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Managing Large-Scale Science Research Programs:
The Genome Canada Experience 2000-2010

Peter W.B. Phillips and Eric Warren
Johnson Shoyama Graduate School of Public Policy, University of Saskatchewan
Contact: peter.phillips@usask.ca

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Abstract

In September 2000, Genome Canada was created as an arms-length not-for-profit Crown Corporation mandated to fund large-scale science projects and their accompanying science and technology platforms. Given its goal to leverage private sector R&D, Genome Canada provided up to half of the operating capital, on the condition that other eligible partners contribute the remaining funds. In the first decade, Genome Canada conducted four major competitions. In each competition scientific leads prepared and submitted proposals for large-scale projects. Genome Canada then conducted a lengthy review process, evaluating the merit with respect to the scientific and commercial potential, managerial competence, financial capacity, and socio-economic impact. Those judged, through a mixture of in-house and external peer review, to have high potential received Genome Canada funding. The criteria for merit and potential changed over time, or are at least was managed in different ways. The structure of the contests themselves also changed, in some ways quite dramatically. This paper examines Genome Canada's first decade of managerial practices by looking closely at the structure and substance of the major funding competitions.

Key Words

Science management; big science; Genome Canada; genomics; administration

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Managing Large-Scale Science Research Programs:
The Genome Canada Experience 2000-2010

Introduction

Research and development has become a cornerstone of modern economic activity. Canada is no different. Increased efforts into research and development and innovation practices by the federal government have resulted in a changing climate for natural and social science research initiatives. Government bodies have been established to offer public funding for R&D and to help network the public, academic, and private spheres to foster collaboration and commercialization of results.

Genome Canada is one example of a quasi-government body established to serve such a purpose. With a focus on genomics, it funds large-scale science projects using an open competition format, whereby the scientific community partners with government, the private sector, and international organizations to carry out research in targeted areas. This study examines the structure and nature of Genome Canada's funding competitions, how it has changed over its first decade of operation, and whether these changes led to a more effective and efficient funding process.

This paper places Genome Canada in the wider federal R&D policy context and then provides thorough examination of the content and processes of each of the four major competitions.

Background

During the mid-1990s, it was acknowledged by the Government of Canada that a productivity gap existed between itself and the neighbouring United States.[1] This prompted Canadian policy makers to consider the adequacy and competitiveness of Canada's R&D and innovation regimes. Comparative studies showed that Canada did not have a sufficient commercialization strategy, and as a result, commercial use of results lagged behind other countries, particularly the UK and Sweden.[2] The Canadian government then began a rigorous process of strengthening Canada's knowledge-based economy. Favourable budgets in the late 1990s and early 2000s allowed increased investment of public money into R&D.[3] At first no

specific strategy was advocated by the federal government. Rather, a series of ad hoc policies were rolled out, including corporate and capital tax cuts to stimulate private investment, increased support for private, university, and government R&D, and support for graduate work and changes to immigration policy to increase the stock of highly qualified personnel.[4]

In 2000, Paul Martin, then Canada's finance minister, laid the groundwork for future innovation policy in Canada calling for a tripling of government expenditures in R&D by 2010, moving Canada from 15th to 5th among OECD countries.[5] Alan Rock, Minister of Industry at the time, set out to study what Canada needed to do in order to create a competitive innovation regime and meet Martin's proposed objectives in time. This study led to the creation of *Canada's Innovation Strategy* in 2002, which gave organization managers a useable framework for "effective" funding management, helped to coordinate R&D efforts towards commercialization of results, and made recommendations for setting up an appropriate regulatory and business environment to encourage investment.[6] While this strategy was never fully implemented, it did work to inform federal government actions in the areas of R&D and innovation from that point on.

Genome Canada, one of the related developments, provides a particularly interesting window into the federal government's efforts to increase public and private R&D expenditures, conduct research with commercial potential, close Canada's production gap, and bolster Canada's position as an innovation leader. Established as an arms-length, not-for-profit corporation in the February 2000 federal budget,[7] Genome Canada's overarching mandate was to ensure that Canada become a world leader in genomics research in targeted sectors, including agriculture, forestry, fisheries, health, the environment, and later, the accompanying GE^3LS issues. As a non-profit, Genome Canada does not have shareholders or seek dividends, but rather is governed by a board of directors. Genome Canada operations (i.e. salaries, infrastructure, project money) are funded through federal grants, originally administered by Industry Canada and now ISED.[8] Genome Canada is required under the Canada Corporations Act to hold at least one annual board of directors meeting, solicit an external auditor (unless otherwise agreed upon by all board members), produce annual financial statements, and write an annual report.[9] These measures ensure accessible and open information regarding Genome Canada's affairs, and keep the principle of responsibility intact, reporting to Parliament through the Minister of Industry/ISED via annual reports and financial statements. Genome Canada has a number of

supporting mechanism for reporting, such as the Performance Audit and Evaluation Strategy, the Risk Management Policy, and the Recipient Audit Framework.

Genome Canada and its original five (now six) regional centres are maintained and staffed using federal conditional grants. Some provinces, especially Quebec and British Columbia, provide core grants or block grants to support projects, while others find it difficult to find funds to support operations and matches for the grants. Large-scale research projects and technology platforms are usually financed using 50% federal funding and 50% funds from other sources, including provincial governments, private industries, and foreign investments. Because of the nature of large scale science, project funding has traditionally been granted based on multi-year investments that enable three to five years of project activity. This was convenient for the federal government in some years, as this structure allowed them to commit funds and expend them in years with budgetary surpluses. In the period under review, Genome Canada and the ministry of Industry/ISED negotiated agreements in 2000 and 2005, with supplementary agreements in 2007 and 2008.

Methodology

Using the evolving policy landscape as a backdrop, it is possible to track the evolution of Genome Canada operations, either in sync with, or counter to, changing government policies. On top of this, changes in Genome Canada's practices in and of themselves can be compared. There is no better place to look for analysis than Genome Canada's open and competitive funding competitions, their guidelines, evaluation criteria, and structures.

In order to compare Genome Canada's funding competitions over time, it is useful to analyze each set of competition guidelines and evaluation criteria. These documents shape the application content and process, from the submission of letters of intent, to Genome Canada's announcement of successful projects. Applicants are asked explicitly to follow the competition guidelines and be mindful of the evaluation criteria when drawing up project proposals. Adhering to Genome Canada's instructions increases the likelihood of receiving project funding. A timeline of each Genome Canada funded competition allows for a comparison, at a basic level, of competition processes and how they have changed over time. Contrasting the actual structures and layouts of the competition guidelines makes visible the evolution and shifting focus of the funding competitions. After each competition round, issues that emerged were addressed and

remedied in the next set of competition guidelines – in effect, Genome Canada had a sort of moving target approach.

As a result, successive competition guidelines became more detailed and on occasion new sections or foci were added. But it is not clear whether this evolution has led to a "better" competition process. The rest of this paper explores whether Genome Canada practices have followed the federal government's vision for research and development in Canada and done so in an efficient and effective way.

Observations

1. Competition Overview

Before going into the specific details of the project proposal process and criteria, the guidelines provide a general overview of the competitions. This overview is a useful tool for discerning the overall mood, direction, and goals of the competitions. The comparison is made difficult by the nature of the first competition, which included the establishment of the Genome Centres. However, it can be said that due to the structure of Competition I, and its emphasis on creating regional centres, information regarding large-scale project structure and content was vague and limited. In fact, beyond the broad goals of the project proposals being large-scale, genome-wide, and in a sector considered important to Canada (agriculture, health, forestry, fisheries, and environment), there are no explicit references to project content at all.[10]

Competition II provides a lot more detail and gives some context to the term "large-scale", stating that projects must be "of such scale and scope that they cannot currently be funded at internationally competitive levels through existing mechanisms."[11] The guidelines for Competition II also begin to place more of an emphasis on GE^{3}LS. While the first competition simply asked each centre to have a program in place to deal with GE^{3}LS related issues, a few GE3LS specific projects were pitched and funded. Competition II more explicitly allowed projects with a strictly GE^{3}LS focus to be submitted for funding and hinted that embedded GE3LS work would be considered.[12] Still, the background information remains brief.

Competition III was marked with some significant changes in its preamble. First off, the competition called for large-scale genomics projects, but added that they were seeking projects with a specific duration of 3 or 4 years.[13] This was simply added for clarification, as all previous

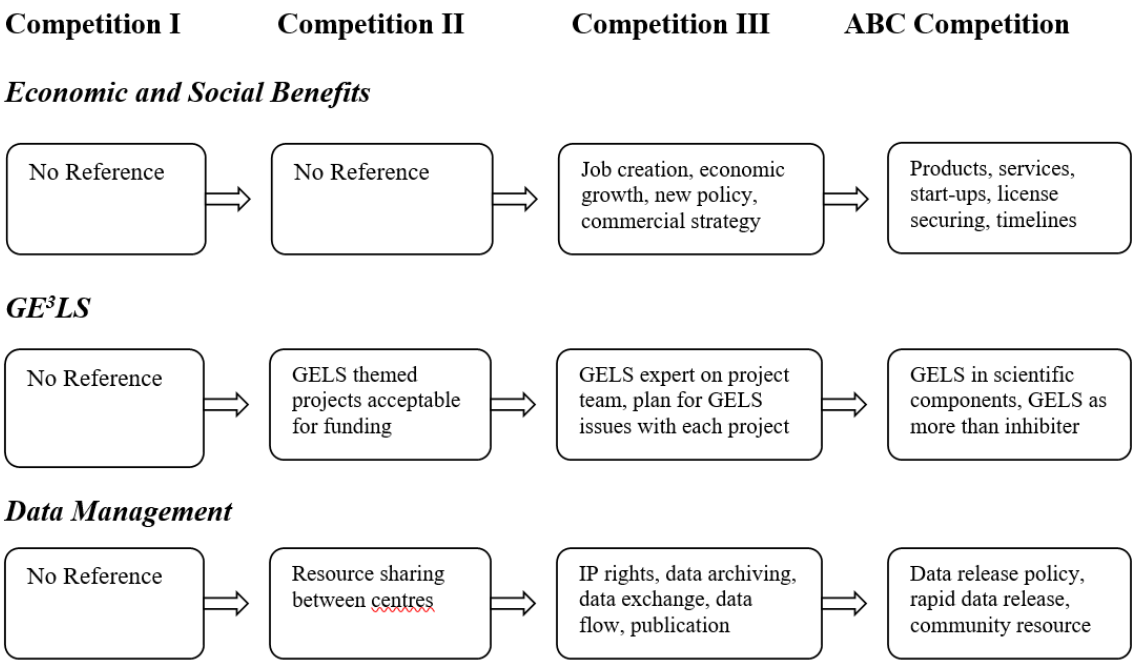
projects funded by Genome Canada fell into this range anyway. It also widened the research scope by calling for projects in genomics *or* proteomics, the latter being the study of protein functions and structures.[14] Competition III also directed that applicants have a plan in place to address GE^{3}LS aspects of their projects, sharpening the focus on social issues. Each project was now required to have one or more GE^{3}LS experts as a co-applicant, collaborator, or advisory committee member.[15] Also, an entire section in the preamble was dedicated to social and/or economic benefits of the research. This was made clear by the directive: "Note that in this competition Genome Canada will place much greater emphasis on the potential ability of the proposed research to lead to social and/or economic benefits for Canada."[16] The guidelines referenced job creation, economic growth, and impact on quality of life, the environment, health, and policy development.[17] It goes on to indicate that the proper plans and personnel must be in place in order to transmit the research into tangible social and/or economic goods and services.[18] There had never been such a blatant focus on realizing economic benefits.

Competition III added another new section that stressed plans for dealing with intellectual property rights, the sharing of benefits between contributors, and a commercialization strategy.[19] Although these issues were brought up in Competition I, they were in reference to the Centres, not to individual projects, and were much less detailed and specific. Also a significant change was a paragraph titled data management. Project applications were required to include a detailed plan for the handling of scientific data generated from the research.[20] This plan included data archiving and data exchange with the wider scientific community. In Competition III, strong attention was paid to realizing economic benefits for Canada and dealing with the storage and sharing of scientific data, as well as a more comprehensive inclusion of GE^{3}LS related issues.

The ABC competition further developed the focus on GE^{3}LS by providing more detail about the format of the plan needed by project proposals to address GE^{3}LS issues. There was an indication that in past competitions that GE^{3}LS issues were addressed only as an impediment (economic, legal, or otherwise) to the success of the project. The ABC competition asked project proposals to look at the other side of GE^{3}LS issues as well, specifically how they could enhance the research and realize maximum benefits.[21] The guidelines asked applicants to integrate GE^{3}LS issues into the scientific components of their proposals, a concept absent from previous competitions.[22]

The two sections referring to benefits for Canadians and commercialization were melded into one section in the ABC competition. The guidelines also added references to product and service development, the start-up of spin off companies or securing of licenses, and the stipulation that benefits should be realized within five years of project completion.[23] Applicants were instructed to seek out expertise for advice in the commercialization process, including market analysis and marketing.[24] The ABC competition guidelines became more precisely worded, exchanging words like "economic growth and social benefits" for "product and service development."

Figure 1: Evolution of Impact Factors in Genome Canada Competitions



Source: Competition Guidelines I, II, III and ABC

In the ABC Competition, applicants were also asked to be in compliance with Genome Canada's Data Release and Resource Sharing Policy, created in July of 2005 to formalize a data management strategy.[25] The policy sought to treat Genome Canada funded projects as a "community resource project, defined as a research project specifically devised and implemented to create a set of data, reagents or other material whose primary utility will be as a resource for the broad scientific community."[26] The object was to ensure the rapid release of new data to the wider

scientific community to ensure "the timely development of projects that will benefit humankind."[27] The previous statement out of Genome Canada's Data Release and Resource Sharing policy fuses the idea of data management with the realization of economic and social benefits.

2. Financial Resources

The initial funding competition in 2000 proposed by Genome Canada was unique in that project proposals were included in a package with an application for the establishment of a Genome Centre. Genome Canada wanted to establish five regional genomics centres in order to engage leading academics and industries across the country, allowing them access to world class science and technology platforms. Before the announcement of the competition, Genome Canada received a grant of $160 million from the federal government to "support a national genomics research initiative."[28] This grant covered the initial costs to start the centres as well as a portion of project funding. In February of 2001, two months after 31 project proposals were chosen for submission to an international panel for peer review, Genome Canada received an additional $140 million in funding from the federal government through industry Canada.[29] Combine, all of the necessary funding for Genome Canada was in place for the first two rounds of funding.

Of the initial grants of $160 million and $140 million from the federal government, Genome Canada committed $135 million to Competition I projects, science and technology platforms, and the establishment of the five regional genome centres.[30] In July 2001, a further $155.5 million was allocate to 34 large-scale projects and platforms for Competition II.[31]

Competition III differed from the first two endeavors in that, upon its announcement, there was no secured funding in place. Rather, Genome Canada was in the process of "finalizing its five-year strategic plan for submission to the Federal government for funding approval."[32] Genome Canada stated that they were optimistic that funding would be obtained from the federal government, but that delaying or canceling the competition was a possibility.[33] However, Genome Canada received a grant of $165 million in February of 2005, about halfway through the competition, and it proceeded as planned with no delays.[34] This grant was to cover the costs of projects under Competition III for the first three years. In August of 2005, $167.5 million was invested in 33 large-scale projects, the largest investment in a competition by Genome Canada.[35] In March of 2007, an additional sum of $100 million was allocated by the federal government to cover the remaining costs of Competition III.[36] All previous grants had been given to Genome

Canada in one lump sum, but according to the new funding agreement with Industry Canada, the grant in 2007 was cash flowed over two years, according to need.[37] While this affected Genome Canada's investment income, more importantly it required tighter control of project funds by way of increased reporting and funding management (to be discussed later).

In 2006, Industry Canada recommended that Genome Canada pursue a different style of funding competition. Competitions I, II, and III left the field of genomics wide open (besides the necessity that the work be important to Canada), which allowing the research community to submit projects of scientific merit on any topic in any of the human, plant, animal and microbial domains. This led to a new process of building priorities.

Genome Canada invited teams of scholars to work collaborative to develop theme papers that made a pitch for research in a subject area. This fell in line with the federal government's new policy, *Mobilizing Science and Technology to Canada's Advantage*, and its focus on targeted research. In 2007 the Position Paper Process—what Genome Canada calls 'an approach for allocating funding to targeted strategic research themes in nationally recognized areas of interest and of socio-economic importance to Canadians' – began to drive Genome Canada programming. The 2007 process yielded the strategic research themes of agriculture–plants and bioproducts (ABC), a combination of two research themes that had been recommended in the first Position Paper cycle. This process also identified two more strategic research themes—child health and agriculture-animals—as areas which merit funding support.

The ABC Competition delivered 12 projects worth $114 million.[38] Genome Canada had received a grant of $140 million in the 2008 federal budget in February, $53 million of which was dedicated to fund the Genome Canada share of the ABC competition.[39] Again, these funds will be disbursed according to the annual requirements of Genome Canada. The whole sum of $140 million was spread out over five years.[40]

To summarize, Genome Canada had funding in hand for competitions I and II for their entirety in the form of a lump sum grant from the federal government. Competition III began with no funding but in February of 2005, about half way through the review process, a lump sum federal grant (the last) was received by Genome Canada to fund the majority of the competition. In March 2005, a new funding agreement was negotiated between Genome Canada and Industry Canada requiring that funding be disbursed annually according to cash flow statements and

project flow. This forced Genome Canada to modify its funding and management procedures to ensure that projects remained on budget and on schedule.

Table 1: Cash flows related to first four Genome Canada Competitions

	Competition I	Competition II	Competition III	ABC Competition
Grants from Federal Government	$160M + $140M	None	$165M+ $100M	$53M
Cost of Competition	$135M	$155.5M	$167.5M	ongoing
Funding Secured Upon Competition Announcement	Yes	Yes	No	Yes, based on annual need.

Source: Genome Canada Annual Reports 2000-2008

3. Objectives

Each competition began with a set of stated objectives. The overriding objective throughout the period was that Genome Canada wished to "become a world leader in selected sectors that are of strategic importance to [Canada], such as health, agriculture, environment, forestry and fisheries."[41] In Competitions II and III, economic, social, and industrial benefits for Canadians were added, representing the first sign of a continuing trend: a focus on projects with commercial potential.[42] The ABC competition added technology development to its list of selected sectors.[43] The ABC also modified the competition objectives to adapt to the new funding agreement signed in 2008.[44] The list contained a number of objectives melded together from previous competitions with some elements omitted or modified, resulting in the list being shortened from nine objectives to just five. Overall, they remained similar, but with a few differences. Particularly interesting is the addition of, "the development and establishment of a coordinated national strategy for genomics research to enable Canada to become a world leader in areas such as health, agriculture, environment, forestry and fisheries", which was listed as the first objective.[45] This reflected the new funding agreement with Industry Canada, and its focus on a targeted research effort. The objectives changed over the competition rounds to focus on the economic and social benefits of the research as well as on targeting specific areas of research, the latter evidenced by the thematic nature of the ABC Competition.

4. Letter of Intent stage

A letter of intent is used to express interest in a Genome Canada competition. They are brief and general descriptions of projects or tech platforms. Competition I began with the submission of letters of intent. These LOIs included an outline of a plan to establish a Genome Centre as well as a package of large-scale genomics projects and the accompanying science and technology platforms. The whole document had to be kept to a five page maximum with only a single section devoted to the description of potential projects.[46] The project descriptions were to include an indication of the needed platforms and were to be categorized into one of Genome Canada's targeted sectors. The main purpose of the project description was to "facilitate integration of large-scale projects among Centres to stimulate cooperation and avoid unwanted duplication of effort."[47] The five established regions received a combined 275 LOIs for Competition I, a number that Genome Canada had not anticipated.[48] Many projects proposed did not meet Genome Canada's broad eligibility criteria, and some even failed to capture a focus on genomics. This was simply the result of using a new process. Subsequent competition rounds offered more details for the LOI process.

Genome Canada had learned from the high volume of LOIs it received in Competition I, and put greater detail and specificity into the guidelines, evaluation procedures, document structures, and evaluation criteria. In Competition II, the LOI stage was omitted. Instead, a registration process was initiated, which was actually quite similar to the LOI stage. Each registration has a cover page that included the names and affiliations of the principal investigators and co-investigators as well as the signature of the Chairman of the Board and President and CEO of the Genome Centre approving the project for submission.[49] Three pages were then devoted to a summary of each project or science and technology platform and two pages for a description of the role each member of the research team was to play.[50] Next was a preliminary budget complete with cost estimates and cost recovery plans for science and technology platform proposals.[51] The following one page section required applicants to list the collaborators and partners and the role they will play.[52] The registration ended with a form for project leaders to suggest potential reviewers and allowed applicants to indicate anyone whom they would not like to review their proposal.[53] It was a requirement of each Genome Centre submitting projects to ensure that Genome Canada's broad requirements of eligibility were met. The Genome Centres thus took on a greater responsibility in the review process, screening those

projects which did not meet the broad criteria. The registration process was not used by Genome Canada to assess projects but to provide guidance for setting up an appropriate international review team.

Competition III saw a change with Genome Canada taking on the task of reviewing the registration packages. While the initial Genome Canada review was not intended to determine scientific merit, but rather to ensure the projects had potential in terms of proper funding and management criteria; some projects were not invited to submit full proposals. The registration documents included and executive summary, a three page project description, identification of project leaders and collaborators, a management plan, preliminary financial details, and a description of the potential benefits for Canadians.[54] The addition of a two page description of the potential benefits to Canadians reflects the explicit goal of the competition to focus more on economic and social benefits.

The ABC Competition returned to using LOIs. Again, a cover page listing the principal investigators, collaborators, and authorization of at least one Genome Centre was needed. The LOI form stressed that the submissions would be evaluated jointly by all Genome Centres and Genome Canada in order to identify any project synergies and potential for collaboration, due to the thematic nature of the competition.[55] A one-page executive summary of the project was followed by a five-page detailed proposal, outlining the goals of the research and the plans to achieve those goals.[56] The description of the project team included names, roles, time commitments, and reasons for inclusion of the research team members.[57] Next the package required a project management organization chart which included the role of the project manager, whose job was to administer the project and report on its progress, and a description of how the Scientific Advisory Board (SAB) fit into the management scheme.[58] A two-page section on GE^{3}LS followed, directing applicants to demonstrate how these issues were *integrated* into the overall structure of the project.[59] Individuals with expertise on the subject were to be included. Applicants were also asked to draw up a one-page summary of the expected benefits of the projects research. The summary included potential benefits for Canadians and expected outcomes of the research, as well as a list of individuals with expertise in commercialization, IP rights, or other relevant fields who would help the project realize those benefits.[60] Finally, the LOI required a preliminary financial plan including cost estimates and a list of secured or potential funding sources.[61]

Table 2: Evolving structure of the Genome Canada LOIs/Registrations

	Competition I	Competition II	Competition III	ABC Competition
Number of Pages*	Not specific; 5 page document	**7**	**10**	**11**
Description	Clarify sector and needed tech platforms.	List of investigators and collaborators, 3 page summary, preliminary budget, roles of project team, suggested reviewer list	Executive summary, 3 page summary, 2 page benefits section, preliminary budget incl. potential co-funding sources, management chart	5 page summary, 2 page GELS section, 1 page benefits section, list of potential *or secured* co-funders, role of project manager
Standard Form Provided	No	No	Yes	Yes

*excludes budget information
Source: Competition Guidelines and Evaluation Criteria I, II, III, and ABC

5. Full Proposal Stage

For Competitions I and II, no standard form for a full application was provided. Rather, project leaders were to follow the application format in the guidelines of each competition.

Competition I applications involved a maximum of ten pages of text and four pages of figures and tables for each large scale project.[62] A separate detailed budget for each project was also required, details of which were sparing.[63] In total, each research proposal was given roughly fifteen pages to state its case, excluding any budget information. The submission of these applications was somewhat wrapped up with the formation of the regional genome centers, which complicated the presentation.

Competition II also did not use a standard form, but did provide a more detailed outline for the full project proposals. First, a cover page was included with some basic information and the names and contact information for principal investigators and project leaders. The cover page was followed by a one-page lay summary including a description of how the project relates to Canadian genomics strengths, the nature of international impact of the project, and a brief of the potential economic and social impacts of the research.[64] Next was a one-page scientific summary followed by a twenty-page detailed description of the research proposal.[65] The in-depth project description included a discussion of the objectives, research methods, expected outcomes, communication strategy, and management structure, among other things. The project team was then required to include a list of all the researchers involved and what their role and time commitments were.[66] Financial details included commitment for co-funding, or a feasible plan

for which co-funding could be secured, and letters showing these commitments were viable.[67] The financial section asked applicants to clearly state what portion of their budget was being requested from Genome Canada and what portion was to be obtained from others. The full application for Competition II was much more in-depth than that of Competition I.

The full application for Competition III was markedly different than in the first two competitions. First off, it was to be drawn up using a standardized form provided by Genome Canada. This allowed Genome Canada to control the process, making applications more predictable and easier to review. The application was much more robust and detailed in nature. It began by identifying the research team and other collaborators.[68] This was followed by a one-page lay description and a one-page scientific summary of the project.[69] Next was a twenty-five page in-depth description of the project, five pages longer than that from Competition II.[70] Another new component of the application was a two-page section dedicated to GELS.[71] Two four-page sections, one on project management and one on intended social and/or economic benefits, followed.[72] The budget section, following Competition III's evaluation criteria, contained greater detail and asked for a three page co-funding strategy as well as the appropriate documentation proving viability of co-funding sources, such as written confirmation and audit reports from the source.[73] A budget template was also provided to the Genome Centres and was meant to guide project leaders to display the appropriate budget information.

Competition III include the introduction of the Scientific Advisory Board (SAB) as a part of each project. Its job was to give informed and critical advice and guidance to the research team once the project was off and running. SABs were established by the responsible Genome Centre and were to be sufficiently independent of the research team in order to avoid any conflict of interest. It provided a sort of outside eye and ongoing review process. The SABs overall mandate was to provide expert advice and to ensure that "that the project achiev[ed] its stated goals and milestones." SABs were required to track and submit information for the interim review process. Each project proposal had to include a list of names to sit on the SAB.

A GANTT chart was also used to project milestones and track the progress of the project.

The ABC competition application format used eleven point font rather than twelve, magnifying the length of the application form in comparison to Competition III.[74] It began with a list of investigators, collaborators, and participating organizations.[75] Next was a one-page lay summary and a two-page scientific summary, which was a page longer than in Competition III to

accommodate for the inclusion of a discussion of GELS-related issues. It was also noted that the lay summary may be used for communication with the public. The full research proposal description was allowed to take thirty pages, including five pages to discuss any GELS issues arising from the project, significantly more than the two pages in Competition III.[76] Twenty extra pages were allowed for tables and charts, considerably more than the four allowed in Competition I, and something that went unspecified in Competitions II and III.[77] This section contained considerably more detail. A two-page section was then devoted to a data and resource handling plan, another new component. A strategy for the sharing of resources generated from the project with the wider scientific community was to be included. A four-page section pertaining to management of the projects, similar to Competition III, followed. This included an organizational chart showing management structure, previous managerial experience of the research team, and a description of the processes used to oversee the project.[78] Two pages were then dedicated to describing a plan for communications and public outreach. A GANTT chart was also required, as in Competition III.

The budget section for the ABC Competition included an interesting caveat not present in previous application formats. It said that the Genome Centres would provide guidance in the preparation of the budget proposal before sending it to Genome Canada.[79] Another interesting addition to the ABC application form was that applicants were to document any previous Genome Canada funded projects that they were involved in, and noted that this information would be used to assess the applicants experience in managing a large-scale project.[80] Applicants who had been part of a previous project were asked to list the project objectives, outcomes, and impacts in a five-page summary.[81] The potential of this consideration is that funding could be concentrated towards those who have worked on a previous Genome Canada project, tightening the network and making it more difficult for new actors to get involved.

Again, similar to the LOI/Registration stage, each successive competition rounds became a more rigorous endeavor, taking more time, effort, and money to secure the necessary parts to be considered for Genome Canada funding. This did, however, put Genome Canada in a better position to fund projects, as strict conditions for co-funding, project management, and project readiness tried to safeguard against fallen partnerships, budget overruns or lapses, and inefficient delays.

Table 3: The evolving structure of the full application

	Competition I	Competition II	Competition III	ABC Competition
# Pages*	10	About 25	About 48	About 63
Details	Detailed research proposal, 5 publications from past five years related to Project	Lay summary, scientific summary, 20 page in depth description, list of researchers, roles, and time commitments, co-funding plan with supporting documentation	25 page in depth description, 2 page GELS discussion, 4 page management plan, 4 page benefits section, 3 page co-funding strategy, GANTT chart	2 page scientific summary with GELS, 30 pages in depth description with GELS, 2 page data management plan, 2 pages communication and public outreach, previous Genome Canada funded project experience, GANTT
Standard Form	No	No	Yes	Yes

*excludes budget information, figures and tables, or sections that do not apply to all projects (i.e. certification forms for human subjects)
Source: Competition Evaluation Criteria and Guidelines I and II and Application Format Competition III and ABC.

6. Review Process

In the summer of 2000, five regional Genome Centres were incorporated.[82] Upon incorporation however, the centres existed only on paper. It was Competition I, called on September 15, 2000, that proposed projects which needed the appropriate science and technology platforms to carry out research. Therefore, the first funding competition went hand in hand with the establishment of the regional genomics centres. Not only were Genome Canada and the international review panel evaluating the project proposals, but also the business plans of the Genome Centre applications. The review process for the first competition was by far the least rigorous in comparison with subsequent contests, another testament to the moving target approach Genome Canada had taken. The Genome Centres received 275 LOIs. After project withdrawals and consolidations, 73 teams developed full proposals for submission to Genome Canada. Out of the 73 submissions, 31 were chosen by Genome Canada to be submitted to an International Panel of experts for peer review. The panel made its recommendations to Genome Canada's board of directors, and 17 projects were chosen to be funded.[83] The review process had three stages and a fourth quasi-stage at which Genome Canada's Board of Directors made the final decision based on recommendations from the international panel. On April 4th of 2001, the winners of the competition were announced. Competition I had the shortest length of time between its announcement and its notice of award, but also used the least rigorous review process.

On July 19, 2001, Genome Canada sent out a request for applications for a second competition for the funding of large-scale genomics projects. Interested persons or groups were asked to submit their project ideas through the appropriate Genome Centre. Each Genome Centre worked with the principles to compile a registration package, which included a short summary of each project. The initial review stage, which was conducted by each Centre's board of directors, screened out those projects which did not meet Genome Canada's broad eligibility criteria.[84] The decision to send proposals to Genome Canada was at each centre's discretion. In total, 67 registration packages were submitted by the Genome Centres to Genome Canada on/before November 1, 2001. The main purpose of the registration package, as stated in the competition guidelines, was to assist Genome Canada in assembling an appropriate panel of peer reviewers, and not to determine eligibility.[85] Project applicants were then invited by Genome Canada to submit a full project proposal. By December 13, 2001, full applications for funding of the projects were submitted to Genome Canada.[86] In Competition II, Genome Canada received 64 full proposals.

The second review process, conducted by Genome Canada, ensured that indeed the projects met the broad eligibility criteria, and that, based on a due diligence review, the financial and managerial plans were reasonably sound, before sending them for peer review.[87] Simultaneously, a panel of domestic external reviewers were solicited to prepare a brief write up of each proposal to assist the international peer review panel; 62 projects were sent for vetting by the international panel of reviewers. Along with the solicited reports, due diligence information was made available to the panel of peer reviewers in advance of their meeting.

A multidisciplinary and international panel was established to provide expert advice in a comprehensive review of each proposal.[88] The panel met in March of 2002, beginning the third round of reviews. They compared each project proposal to the evaluation criteria put forward by Genome Canada. Project Investigators and their teams were invited to the meeting and spoke face to face with the reviewers. The review panel offered recommendations based on its review process to Genome Canada's Board of Directors. Projects were rated A (highly recommended), B (recommended), or C (not recommended). The board conducted the final reviewing stage, acting on the advice from the international panel of experts. In the first week of April, 2002, Genome Canada announced the 34 winners of the competition. After the notice of award, each project proposal, successful or otherwise, received the evaluation from the peer review outlining

the project's strengths and weaknesses.[89] For Competition II, the total process took about 258 days.

Competition III was marked with some significant changes from the first two competitions in terms of its review processes. Again, applicants were asked to submit their project proposals through the appropriate Genome Centre. Each Centre used its own discretion in choosing which projects to send forward in its registration package, filtering out those which did not meet the eligibility criteria (remember, a time parameter of 3 to 4 years was added).

Genome Centres sent in registration packages to Genome Canada, but this time around, Genome Canada did not request full proposals from all project registrations submitted, marking a change from Competition II.[90] Of the 117 registrations received, 93 were invited to submit full proposals.

The third round of reviews took place after Genome Canada received the full applications from the Genome Centres. Due diligence reviews of the financial and management components of the projects were conducted by Genome Canada and hired consultants.[91] The review included face to face meetings with project leaders, co-funders, and Genome Centre representatives. The results were offered as recommendations to Genome Canada's Board of Directors.[92] Proposals that were deemed unfit according to financial and management criteria were either not submitted for peer review or given a chance to be revised and resubmitted.[93] Information collected from the due diligence review process was given to the international peer review panel.

The fourth review process in Competition III was conducted in June of 2005 by a multidisciplinary and international panel of experts. Again, as in Competition II, external domestic peer reviewers were solicited to provide written reports to the panel members in advance of their meeting.[94] This information, along with the due diligence reports, was to assist the international panel in their review of the project proposals. Project leaders had a chance to meet face to face with the panel to discuss any part of the proposal.[95] Once again the panel offered advice to the board of directors at Genome Canada before the final decision was made. Applicants were also provided with a write up from the peer review process of the strengths and weaknesses of their projects.[96] Competition III saw 33 projects approved out of 93 full proposals submitted in a process and took roughly 391 days to complete.

In 2006, Genome Canada decided to pursue a different style of funding competition. This "new strategy for the future [would] focus on Canadian strengths, for example, research areas

that reflect[ed] Canada's unique biodiversity, diverse population, and Canadian sectoral strengths."[97] The premise was that research funding would be targeted towards specific areas of strength and socio-economic importance to Canada. This way, money could be pinpointed into particular sectors, resulting in a more efficient use of funds. After a Genome Canada retreat in February of 2006, and a subsequent summer tour, it was agreed that the theme areas would be determined through a position paper process.[98] This was not the first themed competition. In 2004, Genome Canada undertook a directed funding competition in Applied Human Health, but that topic was "handed down" by the federal government. In this competition, the task of choosing themes was left up to the scientific community and other collaborating stakeholders. It was argued that the position paper process would engage interested persons, organizations, and industry and allow projects easier access to co-funding.

The position paper process began on October 2, 2006, with an advertising campaign run by Genome Canada to inform interested parties of the new style of competition. The first step called for the submission of expressions of interest (EOIs). The EOI was to be submitted by a "champion" of the theme and address a number of broad criteria in order to be considered for development into a position paper. Beyond the basic content, such as the title of the theme and contact information for theme leaders, the criteria included, first and foremost, a discussion of the "importance of the problem(s) to be tackled and the expected socio-economic outputs, outcomes and impacts on the sector or discipline covered by the themes in the short to mid-term (~ five years)."[99] Other content included the state of infrastructure and human resources currently available, a list of supporters, a discussion of the state of the science in Canada and internationally, and letters of support from two Genome Centres.[100] Also interesting is that the EOIs were posted on Genome Canada's web site: "The web site will be a transparent vehicle for the dissemination of information to all interested individuals. In addition to viewing the EOIs and registration of support, a discussion space will be made available to allow comments and suggestions to flow between the proposed champions and interested parties."[101] This allowed supporters to view the submission, and register their interest as a co-funder or otherwise. Part of Genome Canada's advertising awareness campaign was directed at luring Canadian and international support.[102] The website operated for about a month allowing potential themes to gain support.

From December 15, 2006, until January 15, 2007, Genome Canada's staff, Genome Centre representatives, and the SIAC evaluated the EOIs.[103] Genome Canada placed a cap of 15 themes to be developed into full position papers.[104] This meant that potential themes needed to be prioritized and that even if an EOI met the eligibility criteria (to be discussed later), it may not be developed into a position paper. It was also noted that some EOI titles might change due a merging of two or more into a broader theme.[105] Theme champions were notified in order to choose a leader, if indeed this were the case.

The first cycle of the position paper process attracted 60 EOIs.[106] Following consolidation by the SIAC, and a series of consultations and workshops, 11 position papers were invited to be developed by July 2007.[107] Developing a position paper required a significant effort by the champions who were asked to spend substantial time over a six-month period fact finding, writing, and building support for their theme through national workshops.[108] Genome Canada made a maximum of $15,000 available to each theme champion in order to develop the position paper.[109] This cost covered administrative needs, fact finding exercises, and market studies, but could not be used for the salary of the champion. Genome Canada also paid for any national workshops held for the position paper. In the end, from 11 position papers, the international peer review committee selected two themes, Agriculture–Plants (Crop Genomics for a Healthy Canada), and Bioenergy and Bioproducts (Securing Canada's Future Bio-based Economy through Genomics), to run a new style of open competition. In total, the theme identification process took 332 days.

Table 4.1: Competition timelines Competitions I-III (Days to complete stage)

	Announcement of Competition to LOIs/Registration Due (To Centre)	LOIs/ Registration Due to Invitation for Full Proposals	Invitation for Full Proposals to Due Date for Submission to Genome Canada	Length of International Peer Review Process	Completion of International Peer Review to Notice of Award	Total days
Comp I	53	~ 20 *	~ 37 *	35	33	201
Comp II	104	43		~ 30 *	~ 15 *	258
Comp III	93	14	74	~ 20 *	~ 61 *	391

*Only specified by time of month (i.e. early June), exact dates not known. All total times are correct.
Source: Competition Guidelines I, II, III and Annual Reports 2000-2008.

Only after the completion of the position paper process could the ABC competition begin. During June of 2008, Genome Canada conducted information sessions in each of the six regions in order to clarify the guidelines and scope of the competition for those approved to submit a full proposal.[110] The development and review process for the ABC competition reverted back to the submission of LOIs. Due to the thematic nature of the competition, potential synergies and overlap had to be assessed. Project leaders were contacted confidentially if a partnership appeared logical.[111] Those LOIs that did not meet Genome Canada's broad eligibility criteria were not asked to submit full applications. No quotas were attached to each theme. That is, projects were assessed and approved based on excellence, and no specific amount of money was held for each theme.[112] Although not mentioned in the project application guidelines, the due diligence evaluation was no longer conducted before the international peer review, but instead at the same time.[113] This change was initiated because of concerns in previous competitions that a number of projects with scientific merit were dropped from competitions because of the results of the due diligence evaluation, which assessed their managerial and financial stability rather than their scientific merit.

The ABC competition added an additional review process in response to a high volume of LOIs (48) accepted and developed into full proposals.[114] In order for the face to face full review meetings with project investigators to remain feasible, Genome Canada on August 1, 2008, introduced an interim step, with each proposal being given a full scientific review by selected members of the international review panel.[115] Those deemed "non-competitive" by the majority of reviewers were dropped from the competition. All panel members were then given an opportunity to make their case for any project and save it from elimination.[116] In the first week of December, unsuccessful applicants were informed that they did not pass the streamlining process, and were sent copies of the panel review.[117] Out of 48 full proposals, 27 were sent to full peer review.

In KPMG's 2009 performance audit report, it was suggested that Genome Canada continue to hold open competitions to encourage new actors, ideas, and the recognition of emerging themes, as well as to shorten the approval process.[118] Also noted in the performance audit was that, due to the time and effort required, "there is a concern that past participants in the process may lose interest in participating in future years."[119]

Table 4.2: Position Paper and ABC Competition timelines

First	Announcement of Process to LOI Due Date	LOI Analysis	LOI Due Date to Announcement to Submit Full Position Paper	Announcement of Successful LOIs to Position Paper Submission	International Peer Review of Position Papers	Total days
Pos. Paper	53	31	52	169	57	332
Then	Announcement of Competition to LOIs/Registration Due (To Centre)	LOIs/ Registration Due to Invitation for Full Proposals	Invitation for Full Proposals to Due Date for Submission to Genome Canada	Length of International Peer Review Process	Completion of International Peer Review to Notice of Award	
ABC Comp	31	~ 25 *	129	~ 40 *	~ 95 *	384

Source: Competition Guidelines Theme Call I and ABC and Annual Reports 2000-2008.

Overall, the development and review process grew from a modest 201 days in Competition to 716 days to get through the combined position paper and ABC competitive process.

7. Competition Success Rates

The processes above solicited about 517 intentions/registrations of research teams, each which on average would include at least 5 investigators, collaborators or researchers. While there is some obvious repeat activity by some individuals and teams, this level of interest would represent something in the range of 2,500 investigators showing some level of interest in the funding area. Just over half of those expressing interest (213) actually submitted a full proposal. The review processes culled 65 before full peer review (23%). The overall success rate for applicants of this tranche of competitions was about 35%, with the highest success rate in Competition II and the lowest in the ABC competition.

Table 5: Project flow through the development and review process

	Competition I	Competition II	Competition III	ABC Competition	Totals for 4 Comps
Letters of Intent/Registrations	275	67	117	58	517
Full Proposals	73	64	93	48	278
Submitted for Peer Review	31	62	93	27	213
Approved	17	34	33	12	96
Approved % full proposals	28%	53%	36%	25%	35%

Source: Genome Canada, Genome Canada website Competitions and Initiatives

Overall, the four competitions allocated $750 million over the 2000-2010 period for the four open competition. In total, the average approved funding (50% from genome Canada and 50% from partners) was about $7.8 million over an average of about four years, with average annual flows of just under $2 million.

Table 6: Funding approved by competition and project, Comps I, II, III and ABC

	Approved projects	Total Approved Funding $M	Average funding per project $M
Competition I	17	136	8.0
Competition II	34	155.5	4.6
Competition III	33	346	10.5
ABC Competition	12	112	9.3
Total	96	$749.5	7.8

Source: Calculation from Genome Canada Corporate plan 2011-2012, Ottawa.

8. Funding requirements and financial management

Generally, Genome Canada covers 50% of the eligible costs of each project that is approved, although as of March 1, 2008, it had actually contributed 47% of project funding, amounting to $900 million.[120] Over the competition rounds, the definition of eligible costs has changed, and so have the requirements for securing co-funding prior to the projects actual approval. Overall, Genome Canada has requested a more comprehensive plan and detailed documentation in order to be approved for the international review stage. This has mitigated some of the risk of Genome Canada funding, ensuring that feasible funding plans are in place prior to the release of public monies, but has also led some in the scientific community to question whether projects with a high degree of scientific merit are being dropped for administrative reasons.

Competition I initiated Genome Canada operations and was very vague regarding the projects funding requirements. It simply states that maximum effort must be given by the Genome Centres to secure funding from other institutions, government bodies, the private sector, and international organizations.[121] Financial details were quite sparing in reference to the research projects themselves, but were eluded to in general terms in discussion of the centres. For example, the guidelines state that eligible costs include "the cost of salaries of researchers, trainees, technicians, management, and support staff needed for the operation of research infrastructure."[122] Some of these costs would obviously be incurred by a project, but are discussed in terms of the overall budget of the centre.

Much greater financial detail was present in the guidelines for Competition II, which added that Genome Canada would provide up to 50% of eligible costs and that at the time of application the remaining 50% must be confirmed or have a reasonable strategy in place to secure the additional funding.[123] The strategy needed approval from Genome Canada and funding was not dispersed until the remaining funds were secured. The list of eligible costs was modified as well. Costs pertaining to research into new technology development and development costs to host institutions were included, as were reasonable administrative costs.[124]

Competition III clarified a few technicalities, such as the ineligibility of the opportunity costs of using existing infrastructure, salaries of those funded by their host institutions, and budget items already approved for funding from other sources.[125] There were also a couple of interesting additions. Included in the list of eligible costs was funding for research into the GE^{3}LS related issues of the project.[126] Costs associated with developing a strategy to obtain social and economic benefits, including consultation with experts (e.g. market analysts and IP experts), were considered eligible. Also, the guidelines affirmed that administration costs could not exceed 5% of the total budget and salaries could be adjusted to inflation, calculated at 2%.[127]

Competition III guidelines regulated co-funding procedures more carefully than previous competitions. Previously, letters of collaboration and support sufficed. Documentation was now required to ensure the reliability of co-funding sources. All examples of what constituted appropriate documentation were listed in brackets after a general statement, and it was unclear which documents, or combination of documents, were preferred by Genome Canada. For example, the following statement comes from the co-funding section the Competition III guidelines: "Provide documentation to support the financial viability of the company and its ability to fulfill its commitment to the project (e.g. cash flow statement, a recent audited financial statement, a press release announcing significant new funding, etc.)"[128]

Competition III laid out the procedure for funding an approved project. If at the start of the project, co-funding agreements were secured, but had not yet kicked in, Genome Canada would fund the entire costs quarter by quarter to front end their contribution. If co-funding had not been secured, Genome Canada would only release funds based on 50% of the quarterly budget. Therefore, it was advantageous for a project to secure funding as soon as possible in order to avoid any delays due to lack of money. This was a reaction to the change in the funding at Genome Canada. Genome Canada did not have committed funding when Competition III was

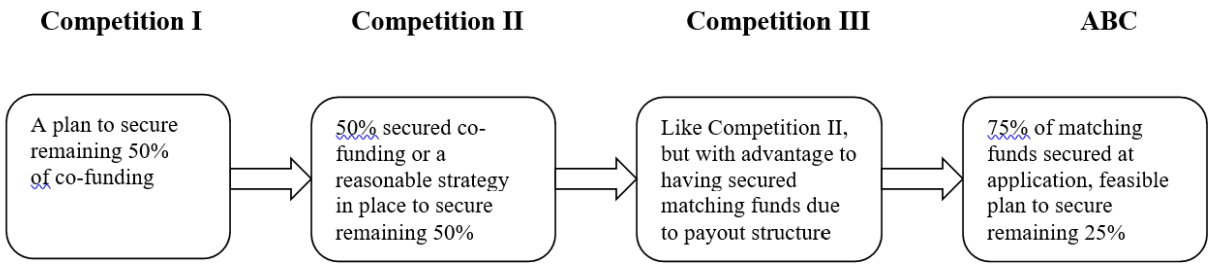
announced. If Genome Canada had to fund the entire project until co-funding was secured, they may have ran out of funding before the competition was over, and if co-funding fell through, the projects would be stuck.

The ABC competition would build on the new cautious principles for co-funding sources, explicitly stating what documentation was required. The ABC Competition presented more in-depth and additional funding criteria. First off, it noted that costs eligible for funding must be incurred after the notice of award, although there were some circumstances where funding could be obtained for project development six months previous of award.[129] The documentation required to support the evidence of reliable co-funding sources became a focus of the ABC competition's funding guidelines. A write-up describing how the funding will *directly* support the goals of the project and an *explicit* acknowledgement that the co-funder would use said funds to support the project were required. Universities often retain some of the funds to cover indirect costs, but these costs were not considered eligible.[130]

Genome Canada also asked, as in Competition III, that project applications include evidence that its co-funding sources were viable. These criteria were mentioned in the Competition III guidelines, but in much less detail. Specifically, the ABC competition required a written letter from a CEO, a board resolution referring to the commitment of funds, or a report of cash flow projections to confirm the matching support.[131] For large cash commitments, audited reports or full financial statements were required, and for smaller funding contributions, a letter from the CEO could suffice. Both the layout and detail of co-funding guidelines had changed in the ABC competition, reflecting an emphasis on ensuring the viability and commitment of co-funding sources.

The most significant change in the funding criteria for the ABC competition was that at the time of application projects needed to have the remaining funding either in place or to have a well-developed and feasible plan for securing said funds. Once a grant was awarded, Genome Canada required that 75% of the necessary co-funding was already secured, and again, a feasible plan for obtaining the remaining 25%.[132] Genome Canada was now receiving grants based on its need on an annual basis. This forced them to change the way they funded projects and required co-funding sources to be secure and ready for the start of a new project. Similar to Competition III, if co-funding was secured via a binding agreement, Genome Canada was willing to adjust the timing of its release of funds in order to allow the project to progress.[133]

Figure 2: Funding requirements



Source: Guidelines and Evaluation Criteria Competitions I, II, II, ABC.

Concluding comments

As Genome Canada matured, it imposed more structure and design to each successive open competition. The goals became more specific, the 'priorities' expanded from world-class science to include GE^{3}LS, commercialization and data management, the proposals became more detailed, the development and review process more than tripled from the first to fourth competition, the financial matching became more rigorous, and the oversight and management of the approved projects became more proscribed. All of these changes added time, money, and effort to both the successful teams but also for those who competed and failed. On the upside, success rates have remained reasonable (about 35% over the period) and the size of the grants warrants more effort both by the granting body and the applicants. A logical next step would be to do a cost-benefit analysis to assess the programs individually and collectively for their efficiency.

As a parting note, we have undertaken a range of analyses of the efficiency and effectiveness of the Genome Canada system, including:

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