Canada's Fundamental Science Review

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1. From the perspective of research, are Canadian universities keeping pace internationally? If not, what changes or new programs are needed to close the gap?

- Some Canadian universities are keeping up—and some recent programs such as CFREF have reinforced the ability of those with strengths in established fields, developed over a long history, to maintain competitiveness or attempt to increase it. While this was an important program in many regards its impact in terms of global positioning for Canada remains to be validated and does not fully address the equally vital need to support emerging and potentially transformative areas. In terms of global positioning it is revealing that no Canadian university in the QS Top 100 under 50 rankings for 2016/17 was supported by the CFREF program, notwithstanding the research and HQP training investments that other countries worldwide are making to boost international competitiveness in this key emerging cohort.
- Canada needs to strengthen its leadership in emerging areas. Researchers in our country have the capacity to meet new challenges. For example, synthetic biology, a breakthrough field of research acknowledged to be a cornerstone of the 4th industrial revolution is a case in point. In 2015, a team led by Concordia and University of California, Berkeley, developed a synthetic pathway to build opiates that was hailed as one of the top 10 science discoveries of the year. The US and UK, followed by others, have developed comprehensive national roadmaps for synthetic biology and are funding it. In Canada there has been no similar road-mapping exercise and this and other exciting new fields generally lack support. The Canadian government needs to develop strategies to be leaders in emerging fields of research such as synthetic biology.
- We know that Canada can be a leader. The creation of Genome Canada positioned the research community to be relatively quick off the mark to respond to something transformative. At the turn of the millenium, with the human genome nearing completion, and sequencing costs becoming more amenable to investigator-led research, we established a funding mechanism for genomics (Genome Canada), and as a result, we are internationally competitive in that area. This type of leadership and quick response to emerging and potentially high risk fields requires directed funding to maximize high-return opportunities.
- Canada's federal funding agencies also lag when it comes to supporting collaborations in major international opportunities, such as Horizon 2020. Canadian researchers are in demand for these projects, but they need to be funded from here to participate on equal footing. We are missing out on international opportunities under the current system, which has provided very few such linked funding initiatives. And Canada's absence has been noted with disappointment by our international collaborators and potential partners. We must be ready to meet the variety of international research opportunities in order to reaffirm the role of Canada in the world.

2. Is the federal funding ecosystem meeting the needs of researchers in your institution(s)? As the needs change, is the ecosystem able to adapt and accommodate?

- The answer depends on the funding agency. Although we lack a medical school or clinical environment, in certain focal areas our university has historically done reasonably well with CIHR; but it is harder and harder to maintain that success, let alone increase it or pursue emerging fields such as prevention. In general NSERC is quite responsive to the needs of researchers and offers a wide range of opportunities, although larger-scale funding is limited and funding in many fields is less and less adequate even to support the rising costs of basic research. SSHRC has to contend with a huge number and range of researchers and lacks enough funding to support the breadth of initiatives it probably should. Mitacs and Genome Canada are more nimble and responsive—the tricouncils might think of emulating some of their practices.
- We need to maintain a stable funding base for fundamental research where new opportunities aren't created out of existing funding, as has sometimes been the case. Researchers need to be able to maintain a baseline of activity from which they can build or branch into new opportunities and engage in more risky types of research. Without stable baseline research support, it is difficult to convince researchers to take part in trying to build these new initiatives.
- The Canada Research Chairs program is in need of rethinking, particularly given the gap in support for mid-career faculty, the challenge of recruiting truly world-class Tier 1 researchers, and

the lack of flex moves available to institutions that could enable them to build more early career researcher capacity. In a context where truly innovative research goes beyond disciplines, the historic tendency of the Canada Excellence Research Chairs program or the Network Centres of Excellence program to fund domains exclusively in the pure science and medical fields has failed to capitalize on the country's world class excellence in the arts, humanities and social sciences.

- CFI is doing a very good job of providing opportunities for infrastructure funding, but there should be more opportunities that are aligned with the priorities of medium-sized institutions. Although program names and criteria have changed, and administrative processes have been improved, CFI has not changed what it funds much in its 20-year history. Similarly, there is a negative distortion, often noted, in CFI support for major initiatives in the arts, humanities and social sciences where technology and instrumentation are increasingly integral to world class training and high impact research and research-creation.
- Similarly, for the Research Support Fund—formerly Indirect Costs—the same model has existed for years. It recently underwent cosmetic changes in branding and increased reporting requirements, but there should now be a quick and timely assessment of how well the existing model addresses needs and how to better coordinate and cover the indirect costs of research activity.

3. Does the federal science funding community (e.g. the granting councils, the CFI and other agencies or organizations distributing federal funds for research) consult institutions to ensure that their programs are aligned to the needs of administrators? If so, how? If not, should it and how should it?

- The federal science funding community consults institutions reasonably frequently. We have responded to many consultations and the usual outcome is improvements in technical aspects of administrative processes, which are relatively easy to implement. However, changes that would better align funding programs to the needs of our researchers rarely result. We are a large comprehensive university. While it seems that larger medical and smaller institutions have been successful in lobbying for programs that meet their particular needs, this is not always the case for the large comprehensive universities, many of which have built world class facilities and recruited outstanding talent in emerging areas of excellence.

4. 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?

- In Quebec there is good complementarity between federal and provincial funding programs in the sense that the tri-councils fund the operating grant needs of individuals and larger teams whereas the provincial agencies provide funding for networks, smaller teams, new researchers and salary awards.
- CFI is coordinated by the matching program with the provinces—although mechanisms vary from province to province, we are satisfied by the way this works in Quebec for our university.
- Indirect costs funding is provided both federally and provincially and helps to support our research enterprise. However, coordination is not evident. On the operational side it is not a hindrance, but more coordination might ensure the best support possible for indirect costs funding. This is an opportunity to involve universities in this dialogue.

5. 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?

- Yes, application processes for funding could be improved. Applications (together with reporting) are getting more and more complex and this: a) takes up an inordinate amount of researchers' time that would be better invested in research, research-creation and training; b) puts researchers off from applying; c) increases the burden for the reviewers (i.e. other researchers), with potentially

detrimental effects on the pool of qualified reviewers. The balance between accountability and practicality needs to be rethought.

- A further challenge for the peer review system is how to cope with breakthrough fields where national expertise is scarce or where there may be a conservatism or reluctance to support new domains. Equally, in these cases there is the additional challenge that international experts working in breakthrough areas may be unfamiliar with the landscape of Canada's research culture and university system.
- In application forms, standardized and harmonized definitions, as well as CV formats that really are common, would help to relieve the frustration that is felt by the applicants. Keeping the page numbers down would also help. While not all applications can be boiled down to the 5 pages of an NSERC Discovery grant, space limitations do encourage a certain economy of thought and clarity.
- It is becoming all too common in new programs (the first round of CFREF being the most recent example) that application forms are not available in a timely fashion. And although researchers and institutions have to follow strict deadlines for submission, results are often not announced when promised. For example, SIF results were promised in June and it is now almost October, but institutions in some jurisdictions are still awaiting the results. This creates a problem because those institutions could be leveraging a successful SIF investment for other programs, and the lag in decision-making inevitably results in an uneven national playing field. Speedy processes are very much appreciated, but deadlines must be realistic for everyone.
- Better definitions and guidelines are needed for in-kind contributions. For the 20% of CFI not funded by government, there are questions about what can be considered in-kind contributions and whether some specific discounts offered by suppliers are really eligible in-kind contributions: this can take a lot of time to sort out. Similarly with SSHRC, e.g. Partnership Grants, in-kind guidelines are very generic and as a result what institutions truly "provide" are all over the place. Work out well-defined guidelines to establish eligibility and real value of in-kind contributions. This will also ease the burden of reporting on them afterwards.
- Where industry contributions are involved (e.g. Industrial Research Chairs) heavy reporting requirements also place an unwanted burden on the industrial partners—large ones as well as SMEs—that can discourage future investments by industry in these programs or complicate existing relationships between researchers and industry partners because of the increased administrative burden.

6. 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?

- This is a complex question that seems to boil down to: how well does CFI (infrastructure funding) coordinate with others (operating funding) and are there enough resources (indirect costs funding) allocated in a balanced way to support the ecosystem?
- Clearly CFI and granting councils are complementary—neither SSHRC nor CIHR has infrastructure funding and NSERC's (RTI) is very modest. CFI does a good job funding infrastructure for CIHR and NSERC related research, and through its JELF program we have been satisfied by its support for SSHRC-related research projects. However, the CFI IF program, with a few notable exceptions, has a poor record of funding infrastructure for social sciences and humanities research. Better recognition and support for digital media and humanities research, computational design and fine arts research-creation—all heavily invested in technology that is attractive to students and employers—is needed within CFI.
- Implicit in the question is a suggestion that CFI could be more closely tied to operating grants. The separation between the two is very healthy and should be preserved because: a) the current system does not automatically reward funding success with more funding success; and b) it can work the other way as well—infrastructure funding can stimulate applications for project funding.

- The CFI IOF is a very welcome and necessary support mechanism for infrastructure and technical support. It is supplemented by what researchers can provide through project grants and what the institution can provide. At the institutional level an important contributing funding source is the Research Support Fund for the indirect costs. However, given all of the demands on indirect costs programs to fund other parts of research support, there is often a gap in being able to fund technical needs. With the increasing pressure to better manage research data and make it accessible, and all of the resource implications that brings, the pressure on indirect costs will only get worse.

7. What should the balance be across funding risky, novel, or emerging research areas and research with important established lines of inquiry? Do current programs and review processes achieve the right balance?

- For risky, novel or emerging research areas, there is no scoping and foresight capacity within granting councils, which control the lion's share of public research funding; they are not currently able to anticipate the next big thing, let alone to position for it. As a result, Canadian research is often left in reactionary mode. Genome Canada is one of the few national funders that attempts to identify and fund these types of opportunities.
- The standard response from funders when we approach them to support novel, risky or emerging research has been along the lines of: 1) great idea, but no money; or 2) no, we don't need a new funding program, existing program X, Y or Z can accommodate that. The federal funding agencies should not have to compromise what works well to fund new initiatives, and we haven't seen much evidence that their existing programs can adapt to new realities either. In some cases (e.g SSHRC support for Business and Finance research), trial programs are run and then disappear without building to something bigger, or any explanation of why they disappeared.
- Part of the problem of using existing programs is that reviewers are by nature risk-averse so a different mentality may be necessary—programs have to lay out the criteria and find reviewers who are aligned with the criteria for risky, novel and emerging research. Canada has generally done a good job supporting research optimization as opposed to true innovation.
- One risk in creating new programs is that researchers are used to repackaging their ideas differently to appear to satisfy whatever criteria the administrators seem to want now. Agencies need to be discriminating in their determinations of what is really new by validation with working groups of researchers. Programs should have criteria and evaluation processes to ensure that the research being supported really is risky, novel, or emerging.

8. What should the balance be across funding of research to meet broad government priorities and having research priorities determined primarily by the ideas of the research community? Do current programs and review processes achieve the right balance?

- Government priorities have a place but those priorities have to be clear and transparent when creating funding opportunities, and they should be validated by arms-length consultation with the research community before decisions are taken to implement funding decisions based on those priorities. Furthermore, the priorities change with governments, so there has to be a backbone in fundamental research that is preserved despite shifts in government priorities.
- Perhaps the place of government priorities is more in the innovation sector—in making the connection between fundamental research and its application to society, and in finding ways to encourage Canadian researchers to embrace innovation to a much greater extent than they do now.

9. Do current federal programs encourage and support domestic collaboration? Is there sufficient flexibility in federal funding programs for participation in international collaborations? Are there particular research areas where more emphasis on international collaboration is needed?

- Some programs do support domestic collaborations quite well. Examples are the SSGRC PG, PDG and Connection grants. As evidence, these funding opportunities generate the most

correspondence between institutions in our Office of Research. NSERC Strategic Network grants also support domestic collaboration well. CFI actively encourages Canada's researchers to collaborate and it seems to be working. We have noticed that our researchers have historically preferred to go it alone, but in this year's CFI IF competition we have a record number of inter-institutional applications and consultations between our researchers and those at other institutions.

- CFREF helped individual universities to become more competitive on the international stage but, especially in the case of CFREF 1, domestic collaborations were actively avoided as each university tried to show that it was the best and ready to go to the next level. The second round was better in this respect, but most of the collaborative aspect arose after the LOI stage when universities were finally encouraged to talk to each other. CFREF was thus arguably a missed opportunity to build truly national capacity by instead targeting single institutions rather than positioning Canada to compete effectively on a global scale. Why not encourage collaboration from the start, for example in a CFREF-like competition where universities would declare a small number of areas of excellence and strategic importance (similar to CFREF criteria), share them with all participants in the competition, and then let those who have overlapping strengths construct truly collaborative and complementary teams? Promotion of collaboration in this context would allow Canada to build networks of research strength, and possible industry partnerships, both across the country and internationally, in areas that are not necessarily the purview of one institution.
- Researchers will participate in international collaborations whether or not they have specific funding for it. SSHRC PGs are good at helping to support international collaborations in the social sciences and humanities, but for the most part federal funding specifically for international collaborations is lacking. As a prime example, there is little in Canada that funds participation in Horizon 2020, one of the largest opportunities right now to join forces with international partners. Until there are better funding mechanisms for participation in international opportunities, it will be difficult to go above baseline participation as second-class citizens.

10. Are current federal programs supporting the needs of multidisciplinary research programs? If not, how can the situation be improved? Does the funding ecosystem (funding councils and other agencies) work collaboratively and effectively across disciplines?

- Review committees are not often prepared well enough to understand multidisciplinary applications. For example, (and in this we are surely not alone), we had a major SSHRC multidisciplinary grant application fail the first year it was submitted, and pass pretty much in the same form the second time by a different committee. Stories like these suggest that the committees did not have clear and consistent criteria. Committees with individuals from different disciplines also need to have mechanisms to ensure that different viewpoints are accommodated. For example, one of our engineers doing health-related research had an application rejected as a result of debatable negative comments that came from one reviewer with a clinical background. Experiences like this do nothing to encourage researchers to participate in multi-disciplinary applications.
- Funding councils could focus more on encouraging inclusivity across the councils, rather than exclusivity. For example, NSERC and SSHRC screen and reject applicants as being too medically oriented and CIHR rejects natural science researchers. This is needed because some people try to game the system, but it raises the question of what programs those who legitimately straddle the borders of health, natural and social sciences can apply to?
- Why not create a challenge grant program, like the Grand Challenges for health research, that would pose broad questions of societal interest—such as how can we make we make more liveable Canadian cities—that will require bringing together architects, engineers, designers, scientists, social scientists and humanists? Is it possible to create a granting program that genuinely seeds experimental attempts to organize and construct knowledge in new ways?
- Genome Canada grants have, in addition to the science component, always required inclusion of GE3LS components where non-scientists investigate the ethical, environmental, economic, legal and social aspects of the scientific research—why are there not more programs with similar

requirements, or with requirements that could take the logic of GE3LS to the next dimension of innovation?

11. Does your institution participate in major science initiatives or "Big Science," including large international collaborations and facilities? Why or why not? If your institution does participate, how is your participation funded? Are there challenges in identifying or securing funding sources?

- There is some participation in major initiatives/Big Science although it is limited. Perhaps not coincidentally, given there is a Canadian funding mechanism for it, genomics research is quite visible on our campus. Our scientists use Big Science infrastructure such as high performance computing resources provided by Compute Canada and the Canadian Light Source. But as we have said in answers to several of the other questions, the lack of funding mechanisms to participate in international projects limits our scientists to smaller scale collaborations that are supported in ad hoc ways. For example, we have one faculty member who leads an International Energy Agency project who used to be funded by Canadian government sources and now has to be funded by the university and an ad hoc collection of other grants, in stark contrast to the agency support that project leads from other countries receive.
- Participation in large scale projects is not for everyone and one of the barriers is suspicion that centralized resources are not responsive to local needs (e.g. the initial incarnation of Compute Canada), so some researchers find ad hoc solutions on their own. The responsiveness that can be offered links back to the question of infrastructure and technical support, where there definitely seems to be a funding gap – so invest in the kind of support necessary to make participation more accessible.

12. 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?

- Appropriate and new budgets are needed—don't cut existing programs to fund these kinds of things. And don't expect that existing programs will be responsive to including these elements either. Unless there are specific programs with clear guidelines, expectations and reviewer expertise, new initiatives will fall by the wayside. With no support over one or two funding cycles, it will then be too late to catch up with what is going on in other places in the world where proper support mechanisms have been developed.
- By their very nature these kinds of initiatives need to be multi- and trans-disciplinary so that programs need to be constructed, using reliable and prioritized intelligence gathering, where scientists and engineers can work with social scientists, economists, policy researchers, etc. to analyze the implications and feasibility of what they are doing.
- In our own experience we tried to jump-start funding agency interest in synthetic biology, by collaborating with Genome Canada, Génome QC, and Fonds des recherche du Québec (FRQ) organizing a 2014 symposium in collaboration with UK government and its major synthetic biology funders. Given the wide-ranging public policy implications of work in this disruptive field, the symposium not only included researchers from many disciplines and institutions across Canada, but also participants from agencies such as Public Health Agency of Canada, Health Canada, CIHR, etc. A follow up series of high level meetings, which also included the National Research Council of Canada and key partners including the FRQ and Génome QC were held in the UK. The potential and interest on the part of the engaged agencies was high, but their capacity to act was paralyzed by lack of latitude—discretionary funds, and slow capacity for speed to onset support mechanisms to pursue a truly novel initiative.

13. 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?

1. students, trainees, and early career researchers
2. women
3. aboriginals and other underrepresented groups

- The earlier that programs address the needs of women, aboriginal and other under-represented groups, the better. Put in place mechanisms to encourage and support these groups as students and trainees, so that they actually get to the stage of being independent investigators, and give them a boost as new investigators. When we are looking for CRCs, a program that makes a serious effort to try to address these concerns, we go by what areas of research are of strategic importance to the university. It is very frustrating for everyone if that strategic area happens to be one that does not even attract applicants from under-represented groups.
- It is conceivable that some under-represented groups will be more attracted to research careers when there is more emphasis on fast-breaking and transdisciplinary research, coupled with innovation, where there is greater potential to make rapid societal impacts.
- Specifically for students, trainees and early career researchers: we suggest making smaller, shorter seed grants available for projects that are just beginning to be developed. At SSHRC there are Insight Grants and Insight Development Grants, but the proposals for both are lengthy and they don't embrace emerging research projects (though the IDG does to an extent). Early career researchers don't have the CVs or the fully-developed programs of research that even the IDG requires, so a greater number of smaller grants that could seed new projects for new researchers would be a great contribution to developing successful grants further down the line and building research capacity.
- Specifically for Aboriginals and other underrepresented groups: 1) Develop community partnership grant programs. These could be small start-up grants available to scholars interested in working with communities: indigenous communities come immediately to mind, but there are so many other communities and community groups that our researchers are working with. 2) Create more accessible or easy to navigate forms for non-academic collaborators – this would extend from creating forms that are easy to fill out to mechanisms for community partners who do not have access to stable internet service. 3) SSHRC has developed guidelines for research with and by Aboriginal scholars – these are very good guidelines and could be used as a model for thinking about more agile and useful kinds of research grants that would benefit communities as well as scholars working with communities

14. Are there international programs, structures, models, or best practices that Canada should consider adopting? If so, please explain why these should be considered.

- In Canada, international research connections are mostly established on an individual or institutional level. Only rare examples show multiple Canadian institutions from different provinces coming together as one team on the international research front. International relations are encouraged, but they stem from the same design of individual or institutional support. As a result, when it comes to major international calls for research projects such as European Horizon 2020, Erasmus mundus, etc., Canadian institutions can team-up with their international peers on knowledge development, but not as leading or equal partners on the calls.
- Other countries have put in place programs that encourage their institutions to approach international scientific collaborations as a network rather than individually. The benefits of such programs far outweigh the local competitiveness of national institutions. They create an environment that prompts collaborative structures and boosts the ability of Canadian institutions to compete for increasingly mobile resources of people and capital.
- In our opinion, Canada could take the support to a dynamic level that seizes talents and promotes Canadian collaboration on the international scientific scene if the two following programs are re-established: 1) The International Access Program (2001-2006): Such a program would provide access for Canadian institutions to major international funding calls. Furthermore, the program

encouraged Canadian institutions to come together and work with international partners from different disciplines in the development of challenging and transformative research projects. 2) The International Mobility Partnership Program (2006-2013): The program would support projects that develop organizational frameworks for joint student and research mobility, including industry placements. A minimum of two institutions from two different provinces should partner to apply for this program on the Canadian side. International partners bring their own funding.

15. 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?

- As alluded to in earlier responses, we see a need to dramatically re-formulate and re-design the language around research, around 'fundamental science', in order to recognize the value of integration, and of going beyond disciplines
- Canadian science should go beyond rewarding past excellence and invest also in the new breakthrough areas where there will be a price to be left behind. Provide mechanisms to allow researchers working in breakthrough and emerging areas to be players internationally.
- We need to achieve greater synchronicity between a provincially-funded higher education system responsible for delivering training, and which makes substantial investments in infrastructure and research through discreet funding agencies and targeted ministry investments, and critical federal investments in, and direction of, national science strategy. There is a continuous improvement challenge to harmonize investments and open boundaries to facilitate within Canada mobility and collaboration.
- There needs to be a recognition that significant expertise and supporting investments in research infrastructure exist in ~30 universities in Canada, not 15. Strength-building can be done in ways that don't necessarily concentrate strength institutionally.
- Canada should instate support that allows multi-institutional participation in major international funding calls such as Horizon 2020.
- Finally, the training piece is key. As we invest in HQP, we need novel, convergent platforms for learning and exchange; positioning mechanisms for early career researchers; and proactive methods to be inclusive and foster diversity.

16. Are there any other issues or questions that you would like to raise and address?

No, thank you.