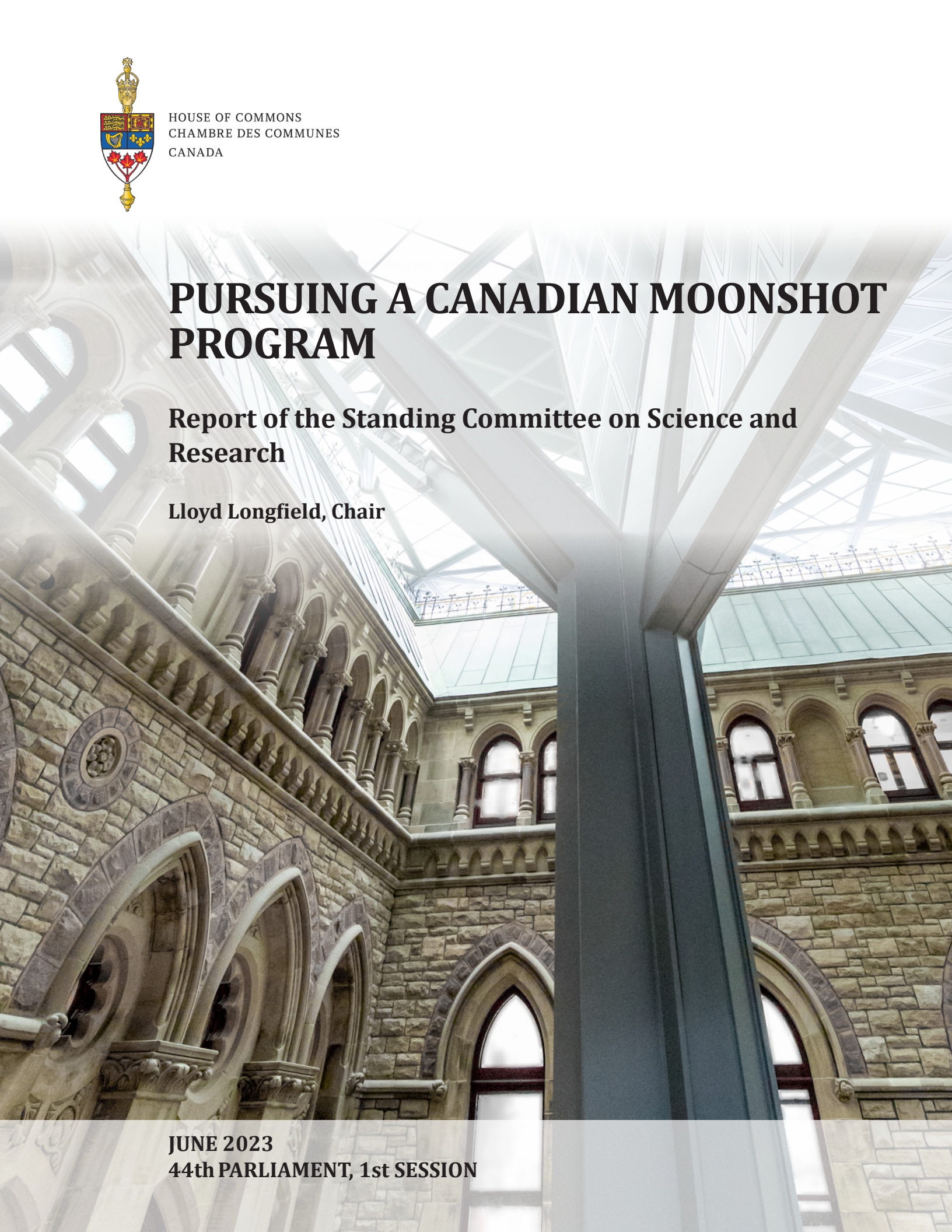

HOUSE OF COMMONS
CHAMBRE DES COMMUNES
CANADA

PURSUING A CANADIAN MOONSHOT PROGRAM

Report of the Standing Committee on Science and Research

Lloyd Longfield, Chair

JUNE 2023
44th PARLIAMENT, 1st SESSION

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Chair

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NOTICE TO READER

Reports from committees presented to the House of Commons

Presenting a report to the House is the way a committee makes public its findings and recommendations on a particular topic. Substantive reports on a subject-matter study usually contain a synopsis of the testimony heard, the recommendations made by the committee, as well as the reasons for those recommendations.

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THE STANDING COMMITTEE ON SCIENCE AND RESEARCH

has the honour to present its

FOURTH REPORT

Pursuant to its mandate under Standing Order 108(3)(i), the committee has studied international moonshot programs and has agreed to report the following:

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SUMMARY

The origin of the term moonshot can be traced back to United States (U.S.) President John F. Kennedy and the expansion of the U.S. space program in the 1960s to pursue manned space flight and lunar exploration. While space exploration continues today, moonshot has come to apply more broadly to risky, resource-intensive, large-scale, long-term and collaborative research programs with ambitious goals.

To consider factors facilitating the successful implementation of a moonshot program in Canada, the House of Commons Standing Committee on Science and Research (the Committee) embarked on a study of international moonshot programs that "aim to resolve difficult environmental and social problems, set ambitious research and development programs, and attract researchers from around the world."[1]

During its study, the Committee heard that moonshot programs need to include both fundamental, curiosity-driven research, as well as applied research and development. While existing funding programs were highlighted, witnesses also spoke to the need for additional funding and more long-term funding opportunities. The Committee also heard testimony on ways to ensure that non-research policies support and enable research goals, the importance of developing and maintaining research infrastructure, and challenges related to education and workforce development. Witnesses also identified the many opportunities for collaboration on moonshot programs, with diverse partners that include provincial and territorial governments, industry and international collaborators.

Finally, the Committee heard testimony related to selecting topics and goals for moonshot programs, including both general tenets related to focusing efforts and addressing global challenges, as well as specific topics for exploration, including climate change, artificial intelligence and health.

Based on the testimony it heard, the Committee made 15 recommendations to government.

1 House of Commons, Standing Committee on Science and Research (SRSR), *Minutes of Proceedings*, 26 September 2022.

LIST OF RECOMMENDATIONS

As a result of their deliberations committees may make recommendations which they include in their reports for the consideration of the House of Commons or the Government. Recommendations related to this study are listed below.

PURSUING A CANADIAN MOONSHOT PROGRAM

INTRODUCTION

On 26 September 2022, the House of Commons Standing Committee on Science and Research (the Committee) decided to undertake a study on international moonshot programs that "aim to resolve difficult environmental and social problems, set ambitious research and development programs, and attract researchers from around the world, and make recommendations regarding what such a program could look like here in Canada."[1]

The Committee held six meetings between 14 November 2022 and 2 February 2023 on the subject. During its study, it heard 27 witnesses and received 28 briefs. The Committee would like to thank all the individuals and organizations that took the time to participate in this study by appearing or submitting a brief.

The evidence compiled by the Committee resulted in recommendations for the Government of Canada on the pursuit of a moonshot program.

DEFINING MOONSHOT PROGRAMS

The origin of the term moonshot can be traced back to United States (U.S.) President John F. Kennedy and the expansion of the U.S. space program in the 1960s to pursue manned space flight and lunar exploration. In a speech at Rice University on 12 September 1962, President Kennedy said:

> We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too.[2]

That ambitious goal was first realized on 20 July 1969, and the pursuit of manned space flight led to multiple other innovations, such as microcomputers, Velcro and Teflon,

1 House of Commons, Standing Committee on Science and Research (SRSR), *Minutes of Proceedings*, 26 September 2022.

2 John F. Kennedy, "Address at Rice University on the Nation's Space Effort," *John F. Kennedy Presidential Library and Museum,* 12 September 1962.

scratch-resistant eyewear, and featherlight foil blankets.[3] Canada's contribution to space exploration and related technological development has included the Canadarm robotic arm, collaboration on the communications technology satellite known as Hermes, and the development of a microgravity isolation mount to protect scientific experiments in low gravity.[4]

As Kevin Smith, Chief Executive Officer of the University Health Network, testified, "It truly and fundamentally changed our economy, quality of life, scientific integrity and every facet of human society."[5]

While space exploration continues today, notably through the Artemis series of missions, moonshot has come to apply more broadly to risky, resource-intensive, large-scale, long-term and collaborative research programs with ambitious goals.[6] An article referenced by Kevin Smith in his testimony wrote, "moonshot innovations do not start with clever answers, rather they start with the painstaking task of finding the right questions."[7]

Witnesses testified that research to support moonshot goals needed to include both fundamental, curiosity-driven research, and applied research and development (R&D). Supporting a balanced research agenda that includes the breadth of research—from education and skills development, through fundamental research and applied research, and on to commercialization and globalization—was highlighted by four witnesses and two briefs.[8] As Alexandre Blais, Scientific Director and Professor, Institut quantique,

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3 SRSR, *Evidence*, 28 November 2022, 2035 (Kevin Smith, President and Chief Executive Officer, University Health Network); and Anne-Laure Mention, João José Pinto Ferreira and Marko Torkkeli, "Moonshot innovations: Wishful Thinking of Business-As-Usual?," *Journal of Innovation Management,* Vol. 7, No. 1, April 2018.

4 Canadian Intellectual Property Office, *Patents in Space: Highlighting Innovation in the Canadian Space Sector*, 2018.

5 SRSR, *Evidence*, 28 November 2022, 2035 (Kevin Smith).

6 Anne-Laure Mention, João José Pinto Ferreira and Marko Torkkeli, "Moonshot innovations: Wishful Thinking of Business-As-Usual?," *Journal of Innovation Management,* Vol. 7, No. 1, April 2018.

7 Ibid.

8 SRSR, *Evidence*, 28 November 2022, 1905 (Arthur McDonald, Gray Chair in Particle Astrophysics (Emeritus), Queen's University, As an individual); SRSR, *Evidence*, 28 November 2022, 1950 (Michael Rudnicki, Scientific Director, Stem Cell Network); SRSR, *Evidence*, 28 November 2022, 2035 (Kevin Smith); SRSR, *Evidence*, 31 January 2023, 1130 (Alexandre Blais, Scientific Director and Professor, Institut quantique, Université de Sherbrooke); BioCanRx, *Submission to the Standing Committee on Science and Research Study on "International Moonshot Programs"*, Brief submitted to the House of Commons Standing Committee on Science and Research, 16 December 2022; and HealthCareCAN, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 11 January 2023.

Université de Sherbrooke, said in his testimony, "The entire chain, from basic research to marketing, should be a priority."[9]

Therefore, the Committee recommends:

Recommendation 1

That the Government of Canada support research along the full breadth of the innovation continuum, including people and skills, fundamental research, applied research and development, partnerships, commercialization and start-ups, and scale up and globalization.

Curiosity-Driven Research and Fundamental Science

Many witnesses spoke to the important value of fundamental research in setting moonshot goals and driving innovation more broadly.[10] Fundamental research refers to the initial phases of research that pursue scientific exploration and scientific discoveries that often serve as the foundation for further research and development. This stage of research cannot necessarily be focused on specific solutions and discoveries. As explained by Yoshua Bengio, Scientific Director of the Mila—Quebec Artificial Intelligence Institute:

> The initial phases of research cannot be completely directed, because it's not clear ahead of time where the moonshots are going to be. The curiosity-driven research helps us figure out what the moonshots are and what directions are worth having a significant investment.[11]

This exploration stage allows researchers to pursue science that may not have explicit commercial viability, but that allows for the discovery of potentially unknown areas of advancement. As Alexandre Blais testified:

> Had the founders of quantum physics focused on innovation rather than understanding the inner workings of nature at the atomic level, they would probably have devoted their efforts to improving the telegraph or candle wax. Had this been the case, technologies that have transformed society and whose development relied on quantum

9 SRSR, *Evidence*, 31 January 2023, 1130 (Alexandre Blais).

10 SRSR, *Evidence*, 28 November 2022, 2035 (Kevin Smith); SRSR, *Evidence*, 14 November 2022, 2100 (Yoshua Bengio, Scientific Director, Mila–Quebec Artificial Intelligence Institute); SRSR, *Evidence*, 21 November 2022, 1855 (Alan Bernstein, President Emeritus, CIFAR); and SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais).

11 SRSR, *Evidence*, 14 November 2022, 2100 (Yoshua Bengio).

> physics—such as computers, lasers and GPS—would not have been possible. In short, technological revolutions are founded on curiosity-driven research, and any moonshot program should reflect that.[12]

For fundamental research, several witnesses highlighted the important role of government funding, because as Alan Bernstein, President Emeritus, Canadian Institute for Advanced Research (CIFAR) testified, "the timelines and the risks are too high."[13] However, this was also emphasized as a challenge in Canada in a brief from the Canadian Cancer Research Alliance which described "dwindling investment in fundamental discovery science."[14]

Therefore, the Committee recommends, in line with recommendation 5 in its report on Successes, Challenges and Opportunities for Science in Canada:[15]

Recommendation 2

That the Government of Canada review, with the potential to increase, its investments in fundamental research through the budgets of the three granting councils, namely the Social Sciences and Humanities Research Council, the Natural Sciences and Engineering Research Council of Canada, and the Canadian Institutes of Health Research.

Industrial and Commercial Research and Development

Once fundamental research has identified areas of promise for further development, science and research moves into the stage of industrial and commercial research to further the development of products and services. As Stéphanie Michaud, President and Chief Executive Officer at BioCanRx, described in relation to biomanufacturing, "you need to be really capable of taking the results—our discoveries—from our laboratories and convert them into products that can be tested on, and potentially cure, human beings. It's essential."[16]

At this stage, the selection of research for further industrial and commercial development is often driven by market forces. As Yoshua Bengio described, government

12 SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais).

13 SRSR, *Evidence*, 21 November 2022, 1855 (Alan Bernstein).

14 Canadian Cancer Research Alliance, *Canadian Cancer Moonshot: Accelerating Cancer Research and Impact*, Brief submitted to the House of Commons Standing Committee on Science and Research, 30 January 2023.

15 SRSR, *Successes, Challenges and Opportunities for Science in Canada*, First report, June 2022.

16 SRSR, *Evidence*, 5 December 2022, 2025 (Stéphanie Michaud, President and Chief Executive Officer, BioCanRx).

funding that is based on matching funds and contributions from industry can help determine which projects are funded.[17] This shared funding model can also help encourage private investment in and adoption of promising research and technology.[18]

However, in some cases, market forces may fail to support research that has limited short-term economic viability, but potential long-term economic and social good, in which case government is called upon to provide additional support.[19] As Yoshua Bengio testified:

> The profit motive of industry is not always sufficient to get this transfer to happen, because it's not always well aligned with the needs of society. This process whereby we rely on industry to create the innovations that follow the basic research doesn't always work, particularly in areas such as health, environment, education or social justice, which are typically the domain of the government.[20]

There was also concern that Canada faces challenges in the commercialization of promising research, with Alexandre Blais testifying that "the danger is that the same thing we saw in the first quantum revolution will happen again: we'll be there at the start, but we won't be able to bring things to market once we get to that stage."[21] This view was also put forward in written submissions by three witnesses who appeared before the Committee: BioCanRx, General Fusion and the Canadian Brain Research Strategy.[22] For example, the speaking notes of Amee Barber, Director, Government Relations and Business Development, General Fusion, wrote that, in regards to fusion

17 SRSR, *Evidence*, 14 November 2022, 2045 (Yoshua Bengio).

18 SRSR, *Evidence*, 14 November 2022, 2100 (Rosemary Yeremian, Vice-President, Corporate Strategy and Business Development, X-energy Canada).

19 SRSR, *Evidence*, 14 November 2022, 2045 (Yoshua Bengio); and SRSR, *Evidence*, 21 November 2022, 1910 (Seth Klein, Team Lead, Climate Emergency Unit).

20 SRSR, *Evidence*, 14 November 2022, 2045 (Yoshua Bengio).

21 SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais).

22 BioCanRx, *Submission to the Standing Committee on Science and Research Study on "International Moonshot Programs"*, Brief submitted to the House of Commons Standing Committee on Science and Research, 16 December 2022; Amee Barber, "Speaking Notes as Prepared for the House of Commons Standing Committee on Science and Research (SRSR) In Support of the Study on International Moonshot Programs," Written submission to the House of Commons Standing Committee on Science and Research, 28 November 2022; and Jennie Z. Young, "Canadian Brain Research Strategy," Written submission to the House of Commons Standing Committee on Science and Research, 17 November 2022.

technology, "Canada's well-known commercialization gap is what could hamper the potential for these disruptive technologies to be delivered to market."[23]

Therefore, the Committee recommends:

Recommendation 3

That the Government of Canada review and strengthen mechanisms for supporting the commercialization of promising research.

SUPPORTING MOONSHOT PROGRAMS

Research Funding Programs

Existing Funding Programs

Regarding funding programs that support moonshot research, several were highlighted by witnesses as important contributors to moonshot-style research programs.

The Canada First Research Excellence Fund (CFREF) supports Canadian post-secondary institutions as they pursue talent and partnership opportunities and implement large-scale, transformational institutional strategies.[24] CFREF funding was mentioned in relation to the recruitment of faculty members at Queen's University and in supporting the long-term vision for the development of quantum science and technology at the Université de Sherbrooke.[25] Regarding the Université de Sherbrooke, Alexandre Blais testified that:

> In the case of Sherbrooke's CFREF, this flexibility and the long-term nature of the program allowed us to take actions that led to the creation of the quantum science innovation zone in the Sherbrooke area to support Sherbrooke-based start-ups and attract companies from abroad. In short, it allowed the Institut quantique to have an impact well beyond producing excellent science. This was made possible thanks to the long duration of the funding and its flexibility.[26]

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23 Amee Barber, "Speaking Notes as Prepared for the House of Commons Standing Committee on Science and Research (SRSR) In Support of the Study on International Moonshot Programs," Written submission to the House of Commons Standing Committee on Science and Research, 28 November 2022.

24 Government of Canada, *Canada First Research Excellence Fund*.

25 SRSR, *Evidence*, 28 November 2022, 1910 (Arthur McDonald); and SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais).

26 SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais).

Yoshua Bengio testified that CIFAR's investment contributed to Canada's strength in deep learning research.[27] CIFAR's portfolio includes the Pan-Canadian Artificial Intelligence Strategy, support for early-career researchers and various research programs on diverse topics that bring together inter-disciplinary teams to address broad issues effecting science and humanity.[28]

The Canada Foundation for Innovation's (CFI) contribution to research infrastructure was highlighted by two witnesses, with Arthur McDonald, Gray Chair in Particle Astrophysics (Emeritus) at Queen's University, describing CFI as "a real addition to the scene."[29]

In a document submitted to the committee following their testimony, General Fusion highlighted funding support from Sustainable Development Technology Canada (SDTC), the National Research Council of Canada's Industrial Research Assistance Program (NRC IRAP) and the Strategic Innovation Fund (SIF) as having been critical to General Fusion's growth and success to date.[30]

John Bell, Scientific Director of BioCanRx, also mentioned the Networks of Centres of Excellence, which provided $40 million of funding to BioCanRx from 2014 through 2024, while also noting that the funding would be ending in 2024.[31]

In a response submitted to the Committee following the appearance of the Minister of Innovation, Science and Industry, the Honourable François-Phillipe Champagne, Innovation, Science and Economic Development Canada (ISED) also highlighted the contribution of the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Global Innovation Clusters as important programs supporting collaborative research between industry, government and not-for-profit partners, as well as the programs mentioned previously.[32]

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27 SRSR, *Evidence*, 14 November 2022, 2115 (Yoshua Bengio).

28 CIFAR, *Impact Report 2021/22*, 2022.

29 SRSR, *Evidence*, 28 November 2022, 1905 (Arthur McDonald); and SRSR, *Evidence*, 28 November 2022, 2105 (Kevin Smith).

30 General Fusion, "Transforming How We Energize the World," Written submission to the House of Commons Standing Committee on Science and Research, 2022.

31 SRSR, *Evidence*, 5 December 2022, 1940 (John Bell, Scientific Director, BioCanRx); and BioCanRx, *Submission to the Standing Committee on Science and Research Study on "International Moonshot Programs"*, Brief submitted to the House of Commons Standing Committee on Science and Research, 16 December 2022.

32 Innovation, Science and Economic Development Canada, "ISED reply and follow-up to Minister Champagne, Appearance before the Standing Committee on Science and Research (SRSR) on February 2, 2023," Written submission to the House of Commons Standing Committee on Science and Research, 21 March 2023.

Several international funding models for moonshot programs were also identified by witnesses as providing valuable financial support to ambitious research projects. In the U.S., the Defense Advanced Research Projects Agency (DARPA) and the Biomedical Advanced Research and Development Authority (BARDA) were both mentioned as models to fund mission-oriented research that also often leads to broader economic transformation through the development of associated science and research.[33] In more specific research areas, witnesses highlighted the U.S. National Institute of Health's Brain Research Through Advancing Innovative Neurotechnologies (BRAIN) Initiative and the National Cancer Institute's Cancer Moonshot.[34]

Representatives from Japan's Moonshot Research and Development Program also provided documentation related to their research program, which "sets ambitious goals and concepts for societal issues that are difficult to tackle but will have profound impact once resolved."[35] Japan's moonshot program uses a portfolio approach of funding multiple projects related to central themes to manage risk and reduce fears of failure.[36]

Funding Challenges

Despite highlighting several Canadian research funding programs in a positive light, witnesses also expressed concerns with Canada's current funding system.

There was an overarching sense among witnesses that Canada's overall level of investment in research was falling behind in comparison to the international community,

33 SRSR, *Evidence*, 14 November 2022, 2125 (Yoshua Bengio).

34 SRSR, *Evidence*, 31 January 2023, 1150 (Jennie Z. Young, Executive Director, Canadian Brain Research Strategy); SRSR, *Evidence*, 28 November 2022, 2100 (Kevin Smith); and SRSR, *Evidence*, 5 December 2022, 2030 (Stéphanie Michaud).

35 Government of Japan, *Outline of Moonshot Research and Development Program*, Brief submitted to the House of Commons Standing Committee on Science and Research, 12 December 2022; and Naoki Tatsuzawa, "Overview of Moonshot Research and Development Program [of Japan]," Written submission to the House of Commons Standing Committee on Science and Research, 9 December 2022.

36 Government of Japan, *Outline of Moonshot Research and Development Program*, Brief submitted to the House of Commons Standing Committee on Science and Research, 12 December 2022.

both generally and in specific fields, including fusion, health and climate change.[37] To illustrate, in a brief submitted to the Committee, HealthCareCAN wrote that, "in 2020, the most recent year for which comparable data is available, Canada invested 1.8% as a percentage of GDP on research and development, while the OECD average was 2.7% and US investment sat at 3.5%."[38]

The many programs highlighted in the previous section were also seen as challenging to navigate for research institutions. In addition, according to witnesses, these funding programs tend to limit the types of research that transcend specific fields, as defined for example, by the tri-councils—the Canadian Institutes of Health Research (CIHR), NSERC and the Social Sciences and Humanities Research Council (SSHRC).[39]

Further, short funding cycles were identified as a challenge for pursuing ambitious, long-term research goals, as researchers are required to commit substantial time to grant writing and face uncertainty as to the sustainability of funding.[40]

In addition, several witnesses expressed that limitations imposed on research by federal funding agreements create barriers to ambitious moonshot research programs, including grant requirements that limit capital investments and industry partnerships, and a lack of flexibility in terms of allocation of funds (e.g., number of students and

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37 SRSR, *Evidence*, 28 November 2022, 2045 (Amee Barber, Director, Government Relations and Business Development, General Fusion); SRSR, *Evidence*, 28 November 2022, 2100 (Kevin Smith); SRSR, *Evidence*, 5 December 2022, 1830 (Chad Gaffield, Chief Executive Officer, U15 Group of Canadian Research Universities); Canadian Cancer Society et al., *Canadian Cancer Moonshot: Collaborating to Control Cancer*, 25 January 2023; HealthCareCAN, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 11 January 2023; SRSR, *Evidence*, 21 November 2022, 1925 (Seth Klein); and Canadian Cancer Research Alliance, *Canadian Cancer Moonshot: Accelerating Cancer Research and Impact*, Brief submitted to the House of Commons Standing Committee on Science and Research, 30 January 2023.

38 HealthCareCAN, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 11 January 2023.

39 HealthCareCAN, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 11 January 2023; and Arinjay Banerjee, "International Moonshot Programs," Written submission to the House of Commons Standing Committee on Science and Research, 2022.

40 SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais); SRSR, *Evidence*, 28 November 2022, 2005 (Arinjay Banerjee, Research Scientist and Adjunct Professor, Vaccine and Infectious Disease Organization, University of Saskatchewan, As an individual); SRSR, *Evidence*, 28 November 2022, 1955 (Michael Rudnicki); HealthCareCAN, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 11 January 2023; SRSR, *Evidence*, 31 January 2023, 1115 (Jennie Z. Young); Canadian Cancer Society et al., *Canadian Cancer Moonshot: Collaborating to Control Cancer*, 25 January 2023; Canadian Cancer Research Alliance, *Canadian Cancer Moonshot: Accelerating Cancer Research and Impact*, Brief submitted to the House of Commons Standing Committee on Science and Research, 30 January 2023; and Naoki Tatsuzawa, "Overview of Moonshot Research and Development Program [of Japan]," Written submission to the House of Commons Standing Committee on Science and Research, 9 December 2022.

researchers, equipment needed, infrastructure development, knowledge mobilization).[41] As Alexandre Blais testified, "[l]arge-scale and long-term initiatives should be given the latitude to make the most out of the allocated funds."[42]

Therefore, the Committee recommends:

Recommendation 4

That the Government of Canada develop a long-term research funding program to provide stability and flexibility for ambitious research projects.

Recommendation 5

That the Government of Canada review and revise research funding requirements to ensure projects can effectively leverage capital investment and industry partnerships.

Policy Supports

Several witnesses spoke to the need for non-research policy supports to promote moonshot research and development goals. For example, the Right Hon. David Johnston, 28th Governor General of Canada, testified that, "we should do a much better job of regulation, of doing it smartly, thoroughly but promptly, all with a sense of dispatch… Finding that right balance of regulation, which is necessary but efficient, is a very key challenge."[43]

Across the research spectrum, several policy areas were identified as having the potential to either support or curtail ambitious research programs in general.

41 SRSR, *Evidence*, 28 November 2022, 2120 (Amee Barber); SRSR, *Evidence*, 28 November 2022, 1955 (Michael Rudnicki); SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais); SRSR, *Evidence*, 31 January 2023, 1135 (Jennie Z. Young); SRSR, *Evidence*, 31 January 2023, 1115 (Alexandre Blais); HealthCareCAN, *Brief,* Brief submitted to the House of Commons Standing Committee on Science and Research, 11 January 2023; U15 Group of Canadian Research Universities, *Written Response,* Written response submitted to the House of Commons Standing Committee on Science and Research, 24 January 2023; and SRSR, *Evidence*, 31 January 2023, 1125 (Jennie Z. Young).

42 SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais).

43 SRSR, *Evidence*, 21 November 2022, 1920 (The Right Hon. David Johnston, 28th Governor General of Canada, As an individual).

Intellectual Property and Open Science

Yoshua Bengio testified to the value of an intellectual property regulatory system that encourages the international adoption of socially conscious research and technology, such as those that can address cross-border impacts of future health threats and climate change.[44] He identified standard clauses in funding agreements from the Bill & Melinda Gates Foundation regarding data sharing as an example of how the federal government could ensure the sharing of important data generated by public funding.[45] The Bill & Melinda Gates Foundation's Open Access Policy requires publication on open access terms, with copyright remaining in the hands of grantees and underlying data available publicly.[46] Jennie Z. Young and Alexandre Blais further identified the potential for legal supports and national guidance to help standardize intellectual property and open science agreements.[47] A written submission to the Committee from ISED highlighted the Strategic Intellectual Property Program Review currently underway to promote intellectual property growth in Canada.[48]

In his appearance before the Committee, the Honourable François-Philippe Champagne, spoke on the need to protect sensitive research and intellectual property (IP) and testified that, "I'm looking at imposing additional requirements when it comes to strengthening research security in Canada, because, to your point, we need to be eyes wide open and we need to ensure that sensitive research and our IP is adequately protected."[49] Following the Minister's appearance, further details were provided in a written submission to the Committee:

> Minister Champagne and Minister Duclos recently requested that the Canada Foundation for Innovation and the granting councils adopt a further enhanced posture regarding national security. This builds on the National Security Guidelines for Research Partnerships, published in 2021 which better position researchers, research organizations and federal granting agencies to identify and mitigate potential national security risks to research. It also builds on the Budget 2022 investment of $159.6 million

44 SRSR, *Evidence*, 14 November 2022, 2130 (Yoshua Bengio).

45 Ibid.

46 The Bill & Melinda Gates Foundation, *Open Access Policy*.

47 SRSR, *Evidence*, 31 January 2023, 1140 (Jennie Z. Young); and SRSR, *Evidence*, 31 January 2023, 1145 (Alexandre Blais).

48 Innovation, Science and Economic Development Canada, "ISED reply and follow-up to Minister Champagne, Appearance before the Standing Committee on Science and Research (SRSR) on February 2, 2023," Written submission to the House of Commons Standing Committee on Science and Research, 21 March 2023.

49 SRSR, *Evidence*, 2 February 2023, 1210 (Hon. François-Philippe Champagne, Minister of Innovation, Science and Industry).

> over five years starting in 2022–23, $33.4 million ongoing, to implement the Guidelines fully, establish a Research Security Centre to provide advice and guidance directly to research institutions, and build research security capacity within [post-secondary institutions] through the Research Support Fund.[50]

Immigration

Michael Rudnicki, Scientific Director at the Stem Cell Network spoke of challenges with the immigration system and delays in processing visa and permanent residency for international scientists and researchers to pursue ambitious research in Canada.[51] This was identified as potentially driving talented researchers away from Canada.

Financial Policy

Chad Gaffield, Chief Executive Officer of the U15 Group of Canadian Research Universities, testified to the valuable role ambitious science and research programs can play in combatting issues such as inflation through research and development:

> There's been a lot of emphasis in Canada recently on the fact that the United States has embarked on a really aggressive Inflation Reduction Act. It actually did, last summer, two things. Right before it did the Inflation Reduction Act, it did the CHIPS and Science Act. Those two go together. It clearly has a two-pronged attack, and there's going to be significant development in a whole variety of infrastructure and a whole variety of aspects of the United States and their transformation. It's all going to be driven by a serious thrust in research and science.[52]

Environmental Regulation

Environmental regulation was highlighted by several witnesses as a tool to support climate and environmental moonshot goals. Yoshua Bengio spoke to the use of regulatory tools such as carbon pricing to encourage innovation addressing climate change.[53] Meanwhile, Anya Waite, Chief Executive Officer and Scientific Director at the Ocean Frontier Institute, spoke of the potential use of blue chip carbon credits to

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50 Innovation, Science and Economic Development Canada, "ISED reply and follow-up to Minister Champagne, Appearance before the Standing Committee on Science and Research (SRSR) on February 2, 2023," Written submission to the House of Commons Standing Committee on Science and Research, 21 March 2023.

51 SRSR, *Evidence*, 28 November 2022, 1955 (Michael Rudnicki).

52 SRSR, *Evidence*, 5 December 2022, 1900 (Chad Gaffield).

53 SRSR, *Evidence*, 14 November 2022, 2045 (Yoshua Bengio).

support further research in ocean carbon sinks.[54] In regard to environmental impact assessments, Rosemary Yeremian, Vice-President of Corporate Strategy and Business Development with X-energy Canada, spoke of the need to balance rigorous assessments with reasonable timeliness to ensure research and development in Canada is competitive for international businesses and across different technologies.[55] She testified to the detrimental effect extended assessment timelines can have on the development of new energy infrastructure:

> I'm a big fan of environmental assessments. I don't want to cut corners, but seven years for the Bruce Power environmental assessment was just way too long for a site that has been studied beyond anything that anyone could possibly ever do more. I was literally, just on Friday, in a meeting with a mining executive in Saskatchewan, who told me that if the environmental assessments are longer than two years, they're just going to go to diesel generation because there's no problem there. It's really a matter of the environmental assessment piece being a competitive disadvantage for Canada.[56]

Therefore, the Committee recommends:

Recommendation 6

That the Government of Canada review and revise associated policy as needed to support and enhance specific moonshot goals.

Recommendation 7

That the Government of Canada review and revise policy on open science, intellectual property and immigration to further support research and development.

Infrastructure

Several witnesses testified to the fact that Canada's research infrastructure represents a strength for conducting large scale international science and attracting world-wide talent.[57] Guy Rouleau, Director of the Montreal Neurological Institute and Hospital, appearing as an individual, shared the following recruitment story:

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54 SRSR, *Evidence*, 5 December 2022, 1915 (Anya Waite, Chief Executive Officer and Scientific Director, Ocean Frontier Institute).

55 SRSR, *Evidence*, 14 November 2022, 2125 (Rosemary Yeremian).

56 Ibid.

57 SRSR, *Evidence*, 28 November 2022, 1845 (Arthur McDonald); and SRSR, *Evidence*, 5 December 2022, 2025 (Guy Rouleau, Director, Montréal Neurological Institute and Hospital, As an individual).

> A woman, a world authority at Yale University, was offered a position as the director of an institute in Germany with a budget of $100 million. When we invited her to come here, she said that here was where she wanted to be. I asked her why and she said that it would cost her $100 million to build what we already have at the Montreal Neurological Institute and Hospital. She also told me that the members of our community were very collaborative. She is therefore coming because she was attracted by our infrastructure and the people who would be her colleagues. Last week I also met a man of considerable renown from New York. He too wanted to come here. When I asked him why, he said that it was a place where people can work together, rather than the competitive environment typical of the United States. He added that we could provide him with all the equipment and colleagues needed to do exploratory work of the best kind in science.[58]

However, three briefs also identified gaps in research infrastructure, including the availability of funding for research organizations that are outside of post-secondary institutions, the maintenance of research infrastructure along the entirety of its lifespan and the need to strengthen key supply chains.[59]

Therefore, the Committee recommends:

Recommendation 8

That the Government of Canada review and revise funding programs to ensure research infrastructure development and maintenance is supported.

Education and Workforce Development

Witnesses discussed the importance of starting science and research education early, during elementary and secondary education and through child and youth programming.[60] As Alexandre Blais testified, “we also need to start early, and for that we need a national program to get young people interested in science and technology. Without that, we won't make it.”[61] Even for those that do not pursue scientific careers,

58 SRSR, *Evidence*, 5 December 2022, 2025 (Guy Rouleau).

59 HealthCareCAN, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 11 January 2023; Canadian Cancer Research Alliance, *Canadian Cancer Moonshot: Accelerating Cancer Research and Impact*, Brief submitted to the House of Commons Standing Committee on Science and Research, 30 January 2023; and T. Rosemary Yeremian, *X-energy: Presentation to Standing Committee on Science and Research on Moonshot Program*, Brief submitted to the House of Commons Standing Committee on Science and Research, 14 November 2022.

60 SRSR, *Evidence*, 28 November 2022, 2010 (Arinjay Banerjee); and SRSR, *Evidence*, 31 January 2023, 1130 (Alexandre Blais).

61 SRSR, *Evidence*, 31 January 2023, 1130 (Alexandre Blais).

this foundational knowledge was identified as valuable regardless of what individuals went on to do.[62] As Arthur McDonald said in his testimony regarding the SNOLAB training program, "they were trained in evidence-based decision-making, which is needed in all aspects of our society."[63] A written submission to the Committee from ISED also highlighted the Mitacs program, which in 2021–2022, "delivered 15,547 ISED-supported work-integrated learning opportunities, connecting students and researchers from 221 [post-secondary institutions] to 3198 businesses, not-for-profits and governments."[64]

Further to that, the Right Hon. David Johnston spoke of the value for scientific thinking of bringing teenagers and young adults to Canada as students, and sending Canadian students abroad.[65] He also testified to the value international students bring to the Canadian economy, through international student fees and as potential permanent residents, and the value of sending Canadian students abroad to promote intercultural understanding.[66] As he explained, "for me, the single easiest thing to do that is relatively inexpensive. It's bringing international students here and sending our young people abroad. Build from that a pool of talent in which excellent research comes along and we'll develop a series of moonshots."[67]

Following foundational education, several witnesses highlighted challenges to recruiting talented researchers in Canada at the doctoral level and beyond, including a limited number of faculty positions at post-secondary institutions, limited salaries for

62 SRSR, *Evidence*, 28 November 2022, 1850 (Arthur McDonald); SRSR, *Evidence*, 28 November 2022, 2020 (Baljit Singh, Vice-President, Research, University of Saskatchewan); SRSR, *Evidence*, 5 December 2022, 1845 (Chad Gaffield).

63 SRSR, *Evidence*, 28 November 2022, 1850 (Arthur McDonald).

64 Innovation, Science and Economic Development Canada, "ISED reply and follow-up to Minister Champagne, Appearance before the Standing Committee on Science and Research (SRSR) on February 2, 2023," Written submission to the House of Commons Standing Committee on Science and Research, 21 March 2023.

65 SRSR, *Evidence*, 21 November 2022, 1830 (David Johnston).

66 Ibid.

67 Ibid., 1855.

research positions and grants for graduate and doctoral studies, and promoting diversity in research.[68] As Michael Rudnicki testified:

> I've had students tell me that they're going to write up their master's thesis and not pursue a Ph.D. because they can't afford to live. This is an equity issue. If you don't have parents helping you, you can't pursue a graduate degree. The approved pay for post-doctoral fellows is $42,000 a year from CIHR. Well, if you have little kids at home and you're trying to make rent, you can't live on that in Toronto, and it's very hard in Ottawa. Both spouses have to work, but they're living in a tiny apartment and they don't have a car. It's very hard to live, so people are leaving… It's below minimum wage.[69]

This was identified as particularly challenging due to expected upcoming skill gaps in research and other related professions.[70] As Baljit Singh, Vice-President of Research at the University of Saskatchewan testified, "the shortage of skilled professionals is occurring across all sectors."[71]

Therefore, the Committee recommends, in line with recommendation 7 of the *Successes, Challenges and Opportunities for Science* report and recommendations 4 and 8 of the *Top Talent, Research and Innovation* report:[72]

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68 SRSR, *Evidence*, 28 November 2022, 1900 (Brandon Russell, Research Fellow, Gérard Mourou Center for Ultrafast Optical Science); SRSR, *Evidence*, 31 January 2023, 1150 (Alexandre Blais); SRSR, *Evidence*, 28 November 2022, 2015 (Arinjay Banerjee); SRSR, *Evidence*, 28 November 2022, 2105 (Kevin Smith); SRSR, *Evidence*, 5 December 2022, 1905 (Chad Gaffield); SRSR, *Evidence*, 28 November 2022, 1845 (Brandon Russell); SRSR, *Evidence*, 2 February 2023, 1240 (François-Philippe Champagne); and Canadian Cancer Research Alliance, *Canadian Cancer Moonshot: Accelerating Cancer Research and Impact*, Brief submitted to the House of Commons Standing Committee on Science and Research, 30 January 2023.

69 SRSR, *Evidence*, 28 November 2022, 2015 (Michael Rudnicki).

70 SRSR, *Evidence*, 28 November 2022, 2020 (Michael Rudnicki); SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais); SRSR, *Evidence*, 28 November 2022, 2020 (Baljit Singh); Canadian Cancer Society et al., *Canadian Cancer Moonshot: Collaborating to Control Cancer*, 25 January 2023; Canadian Cancer Research Alliance, *Canadian Cancer Moonshot: Accelerating Cancer Research and Impact*, Brief submitted to the House of Commons Standing Committee on Science and Research, 30 January 2023; and T. Rosemary Yeremian, *X-energy: Presentation to Standing Committee on Science and Research on Moonshot Program*, Brief submitted to the House of Commons Standing Committee on Science and Research, 14 November 2022.

71 SRSR, *Evidence*, 28 November 2022, 2020 (Baljit Singh).

72 SRSR, *Successes, Challenges and Opportunities for Science in Canada*, First report, June 2022; SRSR, *Top Talent, Research and Innovation*, Second report, October 2022.

Recommendation 9

That the Government of Canada increase the number of scholarships and fellowships to graduate students and postdoctoral researchers and increase their value by 25% and index it to the consumer price index.

Recommendation 10

That the Government of Canada, in cooperation with the provinces and territories, consider ways to encourage post-secondary institutions to create more tenured positions.

Recommendation 11

That the Government of Canada, in cooperation with the provinces and territories, review and revise systems for foreign credential recognition and Canada wide occupational certification to encourage the retention of skilled professionals.

Collaboration

The value of collaborative efforts in supporting moonshot research programs was frequently highlighted by witnesses. Canadian research was identified as having a strong collaborative nature, which assisted in the recruitment of top talent and the pursuit of moonshot goals.[73] More structurally, witnesses spoke of the different factors affecting collaboration at the interprovincial, international, cross-disciplinary and cross-sectoral levels.

Within Canada, witnesses identified ways to strengthen interprovincial and federal-provincial collaboration to facilitate moonshot projects. This includes supporting national qualification and certification programs for various professions that are mandated provincially, and collaborative funding models for research infrastructure between provincial and federal partners.[74] For example, Chad Gaffield testified to collaboration between the Fonds de recherche du Québec and complementary federal initiatives and said, “it would be very good if the other provinces had research funds as

73 SRSR, *Evidence*, 5 December 2022, 1935 (Guy Rouleau).

74 SRSR, *Evidence*, 21 November 2022, 1915 (David Johnston); SRSR, *Evidence*, 28 November 2022, 1915 (Arthur McDonald); SRSR, *Evidence*, 28 November 2022, 2020 (Michael Rudnicki); SRSR, *Evidence*, 28 November 2022, 2115 (Amee Barber); and SRSR, *Evidence*, 5 December 2022, 1900 (Chad Gaffield).

well to increase the effort across Canada. However, federal leadership in Canada is key."[75]

Witnesses also spoke of the need for international collaboration on moonshot goals, as many common moonshot topics transcend national borders and are of a scale that requires actions beyond that of an individual country (e.g., climate change, infectious diseases).[76] As Arthur McDonald testified, "[t]here's no doubt that these moonshots are of such a scale that Canada can't do it alone. There has to be international co-operation."[77] Anya Waite gave the example of the potential collaboration between nations bordering the Atlantic Ocean on deep sea carbon to address climate change, referring to it as a potential "ocean space station."[78]

To enable greater international collaboration on moonshot research, Alexandre Blais recommended building incentives for international research and development partnerships into funding programs.[79]

Finally, the Committee heard about the need for cross-disciplinary and cross-sectoral collaboration to support moonshot goals, including researchers at different post-secondary institution, industry and regulators.[80] As John Bell testified, "the hallmarks of a successful moonshot program include building cross-disciplinary teams of thought leaders."[81]

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75 SRSR, *Evidence*, 5 December 2022, 1900 (Chad Gaffield).

76 SRSR, *Evidence*, 28 November 2022, 2000 (Arinjay Banerjee); SRSR, *Evidence*, 28 November 2022, 1920 (Arthur McDonald); and SRSR, *Evidence*, 5 December 2022, 1830 (Chad Gaffield).

77 SRSR, *Evidence*, 28 November 2022, 1920 (Arthur McDonald).

78 SRSR, *Evidence*, 5 December 2022, 1910 (Anya Waite).

79 SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais).

80 SRSR, *Evidence*, 28 November 2022, 2005 (Arinjay Banerjee); SRSR, *Evidence*, 28 November 2022, 2025 (Cate Murray, President and Chief Executive Officer, Stem Cell Network); SRSR, *Evidence*, 28 November 2022, 2055 (Kevin Smith); SRSR, *Evidence*, 5 December 2022, 1855 (Chad Gaffield); SRSR, *Evidence*, 5 December 2022, 1940 (John Bell); SRSR, *Evidence*, 31 January 2023, 1120 (Jennie Z. Young); SRSR, *Evidence*, 2 February 2023, 1300 (François-Philippe Champagne); HealthCareCAN, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 11 January 2023; Canadian Cancer Research Alliance, *Canadian Cancer Moonshot: Accelerating Cancer Research and Impact*, Brief submitted to the House of Commons Standing Committee on Science and Research, 30 January 2023; and Innovation, Science and Economic Development Canada, "ISED reply and follow-up to Minister Champagne, Appearance before the Standing Committee on Science and Research (SRSR) on February 2, 2023," Written submission to the House of Commons Standing Committee on Science and Research, 21 March 2023.

81 SRSR, *Evidence*, 5 December 2022, 1940 (John Bell).

Therefore, the Committee recommends:

Recommendation 12

That the Government of Canada, in collaboration with the provinces and territories, develop mechanisms for greater collaboration between provincial, territorial and national research programs and goals.

Recommendation 13

That the Government of Canada review research funding programs to encourage and enhance collaboration between academic institutions, industry partners and international allies.

SELECTING TOPICS FOR MOONSHOT PROGRAMS

The Committee heard a wide variety of testimony on both how goals should be selected for moonshot programs, and what topics those goals should fall under. Generally, witnesses spoke to the value of focused moonshot goals to pursue more targeted results.[82] As Joseph McBrearty, President and Chief Executive Officer of the Canadian Nuclear Laboratories, testified, "it means making tough decisions and leaving some projects behind."[83] On a similar vein, Alexandre Blais said that "we need to invest more in research, but in a strategic way. We have to be ambitious and make choices. You can't excel at everything."[84]

Three witnesses testified that Canada's current research funding system lacks the focus to pursue moonshot-style goals.[85] Yoshua Bengio, for example, testified that, "even our funding of industry research tends to be all across the board and not very directed."[86] In regard to more focused programs, such as the National Quantum Strategy, which has committed to $360 million of funding over seven years to developing quantum research and technology, Alexandre Blais testified that:

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82 SRSR, *Evidence*, 5 December 2022, 1945 (Joseph McBrearty, President and Chief Executive Officer, Canadian Nuclear Laboratories); SRSR, *Evidence*, 14 November 2022, 2130 (Yoshua Bengio); and SRSR, *Evidence*, 31 January 2023, 1135 (Alexandre Blais).

83 SRSR, *Evidence*, 5 December 2022, 1945 (Joseph McBrearty).

84 SRSR, *Evidence*, 31 January 2023, 1135 (Alexandre Blais).

85 SRSR, *Evidence*, 14 November 2022, 2100 (Yoshua Bengio); SRSR, *Evidence*, 31 January 2023, 1130 (Alexandre Blais); and SRSR, *Evidence*, 28 November 2022, 2005 (Baljit Singh).

86 SRSR, *Evidence*, 14 November 2022, 2100 (Yoshua Bengio).

> This initial strategy, if I can call it that, uses existing programs to distribute funds very evenly but also randomly in response to small grant applications from small groups across the country. This approach will yield some nice research, but it will be uncoordinated, and that will prevent it from being a moonshot program.[87]

In terms of how to select those coordinated goals, the Honourable François-Philippe Champagne testified that, "it is vital that we focus our attention not only on the immediate matters we are facing as a nation but also on the long-term challenges and opportunities we face as a society, and I would say, indeed, globally."[88] Similarly, Kevin Smith recommended to the Committee that a moonshot program "define a clear, grand challenge anchored in unaddressed real-world needs."[89]

To determine and prioritize these challenges, witnesses recommended engaging different communities, including:

- The Canadian public;[90]
- International partners;[91]
- The academic community;[92] and
- Relevant industry.[93]

Arthur McDonald further mentioned focusing on areas where Canada has a natural advantage, and Alexandre Blais testified that, "to have an impact, moonshots should be based on Canadian issues and build on our strengths."[94]

Within a moonshot topic area, witnesses and briefs further recommended funding a portfolio of projects that includes different risk levels to manage the possibility of failure

87 SRSR, *Evidence*, 31 January 2023, 1130 (Alexandre Blais).

88 SRSR, *Evidence*, 2 February 2023, 1205 (François-Philippe Champagne).

89 SRSR, *Evidence*, 28 November 2022, 2035 (Kevin Smith).

90 Ibid., 2125.

91 SRSR, *Evidence*, 14 November 2022, 2110 (Yoshua Bengio).

92 SRSR, *Evidence*, 14 November 2022, 2110 (Yoshua Bengio); and SRSR, *Evidence*, 28 November 2022, 1920 (Arthur McDonald).

93 SRSR, *Evidence*, 28 November 2022, 1920 (Arthur McDonald).

94 SRSR, *Evidence*, 31 January 2023, 1105 (Alexandre Blais); and SRSR, *Evidence*, 28 November 2022, 1905 (Arthur McDonald).

and the likelihood of success in pursuing ambitious goals.[95] As Chad Gaffield explained in his testimony, "you can't put all your eggs in one basket."[96]

Witnesses identified topics that encompassed a wide variety of fields and sectors as potential areas for focusing Canadian moonshot goals. In particular, climate change, AI and health appeared to often have goals that encouraged research and development in many other areas.

Climate Change

Many witnesses highlighted climate change as an important topic for targeted research and development.[97] Seth Klein, Team Lead of the Climate Emergency Unit, appeared before the Committee to speak to the importance of addressing climate change as a moonshot. He testified that:

> The federal government is now taking climate action, but that action is nowhere close to the speed and scale the crisis demands. I think we will, in coming years, see a slow bending of the curve of our carbon pollution, but not nearly at the pitch and pace the science demands. The federal government's climate policies will be modestly successful, but not moonshot successful. There's no comfort in that. As the great climate writer Bill McKibben said, to win slowly on climate is to lose.[98]

Anya Waite spoke to the scale of the climate change challenge when she said, "without climate mitigation, our future will be confined under the weight of many concurrent catastrophes: mass numbers of refugees, new human health crises, food security challenges and, ultimately, a weakened economy and a weakened quality of life."[99]

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95 SRSR, *Evidence*, 5 December 2022, 1850 (Chad Gaffield); SRSR, *Evidence*, 5 December 2022, 1940 (John Bell); SRSR, *Evidence*, 28 November 2022, 2035 (Kevin Smith); BioCanRx, *Submission to the Standing Committee on Science and Research Study on "International Moonshot Programs"*, Brief submitted to the House of Commons Standing Committee on Science and Research, 16 December 2022; and Government of Japan, *Outline of Moonshot Research and Development Program*, Brief submitted to the House of Commons Standing Committee on Science and Research, 12 December 2022.

96 SRSR, *Evidence*, 5 December 2022, 1850 (Chad Gaffield).

97 SRSR, *Evidence*, 21 November 2022, 1835 (Alan Bernstein); SRSR, *Evidence*, 21 November 2022, 1840 (Seth Klein); SRSR, *Evidence*, 5 December 2022, 1835 (Anya Waite); SRSR, *Evidence*, 2 February 2023, 1250 (François-Philippe Champagne); and The Coalition for Responsible Energy Development–New Brunswick, *Re: Submission to hearings on International Moonshot Programs: Small Modular Nuclear Reactors*, Brief submitted to the House of Commons Standing Committee on Science and Research, 2 December 2022.

98 SRSR, *Evidence*, 21 November 2022, 1840 (Seth Klein).

99 SRSR, *Evidence*, 5 December 2022, 1835 (Anya Waite).

Regarding the scale needed to address climate change through a moonshot program, Seth Klein testified on the need to:

> Spend what it takes to win. […] Sir Nicholas Stern says we should be spending about 2% of GDP to tackle the climate emergency. In the Canadian context that would be about $56 billion a year. If you were to tally up our spending now on climate infrastructure and climate action, generously it clocks in at about $12 billion a year. We're not a little off. We're off by a fourfold to fivefold order of magnitude.[100]

As Alan Bernstein further testified, "climate change will not be addressed by incremental science. Climate change, like COVID, will only be addressed by moonshot science."[101]

Coordination between climate change goals and energy research and development were highlighted, particularly as it relates to the development of non-carbon emitting energy technologies. In their testimonies, General Fusion, X-energy Canada and the Canadian Nuclear Laboratories all underscored zero-emission technologies – including fusion and nuclear—as supporting decarbonization goals through the production of zero-emission electricity.[102]

However, three briefs submitted to the Committee countered the assertion that nuclear was a viable solution to energy and climate change needs, citing concerns related to timelines for deployment, commercial demand and the cost of the electricity produced.[103]

In addition to its role in supporting climate change mitigation efforts, witnesses also stressed the economic potential of a Canadian moonshot program targeting energy research and development, including through the development of nuclear and fusion

100 SRSR, *Evidence*, 21 November 2022, 1925 (Seth Klein).

101 SRSR, *Evidence*, 21 November 2022, 1835 (Alan Bernstein).

102 SRSR, *Evidence*, 28 November 2022, 2040 (Amee Barber); SRSR, *Evidence*, 14 November 2022, 2050 (Rosemary Yeremian); and SRSR, *Evidence*, 5 December 2022, 1950 (Joseph McBrearty).

103 The Coalition for Responsible Energy Development–New Brunswick, *Re: Submission to hearings on International Moonshot Programs: Small Modular Nuclear Reactors*, Brief submitted to the House of Commons Standing Committee on Science and Research, 2 December 2022; M. V. Ramana, *Small Modular and Advanced Nuclear Reactors: A Reality Check*, Brief submitted to the House of Commons Standing Committee on Science and Research, 22 November 2022; and Marton Dunai and Geert De Clercq, "Nuclear energy too slow, too expensive to save climate: report," *Reuters,* 23 September 2019.

technologies.[104] In a brief submitted to the Committee, General Fusion wrote that "government investment in fusion research offers a fourfold return to the economy."[105]

Investing in AI—explored more fully in the next section—was also seen as supporting climate change goals. As the Honourable François-Philippe Champagne testified, "investment in AI is helping climate change, because, with AI, we can do the modelling for climate change better, for example."[106] The Minister also identified ways in which investment in the Canadian Space Agency was also supporting climate change goals through increased ozone monitoring.[107]

In a brief to the Committee, CIFAR highlighted the role quantum technologies can play in furthering electricity and battery technology, and carbon capture and storage.[108]

One witness also indicated that investing in climate change research can address food security challenges.[109] Agricultural innovation and food security were further identified on their own as important research and development areas.[110] Baljit Singh, for example, testified that:

> When the question came on what Canada's international moonshot could be, I thought of many possibilities, but the one that struck close to my heart, based on what Canada can offer the world, was this world, which is well fed and food secure and where people who have enough food to give their children can send their kids to school.[111]

104 SRSR, *Evidence*, 5 December 2022, 1950 (Joseph McBrearty); and SRSR, *Evidence*, 2 February 2023, 1235 (François-Philippe Champagne).

105 Jay Bister, Amee Barber et Kim Nguyen, *Brief for the Standing Committee on Science and Research Study on International Moonshot Programs: General Fusion brief on support for transforming the world's energy supply with clean, safe, and abundant fusion energy,* Brief submitted to the House of Commons Standing Committee on Science and Research, 10 November 2022.

106 SRSR, *Evidence*, 2 February 2023, 1250 (François-Philippe Champagne).

107 Ibid.

108 Canadian Institute for Advanced Research, "SRSR–CIFAR follow ups," Written submission to the House of Commons Standing Committee on Science and Research, 21 November 2022.

109 SRSR, *Evidence*, 5 December 2022, 1835 (Anya Waite).

110 SRSR, *Evidence*, 2 February 2023, 1240 (François-Philippe Champagne); SRSR, *Evidence*, 28 November 2022, 1945 (Baljit Singh); and SRSR, *Evidence*, 5 December 2022, 1910 (Chad Gaffield).

111 SRSR, *Evidence*, 28 November 2022, 1945 (Baljit Singh).

Artificial Intelligence

Witnesses and briefs identified AI as a central technology for supporting ambitious research goals. AI technology was seen as enabling greater data analysis and progress for diverse fields, including food security and agriculture, remote connectivity, pharmaceutical development, neuroscience, cancer, biotechnology, quantum computing and climate change modeling.[112]

As Yoshua Bengio testified, "AI is one technology that is becoming more and more powerful as we develop it more."[113] Multiple witnesses further highlighted Canada's existing investments in AI through the Pan-Canadian Artificial Intelligence Strategy, CIFAR and provincial contributions that have given Canada a competitive international advantage.[114]

Health

Health was frequently identified as the focus for a potential Canadian moonshot program, with witnesses and briefs highlighting a variety of health topics as well as ways in which innovative health initiatives could be supported by different non-health specific research and development areas.

Arinjay Banerjee, Research Scientist and Adjunct Professor with the Vaccine and Infectious Disease Organization and the University of Saskatchewan, appearing as an individual, explained the links between health and environmental issues, for example:

> Multiple studies by my colleagues have now shown that anthropogenic factors, meaning activities that Homo sapiens, or humans, like doing, cause habitat loss and climate

112 SRSR, *Evidence*, 5 December 2022, 1910 (Chad Gaffield); CIFAR; SRSR, *Evidence*, 28 November 2022, 2020 (Baljit Singh); SRSR, *Evidence*, 5 December 2022, 1935 (Guy Rouleau); SRSR, *Evidence*, 5 December 2022, 1955 (Guy Rouleau); SRSR, *Evidence*, 2 February 2023, 1250 (François-Philippe Champagne); SRSR, *Evidence*, 28 November 2022, 2055 (Kevin Smith); SRSR, *Evidence*, 31 January 2023, 1100 (Jennie Z. Young); Canadian Institute for Advanced Research, "SRSR–CIFAR follow ups," Written submission to the House of Commons Standing Committee on Science and Research, 21 November 2022; SRSR, *Evidence*, 14 November 2022, 2115 (Yoshua Bengio).

113 SRSR, *Evidence*, 14 November 2022, 2105 (Yoshua Bengio).

114 SRSR, *Evidence*, 14 November 2022, 2110 (Yoshua Bengio); SRSR, *Evidence*, 21 November 2022, 1835 (Alan Bernstein); SRSR, *Evidence*, 21 November 2022, 1925 (David Johnston); and SRSR, *Evidence*, 2 February 2023, 1225 (François-Philippe Champagne).

> change, which directly lead to animal migration and nutritional deficiencies in animals, which then directly impact the pathogen spillover from these animals.[115]

To this end, Arinjay Banerjee promoted One Health as a potential focus area for a moonshot program, describing it as "a concept that recognizes the interconnectedness of human, animal and environment health."[116]

Further to Arinjay Banerjee's concerns about pathogens, four witnesses discussed focusing moonshot research on infectious diseases, managing potential pandemic events, vaccine development and anti-microbial resistance.[117] The COVID-19 pandemic was identified as an example of how resources, expertise and production can be deployed quickly and effectively at scale to address public health emergencies.[118] According to a brief submitted to the Committee by Doctors Without Borders, there was, however, a global failure to effectively develop and commercialize vaccines for various strains of Ebola.[119] They contend that this is linked to the privatization of vaccine development, writing that, "this disjointed approach to medical R&D—in which Canada's government invests public funds into discovering important new vaccines and medicines but relies on commercial partners for completion—prioritizes private-sector profitability over public-health needs."[120]

In their testimony, the Canadian Nuclear Laboratories highlighted the role of nuclear technology in the production of medical isotopes contributing to efforts to treat and cure cancer.[121] This view was not unanimous as the Canadian Coalition for Nuclear Responsibility argued in a brief that "modern medicine does not depend on nuclear power."[122]

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115 SRSR, *Evidence*, 28 November 2022, 1935 (Arinjay Banerjee).

116 Ibid.

117 SRSR, *Evidence*, 28 November 2022, 2035 (Kevin Smith); SRSR, *Evidence*, 28 November 2022, 1935 (Arinjay Banerjee); SRSR, *Evidence*, 14 November 2022, 2110 (Yoshua Bengio); SRSR, *Evidence*, 14 November 2022, 2045 (Yoshua Bengio); and SRSR, *Evidence*, 2 February 2023, 1210 (François-Philippe Champagne).

118 SRSR, *Evidence*, 2 February 2023, 1245 (François-Philippe Champagne).

119 Jason Nickerson and Adam Houston, "Doctors Without Borders," Written submission to the House of Commons Standing Committee on Science and Research, 2022.

120 Ibid.

121 SRSR, *Evidence*, 5 December 2022, 1945 (Joseph McBrearty).

122 Gordon Edwards, *Medicine and Nuclear Power: Fact Sheet Produced by the Canadian Coalition for Nuclear Responsibility,* September 2022.

In a brief to the Committee, CIFAR also highlighted the role quantum technologies can play in furthering health goals, including drug discovery.[123]

Brain disease was another topic discussed by witnesses and briefs. They called for further research in neuroscience, dementia, brain cancers and psychiatric illnesses.[124] In a brief to the Committee, the Brain Canada Foundation cited World Health Organization data classifying brain disease and disorders as "the second leading cause of death after heart disease, and the leading cause of disability."[125] As Jennie Z. Young testified:

> We are on the threshold of making remarkable advances in understanding the brain, ones that could lead to treatments and cures in our lifetimes for our families. Canadian

123 Canadian Institute for Advanced Research, "SRSR–CIFAR follow ups," Written submission to the House of Commons Standing Committee on Science and Research, 21 November 2022.

124 SRSR, *Evidence*, 28 November 2022, 2035 (Kevin Smith); SRSR, *Evidence*, 5 December 2022, 2005 (Guy Rouleau); SRSR, *Evidence*, 5 December 2022, 1935 (Guy Rouleau); Azrieli Foundation, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 15 December 2022; Brain Canada Foundation, *Addressing the rising tide of brain disease and disorders through the One Brain approach*, Brief submitted to the House of Commons Standing Committee on Science and Research, 9 December 2022; Brain Injury Canada, *The Case for a Canadian Brain Research Moonshot*, Brief submitted to the House of Commons Standing Committee on Science and Research, 8 December 2022; Canadian Concussion Network, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 25 January 2023; SRSR, *Evidence*, 31 January 2023, 1100 (Jennie Z. Young); Neurological Health Charities Canada, *The Case for A Canadian Brain Research Moonshot*, Brief submitted to the House of Commons Standing Committee on Science and Research, 9 December 2022; Cancer Research Society, *Subject: Brain Moonshot for Canada*, Brief submitted to the House of Commons Standing Committee on Science and Research, 9 January 2023; Dystonia Medical Research Foundation Canada, *Re: Brief for SRSR Study on International Moonshot Programs*, Brief submitted to the House of Commons Standing Committee on Science and Research, 12 December 2022; Institute for Advancements in Mental Health, *Re: Current study on International Moonshot Programs*, Brief submitted to the House of Commons Standing Committee on Science and Research, 12 December 2022; Hydrocephalus Canada, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 12 December 2022; Multiple Sclerosis Society of Canada, *Submission to the Standing Committee on Science and Research International Moonshot Programs Study*, Brief submitted to the House of Commons Standing Committee on Science and Research, 9 January 2023; Huntington Society of Canada, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 9 January 2023; Heart & Stroke Foundation, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 26 January 2023; Ontario Brain Institute, *Support for a Canadian Brain Moonshot Program: A Summary*, Brief submitted to the House of Commons Standing Committee on Science and Research, 12 December 2022; Centre for Aging + Brain Health Innovation, *Brief*, Brief submitted to the House of Commons Standing Committee on Science and Research, 31 January 2023; Canadian Brain Research Strategy, *A National Brain Research Initiative for the Health, Social, and Economic Advancement of Canada*, Brief submitted to the House of Commons Standing Committee on Science and Research, 15 February 2023; and Canadian Association for Neuroscience, *Brain and Mental Health Research as a National Priority*, Brief submitted to the House of Commons Standing Committee on Science and Research, 20 February 2023.

125 Brain Canada Foundation, *Addressing the rising tide of brain disease and disorders through the One Brain approach*, Brief submitted to the House of Commons Standing Committee on Science and Research, 9 December 2022.

> neuroscientists and mental health researchers—and we rank in the top five in the world—are poised to make a major leap, a moonshot, in brain science.[126]

The Canadian Brain Research Strategy, in a brief submitted to the Committee, also identified brain research as a global priority, with brain moonshot programs underway in the European Union, the U.S., Japan and Korea, and in the planning stages in Australia, Finland, New Zealand, Latin America and Africa.[127]

Cancer was also often mentioned regarding goals for a health moonshot program. In a brief submitted to the Committee, the Canadian Cancer Society cited data that:

> Two in five Canadians will be diagnosed with cancer in their lifetimes (this is exacerbated by our aging population). About one in four will die of their cancer. The direct costs of this burden are massive - $26.2 billion in 2021. The indirect costs are incalculable, but the burden is apparent to all Canadians.[128]

That brief further called attention to the fact that Canada invests relatively less in terms of percentage of GDP and amount per capita in cancer research compared to the U.S.[129] In witness testimony from BioCanRx and the University Health Network and briefs submitted to the Committee, four organizations called for the development of a Canadian cancer moonshot program with significant funding allocations and building on U.S. moonshot research accomplishments.[130]

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126 SRSR, *Evidence*, 31 January 2023, 1100 (Jennie Z. Young).

127 Canadian Brain Research Strategy, *A National Brain Research Initiative for the Health, Social, and Economic Advancement of Canada*, Brief submitted to the House of Commons Standing Committee on Science and Research, 15 February 2023.

128 Canadian Cancer Society et al., *Canadian Cancer Moonshot: Collaborating to Control Cancer*, 25 January 2023.

129 Ibid.

130 Canadian Cancer Society et al., *Canadian Cancer Moonshot: Collaborating to Control Cancer*, 25 January 2023; Canadian Cancer Research Alliance, *Canadian Cancer Moonshot: Accelerating Cancer Research and Impact*, Brief submitted to the House of Commons Standing Committee on Science and Research, 30 January 2023; BioCanRx, *Submission to the Standing Committee on Science and Research Study on "International Moonshot Programs"*, Brief submitted to the House of Commons Standing Committee on Science and Research, 16 December 2022; SRSR, *Evidence*, 5 December 2022, 1940 (Stéphanie Michaud); and SRSR, *Evidence*, 28 November 2022, 2035 (Kevin Smith).

The potential for genetic and stem cell research to strengthen health outcomes, including through the development of personalized medicine and regenerative medicine, was also highlighted to the Committee.[131]

Finally, witnesses and briefs recommended pursuing further research and development in health care systems, such as more integrated health networks and equitable health services, and tackling inflammation as a central health problem.[132]

Therefore, the Committee recommends:

Recommendation 14

That the Government of Canada, in consultation with the provinces, territories, Indigenous governing bodies, academics, international partners and citizens, determine relevant and focused goals for a moonshot program that takes advantage of Canada's existing strengths.

Recommendation 15

That in determining relevant and focused goals for a moonshot program, the Government of Canada ensure cross-cutting social, environmental and economic good for all Canadians.

131 SRSR, *Evidence*, 28 November 2022, 1915 (Arthur McDonald); SRSR, *Evidence*, 28 November 2022, 1940 (Cate Murray); and Stem Cell Network, *Regenerative Medicine in Canada,* November 2022.

132 HealthCareCAN, *Brief,* Brief submitted to the House of Commons Standing Committee on Science and Research, 11 January 2023; SRSR, *Evidence*, 28 November 2022, 2125 (Kevin Smith); and SRSR, *Evidence*, 28 November 2022, 2105 (Kevin Smith).

APPENDIX A
LIST OF WITNESSES

The following table lists the witnesses who appeared before the committee at its meetings related to this report. Transcripts of all public meetings related to this report are available on the committee's webpage for this study.

Organizations and Individuals	Date	Meeting
Mila - Quebec Artificial Intelligence Institute	2022/11/14	22
Yoshua Bengio, Scientific Director		
X-energy Canada	2022/11/14	22
Rosemary Yeremian, Vice-President, Corporate Strategy and Business Development		
As an individual	2022/11/21	23
David Johnston, 28th Governor General of Canada		
CIFAR	2022/11/21	23
Alan Bernstein, President Emeritus		
Climate Emergency Unit	2022/11/21	23
Seth Klein, Team Lead		
As an individual	2022/11/28	24
Arinjay Banerjee, Research Scientist and Adjunct Professor, Vaccine and Infectious Disease Organization, University of Saskatchewan		
Arthur McDonald, Gray Chair in Particle Astrophysics (Emeritus), Queen's University		
General Fusion	2022/11/28	24
Amee Barber, Director, Government Relations and Business Development		
Gérard Mourou Center for Ultrafast Optical Science	2022/11/28	24
Brandon Russell, Research Fellow		
Stem Cell Network	2022/11/28	24
Cate Murray, President and Chief Executive Officer		
Michael Rudnicki, Scientific Director		

Organizations and Individuals	Date	Meeting
University Health Network	2022/11/28	24
Kevin Smith, President and Chief Executive Officer		
University of Saskatchewan	2022/11/28	24
Baljit Singh, Vice-President, Research		
As an individual	2022/12/05	25
Guy Rouleau, Director, Montreal Neurological Institute and Hospital		
BioCanRx	2022/12/05	25
John Bell, Scientific Director		
Stéphanie Michaud, President and Chief Executive Officer		
Canadian Nuclear Laboratories	2022/12/05	25
Joseph McBrearty, President and Chief Executive Officer		
Ocean Frontier Institute	2022/12/05	25
Anya Waite, Chief Executive Officer and Scientific Director		
U15 Group of Canadian Research Universities	2022/12/05	25
Chad Gaffield, Chief Executive Officer		
Canadian Brain Research Strategy	2023/01/31	26
Jennie Z. Young, Executive Director		
Université de Sherbrooke	2023/01/31	26
Alexandre Blais, Scientific Director and Professor, Institut quantique		
Canadian Institutes of Health Research	2023/02/02	27
Catherine MacLeod, Executive Vice-President		
Department of Industry	2023/02/02	27
Francis Bilodeau, Associate Deputy Minister		
François-Philippe Champagne, Minister of Innovation, Science and Industry		
National Research Council of Canada	2023/02/02	27
Iain Stewart, President		
Natural Sciences and Engineering Research Council	2023/02/02	27
Alejandro Adem, President		

Organizations and Individuals	Date	Meeting
Social Sciences and Humanities Research Council Ted Hewitt, President	2023/02/02	27

APPENDIX B
LIST OF BRIEFS

The following is an alphabetical list of organizations and individuals who submitted briefs to the committee related to this report. For more information, please consult the committee's webpage for this study.

McDonald, Arthur

Ramana, M. V.

Azrieli Foundation

BioCanRx

Brain Canada Foundation

Brain Injury Canada

Canadian Association for Neuroscience

Canadian Brain Research Strategy

Canadian Cancer Research Alliance

Canadian Cancer Society

Canadian Concussion Network

Cancer Research Society

Centre for Aging + Brain Health Innovation

Coalition for Responsible Energy Development in New Brunswick

Dystonia Medical Research Foundation Canada

General Fusion

Government of Japan

HealthCareCAN

Heart and Stroke Foundation of Canada

Huntington Society of Canada

Hydrocephalus Canada

Institute for Advancements in Mental Health

Japan Science and Technology Agency

Multiple Sclerosis Society of Canada

Neurological Health Charities Canada

Ocean Frontier Institute

Ontario Brain Institute

Ontario Institute for Cancer Research

Terry Fox Research Institute

X-energy Canada

REQUEST FOR GOVERNMENT RESPONSE

Pursuant to Standing Order 109, the committee requests that the government table a comprehensive response to this Report.

A copy of the relevant *Minutes of Proceedings* (Meetings Nos. 22, 23, 24, 25, 26, 27, 31, 41 and 46) is tabled.

Respectfully submitted,

Lloyd Longfield
Chair