A Submission to the Panel for

Canada's independent review of federal funding for fundamental science

Executive Summary

The Honourable Kirsty Duncan, Minister of Science, has asked Canadians to provide comment to an expert Panel that will provide an independent review of federal funding for fundamental science. The Panel seeks feedback on 20 different questions about program gaps in Canada's fundamental research funding ecosystem, as well as useful examples from other countries that the Government of Canada could use to help addressing these gaps. The Canadian Association of Physicists, as the voice of physics in our country, recommends the following measures:

Recommendation 1: Keep the NSERC Discovery model strong. The three parts of the NSERC Discovery envelope (merit-based Fellowships, Discovery Grants with high success rates, and RTI grants with required matching funds) each fill unique roles in the Canadian fundamental science ecosystem. This overall model of "unfettered funds" works well and should continue, at a much higher funding rate. We suggest doubling the Discovery envelope by 2020. [Addresses aspects of Questions 1, 6, 7, 9, 10, 16]

Recommendation 2: Develop a unified approach to funding research infrastructure over its entire life cycle, including installation, maintenance, and upgrades. This should accommodate small-scale (single lab) equipment as well as large-scale (national research facilities) infrastructure, and should not be hampered by high matching fund requirements. Good infrastructure maximizes research productivity. [Addresses aspects of Questions 1, 4, 6, 7, 15, 18] *(Note for comment: It is not clear how NRC, telescopes, and other infrastructure will fit in. What good examples from other countries can we offer?)*

Recommendation 3: Allow for diverse funding avenues to support diverse activities, especially when it comes to international collaborations. One size does not fit all. [Addresses aspects of Questions 1, 5, 6, 7, 9, 10, 13, 14, 18] *(Note for comment: What good examples from other countries can we offer?)*

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Recommendation 4: Peer review in equipment and research grants, and giving opportunities to individual researchers -- regardless of their institutional affiliations or priorities -- should be held as paramount. Extremely large grants to single universities or individual researchers do not tend to foster collaboration. [Addresses aspects of Questions 4, 6, 11] *(Note for comment: Do we propose diverting CFREF, CERC, funds to NSERC's Discovery envelope once these programs expire?)*

Recommendation 5: A government science advisor should have a mandate to monitor and review the status of fundamental science in subsequent years to provide continuity and longevity to this Panel's recommendations. [Addresses aspects of Questions 1, 5, 6, 7, 9, 10, 16, 18, 19] *(Note for comment: What good examples from other countries can we offer?)*

We look forward to working with The Panel to help revitalize and invigorate fundamental science in Canada.

Background:

A June 13, 2016 press release outlined the mandate for Government of Canada's review of fundamental science.

The Canadian Association of Physicists (CAP), with 1700 members, is Canada's national association for physicists working in industry, academia and government. The CAP strives to unleash the full potential of physics and physicists for the benefit of Canada. The CAP is recognized and respected for its science and technology expertise, and has testified at House of Commons Committees, including the Standing Committee on Industry, Science and Technology for a study on the "State of Disruptive Technologies" on June 9, 2015.

The CAP's recommendations identify means of support for research that will attract and retain Canada's best talent and will have positive impacts in Canada. This will develop a strong base that is essential for building a resilient and innovative workforce that will help drive Canada's entrepreneurs, businesses, and international collaborations.

One of the most important elements of Canada's innovation landscape is the transfer of knowledge and skills from academic research environments to the private and government sectors via the flow of highly qualified people (HQP) into non-academic careers. A sense of the impact of HQP on the economy can be seen in a recent Stats Can report[1] that found that of doctoral graduates in 2005

[1] Statistics Canada. *Expectations and Labour Market Outcomes of Doctoral Graduates from Canadian Universities.* www.statcan.gc.ca/pub/81-595-m/81-595-m2011089-eng.pdf

trained in computer, mathematics and physical sciences, almost half were employed in non-academic careers. Similar trends were found in a study by the American Institute of Physics of doctoral graduates in physics in 2009 and 2010. These results reflect the value that the quantitative and analytical skills can bring to activities well outside a student's academic discipline.

HQP impact the economy by stimulating and creating employment for others through innovations that create new spin-off companies or increase competitiveness, as confirmed by the OECD: "An economy's ability to encourage research affects its capacity to create new knowledge and stimulate innovation. Increasing specialization and rapid growth in scientific production have made research professionals with advanced research degrees the cornerstone of modern science and innovation systems worldwide."[2] Yet Canada, with 8.2 doctorate holders per thousand population, trails countries like Switzerland (25), Germany (14), the United States (13.5), Great Britain (12.4), and Israel (9.7).[3]

In Canada, NSERC programs support the training of a large proportion of HQP in science.[4] NSERC Postgraduate Scholarships and Postdoctoral Fellowships are the cornerstone programs that attract our brightest young people into a research career. However, the numbers of awards from these NSERC programs are dropping, rather than keeping pace with the growth of industrial and academic needs for these HQP. For example, comparing between 2010 and 2014, there was a drop from 2520 to 1510 post-graduate awards offered and a decline from 286 to 130 post-doctoral awards offered. The number of post-doctoral awards is slipping far below Canada's HQP needs: in academia alone, approximately 400 full-time university professors were appointed in engineering, math, and science in 2010-2011.[5]

Direct support for HQP in the form of long term merit-based scholarships and fellowships that will attract the brightest students and support students throughout the duration of their program of studies must be given a high priority in order that we close the gap in training HQP between ourselves and our OECD competitors. These HQP will be Canada's scientific and engineering leaders in the

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[2] The Organization of Economic Co-operation and Development (OECD) Science, Technology, and Industry Scoreboard 2013. dx.doi.org/10.1787/sti_scoreboard-2013-en.

[3] *OECD/UNESCO Institute for Statistics/Eurostat data collection on Careers of Doctorate Holders 2010*. Cited by reference in footnote 2.

[4] The training of HQP in science is supported by programs that fund trainees directly (the NSERC Undergraduate Student Research Award [USRA] program, a number of postgraduate scholarship [NSERC PGS, Alexander Graham Bell Canada Graduate Scholarships, Vanier Canada Graduate Scholarships] programs and postdoctoral fellowship [NSERC Postdoctoral and Banting Postdoctoral] programs), and programs in which there is a training component (the NSERC Discovery Grant Program and the NSERC CREATE Program, and MiTACS).

[5] 2012-2013 Canadian Association of University Teacher's Almanac.

future, and increasing the number of merit-based awards above 2010 levels will help keep a sufficient number of the best and brightest Canadian trainees in Canada.

One of the most important determinants of knowledge transfer from universities to businesses is the quality and breadth of the research that is pursued in academic settings where highly qualified people are trained before entering the private sector. While market-driven research can address specific issues for industries in the shorter term, it is the fundamental research, characterized by longer timelines and unexpected discoveries, that can generate and incubate unexpected technologies that will become transformative solutions to today's problems and incubate whole new industries of the future.

The core federal program that enables Canada's leadership in fundamental research is NSERC's Discovery Grants program. The 2016 Federal Budget provided an increase of $30 million to NSERC, which it is using mainly for the Discovery Grants program. The CAP strongly supports this initiative because it is a good start toward mitigating the ongoing erosion of this program's capacity to meet the demands of the increasing numbers of excellent researchers that are supported by it.

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[Based on the Panel's mandate, sets of targeted questions have been developed for the different communities within the ecosystem. For our own benefit while writing this response, the full list of questions asked to researchers by the Panel is copied below. The Panel indicates that we do not need to address all questions in our response.

1. Is the federal funding ecosystem meeting the needs of the Canadian research community? As the needs change, is the ecosystem able to adapt and accommodate?
2. Are you currently receiving (or have you received) funding for your research from federal sources? Tell us about your experience including information about the program and size of the award; the award and stage(s) in your career when you received funding; relative changes over time in the amount of any federal funding you obtained; flexibility of the program; and whether you had to seek funds from elsewhere to fully fund your project. How could your experience be improved?
3. Are you currently receiving funding for your research from sources other than the federal government? If so, what are other sources of funding available to you? Please comment on the process for obtaining the funding and competitiveness of this funding source.

4. Could the application processes for funding be improved? If so, what would you suggest? Are there issues with the matching programs associated with various funding programs? If so, how could this be improved?
5. Does the federal science funding community (e.g. the granting councils, the CFI agencies or organizations that distribute funds supporting investigator-led research) consult the research community to ensure that their programs are aligned to the changing needs of researchers? If so, how? If not, should it and how should it?
6. Comment on the coordination between the programs being provided by the granting councils and other funding organizations, provinces, and/or amongst themselves. Are there areas for improvement?
7. Is there a need for the federal government to improve the balance across funding elements (e.g., investments in principal researchers, funding of research staff and other direct costs of research, funding of infrastructure and equipment operations and maintenance, and reimbursement of indirect costs)? If so, how can this balance be achieved? What is the appropriate federal role in supporting infrastructure operating costs? Do CFI and granting councils programs work in a complementary fashion?
8. Comment on career supporting funding versus project-based funding. What are the pros and cons of each structure? Should support structures be higher at the front end of careers and less so as they are established?
9. What should the balance be between funding risky, novel, or emerging research versus research with established lines of inquiry? Do current programs and review processes achieve the right balance?
10. What should the balance be between funding research to meet government priorities and having research priorities determined by the research community? Do current programs and review processes achieve the right balance?
11. Can you identify the peer-review processes (federal or otherwise) that you have participated in, either as an applicant or a reviewer? Do you have suggestions to improve the process in terms of rigour, fairness, and effectiveness?
12. Do current federal programs encourage and support domestic collaboration?
13. To what extent do you collaborate internationally and how important is this to your work? Is there sufficient flexibility in granting council or other funding programs for participation in international collaborations? Are there particular research areas where more emphasis on international collaboration is needed?

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14. Are current federal programs supporting the needs of multidisciplinary researchers? If not, how can the situation be improved? Does the funding ecosystem work collaboratively and effectively across disciplines?
15. Is current support for major science initiatives or "Big Science" including large international collaborations and facilities effectively meeting the needs of researchers? If not, how can this be improved?
16. What is the best way to fund areas of strategic interest such as emerging, transformative or potentially disruptive technologies, and/or areas of broader societal interest? Are granting councils well placed to fund/support these areas or are separate mechanisms required?
17. Identify the unique barriers that the following groups face in obtaining support for investigator-led research. Do current programs address these barriers? What else could be done to address these barriers? a) students, trainees, and early career researchers b) women c) aboriginals and other underrepresented groups
18. Are there international programs, structures, models, or best practices that Canada should consider adopting? If so, please explain why these should be considered.
19. What should the vision be for Canadian science? If we imagine an even more successful future for Canadian science, what does success look like and how should it be measured?
20. Are there any other issues or questions that you would like to raise and address?