order to play a central role in the global networks of the future and should ensure that researchers are supported and encouraged to collaborate with colleagues outside of Canada.

## Young Researchers

Historically, one of the great sources of transformative science has been from relatively young researchers. For Nobel Laureates in the physical sciences, the average age at which they completed their prize-winning work ranges from 37 to 40, depending on the field. However, as research funding has become more competitive, it is young researchers that have suffered. Despite their promise, they lack the track record of discovery that is important to securing funding; in many cases they are even competing against their mentors.

It is important that Canada both compete for promising young talent and ensure that talent in Canada can develop. A global economy that is increasingly talent-based is driving growing demand for the skills of the best young minds. To make the best use of promising talent, these young researchers also need the ability to develop their skills, both through their own research programs, and through connections to high-calibre established researchers that can act as mentors.

This becomes even more critical as more researchers blur the lines between researcher and entrepreneur. By developing the next generation of research talent, we are also developing one of the major sources of new business ideas. This applies to those researchers who develop a new product, service, or patent and create licenses and spin-offs, but also to those who leave academia for a variety of roles in the private sector. The core research skillset which identifies, isolates, and solves problems is needed in the boardroom as well as the laboratory.

In CIFAR's experience, many young researchers are eager for opportunities to engage outside of academia by connecting their research to the public and/or private sectors. They recognize that there are significant challenges facing the world, and that a bilateral exchange of information can both inform their research and accelerate uptake of new ideas and knowledge. However, the pressures of starting an academic career often mean that these activities cannot be prioritized, which represents a great loss of potential for Canada. The Government of Canada should support young researchers' work, as well as programs which identify opportunities for researchers to engage with the public and private sector.

## Problem-Based Research

Many of the great discoveries of the past that have changed the world depended on a single discipline. Facing a looming crisis in the growth of food production, chemists developed synthetic fertilizer. Facing growing inflation and instability, economists developed inflation targeting. Facing the need for a resilient communications network, computer scientists developed the precursor to the Internet.

Today, the world faces problems that cannot be solved by a single research discipline. The solutions to even relatively focused problems depend on many disciplines. For example, understanding many diseases now depends on understanding the interactions between genetic, environmental, and microbial factors. Even technology development requires multidisciplinary work. CIFAR's *Learning in Machines and Brains* program, which pioneered the "deep learning" approach to artificial intelligence that is estimated to become a \$70B industry by 2020, required multidisciplinary

perspectives. This included not just computer scientists, but also neuroscientists to explore how our understanding of the human brain could influence artificial intelligence.

Even more challenging problems, those that are based in complex global systems, like climate change, children's well-being, and ocean health, require solutions based on diverse disciplines working together. If Canada wishes to be at the forefront of solving major world problems, and build the dynamic research environment that can support world-leading businesses, it should ensure that research is not constrained by disciplinary boundaries.

## Research Excellence

Much of the research that leads to improvements in quality of life is incremental, and focuses on adding small but critical new enhancements to existing technology, theory, and practice. It is important that Canada build a strong base of research capacity that can conduct this type of research. However, Canada must also recognize that major research discoveries, and the associated social and economic benefits, stem from truly great ideas by the very best researchers in the world. These researchers focus on new approaches to major challenges that, when successful, can leapfrog incremental research. To capture these benefits, there is now tremendous global competition to develop, attract, and retain the world's best researchers, as well as facilitate their work.

Canada cannot develop true excellence in every field, and must be selective in the important areas of research on which it concentrates, but also cannot predict which approaches within a field will succeed, and must provide its best researchers with the freedom to explore new approaches. Some of these approaches will not be successful, but without risk there cannot be transformative discoveries. Research excellence and risk-taking do not provide a guarantee of transformative discovery, but they are an absolute precondition to it.

CIFAR's recently launched *Bio-Inspired Solar Energy* is illustrative of the value of both research excellence and the freedom to investigate bold new directions. This program brings together top researchers from Canada and 6 other countries to explore how adopting biological processes can make solar energy capture and storage significant more efficient. While the approach is new and may not fully succeed, it has tremendous potential to create disruptive technology, and has already produced early results, including liquid fuels produced from solar energy that can power a car without modifications.

Canada must ensure that its research and innovation investments take into account the need to support important research areas, attract and retain globally excellent researchers, and ensure the freedom for risk-taking necessary to create truly disruptive technologies in Canada.

## Conclusion

Budget 2017 provides an opportunity for Canada to make smart, strategic investments that ensure it can position its businesses for long-term innovation and prosperity by supporting a vibrant research ecosystem. This will require investment, and CIFAR encourages the Government of Canada to take four important perspectives into account when constructing Budget 2017.

Canada should ensure that its investments support global collaboration, young researchers, multidisciplinary and problem-based research, and true global excellence. Each of these factors are important today, and will become even more so as the world becomes ever more interconnected and complex. By making targeted investments today, the Government of Canada can contribute to the long-term innovation and prosperity of Canada's businesses, as well as its economy and society.