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 integrated circuits (which launched the computer revolution), and new physics-based principles lead the development of even more remarkable ultra-small electronic devices. Physics gave the world lasers, on which are built modern communications and entertainment media, vision-correction, and other medical procedures. Medical imaging devices like X-rays, PET scans and MRI are all founded on physics. Inventions based on quantum physics alone have been estimated to account for over 25% of the industrialized nations' GDP.[1] Even the world-wide-web is a spin-off from basic physics research.[2]

Given the time constraints faced by HCFC members, we limit our main text and recommendations to about 3½ pages, giving further details in footnotes. Recommendations are on pages 3 & 4.

<ins>The Future of Canada</ins>. Because of poor growth in productivity, median real earnings in Canada have not improved since 1980, and are declining relative to other nations.[3] With ever-increasing foreign competition, Canada must continually strive to maintain and improve its standard of living in the coming decades. Or we will face a slow, inexorable decline.

<ins>Innovation is crucial to Canada's future!</ins> Leaving aside current economic issues, most economists agree[4] that a nation's prosperity, and all that goes with it, depends more and more on how well it innovates – on whether or not it excels at all the facets of innovation: knowledge creation, downstream R&D, and leveraging the resulting new understanding and capabilities to create world-class products and processes. So critical is this, that it is believed that technological innovation accounts for over 50% of the economic growth of advanced countries.[5,6] Knowledge creation and new understanding are the necessary first steps.

<ins>We must aggressively improve our position versus other countries.</ins> A 2010 special report[7] in the prestigious *Economist* magazine is a wake-up call to the enormous innovation now underway in emerging nations. The company filing the most international patents in 2008 (Huawei) is Chinese. The world leader in money transfer by mobile phone is Kenya. In 2006, the BRIC[8] countries trained half as many doctoral graduates as all OECD countries combined.[9] Infosys and TCS (both Indian) are amongst the world's biggest IT companies. *The Economist* concludes that "*A wave of low-cost...innovation will shake many [rich world] industries to their foundations*."[7]

<ins>Strategic investment must continue</ins>. Studies[10] repeatedly give Canada failing grades in innovation. The only bright spots: (i) scientific output[10] (mainly from academia and government labs), and (ii) academic spin-off companies founded on basic research, where we are a world leader.[11] Federal governments have done much to create these strengths. We propose building on them -- playing to our strengths while addressing our weaknesses.

<ins>Industrial in-house research spending is low by international standards.</ins> Despite generous government assistance over many decades, much of Canadian industry still does little in-house R&D.[12] The persistence of the problem suggests that it may be a result of structural issues, and

Prof. Henry van Driel, President, c/o Francine Ford, Canadian Association of Physicists, Suite 112, McDonald Building, 150 Louis Pasteur, Ottawa ON K1N 6N5 ; (613) 562-5614 ; cap@uottawa.ca

thus permanent.[13] However, industry does collaborate with universities, primarily in downstream R&D: the percentage of Canadian academic research that is supported by industry (while much smaller than support by governments), is second only to Germany in the G7, and 50% more than the G7 average.[14]

As a result of the industrial research situation, academic (and government) research plays an unusually essential role in Canada. World-leading academic research, across a broad spectrum of science and engineering, creates opportunities that industry and governments can exploit, plays a key role in the birth of creative, innovative and successful technology clusters such as in Waterloo, Ontario, and can solve critical practical problems. There are many examples.[15] It also gives us access to the person-to-person networks by which much foreign technology, know-how, and ideas are imported. And world-leading university research educates and inspires outstanding graduates, skilled employees, and creative entrepreneurs, all essential to Canada.

The most significant breakthroughs come from basic research (research not targeted at an immediate, specific application). While targeted academic research (the type of research that industry typically funds) is very important, basic research operates at the very limits of knowledge and therefore is able to create entirely unforeseen advances. These in turn produce truly new opportunities for targeted research and innovation. It is remarkable that *all* the advances mentioned at the top of page 1 are built on basic research.

So world-class innovation requires world-class basic research. A distinguished, business-based Industry Canada advisory committee on R&D *commercialization* wrote[16]: "The recommendations in this report are based on one key premise: continuing government commitment to publicly funded research carried out with little or no expectation of [immediate] commercial application." A May 2010 report by the U.S. Congress Joint Economic Committee entitled "The Pivotal Role of Government Investment in Basic Research" stated that: "the country's productivity and quality of life are ultimately grounded in the results of basic research...some studies have shown that it is the form of R&D that generates the greatest economy-wide returns...Now, more than ever, basic research is needed to chart the way forward."

President Obama has proposed substantially increased basic research spending in the U.S., aimed at doubling the budgets of the key basic research funding agencies by 2017.[17] His proposals generally *reduce* targeted research budgets and *increase* those for basic research.[18] Long before this, the Industry Canada commercialization committee declared: "Added investments in research outside of universities must be complemented by continued increases in the public funding of research in Canada's universities".

Two new economic studies underscore the case for basic research. U.K. evidence[19] strongly suggests high returns to the broad economy from Research Council spending, even within 1-3 years -- much higher than those from private-sector R&D tax credits. In Canada, the direct economic impact of new companies spun-off (by a faculty member or student) from Canadian academic natural science and engineering research (between 1960 and 1998) has been estimated in a peer-reviewed study.[20] With very conservative assumptions, and allowing for the time-value of money, *the export-driven economic impact of this one outcome of basic research is 3-4 times the entire federal/provincial government research funding, direct and indirect, over that period*. Governments will also receive more in additional tax than they spent.

In summary: Canada's future depends on greatly improved innovation. Basic research (research not targeted at an immediate, specific application) is a crucial driver of innovation, especially when in-house industrial research spending is modest. Canadian and foreign experts agree on the importance of increasing support for basic research, at the same time as encouraging more targeted innovation efforts. On its own, a single by-product of basic research (academic spin-off companies) much more than repays the government funding.

Recommendations 1 and 2

1.	The Granting Councils (including NSERC in the natural sciences) are the key funders of basic Canadian research. While funding for NSERC's targeted programs has increased significantly in recent years, essentially all advocates for Canadian academic research agree that additional support for the basic programs is critical for the health and international competitiveness of Canadian research. In recognition of this, the 2010 Budget did increase NSERC's basic-research funding -- a small increase but much appreciated. This year, however, well over one hundred faculty whose research was rated 'strong' on all of NSERC's criteria (based on international standards) could not be funded. It is almost impossible to undertake a serious basic research program without NSERC funding, so these excellent people will not be able to contribute their creative ideas to Canada's innovation effort, nor to train graduate students, the next generation of innovative thinkers. This is a serious loss that Canada cannot afford! CAP calculates that this can be addressed by the following recommendation:
	That the government increase NSERC's funding for basic research (its Discovery Grants program) by 5%. Cost: about $20M p.a.

2.	Since 1997, the Canada Foundation for Innovation (CFI) has committed over $5B, primarily to research infrastructure (facilities, laboratories, equipment, etc.). This has leveraged even larger contributions by other bodies. To ensure the maximum benefit from these crucial investments, it is critical to spend significant amounts (about 10% p.a. of the original capital cost annually, according to the OECD[21]) on operating, maintaining, and upgrading them. CFI and NSERC provide only a small portion of the funds needed, so Canada cannot benefit fully from the investments. CAP recommends a start[22] towards addressing this issue, which is approaching crisis dimensions, via special new funds for CFI or NSERC. For example:
	That NSERC'S Major Resources Support Program be doubled (cost: $35M p.a.)

A Replacement for the Chalk River "NRU" Reactor is Urgently Needed. The well-known problems with the 52-year old NRU research reactor go well beyond the isotope crisis, and threaten Canada's industrial and scientific competitiveness. The NRU will have to close by 2016, if it lasts even that long. The government has recognized that a new research reactor should be considered "based on a thorough assessment".[23]

The NRU was instrumental in the development of what has become an indispensible materials research technique using the scattering of neutron beams. This is in addition to its key role in creating a $350M p.a. isotope business and a domestic $6.5B p.a. nuclear power industry that produces 15% of Canada's electric power (with no greenhouse gases).[24] The basic neutron scattering research earned Canada a Nobel Prize, and the technique has been adopted around the world. In an excellent example of how advances in fundamental understanding feed into very practical applications, neutron beams help firms in every economic sector -- including aerospace, automotive and manufacturing, as well as Canada's four priority areas: energy, environment, health, and communications -- to develop safer, more reliable, and less expensive products. This improves Canada's innovation performance and competitiveness, opens new markets, and has trained thousands of Canadian engineers and scientists.

The worldwide shortage of capacity for neutron beam-based research, and the essential need for it, has been recognized by every industrialized nation. All G8 countries, except Canada, have already taken action to address the problem via refurbished and new facilities.[25]

Recommendation 3

3.	The Canadian Institute for Neutron Scattering has made a detailed proposal[26] for a new Canadian Neutron Centre (CNC), a world-class facility for neutron-based materials research. Over a 50-year lifetime, it would continue the role of neutron scattering as a vital part of Canada's scientific and industrial infrastructure.[27] It could also play an important role in R&D for the nuclear industry. As emphasized by the government's Expert Panel[28], however, it is critical to move *rapidly*, since bringing the facility online may take up to ten years. CAP therefore recommends:
	That the government move rapidly, with the various stakeholders, to establish (in 2011) a formal engineering design, costing, and business analysis for a new CNC. Cost: $5-10M.

FOOTNOTES AND SOURCES OF INFORMATION

1. L. Lederman, *The God Particle. If the Universe is the Answer, What is the Question?* Houghton Mifflin, Boston (1993).
2. See, for example, S. Avery, *Idea finally spins gold for Web's inventor*, The Globe and Mail, Toronto (June 15, 2004).
3. 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. Specifically: "Canada's per capita GDP expressed in purchasing power parity terms (PPP), which ranked 5th highest for the most part of the 1980s and the 1990s, has slipped to 11th highest in 2008, the most recent data available."
4. As the Conference Board of Canada says: "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." http://www.conferenceboard.ca/HCP/Details/Innovation.aspx
5. M. Pianta, *Technology and Growth in OECD Countries, 1970-1990*. Cambridge J. of Economics 19 (1) 175-187 (1995).
6. 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., W. Germany, Japan, France, and the U.K.
7. The Economist, "*The new masters of management*" p. 11 and "*A Special Report on Innovation in Emerging Markets*" (April 17, 2010).
8. BRIC= Brazil, the Russian Federation, India, and China.
9. *OECD Science, Technology and Industry Scoreboard* (OECD, 2009), p.17. The Economist (April 17, 2010, p. 4) points out that China and India alone graduate 135,000 people annually with higher degrees in engineering or computer science.
10. The Conference Board, for example, has for decades given Canada low grades on innovation. In the most recent report (*A Report Card on Canada, Innovation*, The Conference Board of Canada, February 2010: http://www.conferenceboard.ca/HCP/Details/Innovation.aspx), Canada ranks 14th out of its 17-country peer group and, as usual, receives an overall 'D' grade (the lowest ranking). Of 12 individual innovation indicators, Canada scores 'D' on 9 indicators and 'C' on 2. Its only 'B' rating is in Scientific Articles, an area driven largely by the academic community.

11. By ‘academic spin-off companies’, we mean new companies spun-off directly (usually by a faculty member) from Canadian university research. In the definitive survey of the field (S. Shane, *Academic Entrepreneurship: University Spinoffs and Wealth Creation*, Edward Elgar, 2004), index entries and mentions in the text clearly place Canada in the leading group of four countries (the U.S., U.K., Sweden and Canada).

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

13. There may be various reasons for this, including the branch-plant nature of many Canadian firms, the traditions of many resource industries, etc.

14. OECD, *Main Science and Technology Indicators, Volume 2010/1* (2010), page 71.

15. For example: (i) Studies show that the University of Waterloo’s spin-off companies (based largely on Granting Council-funded research) were essential to the development of the well-known entrepreneurial ferment in Waterloo. Without this environment, it is unlikely that a University of Waterloo student would have founded Research in Motion, the inventor of the Blackberry. (ii) NSERC has documented that new companies spun-off directly (usually by a faculty member) from Canadian university research supported by NSERC had annual revenues of roughly $3.5B in 2004, very largely from exports. The work cited in footnote 20 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 .

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

17. For example, the National Science Foundation’s research budget was slated to increase by 9.4% for FY 2011: see the February 4, 2010 *Policy Alert* of the American Association for the Advancement of Science.

18. Valerie La Traverse, S&T Counselor at the Canadian Embassy in Washington, reporting on the 2010 Policy Forum of the American Association for the Advancement of Science (May 2010).

19. “*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).

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

21. OECD Global Science Forum, *Report on Roadmapping of Large Research Infrastructures* (December 2008), p. 12.

22. Assume annual expenses are only 5%, not 10% of initial capital. Total CFI investment to-date is about $5B, of which 30/130 ($1.2B) may have been CFI operating grants; add capital matching from other sources of at least another $7B (60:40), total capital $10.8B. Annual operating costs over say 20 years (20 x 5%) = $10.8B, less the CFI $1.2B contribution = $9.6B. Assume NSERC disciplines are 40% of this = $3.8B, or $190M p.a. for 20 years. NSERC MRS program is $35M, of which say $25M should be applied against this. Shortfall very roughly $165M p.a.

23. Government of Canada, *Response to the Report of the Expert Review Panel on Medical Isotope Production* (2010).

24. Canadian Nuclear Association, *2009 Fact Book*. http://www.cna.ca/english/pdf/nuclearfacts/2009/CNA_Booklet_09.pdf

25. J. Root, *The Importance of Neutron Beams for Materials Research and Development*. In *Nuclear Canada Yearbook 2009*, Canadian Nuclear Association, p.13-17. http://www.cna.ca/english/pdf/yearbook/2009/CNA_Yearbook2009_a.pdf

26. Canadian Institute for Neutron Scattering, *Planning to 2050 for Materials Research with Neutron Beams in Canada* (2009). http://www.cins.ca/docs/CINSweb_2008.pdf .

27. For 50 years, it would enhance Canadian innovation and the competitiveness of our science and industry, reassert Canada's international leadership in the field, continue one of our key national innovation centres, educate and develop skills for thousands of highly qualified people, and support thousands of individual science projects. But without such a facility, all areas of science would be impacted, as essential information about materials would be unavailable, and there would be an irreversible migration of talent out of the country. Canada would also be unable to develop the next generation of nuclear power reactors sorely needed to reduce our dependence on fossil fuels.

28. *Report of the Expert Review Panel on Medical Isotope Production* (November 30, 2009).