KPMG

Advisory Services

Evaluation of Genome Canada – Final Report

Prepared for: Genome Canada

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Executive Summary

This Study. This report discusses findings from an evaluation of Genome Canada (GC) conducted during 2008 – 2009, in accordance with GC's funding agreement with Industry Canada.

Genome Canada. Genome Canada was established in April, 2000, to provide the funding and coordination for a national program in genomics and proteomics research. Its vision and mandate are to position Canada as a world leader in genomics and proteomics research; and to develop and implement a national strategy in genomics and proteomics research for the benefit of all Canadians in key strategic areas (e.g., health, agriculture, environment, forestry, fisheries, etc.) GC addresses genomics-related ethical, economic, environmental, legal, and social (GE^3LS)) aspects either integrated into genomics research, or as stand-alone projects.

GC has established six Genome Centres across the country. GC provides up to 50% of the funding for large-scale research projects, or 100% for science and technology (S&T) platforms (which provide access for researchers to sophisticated technology and expensive research infrastructure). It is the responsibility of the Centres working with the applicants to secure co-funding from other sources (e.g., provincial governments, foundations, industry).

As of October 2008, over 100 large-scale research projects and 10 S&T platforms had been funded, Genome Canada had committed $658.2 million in funding and GC, the Centres, and GC researchers had secured an approximate additional $866 million in co-funding, representing a total investment of over $1.5 billion in genomics research in Canada.

Methodologies. The evaluation methods included: (1) review of GC documents, databases, project interim review reports, and other reports related to GC; (2) web-based surveys and interviews sent to a census of GC genomics project leaders (60), Platform leaders (10 past and present), and GE^3LS leaders (6 leaders of stand-alone GE^3LS projects[1]); (3) a web survey sent to 54 of Genome Canada's most knowledgeable international peer reviewers; (4) a web survey sent to 112 partner organizations that provide co-funding to GC research projects, and/or independently provide genomics research grants; (5) a comparison of GC's model to that of 11 other international genomics granting agencies, including interviews with five of their representatives; and (6) consideration of the findings of a partial benefit-cost analysis of GC research being conducted separately by KPMG. The overall response rate to the surveys was 34%; the response rate for GC researchers was 54%.

Nine high priority evaluation questions were identified in a separate planning study, as well as four medium priority issues (the latter are referred to below as "M" questions.)

Overview of Findings. This study concludes that Genome Canada has had a tremendous impact on genomics and related research in Canada, and its rationale remains strong. The evaluation found that GC has transformed the quality and quantity of Canadian genomics and proteomics research, based both on provision of funding for large-scale research projects and support for critical S&T platform technologies. These activities have been placed within a coordinated national approach to strategic research themes, coupled with increased

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1 As opposed to GE^3LS researchers doing integrated GE^3LS research as part of large-scale genomics projects..

international coordination. This has had the added effect of being important for attraction and (especially) retention of faculty members. As noted, GC has also supported work on GE^{3}LS aspects, both as stand-alone projects and as elements integrated into large-scale genomics research, in a way that is unique internationally. The GC projects are being actively investigated for use in practical socio-economic applications in ways that will be transformational in many areas.

There are, however, some issues outstanding, of which the six most critical are that: (1) Canadian genomics researchers are not as enthusiastic about GC' s impact as are other stakeholders (including international experts), possibly due to a lack of a close working relationship with GC staff and officials, as well as the " cultural shift" required to work within the GC environment; (2) GC must continue to provide strong and continuous support for basic, untargeted research; (3) the role of GC vis-à-vis the Genome Centres requires clarification, and the effectiveness of some Centres is less than others; (4) there remain difficulties in integrating GE^{3}LS topics and researchers within genomics research projects; (5) genomics is in rapid transition, and more responsive research and S&T platform models may be required; and (6) co-funding requirements do not match well with Canadian industrial capacity.

Evaluation Question 1 – Rationale. There remains a strong rationale for GC's continued existence. About 80% of respondents overall (and 75% of GC researchers) believed it is important or very important to continue to organize genomics research through large-scale projects. Further, about two-thirds of respondents overall (and 62% of GC researchers) believe a separate organization needs to lead such projects. There is no obvious other Canadian organization that could take over such projects: the Canadian Institutes for Health Research, for example, have recently terminated their large team grants, and the findings on incrementality (see Evaluation Question 7) demonstrate that other Canadian genomics funding organizations are unwilling to take on such responsibilities.

Evaluation Question 2 – Focus on High Priority Strategic Themes. Genome Canada is seen by over 80% of Canadian partners and the international reviewers as effective or very effective at identifying and focusing on strategic research that is of high importance to Canada. Note that at least 40% of the international reviewers stated that their organizations also seek out such strategic themes, so such efforts are common world-wide. Within Canada, about 70% of the co-funders and other genomics granting organizations also worked in similar fashions.

Evaluation Question 3 – Coordination. The Canadian genomics effort is now considered well coordinated or very well coordinated by over 60% of respondents, *vs*. only 3% who believed it would be this well coordinated if GC did not exist. About two-thirds of respondents believe that GC in particular has been effective or very effective at increasing coordination among Canadian researchers (there are many examples in areas such as forestry, fisheries, oncology, diagnostics, drug development, etc.) Further, GC has also been effective at increasing coordination between Canada and the international genomics effort, although (understandably) there is somewhat less coordination than within Canada – about 49% of respondents overall rated GC as effective or very effective regarding international collaboration.

The Position Paper process currently used is highly consultative, but a number of respondents commented that it is too slow for driving scientific impacts and innovation in this rapidly-evolving field.

Evaluation Question 4 – Leadership in Genomics and Proteomics. Genome Canada has had a transformative impact on Canadian genomics and proteomics science. The performance

data collected directly by Genome Centres show that at least 3,370 publications and 4,864 conference papers have been produced by GC scientists since GC began[2].

In the opinion of respondents, there have been strong increases in the quality of Canadian genomics and proteomics research, increasing from good, on average, pre-GC to between excellent and world-class now. Similar increases are seen in quantity: from fair to good pre-GC to excellent now. The international reviewers rated both the current quality and current quantity of Canadian research as being very similar to those in their own countries. Typical comments from GC scientists and international reviewers were:

> *I think that there is no question that Genome Canada has had a huge impact on genomics in Canada. [GC scientist]*
>
> *"The most important impact was the total transformation of genomics research from an OK level with some impact, to an absolutely world class and in many cases world leading research. [GC scientist]*
>
> *As a long time observer of international genomics research, I have witnessed a dramatic climb of Canada to world class. [International reviewer]*
>
> *GC has done a great job of elevating the level of science in Canada. [International reviewer]*

Regarding this improvement, GC was seen as an effective or very effective facilitator by 82% of respondents for quality; 91% for quantity, and 76% for Canada becoming a world leader in genomics and proteomics. The GE^{3}LS leaders and international reviewers were especially positive about these effects of GC.

Bibliometric analysis was also conducted separately from this evaluation. Key findings were that Canada ranked 5th in genomics quantity and quality behind the US, Switzerland, Netherlands, and UK over 1996–2007, using a multicriteria rating[3]. Over this period, Canada ranked 5th for scientific impact as measured by ARIF[4] = 1.25; this is well above the averages for Canadian natural sciences and engineering in total (1.09), and for biomedical sciences in particular (1.08). The analysis confirmed that GC itself has had an impact on Canadian genomics[5]. Some GC papers were within the top .05% of the most cited genomics papers in the world. Further:

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2 Because of the way Centres collect such information, these figures are almost certainly minimums.

3 Based on scientific impact, output per capita, number of papers, and specialization in genomics and proteomics. In the most recent 2005 – 2007 period, Canada ranked 6th on this multicriteria rating, slightly losing ground because other countries are investing even more heavily in genomics and proteomics.

4 ARIF is the Average Research Impact Factor, an indicator of the global rate of citations of literature in a given field produced by researchers in a particular country. By definition, papers equal to the world average, in a given discipline, in a given country, have ARIF = 1.0.

5 Although the authors cautioned that some of the effect was more through GC's support for the top rank of researchers and a few top papers, rather than for its "average" impact.

- The production of GC researchers increased faster while funded by GC than not
- GC-supported papers ARIF = 1.50
- Non-GC Canadian genomics papers ARIF = 1.22
- World genomics papers (excluding GC) have ARIF = 1.15.

Evaluation Question M1 – Leadership in GE^{3}LS, and Evaluation Question M2 – Integration of GE^{3}LS into large-scale Projects. In the opinion of respondents, Canada's leadership standing in GE^{3}LS research has improved substantially since GC was created, from an average rating of fair to good pre-GC, to excellent now. Nearly half the respondents believe that this improvement is completely, or mainly, due to GC and the Centres. Several of the international reviewers commented on this aspect of GC, e.g.:

> *[GC] has also provided a critical push toward the study of the legal, ethical, and environmental aspects of genomic research.*

Bibliometric analysis conducted separately from this evaluation concluded that Canada is well positioned in GE^{3}LS, ranking 4th from 1996–2007, on a par with Australia, though behind the US, UK, and Denmark, using the same multicriteria rating mentioned earlier. A study done by the European Research Area on Societal Aspects of Genomics (ERASAGE) had a very positive assessment of Canada's approach to GE^{3}LS research, and Canada was in fact used as the benchmark. Finally, almost half the study respondents believed that Canada has integrated GE^{3}LS concerns well or very well into its large-scale projects, and separate review done by the study team showed that GE^{3}LS integration was medium or high for more than half the large-scale projects. The international reviewers see this integration as considerably stronger than do Canadian researchers, and that the internationals also see Canada's GE^{3}LS integration as being better than is done in their own countries. Analysis by the study team of interim review reports of the International Scientific Review Committees showed that more than half the GC genomics projects explicitly demonstrated medium or high GE^{3}LS integration.

Having said this, there are still some significant problems. GE^{3}LS leaders commented that often their topics are not well-integrated into "science" projects, there was a lack of national GE^{3}LS collaborations and communications, and they received insufficient feedback from the rest of the GC community. On the genomics scientists' part, a significant number were not very convinced of the usefulness of GE^{3}LS, considering it a "tax" on the science, believing GE^{3}LS leaders do not sufficiently understand genomics, and believing GE^{3}LS does not have much impact on Canadian genomics credibility (though many of the internationals would not agree). Some genomics scientists did note, however, that when GE^{3}LS was well-integrated within the science it did, in fact, work well and was useful both for both the genomics and the GE^{3}LS scientists

Evaluation Question 5 – Access to S&T Platforms. The S&T platforms are seen as a key strength of GC. Genome Canada's genomics scientists rated both the technical and operational capabilities of the S&T platforms as good to excellent at most platforms: the Genome Science Centre is clearly excellent, and Bioinformatics is fair to good. Over 80% of respondents believe that Canadian genomics research infrastructure is better or much better than what was available prior to GC, and GC is seen as directly or indirectly responsible for much of this change, and in the ability to effectively use the infrastructure through operational funding and salaries. (However, other organizations are also important in effecting this improvement, notably the Canada Foundation for Innovation.) GC is seen as having had a moderate impact on the coordination of platform activities and minimizing redundancy in infrastructure investment. Platform Leaders see few barriers to effective and/or efficient use of the platform infrastructure.

Many respondents commented that large-scale platforms are still needed where new technologies and/or research problems are being addressed – e.g., when dealing with huge amounts of complex information. However, a number commented that the genomics research landscape has changed dramatically since GC was created, and this may imply that refinement of the platform model is required (see the Conclusions section).

Evaluation Question 6 – Potential Socio-Economic Benefits, and Evaluation Question M2 – Integration of S-E concerns into large-scale projects. Many important and transformative S-E impacts are in development. Performance data from the Centres on traditional technology transfer show : 202 patent applications, 53 patents granted, 19 licenses granted, 32 copyrights, $3M in fees from royalties and licenses, and 15 spin-offs. Almost 80% of GC researchers have been actively involved in developing practical socio-economic (S-E) applications of the GC research. Many methods are being used for knowledge transfer and technology transfer, and both types of mechanism appear equally important. It is not only the genomics scientists involved in developing practical S-E applications; so too do GE^{3}LS and platform leaders, and also the organizations providing co-funding or other genomics research grants (but using GC research results in some way).

Roughly a quarter of GC scientists have already applied their research, or are engaged in active development, for applications in public policies or programs, and about 43% for health care. Roughly a third of respondents have already applied their research, or are engaged in active development, through traditional technology transfer for commercial products, and about 40% are engaged in knowledge transfer related to commercial applications. Roughly 20% of respondents have already applied their research, or are engaged in active development, for best practices and for environmental benefits, and about a quarter for other types of societal benefits.

Many examples of potential applications were given during interviews with researchers. The benefit-cost case studies (reported separately) show many of the GC projects are likely to lead to transformative impacts on society. Although many of the furthest along of these are in health care, there are also many other potential applications in a variety of industries, and several also have important environmental implications.

Bibliometric analysis conducted separately from this evaluation indicated that Canada is in an excellent position to reap the S-E benefits of genomics. Over 1996 – 2007, Canada ranked 2nd behind the US on a multicriteria score based on four indicators of technological production[6]. In particular, Canada took 1st place in the ranking of leading countries for their IP in genomics in the most recent three-year period (2005–2007), as a result of an increase in the number of Canadian patents and average relative citations.

Finally, over 40% of respondents believed that Canada has integrated S-E considerations well or very well into its large-scale genomics research projects. The international reviewers see this integration as considerably stronger than do Canadian researchers, and the internationals, on average, also see Canada's S-E integration as being better than is done in their own countries. A review of interim reviews conducted by the International Scientific Review Committees (ISRCs) showed that more than two thirds of GC projects have integrated S-E considerations into large-scale projects to a medium or high extent.

Evaluation Question 7 – Incrementality. The incrementality of GC's projects is high. Fewer than 15% of GC researchers believed their GC projects would have been likely, or very likely, to be supported at similar resource levels by other organizations such as the university granting councils, the Networks of Centres of Excellence, etc., if GC did not exist. Only 15% of co-funding organizations believed it was completely likely, or very likely, that the GC project for which they provided co-funding would have gone ahead without GC (perhaps with additional

6 Number of citations Canada's patents received, patents per capita, specialization, and number of patents

support from other sources). And only 10% of these organizations thought it very likely they would have borne the entire cost themselves – and none thought it completely likely.

If there were no GC, but the same funding were available from other sources (though few respondents believed this would be possible), the researchers believed there would be several negative impacts, including less communication, collaboration, and sharing within the genomics research and user communities; less cohesion in research topics; and no large-scale or integrated GE^{3}LS projects (for those researchers believing these are important). On the other hand, researchers also believed there would be some positive impacts: less project "micromanagement", red tape, and bureaucracy; better, more efficient, long-term fundamental science; no need for GE^{3}LS integration (this would be a benefit in the view of about three-quarters of the genomics scientists); and no need for co-funding (though some recognized the political need for it given the large research project funding).

Evaluation Question 8 – Attraction and Retention. GC is important for attraction, but even more so for retention, of faculty members. A quarter of all PIs surveyed had changed jobs in past 5 years – 70% from another Canadian institution, 20% from industry or government, and 10% from a US institution. GC was an important or very important factor in changing jobs for about a quarter of genomics researchers, and three-quarters of the Platform leaders.

Nearly half the GC researchers have considered taking another position in the past five years but did not, and nearly a third had received firm offers. The GE^{3}LS and Platform leaders were especially likely to have considered a move, and GE^{3}LS leaders were especially likely to have received a firm offer. Despite this, these respondents had not moved, and GC was an important or very important factor in staying for about half the respondents overall, and for three-quarters of the GE^{3}LS leaders and 80% of the Platform Leaders.

Evaluation Question M3 – Co-funding and Leveraging. GC – through the activities of the Genome Centres and individual researchers – has exceeded Industry Canada's requirement of obtaining 50% or more of the total eligible project costs as co-funding from other sources. The total genomics research funding (i.e., GC direct funding plus secured co-funding) is roughly $1,524 million, or 2.3x the GC funding of $658 million alone.

In addition to formal co-funding raised for use in approved GC projects, the Centres have also leveraged additional resources. Leveraged funds are those that – although they are not used to directly fund GC approved projects – would not have been raised if Genome Canada funding had not been available; e.g., funding used to support a complementary research program of an industry partner; or additional research contracts or grants received by the project team to support complementary research. This is a "ripple effect" of GC that would not happen without GC's existence. The Centres' performance data show that leveraged resources have been substantial, being roughly a third of the total co-funding. Thus the total Canadian genomics research investment associated with GC (i.e., direct GC funding, plus co-funding, plus leveraged resources) has been roughly 2.8x the GC contribution alone.

Evaluation Question M4 – Communications. Both GC and individual Centres undertake a very wide variety of communications and outreach activities, some very innovative. GC's communications budget alone has been about $4.5 million over the past five years. The Centres collaborate closely with GC and undertake some activities – especially outreach – even more extensively than does GC. Co-funders and other genomics research granting agencies find communications generally effective – especially at the Project and Centre level. At the GC level, effectiveness is more moderate. Outreach by the Centres and GC was also effective. (Understandably, little outreach is done at the project level.)

A separate study of GC's impact on public perception found that public familiarity with Genome Canada has improved since 2001, there having been a 7% increase in the number of general public being somewhat familiar or very familiar with GC, and a 14% decrease in members of the general public not at all familiar with GC.

Evaluation Question 9 – Alternative Design Models and Delivery Processes. The findings show that the existing GC model is a strong one, although some refinement is possible. Genome Canada employs a hybrid model, attempting to marry the best features of centralized models (chiefly rigour and consistency) with those of decentralized models (usually the ability to respond more quickly and effectively to differing regional needs). It also marries some features of granting councils with those of private sector management. The evaluation has shown that when this works, it works very well, but that success depends on the skills and professionalism of individual Centres and the quality of the individual partnerships between GC and each Centre.

On the GC side, the organization is seen as politically astute, and the international reviewers are impressed with its corporate diligence and commitment to Canadian genomics. On the regional side, most of the Centres provide useful assistance to their community, for example by helping find critical co-funding, providing effective links to GC, strong regional strategic development, liaison with partners and the community, and networking. The best Centres have responsive and helpful management and staff, and assist scientists to prepare applications, develop and manage practical applications, and conduct outreach. In essence, good Centres "ask a lot, but give a lot in return." The findings thus indicate that this hybrid model can work, and work well. However, there is considerable variation in the effectiveness of individual Centres, and they clearly increase administrative requirements.

Some refinements to the underlying model are possible, including:

- Strengthening the support for basic science;
- Clarifying the roles of the Centres;
- Reviewing the existing Platform model in the light of the changing genomics research environment; and
- Using longer project timeframes to help make large-scale projects more effective, and help keep research teams together over a longer time period.

Refinements to the process are also possible, including

- Simplify and harmonize the reporting requirements where feasible;
- Increase interactions between Canadian researchers and GC – there is reason to think the genomics scientists lack understanding of GC's role and activities;
- Simplify and speed up the interim review process, or eliminate it and rely more on Scientific Advisory Committees;
- Speed up the identification of strategic opportunities;
- Improve access for smaller, less expensive projects; changes to genomics now allow $1 – 3M projects to be important, and there appears to be a mid-sized "hole" in this range that neither GC nor the granting councils support (i.e., this is not a GC issue alone);
- Better integrate GE^{3}LS leaders and projects into genomics science programs and projects;
- Continue a strong focus on commercialization and other types of practical exploitation, including strong accountability and management, but have realistic expectations of the timeframes involved.

Conclusions. Overall, the rationale for Genome Canada remains strong and important. There has been a transformative impact of GC on Canadian genomics research. Canada is now a visible and respected world player – Canada is "on the map", with the quantity and quality of Canadian genomics research having markedly improved, mainly due to GC. The large-scale projects and GE^{3}LS emphasis are both envied internationally. All but one of the Platforms are successful, and some are outstanding, providing efficient, large-scale infrastructure for GC researchers across Canada, with excellent technical and operational capability, good staff, and usually offering timely service. Although GE^{3}LS consideration is not unique to Canada, GC's support for both large-scale GE^{3}LS projects and incorporation of GE^{3}LS opportunities and concerns within genomics projects is a feature not seen in other countries. Genomics applications are about to transform many aspects of society. The most obvious of these applications are in health care, in particular personalized medicine, but there are many industrial and environmental applications also being investigated, several of which are critical to Canada's resource industries such as fisheries (including aquaculture), forestry, and agriculture.

There are several qualifications, but the study team emphasizes that the relatively lengthy list does not point to serious problems within GC – only that GC exists within a complex and rapidly changing situation. Qualifications include that federal support for GC and genomics in general is seen as uncertain by the Canadian community. This is at a time when the genomics research landscape is in rapid transition everywhere, and both the research and platform models may need some adjustment to allow more rapid and flexible deployment of resources. The Centres' perceived high "micromanagement" and reporting requirements are disliked by scientists (although other research organizations have found that large-scale science also requires substantial management, reporting, and accountability mechanisms), and the Centres' role vis-à-vis GC remain somewhat unclear. The Canadian genomics researchers are noticeably less enthusiastic about GC's impact than other stakeholders (including international experts). This may partially result from the unusual lack of direct interaction between Canadian genomics scientists – GC only uses international reviewers for scientific review of proposals, and genomics scientists thus mainly interact with their Centre, not GC's central staff and officials themselves – coupled with the cultural shift" required to work within the GC environment of large-scale projects, co-funded with external stakeholders, and focused on strategic topics. Some GE^{3}LS leaders believe that GE3LS integration has not always proceeded smoothly, and

some genomics scientists believe that these aspects have not always provided high added value, although this is a not uncommon feature of multidisciplinary and cross-disciplinary research initiatives. While genomics is clearly on track to have transformative practical impacts, these are mostly in very early stages; realistic time expectations are required. All respondents, Canadian and international alike, emphasized that there will be no practical applications of research without a strong foundation of fundamental knowledge to support them, and there are concerns about GC's recent emphasis on targeted competitions (especially given co-funding requirements and Canada's small industrial base). Although there is still very strong support for large-scale projects, it was suggested that there is currently a gap between GC and the granting councils in support for smaller genomics projects, roughly in the $1M – 3M range. There also needs to be a mechanism to store and maintain important genomics resources developed through individual research projects once those projects are over; e.g., novel animal models, reagents, libraries, informatics, etc. A few respondents commented that more internal genomics knowledge (both on the research and the technology side) was needed within GC staff and officials. Finally, the four-year timeframe is believed by many respondents to be too short for such large-scale projects, especially when students are involved.

1. Introduction

1.1 The Study

This report discusses findings from an evaluation of Genome Canada (GC) conducted during 2008 – 2009, in accordance with GC's funding agreement with Industry Canada. The evaluation was conducted concurrently with a performance audit, which is reported upon separately. Both the performance audit plan and evaluation plan were developed in the spring of 2008[7] and received approval from GC's Audit Committee and Evaluation Steering Committee. During conduct of the evaluation proper, a detailed design was provided to, and approved by, the Evaluation Steering Committee[8].

1.1.1 High Priority Evaluation Questions

The key evaluation questions investigated were:

- **Evaluation Question 1:** Is the rationale for Genome Canada still valid – i.e., is there still a need for a separate organization to fund large-scale genomics and proteomics research projects (and the necessary support technologies) in areas of strategic importance to Canada?
- **Evaluation Question 2:** How effective has Genome Canada been in developing a strategy to identify and focus on high priority strategic research themes?
- **Evaluation Question 3:** How effective has Genome Canada been in increasing coordination among the various national and international parties involved in genomics research?
- **Evaluation Question 4:** To what extent has Genome Canada enabled Canada to become a world leader in genomics and proteomics research (in certain fields)?
- **Evaluation Question 5:** To what extent have Genome Canada and the Genome Centres provided sufficient access to leading-edge technologies to genomics researchers in Canada?
- **Evaluation Question 6:** What are the potential socio-economic benefits of the research that has been funded by Genome Canada?
- **Evaluation Question 7:** To what extent is the research that has been funded by Genome Canada "incremental" – i.e., the research would not have been carried out (or would have been carried out much later or on a much smaller scale) if Genome Canada had not existed?
- **Evaluation Question 8:** What has been the impact of Genome Canada on the attraction and retention of top-rank researchers at Canadian institutions?

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[7] Report on the Genome Canada Evaluation Planning Project. June 3, 2008. KPMG LLP.

[8] Genome Canada Performance Audit and Evaluation Design Report for Evaluation Component. October 24, 2008. KPMG LLP.

- **Evaluation Question 9:** Are there alternative delivery models or changes to the Genome Canada delivery process – including changes to the roles of the Genome Centres – that could improve its cost-effectiveness?

1.1.2 Medium Priority Evaluation Questions

Evaluation Questions addressed to a lesser extent were:

- **Evaluation Question M1:** To what extent has Canada progressed toward a leadership[9] position in GE^{3}LS internationally?
- **Evaluation Question M2:** To what extent have socio-economic and GE^{3}LS considerations been effectively integrated into the conduct of the large-scale research projects?
- **Evaluation Question M3:** How much incremental funding has been leveraged as a result of Genome Canada's activities?
- **Evaluation Question M4:** How effective has Genome Canada's Communications program been in contributing to increased public awareness and support?

1.2 Genome Canada

1.2.1 Overview

Genome Canada was established in April, 2000, to provide the funding and coordination for a national program in genomics and proteomics research. The vision and mandate of Genome Canada are as follows:

> ***Vision***: To position Canada as a world leader in genomics and proteomics research.
>
> ***Mandate***: To develop and implement a national strategy in genomics and proteomics research for the benefit of all Canadians in key selected areas such as health, agriculture, environment, forestry, fisheries, and new technology development.

Genome Canada has five objectives as specified in its funding agreement with Industry Canada[10]:

1. the development and establishment of a coordinated national strategy for genomics and proteomics research to enable Canada to become a world leader in areas such as health, agriculture, environment, forestry, and fisheries;
2. the provision of leading-edge technology to researchers in all genomics and proteomics related fields through regional Genome Centres across Canada;
3. the support of large-scale genomics and proteomics projects of strategic importance to Canada, which are beyond current capacities by bringing together industry, government, universities, research hospitals, and the public;
4. the assumption of leadership in the area of ethical, environmental, economic, legal, social (GE^{3}LS) and other aspects related to genomics and proteomics research, and the

[9] We assume that the term "leadership" in this objective means leadership in GE3LS research.

[10] Genome Canada originally had nine objectives, but these were consolidated by Industry Canada into these five objectives in 2005-06.

communication of the relative risks, rewards, and successes of genomics and proteomics to the Canadian public; and

5. the encouragement of investment by others in the field of genomics and proteomics research.

Genome Canada has established six Genome Centres across the country (Genome British Columbia, Genome Alberta, Genome Prairie, The Ontario Genomics Institute, Genome Québec, and Genome Atlantic), and much of the delivery of the program is administered through these Centres. Applicants for research funding apply for funding to Genome Canada through one of the Centres. Each proposal undergoes extensive review, including a review of scientific merit conducted by a panel of international experts in the field, and an external review of due diligence regarding proposed project management, accountability, etc. Recommendations are then provided to the Genome Canada Board of Directors. Once projects have been approved by the Board, the Centres are responsible for project monitoring and program administration.

Genome Canada provides up to 50% of the funding for large-scale research projects and 100% for science and technology (S&T) platforms (facilities which provide access for researchers to sophisticated technology and expensive equipment and infrastructure, such as DNA sequencing, genotyping, proteomics analysis, information technology, and bioinformatics expertise). It is the responsibility of the Genome Centre working with the applicants to secure the remainder of the funds from other sources (e.g., provincial governments, foundations, industry).

As of June, 2008, 105 large-scale research projects and 10 S&T platforms had been funded. The breakdown of the large-scale projects by funding competition is as follows:

- Competition I – 17
- Competition II – 33
- Applied Genomics in Human Health Competition – 14
- Competition III – 33
- Other projects, including international consortia – 8.
- Technology development - 13

Another competition for large-scale research projects – Applied Genomics Research in Bio-products or Crops – was announced in 2008, and 12 new " ABC" projects were announced on April 20, 2009

The federal government, through Industry Canada, has approved a total of $840 million to Genome Canada since 2000-01: $160 million in 2000-01; $140 million in 2001-02; $75 million in 2003-04; $60 million in 2004-05; $165 million in 2005-06; $100 million in 2007-08; and $140 million in 2008-09. In addition, Genome Canada has earned investment income of over $80 million. The vast majority of these funds have been used for the funding of large-scale research projects and S&T platforms, with the remainder used to support the operations of Genome Canada and the Genome Centres. More than $850million in co-funding for projects has been raised from various public and private sources.

The main differences between the competitions have been:

- In Competition I Genome Canada solicited "combined proposals" which included business plans for the regional Genome Centres together with associated research projects – both large-scale research projects and the S&T platforms that were viewed as necessary for carrying out the large-scale projects. (These large-scale projects and S&T platforms were viewed as the proposed research program of the Centre.)
- Genome Canada adopted a responsive position for Competitions I and II – i.e., there were no specific guidelines regarding the types of projects the organization was looking for or the desired areas of application (health, forestry, etc.).[11] In the competition that followed, the Applied Human Health Competition, however, Genome Canada stated that it was soliciting proposals "focusing on the development and application of genomics and proteomics tools to improve the prediction, prevention, and treatment of human disease…"[12]
- Competition III was not targeted to any specific areas of application, but the application guidelines required proposals to contain specific plans for addressing both GE^{3}LS aspects and socio-economic impacts:
  - "Identify potential GE^{3}LS issues that are raised directly by the proposed research and detail the plan to address them."
  - "Provide a proposal for the transfer, dissemination, use, or commercialization (as appropriate) of the anticipated results of the research proposal. The plan should demonstrate how the research results would (a) contribute to job creation and economic growth in Canada, (b) impact society, quality of life, health, and the environment, and (c) contribute to the creation of new policies in these areas."

1.2.2 Communications

As noted earlier, part of one of Genome Canada's objectives deals with communications: "…the communication of the relative risks, rewards, and successes of genomics and proteomics to the Canadian public." This is considered to be important in order for Genome Canada to secure and maintain an on-going base of strong public (and, therefore, political) support. Recent communications activities have included:

- numerous news releases and news conferences;
- the "GEEE! in Genome" exhibit. This exhibit completed a three-year cross-Canada tour in 2007, and it is currently being updated for another planned three-year tour beginning in the Spring of 2008.
- partnering with several youth education programs;
- participation in a number of genomics and proteomics conferences; and
- the Genomics on the Hill events usually held in the fall, in which genomics researchers displayed some of their best research and related applications to parliamentarians.

Each Genome Centre also has its own communications director and communications plan.

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[11] The main focus of Genome Canada in these competitions was the building up of Canadian research capability in genomics and proteomics.

[12] This focus on human health was mandated by the federal government in the February 2003 budget, as one of the conditions of the funding provided for this competition.

1.2.3 GE3LS

The other part of the same Genome Canada objective deals with GE^{3}LS: "the assumption of leadership in the area of ethical, environmental, economic, legal, social (GE^{3}LS) and other issues related to genomics and proteomics research …"

To this end Genome Canada has done a number of things:

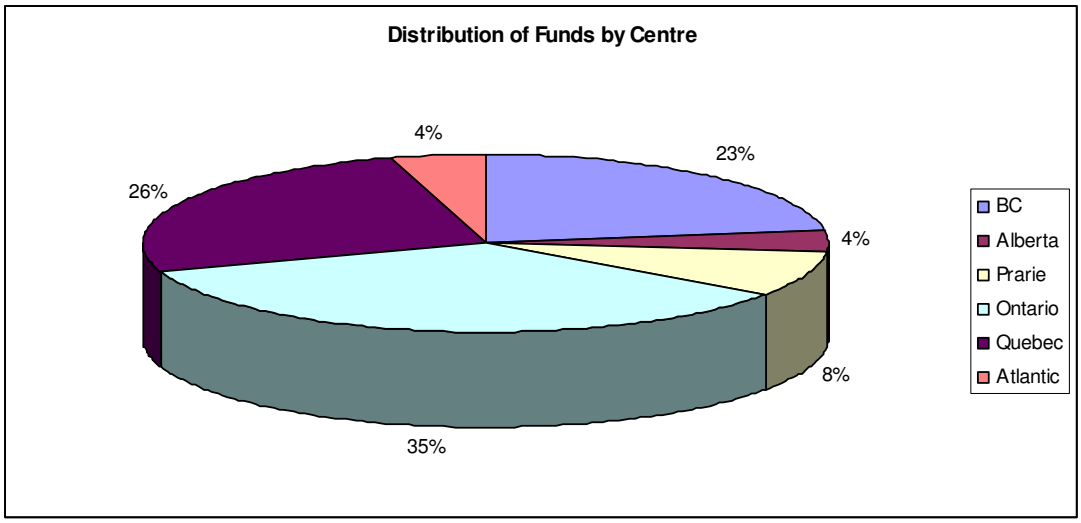
- developed a national GE^{3}LS framework, which outlines strategies for Canada to maintain its leadership in GE^{3}LS research;
- encouraged applications for large-scale GE^{3}LS research projects and funded nine of these;
- set up systems at the Genome Centre level to ensure that appropriate and adequate attention is given to GE^{3}LS aspects in the conduct of the large-scale genomics research projects. These mechanisms vary by Centre, but include, for example, GE^{3}LS committees involving a representative from each project to discuss and resolve GE^{3}LS issues, GE^{3}LS experts on staff at the Centre to advise projects, periodic workshops to discuss GE^{3}LS issues, and so on.
- required all Competition III projects to have an integrated GE^{3}LS plan to address the GE^{3}LS aspects arising from the research; and
- hosted a number of high-profile workshops and symposia.

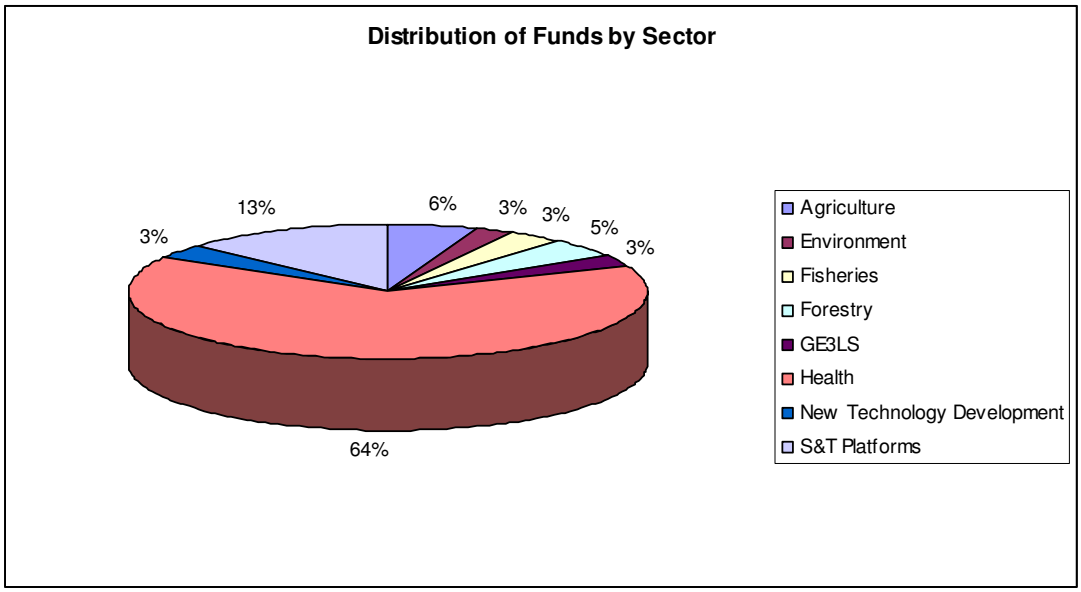
1.3 Projects Funded to Date

The following table provides a breakdown of the (Canadian) large-scale projects and science and technology platforms that had been funded as of June 3, 2008, broken down by region and sector of application.

Sector	BC		Alberta		Prarie		Ontario		Quebec		Atlantic		Canada Total	
Agriculture	2	$9,164	1	$6,806	3	$17,551	1	$814			1	$1,925	8	$36,266
Environment	1	$2,305					2	$8,416	1	$3,756	1	$2,083	5	$16,564
Fisheries	2	$10,553									2	$10,950	4	$21,505
Forestry	2	$15,429					1	$2,327	2	$11,385	1	$910	6	$30,055
GE3LS	2	$1,630	1	$1,330	1	$1,663	3	$9,674	2	$2,430			9	$16,734
Health	18	$80,377	2	$9,175	2	$21,866	22	$175,285	22	$126,368	2	$6,857	68	$419,978
New Technology Development			1	$2,283	1	$8,564	3	$11,745					5	$22,597
S&T Platforms	4	$26,545	1	$5,680	1	$5,024	2	$17,763	1	$23,801	1	$5,805	10	$84,624
Total	31	$146,003	6	$25,274	8	$54,668	34	$226,024	28	$167,740	8	$28,530	115	$648,323

The following figures use the data from this table to illustrate the distribution of funds by Centre and the distribution of funds by sector, again as of June, 2008.


Distribution of Funds by Centre
4%
23%
26%
4%
8%
35%
BC
Alberta
Prarie
Ontario
Quebec
Atlantic


Distribution of Funds by Sector
13%
6%
3%
3%
5%
3%
3%
64%
Agriculture
Environment
Fisheries
Forestry
GE3LS
Health
New Technology Development
S&T Platforms

2. Methodologies

The key methodologies included the following.

2.1 Background Research

This included review of GC documents, databases, and project interim review reports. The purpose of this review was to investigate GC's:

- process for identifying research themes;
- processes to effect coordination;
- incorporation of socio-economic and GE^{3}LS considerations into large-scale projects;
- communications activities;
- performance metric information – these data were collected directly from each Centre; and
- co-funding and other leveraged funding – data on other leveraging were collected directly from each Centre.

A detailed report[13] was prepared based on this review, and a summary of findings is presented here.

2.2 Surveys

2.2.1 Researchers

Web-based surveys were provided to a census of GC Principal Investigators (60 PIs), Platform leaders (10 past and present), and GE^{3}LS leaders (6 leaders of independent GE^{3}LS projects[14]). Extensive telephone contact was made to ensure a high response rate, and in many follow-up interviews were done to clarify points made by respondents to the web survey.

We did not contact:

- PIs for the technology development projects (12), on the basis that they were not far enough along.
- The PIs of all the projects that were concurrently being investigated in the economic benefits study; see below.

We also did not specifically target PIs in the international projects (three funded under the Canada/Spain competition, and four under the International Consortium Initiative), since most PIs in the international projects also participate in Canadian Genome Canada projects.

Introductory emails were sent to all PIs under the signature of Genome Canada's President and CEO, explaining the purpose of the study.

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[13] *Genome Canada Evaluation Background Research Report*. KPMG LLP, March 2, 2008.

[14] As opposed to PIs investigating GE3LS issues within genomics research projects.

2.2.2 International Peer Reviewers

We conducted a web survey of 54 of Genome Canada's international peer reviewers, with the intent of investigating the higher-level strategic issues.

- Both proposal reviewers and interim reviewers from the various Competitions were sampled in consultation with Genome Canada;
- These were individuals who are most familiar with Genome Canada[15], in addition to genomics R&D programs in their own countries. (All GC Review Panel members are internationals.)
- Although these were individuals familiar with GC, they were also provided with a short paper describing Genome Canada to refresh their memory, to assist in answering questions related to the GC model.

Genome Canada also sent emails ahead of time to these reviewers, explaining the purpose of the study.

2.2.3 Key Partners

This group consisted of organizations that provide co-funding to GC research projects, and/or independently provide genomics research grants. Developing the sample required asking each individual regional Centre to identify key sources of co-funding, and/or genomics research grants, as well as to provide contact information for specific individuals. To assist them, Centres were provided a list of all organizations found in GC's databases as having at some point provided co-funding.

A total of 112 key organizations was identified and surveyed. Genome Canada also sent emails ahead of time to these organizations, explaining the purpose of the study.

2.2.4 Survey Response Rate

Exhibit 2.1 shows overall survey response rates[16].

Exhibit 2.1

	PIs	GE^{3}LS leaders	Plat Ldrs	Peer	Co-F and RG	Total
Respondents (n)	28	6	7	21	21	83
Sample Population (N)	60	6	10	54	112	242
Response Rate	**46.7%**	**100.0%**	**70.0%**	**38.9%**	**18.8%**	**34.3%**

The overall response rate from genomics scientists, GE^{3}LS leaders, and Platform Leaders was 54%. Within the context of recent surveys of university researchers (who have much higher reporting requirements than in earlier years), this is a high response rate.

[15] For example, those who have participated in more than one Competition Panel.

[16] "PIs" in this and following tables refers to Principal Investigators who are genomics scientists; i.e., not including the GE3LS leaders or the Platform Leaders. "Co-F and RG" refers to Co-Funders and genomics Research Granting organizations.

Exhibit 2.2 shows that there is a good response rate by researchers across Competitions:

Exhibit 2.2

Competition*	% of Respondents		
	PIs	GE^{3}LS leaders	Plt Ldrs
Comp 1	21.4%		
Comp 2	32.1%		
Comp 3	25.0%		
AH	10.7%		
ST			14.3%
GE^{3}LS		33.3%	
Multi	10.7%	66.7%	85.7%
Total	**100.0%**	**100.0%**	**100.0%**

Exhibit 2.3 shows that there was an appropriate distribution of responses across sectors of application, with human health dominating[17]:

Exhibit 2.3

	Percent of Respondents					
	PIs	GE^{3}LS leaders	Plat Ld	Peer	Co-F and RG	Total
Human Health	54%	67%	71%	100%	65%	69%
Agriculture	25%	33%	29%	44%	24%	30%
Environment	18%	17%	29%	13%	18%	18%
Forestry	7%	17%	29%		18%	11%
Fisheries	11%	17%	14%		24%	12%
New technology development	14%	50%	43%	56%	24%	31%
Other	18%	50%	-	19%	29%	22%

2.3 International Comparison

The purpose of the International Comparison study was to compare the models of selected international organizations with Genome Canada's model, in addition to obtaining expert opinions regarding several of the evaluation questions. A total of 11 organizations were selected for review (see Appendix A). This included organizations reviewed in a similar 2006

[17] Multiple responses possible.

study for Industry Canada[18] as well as organizations from three additional countries with which Genome Canada has (or had) a Memorandum of Understanding in place. Information was gathered from each organization/country in a two-stage process:

- The organization's web site and other available documentation was researched, and the information relevant to each of the items we are investigating was summarized.
- Telephone interviews were held with five individuals knowledgeable about each organization being studied and the country's overall support mechanisms for genomics research. During the interviews, we filled any information gaps from the web research and posed questions related to high level strategy and best practices.

The organizations reviewed are found in Appendix A.

2.4 Consideration of Benefit-Cost Case Study Findings

A concurrent study was carried out to estimate economic benefits from a sample of GC projects. Analysis was done using partial benefit-cost methodology. The cases reviewed are discussed in section 8.5.

[18] *International Organizational Review Study of Genomics R&D Programs*. BearingPoint (now KPMG), January 10, 2006.

3. Findings on Evaluation Question 1 – Rationale forGenome Canada

It is worth noting here and in subsequent sections that the opinions of international reviewers should be given considerable weight. These individuals are usually outstanding scientists in their own right, and have extensive experience both with genomics funding in their own countries and with GC – the latter because they interact extensively with GC (no Canadian reviewers are used by GC) and our sample was deliberately picked to include internationals who have been involved in several GC competitions.

3.1 Need for Large-Scale Projects

Genome Canada has been mandated to support creation of large-scale genomics projects. If these are not, in fact, required, then the underlying rationale of GC would be in question. However, exhibit 3.1 shows that 80% of respondents overall (and 75% of GC researchers) believed it is important or very important to organize genomics research through large-scale projects. This is especially true for Platform Leaders and international reviewers; but about a third of genomics scientists are less certain.

Exhibit 3.1
Importance of organizing Canadian genomics research through large-scale projects

	Very important	Important	Somewhat important	Not very important	Not at all important	Don't know	N
PIs	36%	29%	29%	4%	4%	-	28
GE^{3}LS	50%	33%	17%	-	-	-	6
Plat Ldrs	83%	17%	-	-	-	-	6
All researchers	45%	28%	23%	3%	3%	-	40
Int'l reviewers	67%	33%					21
Co-fund and RG	48%	29%	19%			5%	20
Total	**51%**	**29%**	**16%**	**1%**	**1%**	**1%**	**81**

It is also the case that about half of other genomics funding organizations organize their genomics research mainly through large-scale projects, although this varies considerably by organization, as shown in exhibit 3.2. A number of the international reviewers commented that this was a Canadian strength.

Exhibit 3.2
Extent of organization of genomics research in large-scale projects

	To a great extent	To a considerable extent	To some extent	To a small extent	Not at all	Don't know	N
Int'l reviewers' organizations	14%	33%	33%	19%			21
Co-fund and RG organizations	23%	38%	15%		15%	8%	12
Total	**18%**	**35%**	**26%**	**12%**	**6%**	**3%**	**33**

3.2 Need for a Separate Organization to Lead Large-Scale Projects

Section 3.2 shows that large-scale projects are still required for genomics and proteomics research. But is a separate organization needed to lead these, or could they be led through existing organizations such as the granting councils? Exhibit 3.3 shows that about two-thirds of respondents overall (and 62% of GC researchers) believe a separate organization needs to lead such projects. Again, GE^{3}LS and Platform Leaders are the most convinced among the Canadian researchers, and internationals are strongly convinced.

Exhibit 3.3
If large-scale projects are important, how important that GC lead them?

	Very important	Important	Somewhat important	Not very important	Not at all important	Don't know	N
PIs	19%	26%	11%	30%	11%	4%	27
GE^{3}LS	83%	17%	-	-	-	-	6
Plat Ldrs	67%	33%	-	-	-	-	6
All researchers	36%	26%	8%	21%	8%	-	39

Exhibit 3.4
If large-scale projects are important, how important that a separate organization lead them?

	Very important	Important	Somewhat important	Not very important	Not at all important	Don't know	N
Int'l reviewers	43%	48%	5%	5%	-	-	21
Co-fund and RG	35%	15%	30%	15%	5%	-	20
All non-GC	***32%***	*17%*	*10%*	*2%*	-	-	*41*
Total	**38%**	**29%**	**13%**	**15%**	**5%**	**1%**	**80**

The GC scientists (and especially Platform and GE^{3}LS leaders) usually recognized they would not be able to obtain such large, or well-coordinated, funding through the federal granting councils. Many also recognize that large projects are not politically feasible without emphasis on socio-econmomic (S-E) benefits, with attendant management requirements. Still, many

genomics scientists still wish it could be possible through the councils (e.g., through strategic competitions). They believe there would then be less oversight and "micromanagement" by the funders, which are key complaints of the researchers. A number of Canadian scientists (and some internationals) also noted that a high emphasis on socio-economic impacts (especially if accompanied by the need to find co-funding from potential user organizations) can pervert the course of science, and may ultimately result in fewer S-E impacts if there is insufficient emphasis on the fundamental science underlying them.

> *The co-funding issue drove a wedge between funders and Canadian scientists in 2005. Genome Canada failed to keep its funding at a high enough level to support its major early round investments. . .. Now the government is moving even more towards industrial research and away from basic knowledge.*
>
> *- GC scientist*

The study team notes that other organizations which support large-scale science – especially that which is multidisciplinary and/or networked – also find that management, reporting, and accountability requirements increase correspondingly. A recent Canadian example is the Networks of Centres of Excellence[19]. In the US, the National Academies of Science found that large-scale collaborative biomedical research was distinguished by (among other factors) larger, more complex management structures and more oversight by the funding organizations[20].

3.3 Interpretation of Results

Overall, the need for both large-scale genomics projects and GC to lead them is clear. However, it is notable that GC's genomics scientists are the least convinced of this. This is obviously a complex issue. The study team notes:

1. The Genome Centres have their own reporting and management requirements which are separate from GC's, so the management, reporting, and accountability requirements are not GC's alone.
2. These requirements are strongly disliked by many scientists, many of whom likely underestimate how much management is required for large, networked, multidisciplinary projects.
3. GC avoids potential conflict of interest (COI) within the relatively small Canadian genomics research community during proposal review by only using internationals on its review panels. This appears to have had the unexpected impact that many Canadian genomics scientists are unfamiliar with GC.
4. It is far from clear that the granting councils would support such large projects (CIHR, for example, has recently eliminated its team grants competition). See also section 9: the

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[19] Three reviews of the NCE program all found that individual network management and accountability were often problematical, and their requirements often underestimated and under-resourced. The most recent report was Evaluation of the Networks of Centres of Excellence Final Report. *(Phase II) KPMG Consulting. June 26, 2002. See: http://www.nce.gc.ca/pubs/reports/2021/eval/eval2002.pdf.*

[20] *Large-Scale Biomedical Science (Exploring Strategies for Future Research)*. National Academy of Sciences, 2006.

incrementality of GC projects is high, and in the absence of GC, very few of these projects would have been fully supported by the organizations that supplied the co-funding.

5. The different aims and needs of science vs. government are not always recognized by either side.

Many of the scientists' concerns would probably be greatly reduced if there were a substantial set-aside for periodic open Competitions (these have always been considered part of GC), or if co-funding were not required, or at least not required for fundamental projects. Within such a system, an integrated portfolio of related projects – some fundamental and some applied – could easily be managed. (Some Centres deliberately foster such portfolios.)

4. Findings on Evaluation Question 2 – Identification and Focus on High Priority Strategic Themes

4.1 The Position Paper Process

In the winter and spring of 2006, Genome Canada undertook an extensive consultation process regarding trends in genomics and proteomics research, strengths and opportunities for Canada, and Genome Canada's future research strategy. The February 2006 retreat was attended by more than 140 scientists and stakeholders from Canada and abroad and the results were documented in a proceedings report[21]. Subsequently, the Chief Scientific Officer and the President and CEO of Genome Canada undertook a cross country tour, meeting with more than 250 researchers to further confirm the idea of Genome Canada focussing on strategic research areas.[22]

The outcome of these consultations was a decision by Genome Canada to target future investments to strategic initiatives in nationally-recognized areas of socio-economic importance and the launching of the "position paper process." This is a new strategic "bottom-up" approach for Genome Canada, and is a type of "foresight exercise[23]."

The first request to the scientific community and other stakeholders for Expressions of Interest (EOI) was made in October, 2006. Close to sixty EOIs were received. These were consolidated into a series of strategic research themes, with the advice of the international members of Genome Canada's Scientific and Industry Advisory Committee (SIAC). Subsequent information sessions and workshops held over the Winter and Spring of 2007 resulted in the development of 11 position papers on specific strategic research themes. Following the recommendations of an international peer review panel, which reviewed the papers over the summer of 2007 and met in person in September 2008, the two highest priority strategic research themes were identified – crop genomics and bio-energy/bio-products. These are the themes that were focussed on in the recent competition in Applied Genomics Research in Bioproducts or Crops (ABC).

---

[21] Genome Canada Retreat, Proceedings Report, *February 15, 2006.*

[22] Investing in Genome Canada's Strategic Research Portfolio 2008-09, Appendix I, *Genome Canada, November 2007.*

[23] *Some countries or groups of countries (e.g., UK, EU) have very extensive foresight exercises that are used for making major funding allocations within their strategic plans. For example, the EU's AGRIBLUE Blueprint discusses regional foresight exercises as the major tool to identify EU-wide and trans-national needs.*

Additionally, in the summer of 2006 Genome Canada undertook a Strategic Review for Proteomics Research in Canada that saw a large number of scientists gather at a two day workshop to discuss the strengths and weaknesses of proteomics research in Canada and to identify which research areas should receive particular attention going forward. The results of the workshop were presented to the SIAC in July 2006.

Flowing from the workshop, participants identified six key areas of proteomics research, the continuing need to build the proteomics community in Canada and general consensus was achieved on the vision for one position paper for the proteomics community. A "team of champions" was created, who would further work to identify and develop major research themes for the future and assist in coordinating a response to the position paper process. ("Protein Interaction Networks" was submitted in the second call for papers described below.

The second request for position papers was launched in November 2007. Six new expressions of interest were received and were considered along with the remaining nine strategic research themes from the first cycle. For the next cycle, seven strategic research themes were developed for evaluation and prioritized by an international panel of experts, and then presented to the Board in the Fall of 2008.

Genome Canada intends to request position papers each year for three years to ensure a continuous stream of new strategic initiatives, with the original intent being that, each year, funding from the government would be earmarked for specific strategic research themes. (Budget 2009 did not do so, but it is uncertain what will happen in the future.)

Consideration is being given to maintaining an "open" competition area supporting discovery research outside of the designated (position paper) themes. This would be similar to the strategy used for Competitions I, II and III.

4.2 Themes for International Consortium Initiatives (ICIs)

The International Consortium Initiative (ICI) is based on the premise of capitalizing on those Canadian niche areas that will have significant impact on Canadian science and further enhance the status of Canada and Canadian scientists in the global community.

The ICI projects are significantly larger projects (>$50M over three years) and go typically beyond the scope of one country's capacity. Applications for ICIs are accepted at any time and reviewed on a one-off basis. Genome Canada limits its funding contribution to 25% of project costs.

Here again, Genome Canada does not specify specific strategic areas of importance only that the following criteria must be met:

- The project must have clear international visibility.
- The project must be led by a Canadian researcher whose major research activities will be in Canada.
- The proposed project must involve an international consortium usually with some form of governance in which the funders will have a proportionate seat on the Board, based on the level of their financial commitment.
- The project should be for a minimum of $50M over three years with other partners committing at least 75% of total costs.

At the Letter of Intent stage, the Science and Industry Advisory Committee (SIAC) assists Genome Canada staff in the review of proposed projects and provides advice on the strategic importance of the proposed area(s) of research, the potential for impact in Canada, the potential for sustained leadership by Canadian scientists in the field, and suggestions for the inclusion of experts and other groups working in the area of proposed research. Projects that demonstrate good potential move forward to develop a full ICI proposal and undergo formal peer review process.

There are currently three ICIs:

- The Structural Genomics Consortium
- The Public Population Project in Genomics
- The International Barcode of Life Project

4.3 Effectiveness

Genome Canada is seen by over 80% of Canadian partners and the internationals as effective or very effective at identifying and focusing on high importance strategic research. (Note the Position Paper process did not begin until 2006.)

Exhibit 4.1
Effectiveness of GC's approach to identify and focus on high priority strategic research themes

	Very effective	Effective	Somewhat effective	Not very effective	Not at all effective	Don't know	N
Int'l reviewers	43%	57%	-	-	-	-	21
Co-fund and RG	20%	45%	20%	5%	-	10%	20
Total	**32%**	**51%**	**10%**	**2%**	**-**	**5%**	**41**

Note that at least 40% of the internationals believed that their organizations seek out such strategic themes. Within Canada, about 70% of the co-funders and other genomics granting organizations also worked to this end.

However, a number of respondents commented that – while highly consultative – the Position Paper process is currently too lengthy to easily respond to many arising opportunities in this quickly evolving field, and may involve too lengthy a commitment from individual scientists.

5. Findings on Evaluation Question 3 – Coordination

5.1 Coordination of Canadian Genomics Research

Exhibit 5.1 shows that the Canadian genomics effort is now considered well coordinated, or very well coordinated, by over 60% of respondents, vs. only 3% if GC did not exist.

Exhibit 5.1
Coordination of Canadian genomics effort

	Very well coordinated	Well coordinated	Somewhat coordinated	Not very coordinated	Not at all coordinated	Don't know	N
Current level of coordination							
PIs	7%	29%	46%	14%	-	4%	28
GE^{3}LS	17%	67%	17%	-	-	-	6
Plat Ldrs	17%	67%	-	17%	-	-	6
All researchers	10%	40%	35%	13%	-	-	40
Int'l reviewers	43%	52%	5%	-	-	-	21
Co-fund and RG	15%	38%	23%	-	-	23%	13
Total	**20%**	**43%**	**24%**	**7%**		**5%**	**74**
Coordination in absence of GC							
PIs	-	7%	39%	36%	11%	7%	28
GE^{3}LS	-	-	33%	33%	33%	-	6
Plat Ldrs	-	-	50%	33%	-	17%	6
All researchers		5%	40%	35%	13%	-	40
Int'l reviewers	-	-	10%	50%	20%	20%	20
Co-fund and RG	-	-	31%	31%	-	38%	13
Total	**--**	**3%**	**30%**	**38%**	**12%**	**16%**	**73**

It is possible that this effect occurred because GC has fostered coordination conducted by other organizations, rather than conducting coordination itself, for example by encouraging provinces to develop their own internal strategies. However, exhibit 5.2 shows that about two-thirds of respondents also believe Genome Canada in particular has been effective or very effective at increasing coordination among Canadian researchers (there are many examples in areas such as forestry, fisheries, oncology, diagnostics, drug development, etc.)

Exhibit 5.2
Effectiveness of GC's Canadian coordination

	Very effective	Effective	Moderately effective	Not very effective	Not at all effective	Don't know	N
PIs	13%	33%	33%	13%	4%	4%	24
GE^{3}LS	33%	50%	17%	-	-	-	6
Plat Ldrs	50%	33%	17%	-	-	-	6
All researchers	22%	36%	28%	8%	3%	-	36
Int'l reviewers	48%	38%	5%	-	-	10%	21
Co-fund and RG	15%	38%	23%	-	-	23%	13
Total	**29%**	**37%**	**20%**	**4%**	**1%**	**9%**	**70**

5.2 Coordination with the International Genomics Effort

Genome Canada has also been effective at increasing coordination between Canadian researchers and the international genomics effort, although (understandably) at lower levels than within Canada; see exhibit 5.3. There are many examples here (e.g., GC's participation in the International HapMap Project, a partnership of scientists and funding agencies from Canada, China, Japan, Nigeria, the UK, and the US to develop a public resource that will help researchers find genes associated with human disease and response to pharmaceuticals)[24].

Exhibit 5.3
Effectiveness of GC's International Coordination

	Very effective	Effective	Moderately effective	Not very effective	Not at all effective	Don't know	N
PIs	17%	29%	33%	13%	4%	4%	24
GE^{3}LS	50%	-	33%	-	17%	-	6
Plat Ldrs	-	33%	50%	17%	-	-	6
All researchers	19%	25%	36%	11%	6%	-	36
Int'l reviewers	25%	45%	10%	5%	-	15%	20
Co-fund and RG	-	31%	15%	8%	-	46%	13
Total	**17%**	**32%**	**25%**	**9%**	**3%**	**14%**	**69**

[24] *See: http://www.hapmap.org/*

6. Findings on Evaluation Question 4 – Leadership in Genomics and Proteomics, and in GE^{3}LS

In this section, we present data on Evaluation Question 4 (Canadian leadership in genomics and proteomics) and Evaluation Questions M1 and M2 (integration of GE^{3}LS in GC's large-scale projects, and Canadian leadership in GE^{3}LS, respectively), as they are closely related concepts.

6.1 Leadership in Genomics and Proteomics

Four representative quotes, two from GC scientists and two from international reviewers, demonstrate GC's profound effect on Canadian genomics and proteomics.

> *I think that there is no question that Genome Canada has had a huge impact on genomics in Canada.*
>
> *- GC scientist*

> *The most important impact was the total transformation of genomics research from an OK level with some impact, to an absolutely world class and in many cases world leading research.*
>
> *- GC scientist*

> *As a long time observer of international genomics research, I have witnessed a dramatic climb of Canada to world class.*
>
> *- International reviewer*

> *GC has done a great job of elevating the level of science in Canada.*
>
> *- International reviewer*

6.1.1 Opinions of Respondents

Respondents believe that there have been strong increases in the quality of Canadian genomics and proteomics research (especially in GE^{3}LS), increasing from roughly good pre-GC to between excellent and world-class now; see exhibit 6.1. Similar increases are seen in quantity: from fair to good pre-GC to excellent now. Note that quality and quantity of Canadian research are both now very similar to those in the international reviewers' countries.

Exhibit 6.1
Canadian genomics research quality and quantity

	Avg Canadian pre-GC	Avg Canadian rating now	Avg rating reviewers' country	N
Quality				
PIs	2.9	4.3	N/A	27
GE^{3}LS	2.5	4.5	N/A	6
Int'l reviewers	N/A	4.3	4.2	20
Total	**2.8**	**4.3**	**4.2**	**53**
Quantity				
PIs	2.6	4.1	N/A	27
GE^{3}LS	2.2	4.2	N/A	6
Int'l reviewers	N/A	3.9	3.9	20
Total	**2.5**	**4.0**	**3.9**	**53**

* Scale: 1 = Poor; 2 = Fair, 3 = Good; 4 = Excellent; 5 = World-class

In achieving this increase in quality and quantity of research, Genome Canada has been seen as an effective or very effective facilitator by 82% of respondents for quality; 91% for quantity, and 76% for becoming a world leader. GE^{3}LS leaders and internationals are especially positive about these effects. See exhibit 6.2

Exhibit 6.2
Effectiveness of GC in achieving increases in research quality and quantity

Impact of GC on:	Very effective	Effective	Moderately effective	Not very effective	Not at all effective	Don't know	N
Quality							
PIs	36%	36%	21%		7%		28
GE^{3}LS	50%	33%	17%				6
Int'l reviewers	52%	43%				5%	20
Total	**44%**	**38%**	**13%**		**4%**		**54**
Quantity							
PIs	29%	46%	21%	4%			28
GE^{3}LS	67%	17%	17%				6
Int'l reviewers	48%	43%	5%			5%	20
Total	**48%**	**43%**	**5%**			**5%**	**20**
Canada becoming a world leader							
PIs	22%	44%	19%	7%	7%		27
GE^{3}LS	67%	33%					6
Int'l reviewers	55%	25%	15%			5%	19
Total	**40%**	**36%**	**15%**	**4%**	**4%**	**2%**	**52**

International reviewers made comments such as:

> *GC funding has been instrumental in raising the level of science in Canada.*
>
> *High level state-of-the-art science with coordination required and supported appropriately*
>
> *In my opinion, Genome Canada has done a wonderful service to Canadian research in promoting and supporting genomics research in many areas of research. It has also provided a critical push toward the study of the legal, ethical, and environmental aspects of genomic research.*
>
> *. . . the focus on specifically Canadian needs, rather than just duplicating what programs in e.g. the US or UK are doing, is a strong point for GC.*
>
> *I'm not sure there are other funding mechanisms for large-scale genomic projects in Canada. Not having any, would place Canada in a poor position internationally with respect to high impact science.*
>
> *As someone familiar with [issues in my sector], the GC approaches have been critical in defining "Canadian" efforts and in facilitating state-of-the-art genomics for topics that could really move forward with this critical support.*

6.1.2 Bibliometric Data

Genome Canada contracted a separate bibliometric analysis of Canadian genomics and proteomics research[25], including research sponsored by GC[26].

Canadian context. This study found that, as context, Canada ranked 5th in genomics behind the US, Switzerland, Netherlands, and UK over 1996–2007, using a multicriteria rating (based on scientific impact, output per capita, number of papers, and specialization in genomics/proteomics). However, over 2001–2007, Canada regained share of world genomics production it had lost over 1993 – 2001. (Note that GC was founded in 2000.)

In the most recent 2005 – 2007 period Canada ranks 6th on this multicriteria rating (having fallen slightly behind, mainly because other countries are investing even more heavily in genomics):

- 5th for scientific impact, both observed and expected (ARIF[27] = 1.25, 1996 – 2007)
- 5th for output per capita
- 6th for number of papers
- 10th for specialization in genomics.

The report concluded:

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[25] *Benchmarking of Canadian Genomics - 1996 – 1997*. Science-Metrix, December 2, 2008.

[26] *Bibliometric Assessment of Research Funded by Genome Canada 1996 – 2007*. Science-Metrix, January 13, 2009

[27] ARIF is the Average Research Impact Factor, an indicator of the global rate of citations of literature in a given field produced by researchers in a particular country. By definition, papers equal to the world average in a given discipline, in a given country, have ARIF = 1.0.

The data presented in this scoreboard show that Canada is an important producer of scientific knowledge in genomics at the international level, and that it has been a solid producer of first-rate science in the last decade.[28]

Genome Canada scientists. GC-funded researchers' papers had significantly higher actual and expected impacts than other Canadian genomics papers, or world papers. GC researchers' production increased faster while funded by GC than when not, and some GC papers were within the top .05% of the most cited genomics papers in the world. In particular:

- GC-supported papers ARIF = 1.50
- Non-GC Canadian genomics papers ARIF = 1.22
- World genomics papers (excluding GC) have ARIF = 1.15

However, there was little difference in average ARIF for individual GC scientists, pre-GC vs. during GC support. This suggested to the authors that most GC impact is because of support for a few outstanding scientists, and production of a relatively small percentage of high impact papers that have had tremendous scientific impact[29].

Comparisons to NSERC bibliometric data. The Natural Sciences and Engineering Research Council (NSERC) recently conducted bibliometric analysis of papers authored in the natural sciences and engineering (NSE) fields[30]. Among these findings were that:

- ARIF in Canadian NSE fields overall was 1.09, or 9th in the world; and
- In the biomedical sciences, Canadian ARIF was 1.08, or 11th in the world.

In comparing these results to those above, one sees that the ARIF of Canadian genomics is well above Canadian NSE and biomedical averages. Although genomics and proteomics research does not fall entirely within either NSE or biomedical fields (especially the former), the results still show that Canada's genomics and proteomics research is of very high quality.

6.1.3 Performance Data

The performance data collected directly by Genome Centres show that at least 3,370 publications and 4,864 conference papers have been produced by GC scientists since GC began. Some differences in how individual Centres collect these data mean that the figures are likely minimums.

6.2 Evaluation Question M1 – Leadership in GE^{3}LS

6.2.1 Opinions of Respondents

Canada's leadership standing in GE^{3}LS research has improved substantially since GC was created, from an average rating of 2.5 (or roughly fair to god) pre-GC, to 3.9 (excellent) now.

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[28] *Op cit.* Science-Metrix, 2008, p. 10.

[29] Op cit. Science-Metrix, 2009, p. 21

[30] *A Review of Canadian Publications and Impact in the Natural Sciences and Engineering, 1996 to 2005, Discovery Grants International Review*. Barney Laciak, NSERC, October 27, 2007. Analysis conducted by the Observatoire des sciences et des technologies.

Exhibit 6.3
Canadian standing in GE^{3}LS research

	Current Canadian Standing		Position before Genome Canada	
	Avg rating*	N	Avg rating*	N
PIs	3.6	21	2.5	20
Plat Ldrs	4.5	4	2.7	3
Int'l reviewers	4.5	4	2.7	3
Total	**3.9**	**41**	**2.5**	**35**

* Rating scale from 1 = poor, to 5 = World Leader.

Genome Canada has, of course, not acted alone in this field; there are several other federal and provincial initiatives that have affected Canada's standing in GE^{3}LS. However, exhibit 6.4 shows that respondents believe GC and the Centres have had a significant impact on this improvement in GE^{3}LS leadership.

Exhibit 6.4
Extent to which Canada's standing in GE^{3}LS is due to Genome Canada (or the Centres)

	Completely due to GC	Mainly due to GC	Partially due to GC	Mostly not due to GC	Not at all due to GC	Don't know	
PIs	4%	29%	29%	7%	7%	25%	28
GE^{3}LS	17%	67%	17%				6
Plt Ldrs	17%	50%				33%	6
Total	**8%**	**38%**	**23%**	**5%**	**5%**	**23%**	**40**

6.2.2 Bibliometric Data

Bibliometric analysis conducted separately[31] concluded that Canada is well positioned in GE^{3}LS, ranking 4th from 1996–2007 on a par with Australia, and behind the US, UK, and Denmark, using multicriteria rating.

In particular, Canada's GE^{3}LS research is:

- 5th in scientific impact, both observed and expected (ARIF);
- 3rd in number of papers produced (notable given Canada's population);
- 5th for output per capita; and
- 6th for specialization in genomics.

6.2.3 European Union Data

In 2006, the European Research Area on Societal Aspects of Genomics (ERASAGE) conducted a study to assess similarities and differences in approaches and themes in the study of the

[31] *Op. cit.* Science-Metrix, 2008.

relationship between genomics and society. The study reviewed the Canadian GE^{3}LS[32] program, focusing on the institutions that fund GE^{3}LS research. This included the programming of the Social Sciences and Humanities Research Council (SSHRC – which is the formal ERASAGE partner organization), Genome Canada and the Canadian Institutes for Health Research (CIHR)[33]. Canada was used as the benchmark country for several other European organizations during the study.

The study reported a very positive assessment of Canada's approach to GE^{3}LS research concluding that GE^{3}LS genomics research is strongly developed in Canada and is firmly embedded in the genomics infrastructure (e.g. genomics life sciences network). "Strongly developed" is defined in the ERASAGE report as organizations having a strong focus on GE^{3}LS genomics research and seeing GE^{3}LS genomics research as something that is part and parcel of other research. Although the analysis completed by ERASAGE does not separately consider each organization's individual activity but rather sums the constituent parts, it is clear that Genome Canada has affected the Canadian model and played a major part in the positive findings and elevated status of GE^{3}LS activities in Canada.

The report specifically singles out the following aspects of Genome Canada:

- Identified as one of the main funding bodies of GE^{3}LS research.
- Identified as having a separate, dedicated GE^{3}LS genomics program (i.e., organized competitions)
- Identified as having built a strong GE^{3}LS genomics infrastructure.

6.2.4 Evaluation Question M2 – Integration of GE^{3}LS Considerations in Large-Scale Genomics Projects

Respondent data. Another factor in Canada's ability to lead in GE^{3}LS is that GE^{3}LS considerations must be integrated into its large-scale projects. Almost half the study respondents believed that Canada has done this well or very well. Note that exhibit 6.5 shows that internationals see this integration as considerably stronger than do Canadian researchers, and that the internationals also see Canada's GE^{3}LS integration as being better than is done in their own countries.

Exhibit 6.5
Degree of GE^{3}LS integration into large-scale GC genomics projects

	Very well	Well	Adequately	Poorly	Very Poorly	Don't know	N
Integration in Canada							
PIs	4%	31%	23%	15%	8%	19%	26
GE^{3}LS	17%	17%	33%	33%	-	-	6

[32] Ethical, legal, social aspects (ELSA) is the term used in the ERASAGE report. This is analogous to the term GE^{3}LS used by Genome Canada. We have chosen to use GE^{3}LS to be consistent with the terminology used by Genome Canada.

33 Other organizations were also researched including the Stem Cell Network (a Networks of Centres of Excellence) and the Natural Sciences and Engineering Research Council (NSERC) – but the aforementioned three were the main focus.

Plt Ldrs	-	33%	33%	-	-	33%	6
All researchers	***5%***	***29%***	***26%***	***16%***	***5%***	***-***	***38***
Int'l reviewers	19%	52%	14%	-	-	14%	21
Total	10%	37%	22%	10%	3%	17%	59
Integration in Int'l reviewers' countries							
Int'l reviewers	5%	24%	14%	33%	10%	14%	21

Respondents commented that the stand-alone GE^{3}LS projects were the more conceptual in nature while GE^{3}LS components integrated into the large-scale genomics projects tended to be more practical in nature.

Interim report review. The study team also conducted an analysis of the interim review reports completed by the International Scientific Review Committees (ISRC)[34]. This was a source of third-party, independent review information completed for each project[35]. We reviewed all interim review reports available for Competition I (Comp I), Competition II (Comp II), Applied Human Health (AHH), Competition III (Comp III) and the Genoma España/Genome Canada Joint Program Competition (GE). In total 108 projects were assessed. It should be noted that prior to Competition III, there was no specific requirement for GE^{3}LS aspects to be addressed in research proposals.

This review concluded that GE^{3}LS considerations are integrated into GC projects to a large extent. More than half the projects were rated as showing medium or high integration when N/A and NI projects were not included[36]. The review found that Comp I, II and III projects all have integrated GE^{3}LS considerations. However, the ISRCs frequently noted issues with Applied Human Health projects and none of the Genome España projects had GE^{3}LS components.

Exhibit 6.6
Rating results for degree of GE^{3}LS integration in Genome Canada projects, excluding N/A and N/I

	GE^{3}LS	
High/Medium	44	57%
Low/None	33	43%
Total	**77**	**100%**

[34] Ratings were based on evidence that the research team had thought about and identified the significant GE3LS implications of the research; and that they had analyzed or were analyzing these and developing an appropriate plan to deal with them as required (including potential modification of the research program). A standard set of criteria was established and used to assess the ratings.

[35] All other reports (i.e., proposal submissions, interim reports, and final reports) are essentially prepared by the PIs.

[36] N/A is "not applicable" and NI is "not enough information to rate".

The results are still reasonable even when N/A and NI projects are included. Still more than a third of Genome Canada projects rate high/medium in GE^{3}LS integration. Results are found in exhibit 6.7.

Exhibit 6.7
Rating results for degree of GE^{3}LS integration in all Genome Canada projects

	GE^{3}LS	
High/Medium	44	41%
Low/None	33	31%
N/A	27	25%
NI	4	4%
Total	**108**	**100%**

6.2.5 Discussion of GE^{3}LS Integration

Having noted these positive findings about GE^{3}LS integration, there are still difficulties on this score. On one hand, international reviewers clearly see GE^{3}LS integration as a key defining characteristic of GC, and very valuable. Several cited problems associated with *not* getting the general public "on board" early enough with controversial research topics, and commended GC for attempting this with GE^{3}LS.

On the other, GE^{3}LS leaders commented that they are often not as integrated into genomics science projects as they could be. They observed that they were sometimes "thrown together" with genomics scientists, with insufficient time for real teams to form, or to develop research themes in an "organic" way. They further commented that collaborations among the GE^{3}LS scientists themselves were often accidental and usually regional, not national[37]. Several GE^{3}LS leaders felt isolated from each other, or noted the need for more internal capacity in their field, including the need for more collaborative projects with students and postdoctoral fellows. Some noted they received little feedback from rest of the GC community, which limited their ability to help the genomics researchers and create applications.

[37] Possibly due to it being perceived as better to lead a small regional project, than simply participate in a larger national one.

On the genomics scientists' part, a significant number were not very convinced of the usefulness of GE^{3}LS. These topics were often considered a "tax" on the science, and suffering from the GE^{3}LS leaders not understanding genomics sufficiently well, a possible over-emphasis on ethical aspects (with not enough on socio-economic and environmental factors), and overall not being seen to have much impact on Canadian genomics credibility (though, as noted earlier, many of the internationals would not agree). It was noted, however, that GE^{3}LS topics that *were* well-integrated with the science did, in fact, work well and were useful. (And one genomics researcher pointed out that this benefit flows both ways –GE^{3}LS researchers obtain access to top genomics scientists world-wide, which would be very difficult without their GC involvement.)

The study team notes that GE^{3}LS integration requires a "cultural shift" on the part of both genomics researchers and GE^{3}LS leaders; thus some delay in achieving full effectiveness is not unexpected.

7. Findings on Evaluation Question 5 – Access to Science and Technology Platforms

7.1 Platform Access and Policies

The GC scientists rated general information, and policies and procedures for eligibility and access as moderate to good at most S&T platforms.

Exhibit 7.1
Ratings* of S&T platform information, policies, and procedures

	Bio-informatics	BC GSC	McGill Innovation Centre	TCAG	BC Prostate Centre and Microarray	UVic/GBC Proteomics
(a) Information regarding the platforms (services, pricing, policies)						
PIs	2.7	4.1	3.5	3.8	3.7	3.6
Plt Ldrs	5.0	5.0	4.7			5.0
N	9	12	10	8	9	10
(b) Policies and procedures regarding eligibility of users						
PIs	2.9	3.7	3.4	3.6	3.7	3.6
Plt Ldrs	5.0	5.0	4.7			4.5
N	7	12	7	10	9	8
(c) Policies and procedures regarding access (i.e., priorities)						
PIs	2.9	3.5	3.4	3.8	3.8	3.4
Plt Ldrs	5.0	5.0	4.3			3.5
N	7	11	10	7	9	8

** Rating scale from 1 = Poor, to 5 = Excellent.*

The S&T platforms' pricing, IP policies, and support personnel were rated as moderate to good at most platforms; see exhibit 7.2.

Exhibit 7.2
Ratings* of S&T platform pricing, IP policies, and support personnel

	Bio-informatics	BC GSC	McGill Innovation Centre	TCAG	BC Prostate Centre and Microarray	UVic/GBC Proteomics
(d) Policies and procedures regarding pricing						
PIs	3.3	3.8	3.5	4.2	3.7	3.4
Plt Ldrs	5.0	5.0	4.3			4.0
N	5	10	10	6	7	7
(e) Guidelines regarding intellectual property						
PIs	2.9	3.4	3.4	3.7	3.3	4.0
Plt Ldrs		5.0	5.0			4.0
N	4	10	8	6	4	6
(f) Availability and effectiveness of support personnel						
PIs	2.8	4.1	3.5	3.7	3.7	3.1
Plt Ldrs	5.0	5.0	5.0			3.5
N	8	12	9	7	8	8

** Rating scale from 1 = Poor, to 5 = Excellent.*

7.2 Technical and Operational Capabilities of the S&T Platforms

Genome Canada's genomics scientists rated both the technical and operational capabilities of the S&T platforms as good to excellent at most platforms: the GSC is excellent, though Bioinformatics is fair to good.

Exhibit 7.3
Ratings* of technical and operational capabilities of the S&T platforms

Platform	Average Ratings							
	Technical capability			N	Operational capability			N
	PIs	Plt Ldrs	Total		PIs	Plt Ldrs	Total	
Bioinformatics	2.7	4.0	*2.9*	10	2.5	5.0	2.8	9
BC GSC	4.2	5.0	*4.3*	14	4.0	5.0	4.2	14
McGill Innovation Centre	3.7	4.3	*3.9*	11	3.6	4.0	3.7	11
TCAG	3.7	-	*3.7*	7	3.4		3.4	7
BC Prostate Centre and Microarray	3.4	-	*3.4*	9	3.2		3.2	9
UVic/GBC Proteomics	3.7	4.5	*3.9*	10	3.5	3.5	3.5	8

** Rating Scale: 1 = Poor; 2 = Fair, 3 = Good; 4 = Excellent; 5 = World-class*

7.3 Genome Canada's Impact on S&T Platforms

Canadian genomics research infrastructure is now better or much better than what was available prior to Genome Canada being created, and GC has had a strong effect on this. First, over 80% of respondents believe Canadian genomics research infrastructure is better or much better than what was available previously,

Exhibit 7.4
Adequacy of Canadian genomics research infrastructure compared to pre-Genome Canada

	Much better	Better	About the same	Worse	Much worse	Don't know	N
PIs	37%	48%	7%	-	-	7%	25
GE^{3}LS	17%	83%	-	-	-		6
Plt Ldrs	100%		-	-	-		6
Co-fund and RG	43%	29%	-	-	-	29%	15
Total	**43%**	**40%**	**3%**	**-**	**-**	**13%**	**52**

Other organizations (especially the Canada Foundation for Innovation and individual provinces) have also invested heavily in genomics research infrastructure. However, exhibit 7.5 shows that respondents considered GC to be directly or indirectly responsible[38] for much of the change to Canadian genomics research infrastructure, though these other organizations also important. This effect includes GC's impact on creation of state-of-the-art platforms, plus the ability to use them through research support and (to a more moderate extent) through improvements on centralized infrastructure planning and avoidance of redunancies.

[38] For example, by encouraging these other organizations to invest in genomics and proteomics research.

Exhibit 7.5
Ratings* of influence of Genome Canada and other organizations on change in Canadian genomics research infrastructure

	Direct Impact of GC and Centres	Direct Impact of Other Orgs (e.g., CFI)	Indirect impact of GC and Centres on other orgs	N
Quality of the infrastructure				
PIs	3.8	3.8	3.2	21
GE^{3}LS **	3.8	3.0	3.0	6
Plt Ldrs	4.3	4.5	4.8	4
Total	**3.9**	**3.8**	**3.4**	**31**
Quantity of the infrastructure				
PIs	3.8	3.8	3.0	20
GE^{3}LS **	3.6	3.0	3.3	4
Plt Ldrs	3.8	4.2	4.8	4
Total	**3.8**	**3.7**	**3.3**	**28**
Ability to use the infrastructure (e.g., operating funds, salaries)				
PIs	3.6	3.2	3.0	19
GE^{3}LS **	4.0	3.3	3.2	6
Plt Ldrs	4.3	1.6	4.0	4
Total	**3.8**	**2.9**	**3.1**	**29**
Integration of infrastructure across Canada (e.g., because of centralized planning)				
PIs	3.0	2.8	2.4	18
GE^{3}LS **	2.5	2.3	2.3	4
Plt Ldrs	3.0	2.2	3.8	4
Total	**2.9**	**2.6**	**2.6**	**26**
Avoidance of redundancies (e.g., because of large-scale projects)				
PIs	3.1	2.8	2.8	15
GE^{3}LS **	4.2	2.6	2.8	4
Plt Ldrs	3.6	1.8	3.0	4
Total	**3.4**	**2.6**	**2.8**	**23**

* *Rating Scale: 1 =Very low, to 5 = Very high*
** *GE^{3}LS leaders only commented on GE^{3}LS infrastructure*

7.4 Barriers to Effective or Efficient Use of S&T Platforms

The Platform leaders saw no important barriers to effective or efficient use of the S&T platforms.

Exhibit 7.6
Extent of barriers seen by Platform leaders* to effective or efficient use of platforms

	Very large barriers	Large barriers	Moderate barriers	Small barriers	Very small barriers	Don't know	N
Effective use	-	-	17%	33%	17%	33%	4
Efficient use	-	-	20%	40%		40%	3

** Only Platform leaders were asked this question*

7.5 Discussion of the S&T Platforms

Respondents saw the S&T platforms seen as a key strength and success of GC. Many respondents also commented that large-scale platforms are still needed where new technologies and/or research problems are being addressed – e.g., when dealing with huge amounts of complex information. However, a number commented that the genomics research landscape has changed dramatically since GC was created:

- Many research projects can now be done much more easily, quickly, and cheaply, using more inexpensive infrastructure;
- Breakthroughs in research questions and research methods arise very quickly; and
- The international genomics research community is intensely networked and is instantly aware of opportunities arising.

As a result, the "one size fits all" national platforms may not work so well in future, being relatively slow, rigid, and with the successful ones said to be overbooked[39].

These changes appear to be creating a greater need for platform service speed, and flexibility of topics addressed and methods used. Examples given were the ability to respond to highly specific problems posed by researchers, to sometimes use non-model systems (i.e., species not routinely used as models), to better serve smaller research projects (and/or non-GC researchers), or to better foster intense team interactions. (The latter includes more interactions of researchers with the platform technicians; it was commented that the user community is sometimes unsophisticated regarding the infrastructure capabilities, and more training and knowledge transfer would be welcomed.)

[39] *This was not directly investigated in this study.*

The S&T platforms require continual upgrading (rather than occasional big upgrades) to remain competitive, and some research needs might be served well through platforms of more modest size, cost, capabilities, throughput, and overhead. It was commented that "service model" platforms tend to work best when the technology is relatively stagnant, which is not the case for genomics and proteomics. In all cases, the need for high quality control and accountability was stressed. Although there is probably some role for web-based tools, it is still unknown exactly how to make them successful (or exactly who wants to use them, and how).

One final point mentioned is that the current research program and platform models do not make it easy to store and maintain important genomics resources developed through individual research projects once those projects are over; e.g., novel animal models, reagents, libraries, informatics, etc. There are no GC funds specifically for maintaining such resources, even though they may be valuable for other research projects in future.

8. Findings on Evaluation Question 6 – Potential Socio-Economic Benefits

8.1 Involvement of Researchers in Developing Socio-Economic Applications

Almost 80% of respondents have been actively involved in developing practical socio-economic (S-E) applications of the GC research.

Exhibit 8.1
Percent of respondents* who have actively explored practical applications

		N
PIs	74%	27
GE^{3}LS	100%	6
Plt Ldrs	100%	6
All researchers	82%	39
Co-fund and RG	68%	19
Total	**78%**	**58**

*Note: GE^{3}LS leaders asked about GE^{3}LS research only. Co-funders and granting organizations were asked about of the use of GC-supported research by their own organizations (including in their own research design, or as subsequent funders of genomics research).

Many methods are being used for knowledge transfer and technology transfer, as seen in exhibit 8.2. Both types of mechanism appear equally important – the study teams notes that this is critical, as experience has shown that "traditional technology transfer" (i.e., through patents, licenses, and spin-offs) usually only reflects a small proportion of the important mechanisms for generating S-E benefits[40]. It is also worth noting that it is not only the genomics scientists involved in developing practical S-E applications; so too do GE^{3}LS and platform leaders, and the organizations providing co-funding or other genomics research grants (but using GC research results in some way).

[40] See, for example: *Review of Best Practices for the Assessment of S&T Impacts – Summary Report.* Prepared for: National Research Council of Canada. KPMG, August 10, 2008.

Exhibit 8.2
Percent of respondents* Involved in S-E applications

	PIs	GE^{3}LS	Plt Ldrs	Co-F and RG	Total
Invited presentations, w/shops at user organizations	64%	67%	43%	43%	**55%**
Forming new research consortia, networks, etc.	46%	67%	71%	48%	**52%**
New product/process development	46%	17%	57%	43%	**44%**
Major health R&D projects	21%	67%	43%	38%	**34%**
Consultation, "first point of contact" service, etc.	14%	50%	57%	38%	**31%**
Data or services (e.g., testing, analysis) for users	14%	50%	57%	33%	**29%**
New standards, regulations, codes of practice, etc.	29%	67%	29%	19%	**29%**
Contract research	21%	17%	43%	29%	**26%**
Major industrial R&D projects	25%	-	43%	29%	**26%**
Input into models (e.g., ecosystems)	4%	17%	29%	14%	**11%**
Other	7%	17%	14%	-	**6%**
N	28	6	7	21	**62**

** In all tables in this section, we assumed that non-respondents were not developing any S-E applications.*

Many sectors are involved, and many examples of potential applications were given during interviews with researchers. Some of these are further discussed in section 8.5. Roughly a quarter of respondent have already applied their research or are engaged in active development for public policies or programs, and about 43% for health care, as seen in exhibit 8.3.

One point was raised regarding the interaction between co-funding requirements and creation of these S-E applications. It was noted that Canada's relatively small industrial sectors means that there are not ready sources of private capital or of receptor capacity for leading-edge research results. Thus the co-funding requirement is seen by a number of respondents as somewhat of a mis-match with the Canadian situation, or with the need to support open research to provide a strong foundation for technology transfer (presuming, of course, that one agree such a need is valid).

Exhibit 8.3
Percent of respondents* Involved in S-E applications related to public policies/programs, and health care

	Already applied	In active development	Possibilities being explored	No applications planned*	N
New or improved public policies or programs (including improved regulations, standards, codes of practice, decision tools, etc.)					
PIs	14%	7%	14%	64%	28
GE^{3}LS	17%	50%	17%	17%	6
Plt Ldrs	14%	14%	29%	43%	7
Co-fund and RG	10%	10%	24%	57%	21
Total	**13%**	**13%**	**19%**	**55%**	**62**
New or improved health care protocols, diagnostics, prognostics, therapeutics, etc.					
PIs	4%	21%	18%	57%	28
GE^{3}LS	17%	17%	-	67%	6
Plt Ldrs	29%	14%	43%	14%	7
Co-fund and RG	10%	19%	19%	52%	21
Total	**15%**	**29%**	**29%**	**27%**	**62**

* Note that discussion of S-E applications was not required for Comp I and Comp II applications.

Exhibit 8.4 shows that roughly a third of respondents have already applied their research or are engaged in active development through traditional technology transfer for commercial products, and about 40% are engaged in knowledge transfer related to commercial applications. Note that discussion of S-E applications was not required for Comp I and Comp II applications, and a number of the respondents were commenting on projects funded during those competitions.

Exhibit 8.4
Percent of respondents* Involved in S-E applications related to technology transfer or knowledge transfer

	Already applied	In active development	Possibilities being explored	No applications planned*	N
Direct technology transfer for new or improved commercial products, processes, or services (e.g. patenting, copyrights, licensing etc.)agreements, spin-off companies					
PIs	25%	14%	11%	50%	28
GE^{3}LS	-	17%	-	83%	6
Plt Ldrs	57%	14%	-	29%	7
Co-fund and RG	10%	14%	29%	48%	21
Total	**21%**	**15%**	**15%**	**50%**	**62**
Indirect technology and knowledge transfer for new or improved commercial products, processes, or services (e.g., trade secrets, tacit knowledge, etc.)					
PIs	11%	29%	11%	50%	28
GE^{3}LS	17%	-	33%	50%	6
Plt Ldrs	43%	29%	14%	14%	7
Co-fund and RG	14%	19%	10%	57%	21
Total	**16%**	**23%**	**13%**	**48%**	**62**

* See text

Exhibit 8.5 shows that roughly 20% of respondents have already applied their research, are engaged in active development for best practices and for environmental benefits, and about a quarter for other types of societal benefits.

Exhibit 8.5
Percent of respondents* Involved in S-E applications related to best practices, environmental benefits, or other societal benefits

	Already applied	In active development	Possibilities being explored	No applications planned*	N
Best practices in manufacturing, organizational structure, healthcare, etc.					
PIs	4%	7%	4%	86%	28
GE^{3}LS	50%	-	-	50%	6
Plt Ldrs	14%	14%	43%	29%	7
Co-fund and RG	10%	14%	10%	67%	21
Total	**11%**	**10%**	**10%**	**69%**	**62**
Environmental benefits (e.g., reduced harmful impacts, improved ecosystem)					
PIs	7%	11%	11%	71%	28
GE^{3}LS	17%	-	17%	67%	6
Plt Ldrs	14%	-	43%	43%	7
Co-fund and RG	14%	5%	5%	76%	21
Total	**11%**	**6%**	**13%**	**69%**	**62**
Other societal benefits (e.g., better teaching methods, community planning, social structure, economic reform, justice system, etc.)					
PIs	7%	11%	11%	71%	28
GE^{3}LS	33%	17%	-	50%	6
Plt Ldrs	43%	-	14%	43%	7
Co-fund and RG	10%	10%	14%	67%	21
Total	**15%**	**10%**	**11%**	**65%**	**62**

* Note that discussion of S-E applications was not required for Comp I and Comp II applications.

8.2 Evaluation Question M2 – Integration of Socio-Economic Considerations in Large-Scale Projects

It is the intent of GC and the Centres to incorporate consideration of S-E within its large-scale projects as one means to ensure such impacts actually occur. (It should be noted that prior to Competition III, there was no specific requirement for S-E aspects to be addressed in research proposals.) Over 40% of respondents believed that Canada has integrated S-E considerations well or very well into its large-scale genomics research projects. Note that exhibit 8.6 shows that internationals see this integration as considerably stronger than do Canadian researchers, and that the internationals also see Canada's S-E integration as being better than is done in their own countries.

Exhibit 8.6
Degree of S-E integration into large-scale genomics projects

	Very well	Well	Adequately	Poorly	Very poorly	Don't know	N
Integration in Canada							
PIs	4%	22%	30%	22%	4%	19%	27
GE^{3}LS	-	33%	50%	17%	-	-	6
Plt Ldrs	17%	-	50%	-	-	33%	6
All researchers	*5%*	*21%*	*36%*	*18%*	*3%*		*39*
Int'l reviewers	19%	52%	14%	-	-	14%	21
Total	**10%**	**32%**	**28%**	**12%**	**2%**	**17%**	**60**
Integration in Int'l reviewers' countries							
Int'l reviewers	5%	14%	33%	24%	10%	14%	21

Interim report review. The study team also conducted an analysis of ISRC interim reviews as described in section 6.2.4, but in terms of integration of S-E considerations[41].

Review findings. More than two thirds of Genome Canada projects have integrated socio-economic considerations to a medium/high extent.

	Socio-Economic	
High/Medium	56	68%
Low/None	26	32%
Total	**82**	**100%**

Still more than half of projects rated high/medium when N/A and NI projects included.

	Socio-Economic	
High/Medium	56	52%
Low/None	26	24%
N/A	19	18%
NI	7	6%
Total	**108**	**100%**

[41] Ratings were based on evidence that the research team had thought about and identified the potential applications of the research outside of the research community and the resulting potential SE impacts; and the research team had some plan—or had carried out some activities—to increase the likelihood that these applications will occur, e.g., dissemination of results to the user community, involvement of users in the conduct of the research, etc.

Integration was lower in the first two competitions, but this is to be expected as GC was building capacity. Following implementation of S-E conditions for Comp III, the average rating of integration increased as expected. Less expected was that the Applied Human Health projects rated lower in spite of their supposedly applied emphasis; however, the AHH competition was run before Comp III, so possibly this is also part of a learning curve, even though AHH projects were intended to have applications within five years. (The ISRCs specifically noted that S-E strategies were not effectively integrated or not in place for several AHH projects.)

8.3 Performance Metrics

Performance data related to traditional technology transfer collected by the Centres are shown in exhibit 8.7.

Exhibit 8.7
Technology transfer metrics

Item	Number
Revenue from licenses and royalties	$3,051,500
Number of companies formed	15
Number of patent applications	202
Number of patents issued	53
Number of invention disclosures	196
Number of licenses granted	19
Number of material transfer agreements*	69
Number of copyrights*	32

** Minimum – missing GQ*

8.4 Bibliometric Data

Bibliometric analysis[42] of Canadian data related to technology transfer indicated that Canada in excellent position to reap S-E benefits of genomics:

- Over 1996 – 2007, Canada ranked 2nd behind the US in multicriteria score based on four indicators of technological production:
  - 2nd for number of citations its patents received;
  - 3rd for number of patents per capita;
  - 3rd for specialization index; and
  - 5th for number of patents

In particular, Canada took 1st place in the multicriteria ranking of leading countries for their IP in genomics in the most recent 3-year period (2005–2007), as a result of an increase in number of patents and average relative citations.

[42] Op. cit. Science-Metrix, 2008.

8.5 Discussion of Benefit-Cost Case Studies

A concurrent partial benefit-cost analysis is being conducted of a sample of GC research projects and their actual or potential practical applications. These results are not yet publically available. However, the table below summarizes the cases under review, of which the first four have been selected for more intensive analysis. The discussions have been left deliberately general, since many of these are in active development.

Project or Theme	Importance and Nature of Benefits	
	Opportunity	Public Good Benefits
Colorectal Tumors (ARCTIC)	Personalized medicine based on a genomics-based colon cancer risk prediction tool.	New diagnostic and therapeutic methods, earlier detection of disease, reduced risk of death and disability, reduced health care costs
Novel Rapid Molecular Theranostic Technologies for Nucleic Acid Detection	Development of molecular diagnostic tests, rapid Point-Of-Care tests, to detect certain specific, common, and serious pathogens.	Easy to use, no special skill required, rapid detection. Allows treatment highly specific to the infectious agent, reduced use of unnecessary antibiotics.
ARBOREA II – Genomics for molecular breeding in softwood trees	Molecular marker development for tree breeding (targeting growth and forest productivity (yield) and wood quality, to enhance value recovery from plantations of forest trees.)	Faster tree growth, reduced disease, higher annual yield. Help sustain Canadian forest industry
Genotype-specific approaches to Therapy in Childhood (GATC)	Identification of adverse drug reaction (ADR)-predictive genetic markers, incorporation into diagnostic tools to provide personalized dosing recommendations based on an individual's genotype to predict and prevent ADRs in children.	Reduced risk of death and disability. Personalized medicine based on genomic markers, allowing improved health outcomes, improved patient safety, reduced health care costs, reduced serious long-term disabilities. Several important ADRs identified.
Enabling technologies for proteomics and genomics research	Development of novel instrumentation and ancillary equipment for research community	Improved diagnostic capabilities, earlier health intervention
GRASP - Atlantic Salmon	Provide resources for understanding the genome of Atlantic salmon.	Contribute to policy decisions regarding stock assessment and harvesting plans. Enhance conservation and enhancement of wild stocks
Genomic approach to identify fungal enzymes for industrial and environmental applications	Applications for fungal enzymes for utility in industrial applications and processes across numerous industries	Many potential industrial applications.

Project or Theme	Importance and Nature of Benefits	
	Opportunity	Public Good Benefits
Autism	Diagnosis using genetic markers. Database development, information generation/distribution	Early diagnosis of disease, better health care outcomes.
Functional Annotation of Essential Alternatively Spliced Isoforms	To annotate and analyze splice isoforms of genes expressed in certain specific cancers. (Splice variants used as disease markers)	Early diagnosis of disease, more accurate prognosis, targeted therapies for personalized medicine,
BAC CGH development -- Application of pharmacogenomics for rational chemotherapy of cancer	Utilize genomic methods to identify DNA signatures that can predict treatment failure, identify patients for novel therapy trials, and provide data for discovery of molecular targets for development of new anticancer drugs to overcome drug resistance.	Improved health benefits, reduced risk of death and serious disability, reduced health care costs.
GrapeGen	Establish genomic resources for gene and protein discovery associated with grape berry quality traits.	Improved industry competitiveness
Structural Genomics Consortium	Determine the three dimensional structures of proteins of medical relevance, and place them in the Protein Data Bank without restriction	New drug development – many potential applications.
Microbial Envirogenomics	Elucidate and exploit the physiology and functioning of environmentally important bacteria	Treatment for contaminated soil Improved human health (e.g., therapeutics for tuberculosis)
Haplotype Map of the Human Genome	Develop public database of for four human populations, generate tag SNPs, develop genotyping technologies, analytical tools and ethical guidelines for large scale population studies.	Improved heath and disease diagnostic capabilities.
Fibre optic nucleic acid (FONA) biosensor based gene profiling	Development of diagnostic technologies to provide high throughput platform (lower cost, more informative, more broadly adoptable)	Reduced cost and time for diagnosis of disease (presymptomatic and potentially prenatal), timely prevention of spread of pathogens in both heath care and food safety systems.
High resolution analysis of certain specific cancer genomes	Identifying genomic rearrangements certain cancers, and progress to more serious stages, and their effect on gene structure and gene expression	Targeted testing and treatment of cancer, with knowledge of drug response and potential toxicity.

The conclusion from these cases is that many of the GC projects are likely to lead to transformative impacts on society. Many of the furthest along of these are in health care, especially for personalized medicine, which will revolutionize the way many illnesses and

diseases are diagnosed and treated. However, there are also many other potential applications in a variety of industries, and several also have important environmental implications. Applications in the resource industries are expected to be especially important, such as fisheries (including aquaculture), forestry, and agriculture.

9. Findings on Evaluation Question 7 – Incrementality

9.1 Likelihood of Project Proceeding in Absence of Genome Canada

Fewer than 15% of PIs believed their GC projects would have been likely, or very likely, to be supported at similar resource levels by other organizations such as the university granting councils, the Networks of Centres of Excellence, etc., if GC did not exist. Platform leaders were slightly more positive about the possibility of obtaining infrastructure support from other sources, but over 70% still considered this possibility highly unlikely.

Exhibit 9.1
Likelihood of similar support from other sources, in absence of GC

	Very likely	Likely	Somewhat likely	Not very likely	Not at all likely	Don't know	N
Research projects							
PIs		7%	7%	30%	48%	7%	27
GE^{3}LS		-	-	67%	33%	-	6
Plt Ldrs		-	29%	14%	57%	-	7
Total		**5%**	**10%**	**33%**	**48%**	**5%**	**40**
Platform infrastructure*							
Plt Ldrs		-	29%	-	71%	-	7

**Platform leaders were asked separately about the chances of conducting similar research, and of developing similar research infrastructure, through other funding sources.*

Exhibit 9.2 shows that co-funding organizations would likely support a small to modest proportion of similar projects in absence of GC, but it is very unlikely that they would provide all the required funding. Only 15% of co-funding organizations believed it was completely likely, or very likely, that the GC project for which they provided co-funding would have gone ahead (perhaps with additional support from other sources). And only 10% thought it very likely they would have borne the entire cost themselves – none thought it completely likely.

Exhibit 9.2
Likelihood of support from co-funding organization or other genomics granting agency, in absence of GC

	Completely likely	Very likely	Moderately likely	Not very likely	Not at all likely	Don't know	N
Likelihood project would go ahead	5%	10%	33%	38%	10%	5%	21
Funded entirely by their organization	-	10%	10%	14%	62%	5%	21

9.2 Changes to Projects if Supported by Non-Genome Canada Sources

If there were no GC, but the same funding were available from other sources (though few respondents believed this would be possible), the researchers believed there would be several negative impacts:

- Less communication and collaboration within community;
- Less sharing within research and user community;
- Less cohesion in research topics; and
- No large-scale or integrated GE^{3}LS projects (this would be especially important, of course, for the GE^{3}LS leaders).

On the other hand, researchers also believed there would be some positive impacts:

- Less project management, red tape, and bureaucracy;
- Better, more efficient, long-term fundamental science;
- No need for GE^{3}LS integration (this would be a benefit in the view of about three-quarters of the genomics scientists); and
- No need for co-funding. About three-quarters of the GC researchers would prefer this as well – again, assuming funding through normal council sources and no additional management or reporting being required – though some recognized the political need for co-funding given the large research project funding amounts.

10. Findings on Evaluation Question 8 – Attraction and Retention

10.1 Attraction

A quarter of all PIs surveyed changed jobs in past 5 years – 70% from another Canadian institution, 20% from industry or government, and 10% from a US institution. GC was an important or very important factor in changing jobs for about a quarter of genomics researchers, but three-quarters of Platform leaders.

Exhibit 10.1
Importance of GC in researchers' deciding to move to current position

	Very important	Important	Somewhat important	Not very important	Not at all important	Don't know	N
PIs	14%	14%	-	14%	57%	-	7
GE^{3}LS	-	-	-	-	-	-	0
Plt Ldrs	50%	25%	25%	-	-	-	4
Total	**27%**	**18%**	**9%**	**9%**	**36%**	**-**	**11**

10.2 Retention

Nearly half the GC researchers have considered taking another position in past five years but did not, and nearly a third had received firm offers. Note that exhibit 10.2 shows that GE^{3}LS and Platform leaders were especially likely to have considered a move, and GE^{3}LS leaders were especially likely to have received a firm offer.

Exhibit 10.2
Percentage of researchers considering taking a different job position in past five years*

		N
Considered taking different job position		
PIs	33%	27
GE^{3}LS	67%	6
Plt Ldrs	67%	6
Total	**44%**	**39**
Received firm offer		
PIs	20%	25
GE^{3}LS	75%	4
Plt Ldrs	33%	6
Total	**29%**	**35**

* Or since respondent had accepted current position, if shorter.

Despite this, these respondents had not moved, and GC was an important or very important factor in staying for about half the respondents overall, and for three-quarters of the GE^{3}LS

leaders and 80% of the Platform Leaders. Given the many other factors involved (e.g., remuneration, living environment, research climate in the university), this is a strong finding.

Exhibit 10.3
Importance of GC for researchers' staying in current job position

	Very important	Important	Somewhat important	Not very important	Not at all important	Don't know	N
PIs		36%	27%	27%	9%		11
GE^{3}LS	25%	50%	25%				4
Plt Ldrs	60%	20%				20%	5
Total	**20%**	**35%**	**20%**	**15%**	**5%**	**5%**	**20**

11. Findings on Evaluation Question M3 – Co-funding and Leveraging

A detailed report[43] is available on co-funding. Here we present a brief summary.

11.1 Introduction

GC – through the activities of the Genome Centres and individual researchers – has exceeded Industry Canada's requirement of obtaining 50% or more of the total eligible project costs as co-funding from other sources. Co-funding can be secured from various sources including other federal, provincial, and municipal government departments and agencies, private firms, institutions, or foreign organizations.

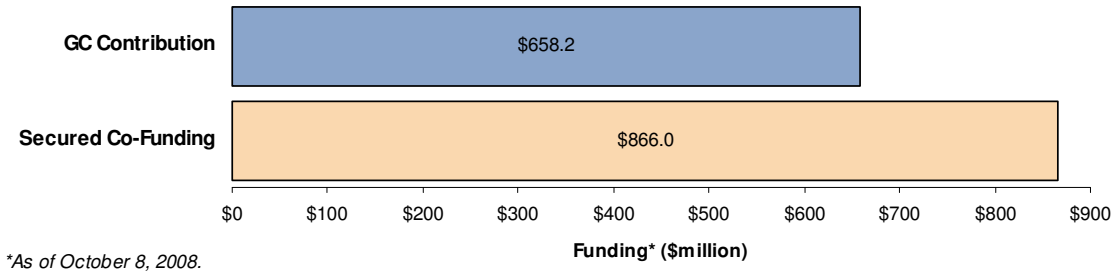
The financial information included in this section is as of October 8, 2008 Additional co-funding may be received and/or committed over time right through to the end of the term of each approved project. Further, additional co-funding will have been raised for all projects approved subsequent to October 2008.. To simplify the writing of this chapter, we have used the past tense, even though some of the projects and funding are still on-going.

11.2 Findings

GC has exceeded Industry Canada's requirement of providing a maximum of 50% of the total eligible project costs.

The total genomics research funding (i.e., GC direct funding plus secured co-funding) is roughly $1,524 million, or 2.3x the GC funding alone.

Exhibit 11.1
Co-funding compared to Genome Canada contribution

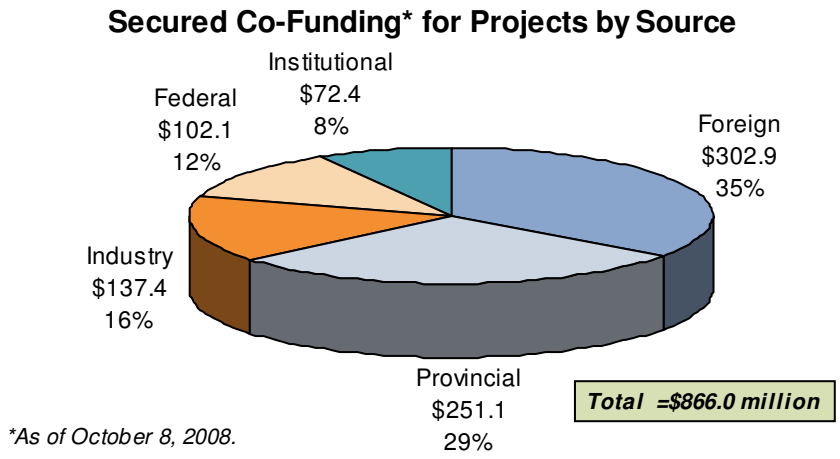


**As of October 8, 2008.*

[43] Op. cit. KPMG LLP, March 2, 2008.

Foreign and provincial sources are the most likely sources of co-funding, as seen in exhibit 11.2

Exhibit 11.2
Sources of co-funding



11.3 Other Leveraged Funding

Leveraged funds seen in exhibit 11.3 are those that - although not directly applied to a GC project – would not have been raised if Genome Canada funding had not been available; e.g., (1) Funding used to support a complementary research program of an industry partner; or (2) Additional research contracts or grants received by the project team to support complementary research. Note that leveraging is a "ripple effect" of GC, that would not happen without GC's existence. Note also that leveraged funding is separate from – and additional to – co-funding.

Exhibit 11.3
Additional resources leveraged by the Centres

Leveraged cash resources for genomics research	$283,537,997
Leveraged in-kind resources for genomics research*	$ 7,010,113

** Minimum, missing data from several Centres*

Leveraged resources are not auditable. However, such ripple effects are important impacts of S&T investments, and are often substantial[44]. These performance data from the Centres show that their leveraged resources (especially cash), have been substantial, being roughly a third of the total co-funding.

[44] The Canada Foundation for Innovation, for example, includes leveraged resources when considering the impacts of its investments through its new Outcome Measurement Studies.

In other words, the total Canadian genomics research investment associated with GC (i.e., direct GC funding, plus co-funding, plus leveraged resources) has been roughly 2.8x the GC contribution alone.

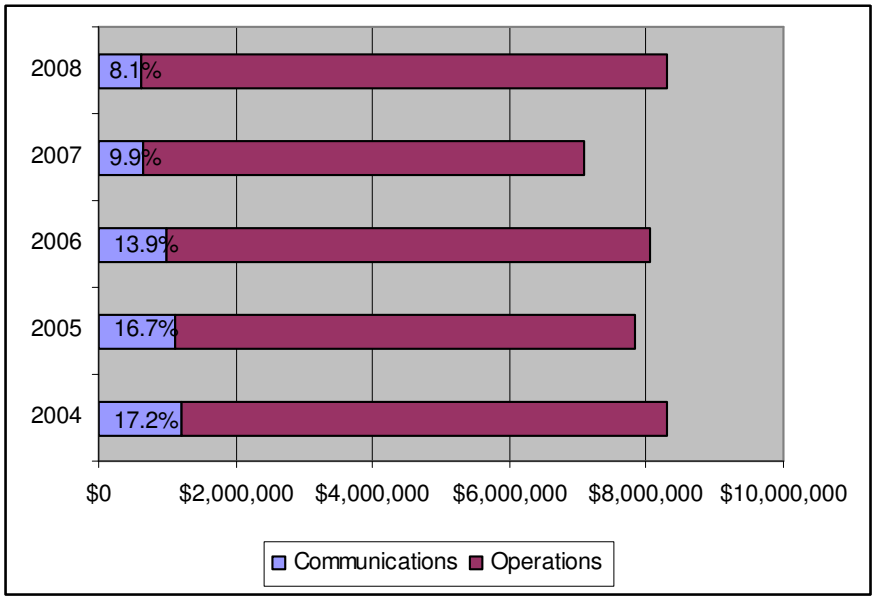
12. Findings on Evaluation Question M4 - Communications

A detailed report[45] is available on communications activities. In section 12.1 we present a brief summary, following by evaluation findings in section 12.2.

12.1 Communications Activities

Both GC and individual Centres undertake communications and outreach. GC's communications budget alone has been about $4.5 million over the past five years. (Data are not available on the Centres' budgets.) There has been a steadily declining trend from 2004 through 2008 in communications expenditures as a percentage of operational expenditures (from 17% to 8%), as seen in exhibit 12.1. When considered as a percentage of general and administrative expenditures, however, (i.e., excluding costs of grants and awards, peer review, workshops and symposia, and GE^{3}LS), communications and outreach have been about 18% of this sub-set of expenditures since 2000, and 19% over the past five years, declining from about 27% in 2004 to 13% in 2008.

Exhibit 12.1
Genome Canada's communication budget as a percentage of operational expenditures



[45] Op. cit. KPMG LLP, March 2, 2008.

Exhibit 12.2
Overview of communications activities undertaken by Genome Canada

Media Relations	Public and Educational Programs/ Special Events	Multimedia (Website and Electronic Communications)	Publications and Advertising	External Relations (Government Affairs, Business and International Development	Scientific Community
▪ One-on-one meeting with media ▪ News releases ▪ News conferences ▪ Sponsorship of Scientific Conferences ▪ Webcasts	▪ "GEEE in Genome Exhibition" Phase 1 and 2 Youth Science Fair Sponsor ▪ Sanofi-Aventis Biotalent Challenge Sponsor ▪ Public screenings of the movie "The Score"	▪ Corporate website Media page ▪ Webcasts ▪ Publicly available databases (e.g., financial, projects) ▪ Content development ▪ Graphic/creative design ▪	▪ Annual Report ▪ Corporate Plans ▪ GE^{3}LS Newsletter ▪ Specific ads in targeted magazines	▪ Genomics on the Hill ▪ Press conferences each year with the Minister of Industry, or the Secretary of State. ▪ Sponsor Biotech Week ▪ International Funders Forum	▪ National and International Conferences, symposiums and workshops

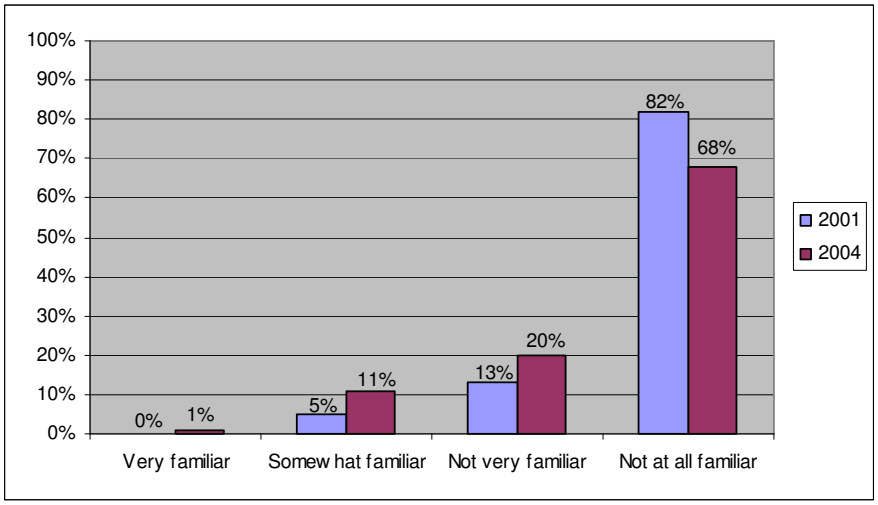
The Centres collaborate closely with GC, and undertake some activities – especially outreach – even more extensively than does GC. Each Centre has its own Communications Director who is responsible for developing the Centre's communication plan, to be approved by the Centre's President and Board of Directors. Although individual Centre's communications plan are not directly tied to that of Genome Canada, monthly conference calls are held with GC and two face-to-face meetings are held with GC each year as a way to ensure that the Centres are linked into the national communications and outreach program and determine any gaps that need to be addressed. Some Centres undertake a broad spectrum of communications and outreach activities using custom delivery mechanisms and very innovative methods to reach their target audiences.

12.2 Effectiveness of Communications

A separate study of GC's impact on public perception[46] found that public familiarity with Genome Canada has improved since 2001, there having been a 7% increase in the number of general public being somewhat familiar or very familiar with GC, and a 14% decrease in members of the general public not at all familiar with GC. See exhibit 12.3.

[46] *Canadians' Perceptions of Genomics and Proteomics Research: A Quantitative-Qualitative Study of Public Opinion*. EKOS Research Associates Inc., October 2004

Exhibit 12.3
Public familiarity with Genome Canada



Source: EKOS, 2004

This evaluation found that co-funders and other genomics research granting agencies find communications generally effective – especially at the Project and Centre level. At the GC level, effectiveness is more moderate. Outreach by the Centres and GC was also effective. (Understandably, little outreach is done at the project level.) See exhibit 12.4.

Exhibit 12.4
Co-funder and research granting organizations' opinion* of communications and outreach

	Very effective	Effective	Moderately effective	Not very effective	Not at all effective	Don't know	N
Communications:							
By GC	10%	19%	33%	10%	19%	10%	21
By the Centres	10%	38%	24%	14%	-	14%	21
By the Project Leaders	33%	33%	19%	5%	-	10%	21
Outreach:							
By GC	5%	33%	24%	-	5%	33%	21
By the Centres	10%	43%	19%	-	-	29%	21
By the Project Leaders	24%	19%	14%	-	-	43%	21

**As the main recipients of communications, only co-funders and research granting agencies were asked this question.*

13. Findings on Evaluation Question 9 – Alternative Delivery Models and Processes

13.1 Possible Changes to Genome Canada's Model

Comments made by GC researchers, co-funders, other Canadian genomics research granting organizations, and the international reviewers, suggest that the existing GC model is a strong one. However, some refinement is possible; key points are listed below.

Possible Model Changes

- Keep (and ideally strengthen) existing support for basic science
- Clarify the roles of Centres
  - Relative to GC
  - Encourage more collaboration among them
  - Encourage more focus on regional research program development, rather than administrative matters
  - Many PIs (and some reviewers) would suggest either disbanding the Centres, or giving them real authority (i.e., full partners in funding decisions and disbursements)
- Review the existing Platform model in the light of the changing genomics research environment; e.g.:
  - Provide support for continual upgrades and needs analysis, technology development, quicker turnaround, and more support for small science projects;
  - Support more research and technology development projects done collaboratively between genomics scientists and platform technologies.
  - Support some smaller platforms where the technology has moved to allow small-scale infrastructure to be effective, inexpensive, and have lower overhead.
- Use longer project timeframes to help make large-scale projects more effective, and help keep research teams together over a longer time period.
  - It was noted that the existing four-year time frame is very short for building a research team, getting multidisciplinary or cross-disciplinary collaboration working properly, running the project, and winding it down (especially for dealing with student support)

Possible Process Changes

- Simplify and harmonize the reporting requirements where feasible – note that individual Centres have their own reporting requirements in addition to GC's
- Increase interactions between PIs and GC – reason to think PIs lack understanding of GC's role and activities

- Simplify and speed up the interim review process, or eliminate it and rely more on Scientific Advisory Committees – it was believed by researchers that a major interim review after two years was simply too soon.
- Speed up the identification of strategic opportunities
  - The Position Paper process, although highly consultative, is too lengthy to address quickly emerging opportunities
- Improve access for smaller, less expensive projects
  - Changes to genomics now allow $1 – 3M projects to be important
  - There tends to be a mid-sized "hole" in this range that neither GC nor the granting councils support (i.e., this is not a GC issue alone)
- Better integrate GE^{3}LS leaders and projects into genomics science programs and projects
- Commercialization still needs strong focus, accountability, and management
  - But realistic timeframes are critical, and must be understood by GC and Industry Canada.

13.2 Review of Other Genomics Funding Models

13.2.1 Introduction

The findings discussed in section 13.1 are bolstered by the results of the international comparisons. KPMG reviewed 11 other major genomics funding models used world-wide. The characteristics of these other organizations are summarized in Appendix A. As may be seen there, a very wide variety of models is used. Each organization is notably different in terms of mandate, strategic planning, nature of research, focus (of lack thereof) on S-E applications, funding levels, co-funding requirements (or lack thereof), governance, oversight and accountability, reporting, etc. None is exactly equivalent to Genome Canada's model, nor is there any obvious "best practice" being used world-wide. There is reason to believe that each model responds to the unique characteristics of the host nation (see section 13.2.2).

13.2.2 View of Genome Canada by International Funding Agencies

Representatives of some of these international genomics funding agencies were asked their view of GC's model.

STRENGTHS: Key positive points made about the GC model were those below. Note that all respondents believed GC was being very effective at coordinating both Canadian research and international collaborations. GC was noted as "hitting well above its weight".

- There appears to be strong alignment of GC's research clusters to domestic economic generators
  - This includes "legitimacy" derived from government and public knowledge about a focus on S-E impacts
  - There is a strong strategic focus
  - There are strong links to regional needs
- The structure of the research projects allows GC to build on strengths flowing from each phase of research. There appears to be "excellent project coordination".

  - This is assisted by the size of the large-scale projects, which allow effective effort to be made in important areas.
- GC is seen as a catalyst for international collaboration.
  - This is fostered by its centralized coordination of Canadian research effort (as opposed to individual researchers creating collaborations one by one).
- Strong due diligence and accountability, with very strong ability to ensure the research meets high performance and quality standards.

POTENTIAL WEAKNESSES: There were some concerns voiced, primarily those below. (Note that although there are more potential weaknesses than strengths listed, this does not imply that the international representatives believe the model is weak overall; the reverse is the case – GC is seen as having a very strong model.)

- The decentralized relationship of GC with Genome centres might impede integration of cross-sectoral research. (Though the international respondents appreciated that GC's model responds to Canada's unique geographic and economic diversity. The study team notes that GC's model is a unique attempt to marry the benefits of centralization (chiefly rigour and consistency) without its usual flaws (usually an inability to respond effectively to differing regional needs).
- There was concern that there is no avenue to support open competition for discovery research, within the recent focus on targeted competitions.
  - Projects which do not have an obvious immediate application, or which do not fit easily within the established strategic framework, may be difficult to support.
- Limited continuity in funding can be disruptive to development of a pan-Canadian strategy
  - This is exacerbated in applied work by short project timeframes, which do not mesh well with the long time required from research to application
- Although respondents were generally less knowledgeable about how Genome Canada delivers its programs, some notable comments were:
  - As projects become larger, more complex, and more international in scope there may be a need for GC to evolve from a model of supporting projects through Genome centres, to taking a more centralized role in overseeing and leading the projects
- This is a point for further discussion – it was also noted that larger-scale (and especially, centralized) projects are less flexible and responsive to changing situations or emerging opportunities.
- And the international view is not necessarily same as the Canadian one.
  - GC might focus less on the requirement for co-funding in international collaborations, as this can impede collaboration.

IMPROVEMENTS SUGGESTED: Improvements suggested by these respondents include:

- Establish an open competition mechanism.
  - This would enable those projects that have eminent scientific relevance but which are not aligned to identified areas of focus to continue
  - [Note that this has always been a part of GC's strategy, and they have requested funding for such a competition]
- Combine due diligence and site/scientific review process into a single peer review process. (Genome Canada has already done this.)
- Continue to push at high political levels for greater continuity in funding.
- Continue to focus on measuring performance against technology transfer outcomes and patent generation indicators. (The study team notes that – although important – these traditional technology transfer mechanisms are only part of the means of generating strong S-E benefits, depending on the sector involved.)

14. Conclusions

14.1 Achievements

Transformative impact: There has been a transformative impact of Genome Canada on Canadian genomics research. GC has made Canada a visible and respected world player – Canada is "on the map", with the quantity and quality of Canadian genomics research having markedly improved, mainly due to GC. GC's large-scale projects and GE^{3}LS emphasis are both envied internationally, and co-funders and international reviewers also like Canada's strategic coordination. The research projects are inclusive of highly diverse disciplines and types of projects

The results show that the existence of GC is important for attraction of faculty members, but even more so for retaining them. Further, the researchers and Centres have been successful in raising substantially more total funding than GC directly provides. The total genomics research funding (i.e., GC direct funding plus secured co-funding) is roughly $1,524 million, or 2.3x the GC funding alone, or 2.8x if leveraged resources are included.

Overall, the rationale for Genome Canada remains strong and important.

Platforms a key to GC success: All but one of the Platforms are successful, and some are outstanding. They provide efficient, large-scale infrastructure available to GC researchers across Canada, with excellent technical and operational capability, good staff, and usually offering timely service. The S&T platforms are seen by both Canadian and international scientists as essential to the science, especially for large projects, and GC has successfully coordinated genomics infrastructure across the country. Good training is also offered at most platforms.

GE^{3}LS emphasis sets Canada apart from most of world: Although GE^{3}LS inclusion is not unique to Canada, GC's inclusion of both large-scale GE^{3}LS projects and incorporation of GE^{3}LS concerns within genomics projects is a feature not seen in other countries. When it works, it works well, adding significant value to certain kinds of genomics research and to outside parties (e.g., policy makers, regulators), and also increasing the access of GE^{3}LS researchers to world-class genomics scientists and projects. International reviewers – in addition to noting other positive impacts – note that GE^{3}LS is useful for getting the general public "on board" early on with sensitive research topics.

Transformative practical applications: Genomics is about to transform many aspects of society. The most obvious of these are in health care, in particular personalized medicine – the ability to assess an individual's risk of disease, and discern the most effective (and least harmful) treatment options based on each individual's genomic and genetic make-up. In addition, identification of diseases and pathogens will be greatly simplified and speeded up through these technologies, allowing greater ability to target the right problem with the right therapeutics, and avoiding the time and cost associated with using the wrong therapies and pharmaceuticals. In addition, there are many industrial and environmental applications being investigated, several of which are critical to Canada's resource industries such as fisheries (including aquaculture), forestry, and agriculture.

General GC model works well: Genome Canada employs a hybrid program model, attempting to marry the best features of centralized models (chiefly rigour and consistency) with those of decentralized models (usually a quicker and more effective ability to respond to differing regional needs). The evaluation has shown that when this works, it works very well, but that success depends on the skills and professionalism of individual Centres. and the quality of the individual partnerships between GC and each Centre.. (The study team notes that both fully centralized models and fully decentralized ones often suffer substantial problems, so the existence of some problems within GC' s hybrid model is not unexpected. However, these findings suggest that the model is working and has excellent potential, but requires refinement.) On the GC side, the organization is seen as politically astute, and the international reviewers are impressed with its corporate diligence and commitment to Canadian genomics. On the regional side, most of the Centres are useful and helpful, providing effective links to GC, strong regional strategic development, liaison with partners and the community, and good networking. The best Centres have responsive and helpful management and staff, and assist scientists to prepare applications, find co-funding, developing and manage practical applications, as well as conducting outreach. In essence, good Centres "ask a lot, but give a lot in return." The findings thus indicate that this hybrid model can work, and work well.

14.2 Qualifications

While the findings show that Genome Canada has been highly successful in its mission and continues to have a strong rationale, and that the underlying model is sound, there are some features that could be refined. All of the points below are of some importance. However, the study team emphasizes that the relatively lengthy list does not point to serious problems within GC – only that GC exists within a complex and rapidly changing situation.

Changing genomics research landscape: The genomics research landscape is in rapid transition everywhere. The pace of research and technology development is extremely rapid, and the community is intensely networked and very quickly aware of arising issues and opportunities. As a result, more flexible, speedy, and responsive research and platform models may be required. A case in point is the need for a quicker way than the present Position Paper process to identify new strategic opportunities.

S&T platform model: This point is a corollary of the one immediately above. As the research landscape has changed, so too has the type of research infrastructure needed to support it. It has been suggested that the platforms would benefit from refinements such as continual upgrades and needs analysis, more technology development, quicker turnaround, more support for small science, and more of a collaborative (rather than service) model. Possibly, some smaller platforms would suffice for some types of research, and there should perhaps be more access for non-GC researchers

There is also currently one Platform that is clearly less effective than the others.

Role of GC vis-à-vis the Centres: As noted above, GC employs a hybrid model, part centralized and part decentralized. However, not all PIs convinced of the utility of the Centres. The Centres' roles are somewhat unclear (especially because GC has the ultimate funding authority), and the extra layer of bureaucracy and "micromanagement" imposed by some of the Centres is disliked, sometimes intensely (although it is likely that scientists underestimate the degree of management, reporting, and accountability mechanisms required to successfully operate large-scale research programs). Further, some Centres are viewed as less effective, adding less value and not being as responsive or flexible to the scientists' or partners' needs.

Finally, although there is a "G7" group that helps communication and coordination among the six Centres and GC, respondents commented that even more coordination among Centres would be welcomed.

Relationship of Canadian genomics scientists to Genome Canada: For many evaluation questions, the Canadian genomics scientists are less convinced of the importance, effectiveness, and utility of GC than are the GE^{3}LS leaders, Platform leaders, co-funders, other genomics research granting agencies, or the international community. In the study team's experience, this is quite unusual.

This may be an unexpected negative impact of a relatively uncommon feature of GC – in an effort to avoid conflict of interest within the small Canadian genomics community, it only uses international reviewers to assess research proposals. Many of these internationals have been involved in many GC Competitions, and have a very positive view of GC and its mission. But for Canadian scientists, GC is much more of a "black box", and they frequently comment that they don't really understand why or how GC conducts it business. A certain level of mistrust appears to exist, and this lack of a direct, strong connection between GC and its main client community almost certainly affects the issue of the role of GC vs. the Centres noted above.

GE^{3}LS integration: This has not always been effective, or liked by the genomics scientists. Incorporation of GE^{3}LS concerns in the genomics projects is still often forced, and without sufficient interactions and feedback. To some degree this probably reflects insufficient capacity within the GE^{3}LS community itself, while in other cases it probably reflects the short time frame of the large-scale projects, which makes it harder to get multidisciplinary and cross-disciplinary teams to "gel" (if we may coin a phrase). In the experience of the study team with other similar initiatives (e.g., within NCE networks), this is a far from unusual set of problems. However, it is a serious concern here – as it is for other programs – since it inhibits the best multidisciplinary science from being done, and the most effective use of the results.

Most S-E impacts still in early development phases: While genomics is clearly on track to have transformative practical impacts, these are mostly in very early stages. (This is true not just in Canada.) As usual, the heath sector and biologics have especially lengthy "D" times, requiring all the usual due diligence, lengthy human trials, and substantial investments, but with an even longer "R" phase since genomics is still in a heavy research phase. Thus realistic expectations are critical for all concerned.

Support for basic research: An important corollary to the point above is that Canada must provide strong and ongoing support for basic, untargeted, curiousity-driven research. All respondents, Canadian and international alike, emphasized that there will be no practical applications of research without a strong base of fundamental knowledge to support them. Such open competitions could easily be run within a portfolio concept, for example providing a certain proportion of funding for targeted projects, and a certain proportion for free research.

On this score, the co-funding requirement also causes some problems. In addition to consuming considerable amounts of time for the scientists to secure it, this requirement tends to drive the research towards topics that are relatively near-term and relatively applied, reducing focus on the underlying base of knowledge. Further, Canada's relatively small industrial sectors means that there are not ready sources of private capital or of receptor capacity for leading-edge research results. Thus this requirement is seen as somewhat of a mis-match with the Canadian situation, or with the need to support open research (presuming, of course, that one agree such a need is valid).

Mid-sized project support: Although not investigated in detail, it was suggested that there is currently a gap between GC and the granting councils in support for smaller genomics projects, say in the $1M – 3M range (i.e., this is not a GC issue alone).

Support for long-term resources. The current research and platform models do not make it easy to store and maintain important genomics resources developed through individual research projects once those projects are over; e.g., novel animal models, reagents, libraries, informatics, etc. There are no GC funds (or granting council funds) specifically for maintaining such resources, even though they may be valuable for other research projects in future.

There may be need for more scientific capability within GC: This was not investigated in detail, but some key respondents raised this issue with respect both to genomics science and research infrastructure capabilities.

Project timeframe. The four-year timeframe is believed by many respondents to be too short for such large-scale projects. It was pointed out that it is difficult to design the project, build a team, purchase or build research infrastructure, conduct the research, and wind down the project in a well-planned and efficient manner when under this time pressure. It is also difficult to involve graduate students if the project ends before their thesis research is finished, and to keep the research team together for future projects.

APPENDIX A – International Comparison

Appendix A – International Comparison of Genome Canada to other Similar Organizations

Attribute	Australia	Denmark	France	Japan	Nether-lands	Norway	Singapore	Spain	Sweden	UK	US	Canada
Part I: Organizational Structure												
Name of organization	Commonwealth Scientific and Industrial Research Organization (CSIRO)	Danish National Research Foundation	Genomics research programs of the French Ministry of Research	Omics Science Centre (formerly Riken Genome Science Centre)	Netherlands Genomics Institute	The Research Council of Norway	Genome Institute of Singapore (GIS)	Genome España	The Karoliska Institute	Wellcome Trust	National Human Genome Research Institute	**Genome Canada**
Mandate and objectives (primary focus)	Economic and social benefits	Research discovery	Public policy	Research discovery	Economic and social benefits	Economic and social benefits	Economic and social benefits	Economic and social benefits	Social benefits (health)	Social benefits (health)	Social benefits (health)	Research and socio-economic benefits
Legal structure	Crown authority	Non-profit	Ministry	Institute within government authority	Institute within government authority	Institute within government authority	Institute within government authority	Non-profit	University	Non-profit	Institute within government authority	Not for profit
Research role	Funder and researcher	Funder and researcher	Funder	Researcher	Funder and researcher	Researcher	Researcher	Funder	Researcher	Researcher	Funder	Funder

Attribute	Australia	Denmark	France	Japan	Nether-lands	Norway	Singapore	Spain	Sweden	UK	US	Canada
Organizational structure	16 research clusters	30 research centres	Multiple centres and networks	No research centres.	10 research centres	3 research clusters	Internal research. No research centres.	Central agency supporting 4 research regions.	Internal research centres to the university (unknown number)	Internal research. No research centres.	Central agency supporting research centres (unknown number)	Central agency supporting 6 regional research management centres
Annual genomics funding (CDN$)	Unknown	$46.5m	$65m	$250m	$90m ($450m over 5 yrs)	Unknown	Unknown	$30m	Unknown	$980m ($150m directly tied to genomic sequencing)	$605m	Average $200m p.a. from 2000 – 2009
% from gov't	60%	100%	N/A	92%	N/A	N/A	N/A	85%	N/A	N/A	N/A	50%
Governance	Board of directors	Board of directors	Management team	Advisory council	Board of directors	Advisory council	Advisory council	Board of directors	Board of directors	Board of directors	Advisory council	Board of directors
Part II: Strategic Focus												
Research themes	Applied	Fundamental	Applied and fundamental	Fundamental	Applied	Applied	Applied	60% fundamental, 40% applied	Applied	Applied and fundamental	Applied and fundamental	Mix of basic and strategic
Research identification process	National research goals	Internal / strategic planning	Internal / strategic planning	Internal / strategic planning	Research business cases	Internal / strategic planning	N/A	External planning (input from industry)	Internal / strategic planning	Internal / strategic planning	Internal / strategic planning	External strategic planning from stakeholders

Attribute	Australia	Denmark	France	Japan	Nether-lands	Norway	Singapore	Spain	Sweden	UK	US	Canada
Resource allocation process	Strategic plan	Bottom-up	N/A	N/A	Strategic plan	N/A	N/A	Bottom-up	N/A	N/A	Bottom-up	Strategic envelopes; bottom-up for projects
Linkages with domestic research	High	N/A	High	N/A	High	Moderate	Moderate	Moderate	Moderate	High	High	High
Linkages with international research	High	Low	Moderate	Moderate	Moderate	Low	Low	Low	High	High	Low - project by project and no formal agreements	Moderate
Part III: General Operations												
Reporting process to funders	Annual report	N/A	N/A	Annual report	Annual report	Budget submission	Budget submission	Bi-annual report to Board of Directors	Annual report	Annual report	Annual report	Annual report
Reporting process to stakeholders	Outreach centres, publishing and sponsored post-graduate research	Varies by centre	N/A	Symposia for practitioners	Focus on education with general public	Newsletters and networking	Advisory council	Conferences and informal communication with practitioners	Publishes own scholarly journal	Publications and public engagement projects	Public engagement, scholarly publications, and networking	Extensive communications & outreach by both GC and regional Centres
Part IV: Research operations												

Attribute	Australia	Denmark	France	Japan	Nether-lands	Norway	Singapore	Spain	Sweden	UK	US	Canada
Organization by large-scale projects	N/A	N/A	N/A	High	N/A	Moderate	Low	High	N/A	High	High	High
Project identification and selection methods	Long-term planning	Open call and peer review	Open call and peer review	Long-term planning	Open call and peer review	Open call and peer review	Internal planning	Open call and peer review	N/A	Open call and peer review	Open call and peer review	Specific competitions and peer review
Research funding method	Co-funded	Co-funded	Co-funded	Sole sourced	Co-funded	Case by case	Case by case	Co-funded	Co-funded	Co-funded	Varies: Internal projects: sole-sourced; External projects: co-funded	Co-funded
Avg. % of co-funding	30%	N/A	N/A	0%	30%	N/A	N/A	30% (moving to 50%)	High (no exact number)	N/A	N/A	50%
Platform and infrastructure support	Central technology facility	N/A	N/A	Central technology facility	Multiple technology facilities	Investment in centres and projects	Located within	Negotiated fees with existing research institutes	N/A	Extensive - new facility also under construction	Several facilities	Extensive, regionally-based but available Canada-wide

Attribute	Australia	Denmark	France	Japan	Nether-lands	Norway	Singapore	Spain	Sweden	UK	US	Canada
Oversight and accountability	Scientific review	Service agreement with centres	N/A	Annual economic and scientific progress reporting.	Bi-annual project reviews	Online progress reporting	Annual progress review	Bi-annual internal review	N/A	N/A	Bi-annual peer review	Mix of GC central requirements and Centre individual project management
Research dissemination method	Publishing (own) and networking	N/A	N/A	Publishing, networking	Varies by centre	N/A	Meetings with practitioners	N/A	Scholarly publication, networking	Scholarly publication and networking	Scholarly publication and networking	Scholarly publication and networking
Technology transfer	High: Equity in 30 ventures	N/A	No valuation exists	High: Equity in 24 ventures	Moderate: 14% of budget, equity in 4 ventures	N/A	Moderate	Moderate: equity in 8 ventures	High: equity in 40 ventures and 30 license agreements	Moderate: Sanger Institute has no focus on this, while the Wellcome Trust has 3 commercial programs	High	Moderate; see text

Attribute	Australia	Denmark	France	Japan	Nether-lands	Norway	Singapore	Spain	Sweden	UK	US	Canada
Return on investment	High: $80m (2007-08)	N/A	N/A	Low: $3m (2007-08)	None	N/A	N/A	Moderate: receive 10-20% of patent royalties	High: usually receives 40% holding in royalties or equity	N/A	Low	N/A (benefit-cost study in progress)