Canadian Association of Physicists

A BRIEF to the HOUSE OF COMMONS STANDING COMMITTEE on FINANCE

The Canadian Association of Physicists (CAP) is the national organization representing Canadian physicists in all sectors, including universities, government laboratories, and the private sector.

Physics is the most fundamental of the sciences, being essential as an enabler of advances in all the other sciences, technology, and medicine. Advances in physics were the foundation of the key technologies whose impacts have done so much to improve our lives, including even the world wide web[1]! New physics-based principles and discoveries drive many other remarkable advances. Inventions based on quantum physics alone have been estimated to account for over 25% of the industrialized nations' GDP.[2]

Executive Summary: Job growth and continued prosperity depend increasingly on a nation's ability to innovate. Basic research, mainly in universities, is widely accepted to be an essential part of innovation. Understanding this, the EU recently proposed[3] a 45% increase (plus inflation) for research and innovation for its next 7-year plan! Basic university research is especially important in Canada, since our industry relies more heavily on academic expertise. In-house government research plays a critical role too. Even in times of stringency, a continued commitment to publicly-funded research is essential, to provide the fuel for Canada to grow out of austerity. Even temporary reductions would cause damage that could take decades to repair. The Science, Technology and Innovation Council (STIC) in their latest report[4] identified Canada's strengths as "*a strong talent pool and a robust public research capacity*". To maintain both, we recommend:

1. **That the federal government augment the Granting Councils' budgets by a modest 5%, directed to their programs that support basic research. Cost about $120M p.a.**
2. **That the proposed savings from the reduction in the Canada Graduate Scholarships program be used to fund doctoral scholarships and postdoctoral fellowships in universities and industry, by re-directing the funds to the existing Granting Council programs. Cost $17.5M p.a., funding for example 415 doctoral students and 250 postdoctoral fellowships each year.**
3. **At a time when the federal government, like many others, is aggressively pursuing reductions in spending, that Canada emulate many European governments[3] by recognizing the unique importance of government science and ensuring that all essential government research programs are funded appropriately to meet their mandates.**

Why would we call for increased spending in an era of austerity? The HCFC asks '*in particular*' for the *"thoughts and suggestions of Canadians about how to attain high levels of job growth and business investment in order to ensure shared prosperity and a high standard of living for all."* Most economists agree[5] that a nation's place in the world depends increasingly on its ability to innovate. Technological innovation probably accounts for over 50% of economic growth in advanced countries.[6, 7] Research and highly trained people are critical enablers of technological innovation, which in turn is needed to put us on a path to sustainable job growth and improved prosperity.

Why not cut a bit now and catch up when times are better? This may work for many activities. However, like most outstanding research capabilities, Canada's took decades to establish. Failure to stay the course now could cause irreparable damage. Cuts to research would mean being left behind by other countries. The EU, facing difficulties far worse than Canada's, recently proposed increases in spending on research and innovation of 45% over its next 7-year plan, leaving most other major areas flat![3]

Investing in education and research is a top priority. In times of economic crisis, we need investments more than ever. German Ministry of Education & Research. July 2011

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Innovation-wise, where are we now? Unfortunately, studies[8] repeatedly give Canada failing grades for most aspects of innovation. As a result, our productivity growth has been poor, real earnings have not advanced since 1980, and living standards are sliding relative to other nations.[9]

What about the future? The emerging nations, once mainly a source of cheap labour, are well on the way to becoming formidable competitors in technology. In 2008, the company filing the most international patents was Chinese. In 2006, Brazil, Russia, India and China together trained half as many doctoral graduates as the entire OECD.[10] China will soon have more researchers than either the USA or the EU.[11] Two Indian InfoTech companies are amongst the world's biggest.

> *A wave of low-cost innovation will shake many [rich world] industries to their foundations*.
>
> The Economist, April 17, 2010

And our resource sector? It's not immune from major foreign competition. A recent Chinese innovation, for example, provides a low-cost alternative to Canadian refined nickel -- their production is already greater than Sudbury's.[12]

One answer: economists and business people call for *basic* research (research undertaken, typically in universities, without an immediate application in mind -- sometimes called 'fundamental research'):

> *Governments should invest in the infrastructure that supports innovation, from modernized electricity grids .... to basic research and university education*. One of only 3 recommendations 'The Economist' magazine made to governments in 2010 [13], to secure the jobs of the future.
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> *The innovations that have improved the country's productivity and quality of life are ultimately grounded in the results of basic research. Now, more than ever, basic research is needed to chart the way forward*. U.S. Congress Joint Economic Committee, 2010. [14]
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> *Scientific advances represent the world's best chance .... for human survival.* Neil Reynolds, Globe and Mail.[15]
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> [*Our] recommendations ... are based on one key premise: continuing government commitment to publicly funded research carried out with little or no expectation of [immediate] commercial application.... Canada cannot build a more robust commercialization environment without a strong research community committed to excellence in the pursuit and use of knowledge.* Industry Canada's 2006, business-based committee on commercialization. [16]
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> *Investment in research councils produces higher returns than initiatives such as research-and-development tax credits for the private sector.* Editorial in 'Nature', referring to research on the U.K. by economists J. Haskel and G. Wallis.[17]

How can *basic* research possibly help us? Applied (or 'targeted) research is, of course essential. But the most significant breakthroughs come from basic research. As the Industry Canada committee said: "*no one can predict which lines of research effort will generate major, dramatic advances"*. Entirely unanticipated advances produce truly new opportunities for applied research in universities and industry, and enable innovation based on today's breakthroughs, not yesterday's! As previously mentioned, a good example is the spin-off of the World Wide Web. Basic research underlies all modern computers and electronics, modern communication technologies, other laser-based technologies and medical treatments, X-rays, MRIs, PET scans, and a host of other advances whose economic and social impacts have changed our world.

Then why doesn't industry do it? It has been shown many times that the benefits of basic breakthroughs are enjoyed primarily by the general economy and society as a whole, rather than by the organization doing the research. Moreover, the unpredictability of basic research means that a successful program requires long-term work in many disciplines, an expensive undertaking.

If the benefits of basic research are spread widely, why not let other countries do it for us? The evidence is that no country can free-ride on the world scientific system. World-leading research in a wide range of disciplines solves problems and creates major opportunities that industry and governments exploit, typically in the same country as the original research (see just a few examples[18]). It causes increased industrial

research,[19] a very important factor for Canada. Within Canada, it directly spins-off major new Canadian companies. It plays a key role in producing vibrant, creative, economically successful[20] regions such as Waterloo, and thus, indirectly, spawns firms like Research in Motion. Crucially, it creates Canadian intellectual capacity which gains us access to the personal international networks by which much foreign technology, know-how, and ideas are transferred. It plays a critical role in educating and inspiring the next generation of researchers and other leaders, and in attracting foreign students to Canada (who alone contribute $6.5B p.a. to our economy[21]).

Many of the impacts of basic research are pervasive and hard to quantify. But one of them (completely new companies spun-off by academics, over a nearly 40 year period, directly from Canadian academic natural science and engineering research) has recently been very conservatively quantified.[22] This one economic impact, which flows from increased exports, is estimated to be 3 – 4 times the total federal/provincial research funding, direct and indirect, over the whole period, even allowing for the time value of money. Governments themselves will receive more in additional tax than they spent.

Don't we spend enough already? Government support for academic research, as a % of GDP, is about 6th in the OECD[23]. But despite large government incentives over many years, in-house *industrial* R&D spending[24] remains low. The persistence of the problem suggests that it may have structural, permanent roots.[25] In contrast, the proportion of Canadian *academic* research supported by Canadian industry (while small compared with government support) is second only to Germany in the G7, and 50% more than the G7 average.[23] In many cases, then, industry appears to fund applied R&D at universities (which builds on the universities' earlier basic work) rather than performing it in-house. This means that the health of academic research is even more important in Canada than elsewhere, and that a well-above-average investment by government is essential to help offset the poor industrial performance.

According to the Conference Board[5] and STIC,[4] scientific output (primarily academic basic research) and highly trained personnel are the only bright spots in Canada's dismal international innovation rankings. As we address the problem areas, we must continue to nurture and grow these bright spots, The Industry Canada committee said it well: *The challenge for government is to increase - not merely maintain - its investments in publicly funded research, while encouraging private sector R&D.*

Talking of publicly-funded research, what about the government's own in-house research? Government research also plays a unique and indispensible role in contributing to economic prosperity and protecting the health and welfare of Canadians. It has been responsible for many of Canada's greatest scientific and technological achievements, with major social and economic impacts. Products of federal basic and applied in-house research range from hundreds of new wheat varieties to a vaccine for meningitis C (reducing the disease's incidence in millions of children worldwide), and from corrosion resistant concrete to a brain-surgery simulator that will make surgery safer for countless patients; and, of course, canola which alone contributes more than $2B p.a. to Canada's economy.

What else does in-house government research do? It supports: the development of public policy, regulations and decision-making; our public health, safety and security programs; and the development and management of national and international standards. It provides unbiased and authoritative advice to government policy-makers against which competing claims can be measured. It supplies the expertise necessary to run the extraordinarily successful IRAP program, which provides funding to companies at a crucial stage of product development. From SARS to the mountain pine beetle, from water and air quality to fish stocks and nuclear safeguards, Canadians' health, environment and economic prosperity depend on the federal government's ability to effectively monitor serious problems and to contribute to solutions. Few of these capabilities could be sourced elsewhere.

What about government-funded large-scale research infrastructure? Government provides scientific infrastructure (*and* the expertise to operate it), which is used by multiple organizations. For example, the Chalk River NRU reactor is an essential tool for universities and industry, including aerospace, automotive and manufacturing. Advanced materials characterization, using methods invented at Chalk River and

adopted around the world, facilitates development of safer, more reliable, and less expensive products, improves Canada's competitiveness, and opens new markets. Other large publicly-funded capabilities, vital for Canada's competitiveness, include intense X-rays at the Canadian Light Source, muon beams for materials characterization at TRIUMF, and various metallurgical facilities at the CANMET Materials Technology Laboratory.

In summary: Our future depends on greatly improving Canadian innovation. Basic academic research (necessarily funded by government) in physics and other areas is a crucial driver of innovation, particularly as Canadian industry's in-house R&D spending is modest. Canadian and foreign experts agree on the importance of increasing support for basic research. Just the academic companies spun-off from Canadian basic research much more than repay the government funding. Basic research and highly trained personnel are the bright spots in Canadian innovation -- we must continue to nurture and grow them, at the same time as encouraging more applied efforts. We must also take great care not to lose critically important research capabilities within government itself.

Recommendations

1. The Granting Councils form the bedrock of support for Canadian basic research and are admired internationally. While funding for the Councils' *applied* programs has increased significantly in recent years, increased support for *basic* research is also essential to Canada's future prosperity. It is crucial to fund innovative science with long term impact, in order to feed the pipeline that results in economic competitiveness. Recognizing this, Budgets 2010 and 2011 did increase the Councils' basic research budgets -- small but much appreciated increases. Yet very many researchers rated highly by international standards of excellence (i.e. fully worthy of funding) still cannot be funded; in health research for example, only roughly 25% of their research proposals are typically funded. Highly talented individuals are then unable to contribute their research to Canada's innovation and wealth-creating effort. Moreover, *cuts* to the Councils imposed in 2009 will reduce their budgets by $87M p.a. in 2011-12 and beyond. CAP therefore recommends: **That the federal government augment the Granting Councils' budgets by a modest 5%, directed to their programs that support basic research. Cost about $120M p.a.**

2. Ph.D. students and postdoctoral fellows in their first post-PhD positions are a critical part of our research efforts. Moreover, they are the next generation of researchers and innovators, and we need to encourage our brightest minds to remain in Canada. Canada produces proportionately 35% fewer doctoral graduates than the OECD average or the U.S.[26] This has been recognized with, for example, the expansion of the Canada Graduate Scholarship (CGS) program. Yet after 2011-2012, the CGS budget for doctoral students will be *reduced* by $17.5M. CAP therefore recommends: **That the proposed savings from the reduction in the CGS program be used to fund doctoral scholarships and postdoctoral fellowships in universities and industry, by re-directing the funds to the existing Granting Council programs. Cost $17.5M p.a., funding for example 415 doctoral students and 250 postdoctoral fellowships each year.**

3. Government science plays a unique and essential role in innovation and economic competitiveness. Many of its functions cannot be undertaken elsewhere. Science-based departments and agencies have already seen 5% cuts between 2007 and 2011. Moreover, for many years, Canada has badly trailed the G7 and OECD average for government in-house R&D as a % of GDP[23]. Substantial additional cuts would cause irreversible damage. CAP therefore recommends: **At a time when the federal government, like many others, is aggressively pursuing reductions in spending, that Canada emulate many European governments[3] by recognizing the unique importance of government science and ensuring that all essential government research programs are funded appropriately to meet their mandates.**

FOOTNOTES AND SOURCES OF INFORMATION

[1]See, for example, S. Avery, *Idea finally spins gold for Web's inventor*, Globe and Mail, Toronto (June 15, 2004). Tim Berners-Lee invented the WWW while at the international subatomic physics laboratory, CERN, in 1989. It arose from the worldwide subatomic physics community's need to easily share and update information. Canadians have been very active at CERN for many years.

[2] L. Lederman, The God Particle. *If the Universe is the Answer, What is the Question?* Houghton Mifflin, Boston, 1993

[3] C. Macilwain, Nature 475 14-15 (July 5, 2011) *and* European Commission, A Budget for Europe 2020 (June 29, 2011), which includes increases to government science agencies. In addition, German research organizations are guaranteed an annual increase of 5% from the German government http://www.bmbf.de/en/96.php and France and Spain are other examples of EU countries which have also increased research spending for 2011.

[4] Science, Technology and Innovation Council, *State of the Nation, 2010* (2011).

[5] The Conference Board of Canada summarizes it well: "Innovation is essential to a high-performing economy. It is also critical to environmental protection, a high-performing education system, a well-functioning system of health promotion and health care, and an inclusive society. Without innovation, all these systems stagnate and Canada's performance deteriorates relative to that of its peers." (*A Report Card on Canada, Innovation*, February 2010).

[6] M. Pianta, *Technology and Growth in OECD Countries, 1970-1990*, Cambridge J. of Economics 19 (1) 175-187 (1995).

[7] C. Jones, *Sources of U.S Economic Growth in a World of Ideas*, American Economic Review 92 (1) 220-239 (2002). This study (and the 50% estimate) included five nations: the U.S., Germany, Japan, France, and the U.K.

[8] See reference 5, for example. Canada ranks 14th out of 17 countries and receives a 'D' grade (the lowest ranking) overall, as it has for decades. Out of 12 individual innovation indicators, it scores 'D' on 9 indicators and 'C' on 2 indicators. Its sole 'B' rating is in Scientific Articles, an area driven largely by the academic community's basic research.

[9] TD Financial Group, *Post-secondary Education is a Smart Route to a Brighter Future for Canadians. Standard of Living and Education Linked to High Degree* (May 17, 2010), based on OECD data.

[10] *OECD Science, Technology and Industry Scoreboard* (OECD, 2009), pp. 17 and 135.

[11] Hugo Hollanders and Luc Soete, UNESCO Science Report 2010, p. 10.

[12] A. Hoffman, "*A breakthrough in China, another blow for Sudbury*," Globe and Mail Report on Business, pp. 1, 4 (June 11, 2010).

[13] The Economist (August 7, 2010), p. 9. The other recommendations were to improve the environment for business, and to encourage 'winners' to emerge by themselves instead of trying to pick them.

[14] U.S. Congress Joint Economic Committee, *The Pivotal Role of Government Investment in Basic Research* (May 2010).

[15] Neil Reynolds, Globe and Mail Report on Business (December 4, 2009), p. B2.

[16] *People and Excellence: The Heart of Successful Commercialization: Final Report of the Expert Panel on Commercialization*, Industry Canada (2006).

[17] "*Value-Adding Enterprise*", Nature (editorial) 466 p. 296 (July 15, 2010), referring to J. Haskel and G. Wallis, Centre for Economic Policy Research, Discussion Paper 7725 (March, 2010).

[18] For example: (i) CAP member, Andreas Mandelis, a professor at the University of Toronto, has started a company called Quantum Dental Technologies. The firm is introducing an early detection device using a special laser technique that, it says, finds dental cavities before X-rays can. The tooth can then be re-mineralized without drilling or filling. (ii) NSERC has documented that new companies spun-off directly (usually by a faculty member) from NSERC-supported Canadian university research had annual revenues of roughly $3.5B in 2004, very largely from exports. The work cited in footnote 22 shows that physics, while very 'basic,' was more effective at creating economic impact in this way than the natural sciences and engineering as a whole. (iii) Physicists at U. Montreal have found a way to produce the world's most sensitive digital camera. Not only will this give us clearer pictures of outer space, but it may open up new horizons in medical imaging, allowing early diagnosis of conditions before they become more serious. (iv) A UBC physicist has found a cost-effective way to channel sunlight deep into the interior of buildings. This should reduce building energy consumption by at least 25%, as well as providing health benefits. (v) Many other NSERC impact stories are at http://www.nserc-crsng.gc.ca/Media-Media/ImpactStories-ArticlesPercutants_eng.asp.

[19] A.B. Jaffe, *Real effects of academic research*, American Economic Review 78, 957-970.

[20] The Kitchener-Waterloo region is now second only to Toronto in CIBC's list of economically best-performing Canadian regions: see http://micro.newswire.ca/release.cgi?rkey=1907185856&view=14730-0&Start=0&htm=0 . Research In Motion is Canada's largest tech company, OpenText Corporation is the largest software company and COM DEV is its largest satellite company: see http://www.communitech.ca/.

[21] Roslyn Kunin & Associates. *Economic Impact of International Education in Canada*, Final Report to Foreign Affairs and International Trade Canada (2009); see http://www.international.gc.ca/education/assets/pdfs/RKA_IntEd_Report_eng.pdf .

[22] P.S. Vincett, *The economic impacts of academic spin-off companies, and their implications for public policy*, Research Policy 39 736-747 (2010).

[23] OECD, *Main Science and Technology Indicators, Volume 2011/1* (2011), pages 69, 71 and 76.

[24] J. Niosi, *Choices. Connecting the Dots between University Research and Industrial Innovation*, IRPP (2008), p. 9.

[25] Reasons for this could include the branch-plant nature of many Canadian firms, the nature of many resource industries, etc.

[26] *OECD Science, Technology and Industry Scoreboard* (OECD, 2009), pp.17 and 135. The Economist (footnote 13) points out that China and India alone graduate 135,000 people annually with higher degrees in engineering or computer science.