DECODING THE GENOME CANADA RESEARCH NETWORK: AN INSTITUTIONAL ANALYSIS

by

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Abstract

The rise of high-technological innovations in the mid- to late- 20th and early 21st centuries has required the establishment of equally innovative agencies and institutions to guide these technological innovations. This thesis examines the emergence and evolution of Genome Canada, which was created to oversee the proliferation and direction of genomic research within Canada. This thesis examines how genomic research developed in Canada throughout the late 1980s to early 2000s, why it became necessary to create Genome Canada, how the networked model chosen was seen as the preferred model, and how Genome Canada has evolved to date.

This case study of Genome Canada is important because it reveals how public institutions that guide innovation emerge and how they evolve over time. As well, it is important because it reveals how the model used in the genome policy sector may be used again in the future as a framework for establishing other similar institutions.

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List of Acronyms

GCRN: Genome Canada Research Network
ACOA: Atlantic Canada Opportunities Agency
AMGGI: Atlantic Medical Genetics and Genomics Initiative
MDEIE: Québec Ministère du Développement économique, de l'Innovation et de l'Exportation
WCVNET: Western Canadian Vaccine Network
CFGI: Canadian Flex Genomics Initiative
CBGN: Canadian Brassica Genomics Network
SIGNet: Social Impacts of Genomics Network

Chapter 1: Introduction

1.1 Purpose, Objectives and Research Questions

As technology becomes more pervasive within our lives and enters areas that engender public concern, governance systems have a responsibility to become involved in regulating the processes and products of technologically based research projects. This is especially true when the research conducted has not only substantial potential for bettering human life but also potentially dangerous or unpredictable side effects. One such case is genomic research. Decoding the very blueprints of life has struck both the imagination and the fears of people in our society. Genomic research has been undertaken for well over a half century now, and the results are beginning to unlock exciting new areas of possible technological development that engender both hopes and fears, some examples of projects currently underway include understanding cancer genomics, Autism genomics to even potato genomics.[1] This has led governments, as well as academic institutions and private sector agencies to determine key features of the governance and funding system of such programs. In Canada, this has led to the creation of a genome research network consisting of a national agency and several regional centres. While the national agency is primarily responsible for fostering, facilitating and funding genome research in Canada, the core mandate of the regional centres is to develop and maintain the research infrastructure and to manage the research.[2] For purposes of this thesis, Genome Canada and the regional centres are collectively referred to as the 'Genome Canada Research Network' (GCRN).

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[1] Genome Canada, "Health Projects": http://www.genomecanada.ca/en/portfolio/project/health.aspx
[2] Genome Canada, "Vision-Mission-Mandate": http://www.genomecanada.ca/en/about/vision.aspx and Genome Canada, "Regional Centres": http://www.genomecanada.ca/en/centres/

Genomics is the science of understanding how genes interact with each other and their environments to make living things do what they do.[3] By manipulating genetic sequences scientists can change a biological being in some significant ways. Examples of such genomics research covers a spectrum of different research portfolios from understanding how immunity to infectious diseases works, how to grow hardier and more productive crops, how to make forests resistant to disease and even how to develop new, cleaner sources of energy.[4] The importance of this research is its ability to impact humanity at a very fundamental level whether it be through the foods that we eat, the methods through which we produce energy or our own ability to fight off diseases.

The central purpose of this thesis is to provide an overview and analysis of the effects that federalism have had on the configuration, governance, operation, and research agendas of the Genome Canada network. Toward that end, several interrelated research questions are addressed.

1. How and why was Genome Canada created?
2. How is Genome Canada governed?
3. How is the regionalized genomic research network structured?
4. When, how and why were the regional centres created?
5. How are the regional centres governed?
6. What is the research focus of each regional centre?
7. How is the genomic research network funded?

The first two questions are addressed in Chapter 2 (The Genesis and Governance of Genome Canada), the subsequent four research questions are addressed in Chapter 3 (Structure, Governance & Research Foci of Regional Genomic Network), and the last question is addressed in Chapter 4 (Resourcing the Canadian Genomic Research Network).

[3] Genome Canada, "What is Genomics", http://www.genomecanada.ca/en/info/DNA/genomics.aspx.
[4] Ibid.

1.2 Theoretical Perspectives: (The Influences of Canadian Federalism on Canadian Genome Research)

While interesting and important in their own right, the answers to these questions provide some valuable insights on the effects of Canadian federalism on Canadian genomic research. In particular, they provide insights on the effects that federalism has had on the emergence and evolution of the structure, research agenda, and funding of the GCRN.

Co-operative and Competitive Federalism

This thesis is informed both by the two theoretical perspectives and two models of factors that shape policy and program initiatives within Canadian federalism. The two perspectives are the socio-centric and state-centric perspectives, and the two models are collaborative and competitive federalism. Whereas the socio-centric perspective postulates that policy and program initiatives are the products of societal factors, the state-centric perspective postulates that such initiatives are the products of state or governmental factors.[5] Invariably, both of these perspectives profile state and societal institutions and interests in explaining policy and program initiatives. These perspectives point to two alternative sets of factors to focus on in explaining determinants of policy and program initiatives. It is important to note that they are not mutually exclusive, and focusing on a combination of factors highlighted by each of these two perspectives provides a fuller and more accurate description of the factors that influence policy and program initiatives. Within the context of this case study, attention is devoted to the

[5] Alan C. Cairns, "The Governments and Societies of Canadian Federalism", Canadian Journal of Political Science, Vol. 10, No.4 (Dec., 1977), pp. 695-725.

effect that factors highlighted by these two theoretical perspectives had on the genesis, configuration, operation, and funding of the GCRN.

In explaining policy and program initiatives, analysts also tend to employ, either explicitly or implicitly, the collaborative and competitive models of federalism. Whereas the former explains policy and program initiatives as the products of collaboration between the senior orders of government, the latter explains them as products of competition between them.[6] While these two ideal type models provide us with valuable insights, in practice many policy and program initiatives are products of a combination of collaboration and competition among two or more of those governments. It is with that in mind, that this thesis devotes attention to patterns of collaborative and competitive federalism in relation to key aspects of the emergence, evolution, operation and funding of the GCRN.

Networked Federalism

Another useful framework for analyzing the GCRN within the context of the Canadian federal system is 'networked federalism'. This framework is based on the notion that all organizations are made up of nodes, and that nodes are responsible for the generation of information and decision making within organizations regardless of their precise configurations. Janice Gross Stein postulates that such nodes exist within the following four general categories of organization:

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[6] On Cooperative Federalism: Anthony Harold Birch, Federalism, Finance, and Social Legislation in Canada, Australia, and the United States (Oxford: Clarendon Press, 1955), pg. 33.
Fred Cutler and Matthew Menddolen, *Canada* in Explaining Federalism: State, Society and Congruence in Austria, Belgium, Canada, Germany and Switzerland edited by Jan Erk (London; New York: Routledge, 2008), pg. 47.
On Competitive Federalism: Ronald L. Watts, *The MacDonald Commission Report and Canadian Federalism*, Publius, Vol. 16, No. 3, The State of American Federalism, 1985 (Summer, 1986), pg. 195.

- Tribes: These are generally kin-based organizations that are relatively closed and self-sufficient and are usually very difficult for others to access or engage.
- Markets: These are multi-organizational entities in which more than one organization or agent is involved in decision-making and the transactional activities related to it. Each organizational entity has its own decision making nodes and operates within the context of markets that are relatively open and accessible for a wide range of organizations to operate either on their own or in collaboration with others.
- Hierarchies: These are vertically linked or integrated bureaucratic organizational frameworks. In a highly hierarchically structured organization, generally information travels from the bottom to the top and decisions travel in the other direction. Hierarchies are susceptible to what Gross Stein refers to as 'bottlenecks' caused by failures to ensure that information and decisions flow without disruptions.
- Networks: These are organizational frameworks consisting of a multiplicity of organizational entities and a multiplicity of organizational nodes that, unlike hierarchies, are not structured in a highly regimented and inflexible hierarchical manner.

Ideally networks permit nodes to communicate with each other regardless of their relative position in the organization. A failure in one node is mitigated by the information or decision being horizontally routed through other branches of the network. Flexibility and redundancy allow for rapid adaptation to sudden changes in the network.[7] Gross Stein

[7]Janice Gross Stein, *Networked Federalism* from Canada: The State of the Federation 2006/07 Transitions: Fiscal and Political Federalism in an Era of Change, pg. 347.

applies these principles to federalism by explaining that government bureaucracies have traditionally behaved as hierarchies but are progressively moving and should strive to behave more like networks. She adds that today it is imperative to foster and facilitate the opening of policy space to non-governmental organizations and to encourage cooperation between governmental bureaucracies. Something that Gross Stein only seems to infer, rather than explicitly say, is that it seems reasonable to presume hierarchies and networks may coexist within a single organization. As this thesis reveals, this certainly seems to be the case with Genome Canada.

Triple Helix Model

In analyzing some aspects of the organization and operation of the GCRN, this thesis also relies on the Triple Helix model, specifically Triple Helix II. The Triple Helix is an important analytical tool when considering research and development initiatives involving the government, academia and industry. The use of the Triple Helix helps analysts identify key actors who perform key roles in establishing and operating research and development systems. The Triple Helix model is detailed more fully at the beginning of Chapter Two. Here it suffices to note that the Triple Helix model is an analytical concept produced to capture the relationships between key sets of players commonly involved in knowledge generation and dissemination systems. Unlike the double helix of the genetic code (on which the concept is based) which has two genetic strands, the triple helix has three key organizational strands.[8]

The three organizational strands of importance within the triple helix that are likely to be very significant within the knowledge generation and dissemination systems

[8] This paragraph is a paraphrase of the Triple Helix model from Peter W. B. Phillips, Governing Transformative Technological Innovation: Who's in Charge? (Cheltenham, UK; Northampton, Mass.: Edward Elgar, 2007), pg. 41.

are the government helix, the industry helix and the academic helix. As the names suggest the government helix is made up of governmental agencies and agents, the academia helix is made up of universities and research agencies and agents that co-exist within the public and private sectors, and the industry helix is made up of private sector commercial or industrial agencies and agents that are generally presumed to be involved for some venture capital, fiscal benefit or as a necessary partner in the commercialization of technology from the research the policy is focused. The key to the creation, operation and sustainability of the triple helixes is finding a working balance between each of these three components. If a working balance does not exist then problems can develop. Examples of such problems are noted in subsequent chapters.

1.3 Contribution of the Thesis

This thesis makes a contribution to the existing literature both at the theoretical and empirical levels. At the theoretical level it sheds some additional light on the effects that federalism has on the organization of agencies that exist and operate within the context of multi-level governance wherein an array of governmental and non-governmental actors undertake major research initiatives. At the empirical level it provides a detailed analysis of interesting and important governance, management and funding issues related to the GCRN. The contributions of this thesis at the theoretical and empirical levels is likely to be of some practical value in conceptualizing, constructing, and analyzing pan-Canadian research networks and other types of networks in the future.

Chapter 2: Genesis and Governance of Genome Canada

2.1 Introduction

Genome Canada is a public not-for-profit corporation established in 2000 to coordinate genomic research in Canada. The organization adopted a federated governance model with the central national body of Genome Canada existing in a network with its regional affiliates. These include Genome Atlantic, Genome Quebec, the Ontario Genomic Institution, Genome Prairie, Genome Alberta, and Genome B.C., all of which are also non-profit corporations themselves. This chapter provides an explanation of the genesis and the governance of Genome Canada.

2.2 The Genesis of Genome Canada

In explaining the genesis of Genome Canada it is useful to apply the 'Triple Helix' model that was utilized by Peter Phillips in a comprehensive analysis on governing innovation. The model, which was developed by sociologists Etzkowitz and Leydesdor, is very useful in examining the roles and relationships of different actors responsible for scientific and industrial innovation [9] As noted in Chapter One, the Triple Helix model emphasizes the existence of three main actors in innovation promotion and governance: government, academic and industry.

There are three versions of the Triple Helix model. Triple Helix I views government, university and industry as three different institutions that use agencies to negotiate between each other. Triple Helix II, the version used in this thesis, view the three as communication devices that link groups into networks to coordinate activities

[9] Peter W. B. Phillips, Governing Transformative Technological Innovation: Who's in Charge? (Cheltenham, UK; Northampton, Mass.: Edward Elgar, 2007) pg. 41.

efficiently. Triple Helix III views the institutions as able to overlap to certain degrees, for example permitting universities to assume certain levels of governing authority or certain industries to perform strictly scientific research rather than technological commercialization.[10]

The value of the Triple Helix model is that it helps to shed light on the interconnectivity, cooperation between and the need for balance amongst the three helixes. This chapter uses the Triple Helix to shed light on the effect that each of the three helixes performed in the creation of Genome Canada.

The events that led to the creation of Genome Canada started in the 1980s when existing and emerging centers of excellence began to perform research in various genomic fields such as cancer in British Columbia, agriculture in the Prairies, human health in Ontario, fisheries in the Atlantic region, etc. This research initiated at the same time that at the international level a joint United States and British genomic project entitled the Human Genome Project (HGP) was established for the purpose of mapping the entire human genome. From 1987 to 1992 genome researchers within Canada were coalescing with the intentions of lobbying the federal government for additional support and funding to engage in the HGP.[11] Using the HGP as a catalyst to foster interest in genomic research, the genomic researchers in Canada began to organize to lobby to get Canada involved in the HGP. They accomplished their objective in 1992 when Canada was accepted as a member of the HGP.

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[10] Loet Leydesdorff and Henry Etzkowitz, The Triple Helix as a Model for Innovative Studies (Conference Report, *Science & Public Policy*, Vol. 25(3) (1998)), pg. 195-203.

[11] Bartha Maria Knoppers and Charles Scriver, Genomics, Health and Society: Emerging Issues for Public Policy (Government of Canada, 2003) Available at: http://www.policyresearch.gc.ca/doclib/IR_OTHER_genomicbook_e.pdf, pg. 5.

Both prior to and after Canada became involved with the HGP, the regional research groups began to develop into a network to lobby the federal and provincial governments for funding needed to improve the research infrastructure and to fund various types of genomic research projects.[12] This period offered a unique shift in the relations between the organizations in that they began to cooperate in a more comprehensive and sophisticated manner. This shift contributed substantially to the establishment of an emerging network that would eventually become more organized and mature during the Genome Canada period. Efforts to institutionalize and increase research were based on recognition that despite some talented genomic researchers in Canada, such as Dr. Michael Smith, who won the Nobel Prize in Chemistry in 1993 by providing the world with one of the key tools for genomics research, Canada's performance in the field, and particularly in the area of the HGP, was disappointing.[13] Part of the reason that they were underperforming is that the researchers were not only underfunded by the national government, but they were also encumbered by the slow pace of decision-making and inflexibility on the part of federal bureaucrats who dominated the governmental helix. The underfunding and inflexibility of those bureaucrats led the research nodes to turn to the industry helix for funding.

Eventually, the Canadian federal government learned from this process that its traditional bureaucratic institutions could not be relied upon to adequately deal with the needs of something as fast paced and responsive as genomic research, thus requiring the government to reconsider standard practices and to facilitate the creation of a public non-

[12] "The Human Genome Project and Its Ethical, Legal and Social Implications" Prepared by: Tim Williams, Science and Technology Division 26 July 2000, Available at: http://dsp-psd.tpsgc.gc.ca/Collection-R/LoPBdP/BP/prb0008-e.htm (last checked October 16, 2009)
[13] Genome Atlantic "History": http://www.genomeatlantic.ca/faq.php

profit corporation (i.e., Genome Canada), to organize and assist the various research agencies that formed during this period.

After the regional genomic research groups achieved their objectives of getting Canada involved in the HGP and increasing government funding for genomic research infrastructure and research output, they focused on making Canada an increasingly larger player in the international genomic research agenda.[14] The research groups had mixed results with this particular objective. While they made some progress on developing the genomic research infrastructure and conducting some research, they also encountered a major hurdle as a fiscal crisis rocked the Canadian federal government that led to budget cuts in many areas, including genomic research.[15] As funding levels continued to drop during the mid- to late-90s, the continually evolving group of genomic researchers began to become frustrated by the decreasing level of support from the federal government and started to look for other sources of funding. Some of them, such as the B.C. network, relied more on the provincial government, and others relied more on funding from industry. The reliance on industry concerned some because it contained potential risks in having their research agenda shaped by the interests or preferences of the funding industries.

This greater reliance on alternative funding culminated in a crisis for the HGP when in 1998 Celera Genomics, a private corporation from the United States, came forward proclaiming it was entering the race to map the human genome and planned on patenting the decoded genome. Celera Genomics had pegged 2000 as the completion date, three years before the HGP's anticipated completion.[16] The news created some

[14] Ibid.
[15] Jean Soucy and Marion G. Wrobel, Federal Spending: Changing Trends (Government of Canada, 2000), Available at: http://dsp-psd.tpsgc.gc.ca/Collection-R/LoPBdP/CIR/872-e.htm
[16] James Shreeve, The Genome War (New York: Ballantine Books, 2004), pg. 117.

consternation among policy elites when Celera stated that it would patent the human genome and not make their genetic information publicly available without cost.[17] However, Celera's ambitions were stymied when the United States President, Bill Clinton, announced that the American government would not permit patenting of human genetic research.[18] Celera's stocks, along with several other stocks and assets within the biotechnology sector, plummeted precipitously following the announcement. Canada reacted as well, but not as swiftly as the United States, because such expeditious reaction was less necessary as Canada had already rejected the patenting of genetic discoveries for higher life forms,[19] and created a committee to investigate the controversy over patenting genetic discoveries. The committee's work lasted from 2000 to 2003 and concluded that reform was needed to the Patent Act to take into account the innately personal nature of human genetic research.[20] This sudden challenge caused several countries within the HGP to reevaluate their situations, and in Canada this led to a resurgence of interest from the federal government in the area of genomic research. Thus, from 1998 until 2000 federal funding was once again increased to encourage a shift of genomic research away from a dependency on industry funding. The increase was made possible because by the mid-90's the federal government's financial situation had improved.[21]

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[17] Ibid.
[18] Alan Axelrod and Charles Phillips, What Every American Should Know About American History (Holbrook, Massachusetts: Adams Media Corporation, 2007), pg. 354.
[19] "The Human Genome Project and its Ethical, Legal and Social Implications" makes reference to President and Fellows of Harvard College v. Canada (Commissioner of Patents) (T.D.), 21 April 1998, where the Supreme Court ruled against Harvard College's attempts to patent their "Harvard Mouse" in Canada.
[20] "Genetics, Testing & Gene Patenting: Charting New Territory in Healthcare" (January 2002) available at: http://www.health.gov.on.ca/english/public/pub/ministry_reports/geneticsrep02/report_e.pdf (last accessed October 16, 2009)
[21] "Federal Spending: Changing Trends" Prepared by: Jean Soucy, Economics Division and Marion G. Wrobel, Senior Analyst Revised 27 March 2000, available at: http://dsp-psd.tpsgc.gc.ca/Collection-R/LoPBdP/CIR/872-e.htm#D. Federal Budgets of 1990, 1991 and 1992 and(txt)

The creation of a government funded network of non-profit public corporations, rather than a privately funded for-profit corporation, in 2000 resulted from two interrelated factors. First, private sector genomic research firms were not very interested in research in this area because they had to deal with intransigent and inflexible federal and provincial regulatory bureaucracies that could not respond very quickly or well to the innovative nature of genomic research which required much faster response mechanisms to industry changes and scientific-technological breakthroughs. Another reason that private enterprises did not get involved in genomic research was that they could not patent their research in ways that they wanted. A case in point as mentioned previously was Celera Genomics, a privately owned and funded genetic research enterprise in the United States that developed a new method of mapping genes. One crucial distinction to note here is that Celera was permitted to patent its process for mapping genes; they simply were not permitted to patent the genes they were mapping because that plan had met with widespread disapproval amongst the American people.[22] In Canada, members of the public were also opposed to private corporations owning the rights to the fundamental structure of their genetic makeup. The reasoning being that as a matter of public interest it is important for government to insure that any research and development occurring within genomics is properly regulated and appropriate.

In February 2000 Canada took the final step in supporting the academic helix with its research agenda by awarding Genome Canada a total of 300 million dollars for its setup and initial operations.[23] Given the increasingly complex nature of the genomic research groups that had been developing during the pre-Genome Canada period,

[22] Shreeve, pg. 13 and Axelrod and Phillips, pg. 354.
[23]Genome Canada, "Media": http://www.genomecanada.ca/en/medias/news.aspx?i=2

eventually it became a necessity to have a national, not-for-profit enterprise that would spearhead and oversee genomic research funding and regulation in Canada. The federal government had been a constant source of frustrations for this sophisticated network because its bureaucratic ponderous nature had made it insufficiently adaptable to act in light of new and changing situations such as the one posed by competitors like Celera Genomics. Although it was slow in responding and adapting to changing circumstances, the federal government had made a significant positive financial contribution to the creation of Genome Canada and its regional centers (Genome Atlantic, Genome Quebec, Ontario Genomic Institute, Genome Prairie, and Genome B.C.; later Genome Alberta).

By 2003 the HGP had essentially mapped the entire human genome, but further research would be necessary to fill in areas that remained only vaguely understood. Genomic research in Canada had grown exponentially during this time and Genome Canada had already succeeded in several competitions that were quickly defining the role Canada was to play in the genomics agenda. Since 2003 Genome Canada has become a leading international player in the areas of GE^{3}LS (Genomics and its Ethical, Economic, Environmental, Legal and Social Aspects) research and has successfully participated in several international competitions.[24] It has done this within its federated structure, which has provided a good balance between cooperation and competition and centralization and decentralization.

Although the foregoing overview of the genesis of Genome Canada focused primarily on the interaction among the three key sets of actors identified by the Triple Helix, it reveals the dynamics of cooperative and competitive federalism involving the federal and provincial governments in relation to private sector agencies. More

[24]Genome Canada, "About Genome Canada": http://www.genomecanada.ca/en/about/

specifically, it reveals the new way that the federal government became and remained involved in this particular policy sector vis-à-vis the provincial governments and the private sector. While specific discussions regarding Genome Canada's mandate and position within the federal bureaucracy will be forthcoming, for this summary the federal government facilitated and supported the establishment of a relatively autonomous national research agency (i.e., Genome Canada) operating at arm's length from it, which was mandated to ensure constructive coordination and possibly cooperation among various agencies from the three components of the Triple Helix, while at the same time operating at arm's length from each of those agencies.

2.3 Governance Framework of Genome Canada

Genome Canada's governance framework consists of a Board of Directors comprised of 16 individuals drawn from academic, private and public sector communities.[25] The Board has seven committees established to assist in its operations, those being an Executive Committee, Audit Committee, Investment Committee, Election Committee, Corporate Governance Committee, Compensation Committee and a Science and Industry Advisory Committee. The Board members come from various backgrounds and draw from genomic institutions both within Canada and the United States; the present Canadian Board members are drawn from institutes within the provinces of Ontario, Quebec and Alberta. Five of the members are ex-officio advisors, these being the Presidents of the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada, the Social Sciences and Humanities Research Council of Canada, the National Research Council and the Canada Foundation for Innovation.

The following sections explain the function and composition of each of the Committees of Genome Canada's Board of Directors in order to provide a full understanding of the governing bodies of Genome Canada, but also those of the regional centres because the regional centres have committees that mirror Genome Canada.

The Executive Committee exists to oversee the direction and management of the property, business and affairs of Genome Canada. Its membership consists of at minimum three and at maximum six members of the Board of Directors, appointed by the Board of Directors upon receipt of advice from the Election Committee. A majority of

[25]Genome Canada, " Governance: Board of Directors": http://www.genomecanada.ca/en/about/governance/directors.aspx

members must be independent directors, independent entailing that the member is free of any business or other relationship which could materially interfere with the exercise of their independent judgment subject to appropriate disclosure. Genome Canada's President and Chief Administrative Officer are ex-officio, non-voting members of the Executive Committee. The Committee's mandate includes acting on behalf of the Board of Directors when the Board is not in session and to exercise all or any powers vested in the Board except those to adopt, amend or repeal by-laws of the Corporation or appoint any directors of the Corporation and any other acts which must be performed by the directors themselves under the law. The Committee is also limited from passing resolutions that would cause the Corporation to commit funds without a prior specific mandate from the Board of Directors.[26]

The Election Committee is responsible for overseeing the process for selection of new directors to the Board and members to Committees as well as reviewing, from time to time, Board and Committee size, composition and profile. Its membership consists of at minimum three members of the Board, appointed by the Board upon receipt of advice from the Election Committee with the majority being independent directors. The President and CEO is an ex-officio voting member while the Chief Administrative Officer is an ex-officio non-voting member. The Election Committee's primary responsibility is in overseeing a formal and transparent selection process for any vacancies or transitions within the Board of Directors and Committees. What is required in that process is described in detail in the Committee's brief.[27]

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[26]Genome Canada, "Governance: Committees": http://www.genomecanada.ca/en/about/governance/committee/executive.aspx
[27]Genome Canada, "Governance: Committees: Election Committee": http://www.genomecanada.ca/en/about/governance/committee/election.aspx

The Audit Committee assists the Board of Directors in fulfilling its legal fiduciary obligations with respect to matters involving the integrity of accounting, auditing, financial reporting, internal controls and financially related legal compliance functions of Genome Canada. Its membership consists of a minimum of four members of the Board of Directors; similarly to the Executive Committee, members are appointed by the Board of Directors upon receipt of advice from the Election Committee and must be considered independent directors. All or some of the Audit Committee must be financially literate and at least one must have accounting or related financial management expertise. The President and CEO, Vice President Finance and Chief Administrative Officer are ex-officio, non-voting members of the Audit Committee. The Audit Committee is responsible for Genome Canada's accounting, risk management, auditing, financial reporting and all other matters of a financial responsibility all of which contain numerous sub-headings explaining each element in detail.[28]

The Investment Committee is responsible in assisting the Board of Directors in fulfilling its legal and fiduciary obligations with respect to matters involving the investment management of any funds at the disposal of Genome Canada. Its membership consists of at minimum three members of the Board of Directors, appointed by the Board under receipt of advice from the Election Committee, with a majority of independent directors. All or some of the members are to be financially literate and at least one must have accounting or related financial management expertise. One notable difference is that the President and CEO is an ex-officio voting member while the Vice President Finance and Chief Administrative Officer are ex-officio non-voting members.[29]

[28]Genome Canada, "Governance: Committees: Audit Committee": http://www.genomecanada.ca/en/about/governance/committee/audit.aspx
[29]Genome Canada, "Governance: Committees: Investment Committee": http://www.genomecanada.ca/en/about/governance/committee/investment.aspx

The Corporate Governance Committee oversees responsibilities with respect to developing, reviewing and assessing governance principles and guidelines for Genome Canada that are consistent with high standards of corporate governance. Its membership consists of at minimum three members of the Board of Directors appointed by the Board upon receipt of advice from the Election Committee consisting of a majority of independent directors. The President and CEO is an ex-officio voting member and the Chief Administrative Officer and Genome Canada's legal counsel are ex-officio non-voting members. The Corporate Governance Committee's responsibilities include reviewing the frequency of meetings of the Board and Committees, developing evaluation processes for the Board and Committees, insuring with management appropriate orientation and education programs for existing and new directors, monitoring fiduciary and legal responsibilities externally and benchmarking best practices internally, and acquiring expert advice for Genome Canada when necessary. The full list of the Committee's responsibilities is included in the Committee's brief.[30]

The Compensation Committee is responsible for compensation for Genome Canada's employees. Its membership consists of at minimum three members of the Board of Directors appointed by the Board on receipt of advice from the Election Committee consisting of a majority of independent directors. The Compensation Committee deals with compensation at all levels as well as determining performance evaluations for any awarding of bonuses.[31]

Initially adopted in 2008, the Science and Industry Advisory Committee was created in response to Genome Canada's growing research position internationally. Its

[30]Genome Canada, "Governance: Committees: Corporate Governance Committee": http://www.genomecanada.ca/en/about/governance/committee/corporate.aspx
[31]Genome Canada, "Governance: Committees: Compensation Committee": http://www.genomecanada.ca/en/about/governance/committee/compensation.aspx

responsibilities are to assist the Board in fulfilling its objectives of excellence and leadership in genomics research and the ethical, environmental, economic, legal and social aspects (GE^3LS) relating to this research in Canada and provide to the Board of Directors strategic advice on approaches and directions that contribute to the corporation's achievement of its objectives. Its membership consists of at minimum nine to a maximum of sixteen members of the Board of Directors appointed by the Board upon receipt of advice from the Election Committee. The composition must include individuals from Canada who are internationally recognized in science and industry and in fields relevant to the ethical, environmental, legal and social aspects of genomics research. The Committee is tasked with advising the Board of Directors regarding emerging scientific research opportunities and challenges, international trends and possible collaborations, areas of strategic socio-economic importance to Canada, and overseeing the quality, outcomes and impact of research programs and activities performed by Genome Canada.[32]

[32]Genome Canada, "Governance: Committees: Science Committee": http://www.genomecanada.ca/en/about/governance/committee/science.aspx

2.4 Conclusions

To reiterate, the dual purpose of this chapter has been to provide an overview of the genesis and the governance of Genome Canada. This chapter has revealed that Genome Canada was the product of lobbying efforts undertaken by a network of researchers based in academia that originally collaborated to lobby the federal government to partake in the international HGP project, to increase government funding for genomics research, and to create a relatively independent non-profit corporation that would provide national leadership and funding for genomics research. The creation of Genome Canada can also be traced to the special efforts of a company within the industry sector (i.e., Celera Genomics) to appropriate this important and sensitive genomics research agenda. The perceived threat posed by Celera Genomics strengthened the working relationship between the governmental and academic helixes to develop and resource the Canadian genomics research network and to expedite the funding and completion of research.

The second part of this chapter examined the governance framework of Genome Canada, including the composition and mandate of the Board and its various committees. The composition and mandates of these committees and the Board are important to note not only for understanding them, but also because many of the regional centers operate examined in the next chapter developed similar governance frameworks.

Chapter 3: Structure, Governance & Research Foci of Genomic Research Network

3.1 Introduction

Whereas the objective in the previous chapter was to explain why and when Genome Canada was created and how it is governed, the objective of this chapter is to explain how the genome research network is structured, how each regional centre is governed, and the research focus of each centre within the network. The explanations provide valuable insights into the effect that federalism has had on the structure of the genomic research network, as well as the governance and research focus of each regional research centre.

3.2 How is the Regional Genomic Research Network Structured?

The regional genomic research network was formed during the initial round of funding by Genome Canada known as Competition I. During the deliberation process for Competition I there was discussion over how many regional centres should be established. During Competition I it was decided by those overseeing the Competition that the genomic research network should consist of five regional centers: Atlantic, Quebec, Ontario, Prairie, and BC. Initially there were five regional research centers but eventually a sixth would be added when the Alberta researchers and the provincial government decided to establish Genome Alberta and have it operate separately and independently from Genome Prairie.

In 2005 Genome Alberta broke away from Genome Prairie in what was seen as a peaceful separation by mutual consent, thus becoming a separate regional genomics centre within the context of the Genome Canada research network. As there is no

documentation on what precisely led to the separation of Genome Alberta from Genome Prairie there are at least three possible explanations. The first is simple practicality; Genome Alberta and Genome Prairie had both reached sufficient capacity in their capability to perform genomic research that Genome Alberta could exist as its own regional centre without jeopardizing the abilities of Genome Prairie to conduct its own regional research. The second potential explanation stems from the research interests of the groups in Alberta relative to those of Saskatchewan and Manitoba. Alberta's economic and research interests focus more on the energy and human health sectors, while Saskatchewan and Manitoba have a greater interest in bio-products and agriculture. The separation would allow for a greater focusing of each centre's specific agenda and acknowledges and respects the unique interests of each centre equally. The third possible explanation is that the Alberta provincial government preferred a greater Alberta focus regarding research initiatives, and encouraged the creation of Genome Alberta in an effort to increase the accountability and transparency of its share of provincial funding.

Alberta's secession from Genome Prairie resulted in a change from a structure consisting of three research centers, each of which involved only a single province (i.e., Quebec and Ontario and B.C.) and two that involved multiple provinces each (i.e., Genome Atlantic and Genome Prairie), to a structure consisting of four centers each of which involved only a single province (i.e., Quebec, Ontario and B.C. and Alberta), one that involved four provinces (i.e., Genome Atlantic), and one that involved two provinces (i.e. Genome Prairie).

3.3 What is the Research Focus of Each Regional Research Centre?

One of the major decisions that had to be made in establishing the genomic research network was the precise research focus or functions of each regional research centre. Following some extensive negotiations on the matter, it was decided that each regional centre would conduct an array of genomic research, rather than each of them specializing on one particular area of research.

The creation of multiple regional centres with research agendas with multiple broad research foci, rather than a single research focus, was intended to advance several objectives including: providing diversity in the research agenda; increasing specialization in several research areas; increasing expertise in various research areas; and minimizing groupthink across the network. Furthermore, establishing provincial and regional genome centers responsible for conducting an array of research projects related to various categories of genome research, rather than have each of them specializing in one particular area of research, made it possible for provincial governments to invest in research projects that interested them in centers located within their province or region. This seems quite evident in the funding provided by the BC government to Genome BC, and by the Alberta government to Genome Alberta. If the single-specialization model had been used, public funds from some provincial governments for research that interested them would have had to be directed to research centers in other provinces. If the provincial governments were unwilling to do that, research funds would have been reduced substantially. For example, if an Atlantic province wished to do a forestry research project in their province, but in a single-specialization system forestry research was performed by Genome B.C., then those provincial funds would be travelling across

Canada, and the costs of the project would likely be substantially greater as well. In the multiple foci system that was chosen, forestry projects could be undertaken either by one or more academic groups operating within separate research centres across the country on their own or by several groups working collaboratively across the network. This operational framework also helps to reduce the potential for groupthink developing in a subject specific research climate as academics and scientists specializing in different fields exist in the same regional centre, providing ample opportunity for cross-specialization discussion.

3.4 How are the Regional Centres of the Research Network Governed?

In Chapter Two the governance structure used by Genome Canada was described as consisting of a Board of Directors supported by various committees. The governance frameworks for regional centres are quite similar to that of Genome Canada. Like the national agency, they have a governance board and a set of governance and operations committees. Moreover, the governance and management framework is very similar, though not identical, across the regional centres. There are two different models of governance frameworks across the regional centers. Genome BC, Genome Alberta and Genome Quebec have a governance framework that is very similar to Genome Canada with a Board of Directors and a number of Executive Committees. The other three centres have a slightly different governance model. Genome Prairie, the Ontario Genomics Institute, and Genome Atlantic each have a Board of Directors, but while the Board offers insight and direction, the President and CEO and other high ranking executives (CFO, Vice Presidents, etc.) do not serve on the Board, because they are designated as staff members. There are also differences in the configuration of

governance and operational committees across the regional centres. For example, whereas some have an ethics committee (e.g., Genome B.C and Genome Alberta), others do not (e.g., Genome Quebec). Similarly whereas some have an executive committee (e.g., Genome BC and Genome Quebec), others do not (e.g., Genome Atlantic).

Table 3.1: Executive Framework for various Genomic Centres [33]

Genomic Centre	**Executive Committees**
Genome Canada	Executive, Audit, Investment, Election, Corporate Governance, Compensation, Science and Industry Advisory.
Genome BC	Executive, Audit, Investment, Governance & Nominations, Society & Ethics, Business Development, Compensation, and Science.
Genome Alberta	Audit, Investment, Governance, Elections, Ethics.
Genome Prairie	No Committees; high ranking executives (CFO, Vice Presidents, etc.) serve as staff.
Ontario Genomic Institute	No Committees; high ranking executives (CFO, Vice Presidents, etc.) serve as staff.
Genome Quebec	Executive, Audit, Investment, Governance (Genome Quebec's Governance Committee also oversees elections), Strategic and Scientific Advisory Board (SSAB).
Genome Atlantic	No Committees; high ranking executives (CFO, Vice Presidents, etc.) serve as staff.

3.5 Conclusions

When examining the structure and governance of Genome Canada and its regional centers, what becomes apparent is the existence of a highly complex and interconnected network that has a surprising depth of flexibility and self-governance at the regional level. Decision making processes at the regional level are highly decentralized with Genome Canada recognizing the effectiveness of its regional centers in performing their

[33] Information for this section is drawn from each Genomic Centre's websites and documents. It is possible that those centres marked as having No Committees have informal internal organizational groupings that perform the same function as the Committees of other centres, but those centres described as having Committees clearly identify their Committees as such and contain adequate public information on their composition, creation and mandate.

functions and pursuing their objectives without heavy amounts of top-down oversight. Further, the regionalized structured that has been institutionalized allows for diversity in the precise membership and governance frameworks.

What is also apparent is the interest in creating a balanced network that does not privilege some regional centers over others, either in terms of their precise research agenda or in the amount of financial resources that are assigned to them. They are all free to determine the precise focus of their research agenda and all can submit research proposals in the funding competitions. This regionalized network structure facilitates both competition and cooperation amongst its nodes and reduces risks of groupthink, bottlenecks or similar administrative problems noted within the context of networked federalism theory in Chapter One.

For groupthink, the primary concern here is when a group of researchers working in a single facility or location focus on areas of expertise and do not have an open environment that includes researchers from other fields interacting with them on a daily basis the risk of the group adopting a rigid and inflexible view becomes greater. The research environment generated through the creation of a networked, federal system permits researchers to be in contact with researchers in their own fields in their own research facility and while still having access to researchers in other centres within their own fields of expertise as well as other fields of expertise who can offer alternative views and insights into research methods and problems that may not have occurred had that proximity not existed.

Another problem that multi-loci networked systems help to deal with are bottlenecks. Bottlenecks tend to be prevalent and problematical in overly hierarchical

centralized systems in single facilities or locations. Network system has the unique ability of adapting to potential bottlenecks by redirecting any decision making that is being held up by a failing node through another network arm that is responsive to the transfer. Furthermore, by widening the entirety of the decision-making process more comprehensive decisions can be made in shorter times with more input from different research facilities in different locations. While this process does carry some risk of redundancy and an overload of voices being applied to a decision making process, such issues can be mitigated by agreed upon objectives and procedures that members of networks adhere to as constructive members of the network.

Administrative problems exist when it comes to the accountability of funds going through a networked system. It makes sense that provincial governments are keenly aware of where their research funding is going, and that many would prefer that their research funds remain in their province for the sake of political patronage. Were a single centre of excellence system adopted, then funds from one province would be spent entirely in another province, something that could cause stress between the researchers and the province. A networked system with various research interests in each province solves this issue, permitting provincial governments to fund research on a spectrum of topics conducted by research centres located within their own provinces.

Chapter 4: Resourcing the Genomic Research Network

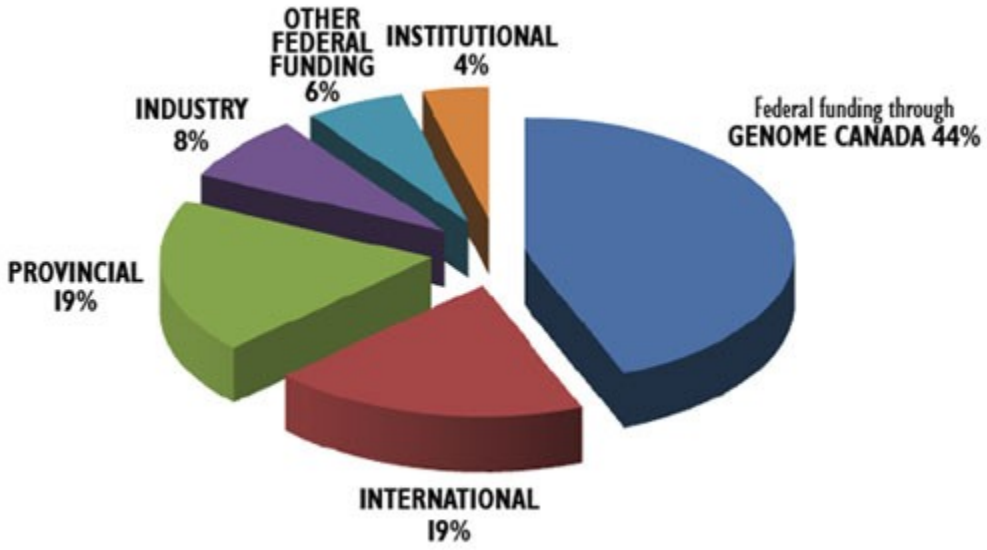
4.1 Introduction

This chapter provides an overview of the financial resourcing of the genomic research network in Canada. It consists of two major sections. Section one provides an overview of the financial resourcing of Genome Canada and section two provides an overview of the financial resourcing of the regional research centers. The second section examines the funding received from three major sources: governmental sources, non-governmental sources, and Genome Canada.

4.2 Resourcing of Genome Canada

Since its inception Genome Canada has invested $1.815 billion. Of this approximately 50% ($915 million) was provided by the Government of Canada, and $900 million was provided in the form of co-funding from provincial governments and non-governmental sources. Genome Canada's governmental funding constitutes 69% of its overall funding, or approximately $1.252 million broken down into the following percentages: Federal funding through Genome Canada 44%, provincial funding 19%, other federal funding 6%. Genome Canada's non-governmental funding constitutes 31% of its overall funding, or approximately $562.65 million, broken down into the following percentages: international funding 19%, industry funding 8%, institutional funding 4%. These percentages of funding since Genome Canada's inception in 2000 are profiled in the pie chart below.

Table 4.1: Genome Canada Funding



[34]

4.3 Resourcing of Regional Genomic Centers

The funding made available to each of the regional centers comes from four sources: Genome Canada; provincial sources, be they the provincial governments directly or institutes, departments or funding bodies funded by provincial governments; and non-governmental sources, typically industry or research groups with strong interest in the research of the centres; and some international sources whether they be governmental or otherwise. This section will go through each of the regional centers individually and discuss what information each has made publicly available regarding their level of funding and funding sources. The information reveals that there is no uniformity amongst the regional centers regarding the form or degree of disclosure of funding sources. Thus, while some of the larger centers like Genome BC, Ontario Genomic Institute and Genome Quebec have annual reports with detailed financial statements that make it far easier to establish the level of funding and the precise sources of their

[34] http://www.genomecanada.ca/en/about/

funding, it is much more difficult to ascertain funding levels and sources for other centers. This is particularly true for Genome Prairie and Genome Alberta. In the case of Genome Atlantic, their list of projects was sufficiently manageable that an analysis of the budget for each project made it possible to clearly identify funding sources.

4.3.1 Funding of Genome Atlantic

Genome Atlantic credits Genome Canada for contributing half of its overall funding and its provincial governmental partners and the federally funded Atlantic Canada Opportunities Agency (ACOA) and other agencies for providing supplementary funding.[35] Genome Atlantic's list of projects each indicates what funders supported each project. The list includes the following governmental and non-governmental agencies: Genome Canada, ACOA, the provinces of Nova Scotia and New Brunswick (Nova Scotia is mentioned in four of their eight projects), Fisheries and Oceans Canada, Scotian Halibut Ltd., Oryzon Genomics, Dalhousie University, Memorial University of Newfoundland, Nova Scotia Agricultural College, University of Saskatchewan, Genome Prairie, Agriculture and Agri-Food Canada, Genome Spain, and several Spanish universities and governmental departments. Their most in-depth project, the Atlantic Medical Genetics and Genomics Initiative (AMGGI), contains a list of fifteen funders.[36]

4.3.2 Funding of Genome Quebec

Funding for Gnome Quebec is provided primarily by the Québec Ministère du Développement économique, de l'Innovation et de l'Exportation (MDEIE), Genome Canada, and other partners. More specific information regarding specific contributors and specific amounts are found in the annual reports. The financial statements in Genome

[35]Genome Atlantic, "About Genome Atlantic": http://www.genomeatlantic.ca/aboutus
[36]Genome Atlantic, "Projects": http://www.genomeatlantic.ca/projects/view/2-Atlantic_Medical_Genetics_and_Genomics_Initiative_AMGGI

Quebec`s 2009-2010 Annual Report indicate that in that fiscal year the contributions were as follows: Genome Canada $138 million, Government of Quebec $122 million, Canada Economic Development $431,000, VRQ $3.76 million, Cancer Care Ontario $3.1 million, Genome Prairie $1.947 million, FQRNT $500,000, FRSQ $439,000, MSSS $100,000, Natural Resources $100,000, and Other $71,851.[37]

4.3.3 Funding of Genome Ontario

The financial statements contained in Ontario Genomic Institute's 2010 Annual Report list Genome Canada and the Government of Ontario's Ministry of Research and Innovation as key funding sources; sources other than these two are recognized as unrestricted or restricted contributions and are recorded separately.[38] In 2010 it received $25 million from Genome Canada; the Government of Ontario Ministry of Research and Innovation contributed an additional $5 million while external contributions, denoted as "Other" in the financial statements, amounted to a mere $100,000.[39] The financial statements in the 2009 Annual report revealed that Genome Canada contributed approximately $31 million, but there were no contributions from either the Government of Ontario or others. It is important to note funding in particular years was low due to the nature of competitions and that this funding is project based not operational based. It is interesting to note that those financial statements revealed that to advance the commercialization of its research, the Ontario Genomics Institute purchased common shares in Genomics Ontario Inc., a for-profit entity which provides investment for certain

[37]Genome Quebec, Annual Report 2009-2010, available at: http://www.genomequebec.com/v2009/gq/publications/publications/rapportAnnuel/GQ-AnnualReport-2009-2010-FINAL.pdf, pg. 23.
[38]Ontario Genomic Institute, 2010 Annual Report Financial Statements, available at: http://www.ontariogenomics.ca/sites/default/files/OGI%20Annual%20Report%202010%20and%20Financials.pdf , pg. 6.
[39] Ibid., pg. 10.

commercialization activities, as well as provided that organization with a loan to fund its operations.[40] With specific mention to projects, that same year OGI reported $67 million in project funding and had a list of projects funded that fiscal year.[41] Funding given for operations, separate from project funding, is stated as $1 million from Genome Canada.[42]

4.3.4 Funding of Genome Prairie

Genome Prairie indicates it has received $188 million in research activity since its inception in 2000. The funding has been provided by Genome Canada along with various other agencies from the governmental, business and university sectors.[43] An annual report lists only the amounts Genome Canada has provided for various research activities, but does not list the information regarding the precise level of funding provided by other entities. In recent years Genome Prairie received $101.5 million, of which $47.51 million was provided by Genome Canada.[44] Genome Prairie's 2009-2010 Annual Report mentions Western Economic Diversification Canada as a leading partner in Genome Prairie's involvement in four Western Canadian Genomics Networks: Western Canadian Vaccine Network (WCVNET), Canadian Flex Genomics Initiative (CFGI), Canadian Brassica Genomics Network (CBGN) and the Societal Impacts of Genomics Network (SIGNet). Of particular note, the Western Canadian Vaccine Network receives funding from the Bill & Melinda Gates Foundation.

The 2009-2010 Genome Prairie Annual Report lists 109 institutions (i.e., universities, governments and industries).[45] However, 'partner' does not necessarily mean they have

[40] Ibid.
[41] OGI, 2010 Annual Report, pg. 6 and 10.
[42] OGI, 2010 Financial Statements, pg. 10.
[43] Genome Prairie, "FAQ": http://www.genomeprairie.ca/NewsMedia/FAQ.aspx
[44] Genome Prairie, "Projects": http://www.genomeprairie.ca/portals/0/Projects%20List%20Updated%20January%202010.pdf
[45] Genome Prairie, 2009-2010 Annual Report, available at: http://www.genomeprairie.ca/LinkClick.aspx?fileticket=uOmERQd6ptA%3d&tabid=40 , pg. 10.

provided any funding for the regional center. In many cases the partners are actually involved in joint research projects where Genome Prairie funding is utilized. Canadian governmental funding agencies included the Governments of Canada, Alberta, Manitoba, Saskatchewan and Quebec. Canadian University contributors include Alberta, British Columbia, Calgary, Dalhousie, Laval, Lethbridge, Manitoba, McGill, Ottawa, Prince Edward Island, Regina, Ryerson, Saskatchewan, Simon Fraser, Toronto, Waterloo and Western Ontario. Non-Canadian University contributors include the College of Agriculture (Nagpur, India), Delft University of Technology (Netherlands), National University of Singapore, Oregon State, Swedish University of Agricultural Sciences, and the Universities of Adelaide (Australia), Auckland (Australia), California (Davis), Edinburgh, Giessen (Germany), and Versailles Saint-Quentin-en-Yvelines (France). International partners include the European Union along with institutes in India, Ireland and the United States.

4.3.5 Funding of Genome Alberta

Funding partners for Genome Alberta include several governmental agencies within Canada as well as some international agencies. According to information on Genome Alberta's website, Canadian governmental funding agencies include: the province of Alberta, Genome Canada, Genome Quebec, Agriculture and Agri-Food Canada, Western Economic Diversification Canada, Industry Canada, Alberta Agricultural Research Institute, Alberta Heritage Foundation for Medical Research, Alberta Ingenuity Foundation, Alberta Network for Proteomics Innovation, Alberta Science and Research Authority, BioTools Incorporated, Canadian Foundation for Innovation, Capital Health University Hospital Foundation, MDS Sciex, Sun Microsystems of Canada Inc., the

University of Alberta, the University of Calgary and the University of Lethbridge. International funding sources include BMBF, a federal department of Germany, and GABI-WPG, a German Plant Biotechnology Industry Consortium.[46]

4.3.6 Funding of Genome B.C.

Genome BC's institutional evolution is unique amongst the other regional centers. The reason for this is that it had already been highly institutionalized and it was granted substantial funding by the provincial government even before the creation of Genome Canada. The BC provincial government has awarded Genome BC $307 million dollars in funding since its inception in 2000. By doing so, it out-funded the other provincial governments, including those of larger provinces such as Ontario or Quebec. Recently it awarded an additional $50 million to Genome BC for the period from 2008 to 2015.[47] The provincial contributions to other regional centers have been substantially less since their inception. For example, Genome Prairie was awarded only $120 million over the same timeframe despite the fact that initially it had three provincial governments, and subsequently two, from which to access funds.[48]

This funding provided by the BC provincial government to Genome BC gives the latter a much more flexible and autonomous position within the greater network of Genome Canada. The level of funding set the regional center up as a powerful and important node within the network. This has allowed Genome BC to go so far as to host competitions on its own accord without the need for a Genome Canada wide Competition.[49] This also allowed Genome BC to expand the network of genomic

[46] Genome Alberta, "Funding Partners": http://www.genomealberta.ca/about/partners/
[47] Genome BC, 2008 Annual Report, available at http://www.genomebc.ca/aboutus/publications_resources/documents/GenomeBC2008AnnualReport.pdf
[48] Genome Prairie, Annual Reports, available at http://www.genomeprairie.ca/about_genome_prairie.html
[49] Genome BC, "Portfolio: Timeline": http://www.genomebc.ca/portfolio/timeline/

research to research agencies that focused on areas of interest to Genome BC that did not readily fit into areas of research of interest or importance to Genome Canada. By providing funding to these other research agencies, Genome BC was helping to broaden and enhance the positive achievements of the network as a whole. A major reason for the consistently high level of provincial funding for Genome BC is that its primary research focus, namely cancer, has a higher level of public support than some other areas of genomics research.

4.4 Resourcing of the Network through Funding Competitions

A substantial portion of the funding for the regional genomic research centers has been provided through a series of funding competitions by Genome Canada. The five funding competitions were or are: Competition I, Competition II, Competition III, ABC Competition/Theme I, and Post ABC Competition/Theme II. The key features and importance of each of these are discussed in turn below. In doing so, some attention is devoted to the purpose, funding strategies and effects of various competitions. The key features of each of the funding competitions are profiled in Table 4.1.

Table 4.2: Key Features of Funding Competitions

	Projects Submitted	Time	Unique Elements
Competition I	275 received, 17 selected	7 months	- Created five Genome Centers. - Open Letter of Intent method led to more applications than anticipated.
Competition II	64 received, 34 selected	7.5 months	- First "true project" competition. - Registration Packages replace Letter of Intent method. - Packages vetted by regional centers, seeing far less rejected projects.
Competition III	Unclear	13 months	- Registration Package requires further details, doubling application size since Comp. I. - First Competition where funding was not already available. - Due Diligence Review added to application procedure. - GE^{3}LS, intellectual property, information sharing and international collaboration also become increasingly important issues.
ABC Competition/ Theme I	58 Letters received,	12 months	- Return to revamped Letter of Intent method.

	11 Themes considered, 2 selected		- GE^3LS issues require 2 pages of the application package, which are now 11 pages in length.

4.4.1 Competition I

Initially Genome Canada needed to develop a formal network to manage its various science and technology platforms that it intended to fund. This objective was addressed within the requirements of Competition I by having interested research teams put forward Letters of Intent for research projects that were coupled with the objective of creating five genomic centers across Canada.[50] One interesting point to consider is how geography, or more precisely provincial and regional economies, could have influenced the creation of the regional research centers but did not. Originally there were five themes Genome Canada considered important to Canada: agriculture, health, forestry, fisheries and the environment.[51] During Competition I it was decided to create five centers: Genome BC, Genome Prairie, the Ontario Genomic Institute, Genome Quebec and Genome Atlantic. Given the geographic locations of the centers, research themes could have been assigned along the following lines: Genome Atlantic for fisheries, Genome BC for forestry, Genome Prairie for agriculture, etc. However, Genome Canada did not select this model. Instead, each of the genome centers could undertake research within any one or more of the five general themes.

To reiterate, dispersing the expertise for research themes across the network, rather than consolidating them in each center, allowed for greater collaboration within and across centers, and allowed for greater flexibility and innovation within each center. For example, researchers working on an environmental project could use not only the

[50] Eric Warren and Peter Phillips, Working Paper on Guidelines and Evaluation Criteria for Funding Competitions: A Comparison of Structure, pg. 5
[51] Ibid., pg. 3

expertise of other researchers at their center to complement their own expertise, but also that of members of other regional centers in Canada, or even those in other countries. Consolidating expertise for each theme only in one of the centers could have created less collaboration across centers. Moreover, it could also have stymied some cross fertilization across the thematic areas, or the problem of groupthink, as experts in one centre may have failed to devote attention to some facets of research that fell outside their own specialty and that of their colleagues at their respective centres.

According to the interim report of Genome Canada, this formative stage focused on three objectives: establishing a solid network between Genome Canada and its regional centers to encourage project merging and cooperation to see more efficient use of infrastructure and funding; offer professional management to allow researchers to focus on research; and obtain necessary infrastructure to accommodate a shift to large scale research projects.[52]

During the selection process of the research projects, Genome Canada played a role investigating where projects could be pooled together to more efficiently use available infrastructure and funding. For example, it considered whether a fisheries proposal from Genome Atlantic could be bundled with a similar fisheries project from Genome BC provided both centers agreed. This encouraged greater cooperation and made the combined projects more appealing for funding given the larger scale of the new combined project, as large-scale was a predominant requirement of Competition I's guidelines.[53] While at this early stage cooperation and collaboration were merely recommended to similar projects, eventually Genome Canada became increasingly

[52] Genome Canada, "Interim Report", available at: http://www.genomecanada.ca/medias/PDF/EN/Five-year_Evaluation.pdf, pg. 13.
[53] Warren and Phillips, pg. 3

committed to fostering such cooperation to the point where the practice eventually became commonplace and a central focus of Genome Canada's subsequent funding Competitions.

The introduction of professional management services also greatly benefited genomic research in Canada. Prior to Genome Canada a primary source of funding for genomic research was tri-council funding (i.e. SSHRC, NSERC, CIHR), which involved individual research groups applying for grants in which they also had to provide their own management services such as accounting, increasing the amount of administrative downtime researchers had to allocate away from performing actual research.[54] Following the establishment of Genome Canada's research network, the regional centres oversaw the professional management of selected projects, becoming the primary agents for project monitoring and program administration.[55] Although this was mostly beneficial it required additional due diligence procedures in funding Competitions to insure projects were financially viable.[56]

The interim report strongly applauded Genome Canada for establishing the necessary infrastructure.[57] Establishing a national public corporation to oversee genomic research led to the consolidation of various research infrastructures and a comprehensive record of what infrastructure was available and necessary to achieve Genome Canada's objectives. The funding granted by the federal government for Genome Canada also allowed for the expansion of infrastructure to regional centers, such as Genome Atlantic, that otherwise would not have been able to acquire sufficient funding to purchase such

[54] Interim Report, pg. 3
[55] Ibid.
[56] Ibid.
[57] Ibid., pg. 13

equipment otherwise.[58] This added infrastructure also helped promote the efficiency and overall success in Canada's research endeavors.

Genome Canada's first competition was described as somewhat ill defined, being too open, and lacking clarity in its agenda. Consequently, it produced too many project proposals, many of which could not survive the application process. Another reason that so many proposals were received is that at that point an application, even for the creation of a research centre, only required a Letter of Intent along with a five page explanation of what was planned and required. Genome Canada received 275 Letters of Intent for projects, much more than it had anticipated. Of those, 73 passed the first stage of Genome Canada review. Of those 73, only 31 were invited to submit full proposals. Eventually 17 of those 31 full proposals were finally approved for funding. Thus, of the 275 original Letters of Intent less than one-tenth made it to the final stage. According to Warren and Phillips the requirements for recommendations were too broad and open requesting little more from applicants than that their proposals be large-scale, genome-wide, and in a sector considered important to Canada (those being agriculture, health, forestry, fisheries, or the environment).[59] There were no explicit references to project content at all.

Spending time and effort on projects that in some cases had nothing to do with the areas which Genome Canada was interested in funding was a terribly inefficient method of proceeding. If fewer projects had been submitted they could have been reviewed in a shorter time frame and with less cost. Interestingly, however, the process of going from the original 275 Letters of Intent to the 17 funded projects and the five genome centers

[58] Interim Report., pg. 29
[59] Warren and Phillips, pg. 3

took only seven months, which was a shorter period than for any of the future Competitions.[60] The proposals only being five pages likely contributed to this short timeframe. Warren and Phillips describe the timeline for Competition I as follows:

- September 15, 2000 – Call for Letters of Intent and circulation of guidelines
- November 17, 2000 – Letters of Intent due to Genome Centers, 275 received.
- November 30, 2000 – Initial round of screening by Genome Centers' Board of Directors, 73 Letters of Intent chosen for submission to Genome Canada.
- December 2000 – Of the 73 proposals, 31 chosen by Genome Canada's Board of Directors to develop into full proposals.
- January 26, 2001 – Full project proposals due.
- March 2, 2001 – Completion of international peer review, 17 projects and 5 Genome Centers chosen.
- March-April, 2001 – Board of Directors of Genome Canada deliberates based on recommendations from international panel.
- April 4, 2001 – Announcement of Competition winners.

Total time: 7 months[61]

Several important developments occurred during the Competition I period following Genome Canada's creation. First, Competition I created the five regional genome centers in an efficient and accountable manner. Second, Competition I also made it clear to Genome Canada that more detail and clarity would be needed in future Competitions to prevent the same problem of over-applications that occurred in Competition I. Thirdly, despite the unexpected quantity of submissions, Competition I still remained the least time consuming of the Competitions. The review process was completed in seven months. The efficiency was made possible largely because many of the submissions obviously did not align with Genome Canada's interest or the general criteria that had been articulated. This made it possible for the 275 proposal to be reviewed and ranked by the regional centers in only thirteen days in the fall of 2000.

[60] Warren and Phillips, pg. 10.
[61] Ibid.

4.4.2 Competition II

Four months following the completion of Competition I, Genome Canada announced the beginning of Competition II. The shortness of time between the completion of Competition I and the commencement of Competition II was because whereas Competition I was intended primarily to establish the five genome centers and formalizing the genomic research network in Canada, Competition II was the first "pure project" Competition. The number of research projects that would eventually be selected through Competition II was twice that of Competition I.[62] The other reason for the short timeframe between the first two Competitions is that there was little reason to hesitate since Genome Canada already had the funding available from the initial grants provided by the federal government. Warren and Phillips describe the process for Competition II as follows:

- July 19, 2001 – Request for registration package
- November 1, 2001 – Registration packages due to Genome Canada
- December 13, 2001 – 64 full proposals sent to Genome Canada for international review
- February, 2002 – International peer review panel evaluates project proposals
- March, 2002 – International peer review meeting
- April, 2002 – Genome Canada board of directors, on advice of the international review, announce 34 successful proposals.

Total Time: 7.5 months[63]

The key steps in the Competition II process were somewhat different than those for the Competition I process. Competition I began with the submissions of Letters of Intent. Genome Canada had experienced issues with that process, and thus experimented in Competition II with a more formalized and directed registration package to make Letters of Intent more easily evaluated along Genome Canada's criteria. This increased

[62] Warren and Phillips, pg. 1
[63] Ibid., pg. 11

the materials necessary from five pages to seven, and reinforced the practice of regional genome centers playing a significant role.[64] Warren and Phillips explain that the reason for this is that proposals had to be vetted by the regional centers before being forwarded to Genome Canada for review. The completed registration packages given to Genome Canada were principally used to develop international review panels chosen from the full proposals that the regional centers decided would be reviewed by those panels.[65] The regional centers were also heavily involved in the formulation of registration packages, partly as a means of making the performance review process easier downstream.[66] This also indicates a certain degree of regional authority in Competition II that seemed less apparent in Competition I, for each regional center could send proposals to Genome Canada at their own discretion.[67]

This regional assurance that proposals met Genome Canada's eligibility criteria allowed for a greater streamlining of the process and required greater details from Genome Canada with regards to said eligibility guidelines. Vague wording in the Competition I guidelines such as "large-scale" became more detailed in the Competition II guidelines.[68] While these clarifications seem to explain the higher number of full proposals that made it to international peer review between Competitions I and II, with 31 from Competition I and 64 from Competition II. It needs to be recalled that Competition II was designed to be a pure project Competition. Where the effectiveness of the Competition II model becomes apparent is the efficiency in selecting twice as many proposals as Competition I. By the end of the international review process 34

[64] Warren and Phillips, pg. 6
[65] Ibid., pg. 11
[66] Ibid.
[67] Ibid.
[68] Ibid., pg. 7

successful projects were selected, twice that of Competition I even having taken only two weeks longer than Competition I.

The Interim Report also comments on Competition II, noting Genome Canada continued to play a significant role in empowering regional centers primarily through what the interim report titled "Effective Communications and Outreach Programs".[69] Genome Canada worked extensively during the Competition II period to help promote a brand image that supported both the regional centers and the Genome Canada network as a whole. This served the regional centers in two ways. First, since Genome Canada was centrally spearheading this branding exercise the regional centers did not have to invest resources developing regional communications and outreach programs.[70] Secondly, this also served the regional centers' goals as it allowed them to broaden their funding opportunities by allowing them access to new funding sources by utilizing Genome Canada's outreach programs.

The Interim Report's findings also suggest a growing federated organizational system developing between Genome Canada and its regional centers. Much like the Canadian federal-provincial system, authority was highly decentralized to the regional centers for the administration and oversight of genomic research directly, while Genome Canada operating as a central authority set agendas, managed funding competitions, dispersed funds and dealt with communications and outreach.[71]

In summary, the differences between Competitions I and II were minor. Nevertheless, significant changes made to the review process after Competition I made it possible to review twice as many projects in roughly the same amount of time in

[69] Interim Report, pg. 33
[70] Ibid.
[71] Ibid.

Competition II. Continued outreach and connectivity between the regional centers, Genome Canada, and various levels of government in Canada produced greater support and cohesion amongst the various agents within this growing genomics research network. Consequently, Competition III, which would occur two years later, would result in further improvements in efficiency and effectiveness in the Genome Canada Competition models.

4.4.3 Competition III

The focus of Competition III, like that of Competition II, was on project funding. Efforts at improving the process and documentation for the funding review process continued. Toward that end the registration package was expanded from seven pages to ten, doubling in size since Competition I's Letters of Intent. Warren and Phillips outline the timeline for Competition III as follows:

- July 30, 2004 – Request for registration
- November 1, 2004 – Registration packages from Genome Centers due
- November 15, 2004 – Invitation for full applications for projects passing initial review
- January 28, 3005 – Full application due to Genome Canada
- February to March, 2005 – Due diligence review
- March 2005 – Board of Directors decision to send proposals to peer review based on due diligence review process
- Early June 2005 – International peer review panel meeting
- Late June 2005 – Board decision on competition winners
- August 25, 2005 – Notification of decision of competition winners

Total time: 13 months[72]

A number of differences are readily apparent between Competition III and the previous competitions. First, is the extended due diligence review process. Over the course of the three competitions due diligence had become increasingly intensive, and while never explicitly explained, it seems logical to presume issues with past projects warranted this additional measure. As Warren and Phillips point out for Competition III

[72] Warren and Phillips, pg. 12.

"Proposals that were deemed unfit according to financial and management criteria were either not submitted for peer review or given a chance to be revised and resubmitted."[73] Registration packages and proposals submitted for Competition III also required clear links to eventual commercialization benefits with an expected timeline for the completion of the project, with preference given to projects with a lifespan of between three to four years.[74]

The lack of readily available funding by Genome Canada for Competition III could be considered indicative of these extended due diligence requirements. At $167.5 million dollars Competition III was the most financially intensive funding Competition undertaken by Genome Canada, but unlike Competitions I and II where Genome Canada had the total amounts of funding in place at the start of the competitions, with Competition III Genome Canada did not but remained confident the federal government would supply them with the funding necessary.[75] Despite its optimism, Genome Canada had cautioned the centers that Competition III might be delayed or even cancelled if the federal government did not grant sufficient funds.[76] Fortunately, the federal government awarded Genome Canada $165 million of the $167.5 million required for Competition III halfway through the Competition, allowing it to continue without delay.[77] An additional $100 million follow-up contribution would be made by the federal government to assist with upkeep costs of past and present projects; however, those funds were to be reserved by Industry Canada and granted annually only as needed.[78]

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[73] Ibid., pg. 12.
[74] Ibid., pg. 3
[75] Ibid., pg. 2
[76] Ibid.
[77] Ibid.
[78] Ibid., pg. 2.

In the unpredictable world of scientific and technological research not everything can be anticipated. In genomics this is no different, which was why Science Advisory Boards (SABs) became another change that took place during Competition III that Warren and Phillips outline, and while SABs were seen in Competition II to a lesser extent, Competition III was where they became mandatory during project submission. SABs were responsible for giving informed and critical advice and guidance to research teams once a project encountered an unexpected situation.[79] Supported by the regional centres, these SABs were to be sufficiently independent of the research teams in order to avoid any conflicts of interest.[80]

Issues such as GE^{3}LS, intellectual property and information sharing also expanded in Competition III. While these issues had always been of interest in the general Genome Canada guidelines they became an entrenched part of the registration process beginning in Competition III. These issues rose to prominence amongst the regional centers and Genome Canada for a number of reasons. With regards to GE^{3}LS, Warren and Phillips indicate a continual appreciation within Genome Canada for the role GE^{3}LS work plays in genomic research and the importance of its considerations.[81] Intellectual property issues were an obvious concern with regards to commercialization and who was credible and responsible for a project's developments. As for information transfer, Genome Canada encouraged the publication of a project's findings as expeditiously as possible to allow for as much usage of the knowledge as possible. Thus, starting in Competition III considerations were added to proposals to consider how quickly they could distribute the results of projects. This also carried an international

[79] Ibid., pg. 12
[80] Ibid.
[81] Ibid., pg. 4

element as a notable increase in participation with international projects also encouraged or required the release of results to more public venues.

On that point, international collaboration was also a focal point of Competition III. While increased international collaboration had always been an objective of Genome Canada it took on a more pressing importance in Competition III. This shows a general maturation of Genome Canada's system as attention shifted from intra-network development and collaboration to international collaboration on major research projects.[82]

4.4.4 Theme I/ABC Competition

The ABC Competition, following the Theme I call for strategic research themes, was created by Industry Canada for Genome Canada to identify strategic research themes for targeted research objectives.[83] The timeline for the Theme I/ABC Competition as outlined by Warren and Phillips was as follows:

- April 1, 2008 – Announcement of competition, request for application
- May 2, 2008 – Deadline for letters of intent to Genome Centers
- May 20, 2008 – Deadline for letters of intent to Genome Canada
- Late May 2008 – Review of letters of intent and decision to invite full applications
- June 2008 – Information sessions
- August 29, 2008 – Deadline for full applications to Genome Centers
- October 3, 2008 – Deadline for full applications to Genome Canada
- November 23, 2008 – Deadline for receipt of outstanding co-funding documentation
- Early December 2008 – International peer review of project proposals
- January 2009 – Decision by Board of Directors of successful projects
- April 20, 2009 – Notice of Award
- July 2009 – Deadline for applicants to be in a position for funding

  Total time: 12 months

The ABC Competition model removed the registration process used in Competitions II and III and returned to a more sophisticated version of the Letters of Intent model used in Competition I.[84] During the Theme I call 58 "Expressions of Interest" were received

[82] Ibid.
[83] Ibid., pg. 13
[84] Ibid.

by Genome Canada and the Science and Industry Advisory Committee (SIAC), which were sorted into eleven themes.[85] A Leader was then selected for each of these themes and given six months to campaign for their theme and bring together interested researchers for said theme.[86] These groups of researchers then submitted eleven position papers outlining research foci to Genome Canada.[87] From this process two themes were selected by committee recommendations and the Board of Directors, those being bio-products and crops, as the focus of the first ABC Competition.[88] Shortly thereafter, the process of project approval, similar to those of Competitions I, II and III began.[89] This system succeeded in that the thematic competitive process included explicit needs for cooperation, networking and generation of policy interests from outside the research network.

The length of proposals was expanded again to eleven pages, at least two of which were required to address GE^{3}LS issues, and in this Competition GE^{3}LS issues had to be considered as an integral component that complemented the project's objectives rather than as the limiting factors for the research, which had become the norm in previous Competitions.[90]

The ABC Competition also witnessed Genome Canada more actively pursue developing collaborations across the network, actively seeking out synergies and overlap and confidentially contacting project leaders to ask whether a partnership appeared

[85] Ibid.
[86] Ibid.
[87] Ibid.
[88] Ibid.
[89] Ibid.
[90] Ibid.

logical.[91] Warren and Phillips also note a change in the due diligence process that took place within the ABC Competition from issues that had arisen from Competition III:

> Although not mentioned in the project application guidelines, the due diligence evaluation was no longer conducted before the international peer review, but instead at the same time. This change was initiated because of concerns arising in Competition III. Discontent was expressed because it was thought that a number of projects with scientific merit were dropped from the competition because of the results of the due diligence evaluation, which assessed their managerial and financial stability.[92]

The funding structure for the ABC Competition changed as well. Industry Canada was given control over the $140 million federal grant intended for the ABC Competition and required Genome Canada to submit a strategic research portfolio in order to gain access to this grant.[93] This was the primary reason for the thematic shift in the ABC Competition's model, as this created an intensive procedure for determining Genome Canada's preferred research objectives, which led to the longest timeframe of the Competitions. Despite this, Genome Canada's KPMG 2009 performance audit report suggested Genome Canada continue to hold open competitions to encourage new actors, ideas and the recognition of emerging themes, as well as to shorten the approval process.[94]

[91] Ibid., pg. 14
[92] Ibid.
[93] Ibid.
[94] Ibid., pg. 15

4.4.5 Post ABC Competition/Theme II

Considering the last public competition, the ABC Competition, occurred so recently it is too soon to tell what affect this new thematic phase, colloquially referred to at present as Post-ABC/Theme II, will have on Genome Canada. However, it is likely that Genome Canada will continue proactively increasing efficiency in the proposal selection processes, performing more thematic competitions, and further encouraging regional and international cooperation and collaboration. Also, with the regional centers seemingly content with Genome Canada's present agenda it seems unlikely, barring any impossible to predict "Black Swans"[95], that there will be any transformative breakthroughs in research.

Early in 2009 Genome Canada was featured in news media as rumors spread that the Conservative minority government of the day was considering, given the onset of a fiscal crisis and economic recession, cutting the organization's funding in the new 2009 budget.[96] This turned out to be a mixed truth, for while the federal budget awarded no new funding for Genome Canada it continued to supply previously established funding agreements made between Genome Canada and previous federal governments. The impact this had on Genome Canada's operations seems minimal. The current level of federal funding is sufficient for Genome Canada to continue funding genomic research, especially given that there are also alternative sources of funding that supplement the federal government's funding. In this Post-ABC/Theme II period, the success of Genome

[95] Black Swans are a term given to events that are so statistically improbable that there is no adequate means of preparing for their occurrence. The term was taken from Nassim Nicholas Taleb's book The Black Swan: The Impact of the Highly Improbable (Random House; New York, New York: 2007).
[96]The Globe and Mail, "Budget erases funding for key science agency", January 29, 2009: http://v1.theglobeandmail.com/servlet/story/RTGAM.20090129.wbudgetscience29/BNStory/budget2009/home

Canada and its regional centers to access funding from other sources has minimized the risks of serious financial constraints resulting from reductions by the federal government.

Table 4.3: Summary of Funding from Competitions

Sources of Funds	GBC	Genome Alberta	Genome Prairie	OGI	Genome Quebec	Genome Atlantic
Competition I	**42,707,206**	**n/a**	**22,783,650**	**36,874,000**	**51,755,770**	**8,748,751**
% Genome Canada	21,261,283 (50%)	n/a	11,391,825 (50%)	18,282,738 (50%)	25,787,413 (50%)	4,221,108 (48%)
% Province and Other	21,445,923 (50%)	n/a	11,391,825 (50%)	18,591,262 (50%)	25,968,357 (50%)	4,527,643 (52%)
Competition II	**33,802,522**	**n/a**	**54,256,924**	**111,681,965**	**96,186,116**	**8,533,528**
% Genome Canada	16,738,843 (50%)	n/a	25,681,356 (47%)	56,762,424 (51%)	44,260,642 (46%)	2,724,250 (32%)
% Province and Other	17,063,679 (50%)	n/a	28,575,568 (53%)	54,919,541 (49%)	51,925,474 (54%)	5,809,278 (68%)
Competition III	**98,935,112**	**25,745,919**	**28,503,651**	**165,211,071**	**77,037,183**	**27,479,418**
% Genome Canada	49,349,670 (50%)	10,658,707 (41%)	12,426,961 (44%)	75,572,589 (46%)	37,551,259 (49%)	13,086,663 (48%)
% Province and Other	49,585,442 (50%)	15,087,212 (59%)	16,076,690 (56%)	89,638,482 (54%)	39,485,924 (51%)	14,392,755 (52%)
ABC Competition	**21,714,195**	**24,861,616**	**27,773,060**	**17,377,748**	**22,081,872**	**0**
% Genome Canada	10,283,174 (47%)	11,476,794 (46%)	13,076,268 (47%)	7,880,937 (45%)	10,338,033 (47%)	0
% Province and Other	11,431,021 (53%)	13,384,822 (54%)	14,696,792 (53%)	9,496,811 (55%)	11,743,839 (53%)	0

[97]

This table is a summary of the amount of funding each regional centre received throughout each of the funding competitions explained in this chapter. There are some interesting points to consider, with a reminder that the table represents funding acquired through Genome Canada competitions only. Genome Canada has created a roughly equal, 50/50 funding scheme from its competitions. Granted, Genome Atlantic's not getting a project through the ABC Competition is likely an area that needs improvement but generally speaking the system seems to have worked according to intent. There is also evidence to suggest regional centres are becoming less reliant on majority Genome Canada funding with Genome BC, OGI and Genome Quebec seeing a lowering

[97]Genome Canada, "Genome Financial Reporting System": http://genomereports.ca/section.php?Lang=En&ID=3&Nav=Section.

percentage of Genome Canada funds for projects in later competitions than in earlier ones. The creation of Genome Alberta resulted in half the usual research funds finding their way to Genome Alberta rather than Genome Prairie beginning in Competition III, but still Genome Prairie did exceptionally well relative to other regional centres in the ABC Competition, likely in part contributable to the research focus being agriculture and bio-products. Genome Canada shows itself to be an evolving network seemingly succeeding in its intended purposes in a method that still has areas of improvement that can continue to be perfected.

4.5 Conclusion

To reiterate, the objective in this chapter has been to provide an overview of the level and sources of funding both for Genome Canada and each of the regional research centers. The chapter reveals that the entire GCRN system is funded from a vast array of governmental and non-governmental sources. The chapter also reveals that both funding levels and funding sources have increased substantially over time both for Genome Canada and for the regional centers. The funding commitments of the federal and provincial governments are influenced primarily by their fiscal capacities and priorities, and to some extent also the special research interests of some provincial governments based on what they consider important for the respective economies. The chapter also reveals that the creation of Genome Canada and the regional research centers has provided a functional research framework within which the federal and provincial governments, as well as non-governmental funders, can channel funding to foster and facilitate research agendas and projects of importance to each of them.

Furthermore, the success of Genome Canada and the regional centre's roles as coaches and collaborators for research projects is commendable, and continued progress along this path needs to be encouraged for Genome Canada to begin to reach outward into international expansions. Genomic projects of the future are likely to be global or issues that affect every person, not limited to national or regional boundaries. Genome Canada and the regional centres need to continue to collaborate internationally and be prepared to be a part of or spearhead future international genomic projects. Fortunately, the trend outlined in this chapter suggests that is current path of Genome Canada.

Chapter 5: Conclusion

The objective in this concluding chapter is to summarize the key findings, briefly analyze or comment on the relevance of the findings, discuss some potential directions for changes to the funding, structure and research agendas of the GCRN, and to highlight some directions for further research.

5.1 Summary and Analysis of Findings

In summarizing and analyzing the findings of this thesis it is prudent to return to the original seven questions posed in Chapter One:

1. How and why was Genome Canada created?
2. How is Genome Canada governed?
3. How is the regional genomic research network structured?
4. When, how and why were the regional centres created?
5. How are the regional centres governed?
6. What is the research focus of each regional centre?
7. How is the genomic research network funded?

The findings related to each of these questions are dealt with in turn below. In addition to answering those particular questions, the chapter also devotes some attention to the general research question in this thesis, namely what effect did the Canadian federal system have on the creation, operation and funding of the GCRN.

5.1.1 Summary and Analysis of Findings on Questions 1 and 2

The first two questions regarding how and why Genome Canada was created and how it is governed were addressed in Chapter Two. In explaining the emergence of Genome Canada, the chapter traced the evolution of Canada's genomic sector from the time it was a limited research initiative during the late-80s that began to rise in importance due in part to the Human Genome Project. Consequently, gradually Genome Canada was established as a national public research agency to foster, facilitate and

support genomic research in Canada in partnership with a network of regional research centres. The chapter also revealed that Genome Canada was created in response to national and international developments and dynamics in genomics research. As the 1990s came to a close, private interests began to intersect with the public interests in genomics research. Governments around the world, including Canada, took notice and altered their funding practices to create a polycentric and competitive policy space that insured no single hierarchical or market oriented command and control system over genomic research.

The concept of the Triple Helix, as described in Chapter Two, was useful in explaining why this strategic approach to genomics research occurred in Canada. A shift occurred in the Triple Helix between the pre-Genome Canada period and the period following Genome Canada's genesis. In the pre-Genome Canada period the Triple Helix was adversely affected by a fiscal crisis that reduced the ability of the federal government to perform fully its funding role within the Triple Helix. This required the academic helix to seek greater support from the industry helix, which led to the problems surrounding Celera Genomics. Following the events surrounding the Celera Genomics period and the end of the fiscal crisis, the government helix recognized its failures and realigned itself with the needs of the academic helix by creating Genome Canada as a public research agency funded by the government. The end result was that the governmental helix as it stands now is operating more in line with the wishes of the genomic agencies of the early 90's than the way it operated during the fiscal crisis of the mid- to late-90's.

In retrospect, one is led to ask whether Genome Canada would have turned out the same had there been no fiscal crisis. The crisis led regional centers to adopt a more

formal networked approach to their governance and operations and to seek out alternative forms of funding from provincial or industry sources. Without that fiscal crisis and the continuation of full federal funding there may have been no need to move towards a more institutionally formal and funding flexible network; rather, they may have remained a more informal network that was more heavily dependent on the federal government. The shortage of resources led to a decentralization of functions and the adaptation of the network. The emergence of this network was valued by various actors because it was believed that it would be more efficient and effective if there were multiple actors engaged in collaborative and competitive behavior. In network theory hierarchies have a tendency to form bottlenecks as vertical decisions and reactions reach nodes that perform less efficiently, or they are incapable of rapidly adapting when a node fails. As network theory posits, networks accept and facilitate the development and operation of multiple nodes to extend policy spaces as far and wide as possible. The assumptions underpinning the Networked Federalism model outlined in Chapter One would suggest the importance of continuing the process of extending the genomic research network as widely as possible, incorporating as many nodes as possible and creating denser regional or provincial networks much as Genome B.C. and Genome Quebec have been doing by instituting their own smaller regional funding competitions. In so doing the ability for the network to readily adapt, despite the inherent issues with hierarchical government bureaucracies, can continue to improve. For Genome Canada's positive reputation among international genomic research groups to continue to improve it is imperative that this experiment in regionalized networked research and networked federalism is succeeding.

5.1.2 Summary and Analysis of Findings on Questions 3, 4, 5 and 6

Chapter Three examined questions three, four, five and six regarding how the Canadian genome network is structured; when, how and why the regional centres were created; how the regional centres are governed; and, the research focus of each regional centre.

In the case of question three, that chapter revealed that the genome network has been essentially structured as a federated system consisting of a national agency and several regional agencies, each of which performed key functions either on their own or in relations to each other. This organizational framework was achieved through collaboration and coordination within the Triplex Helix. It occurred largely by establishing the national agency and consolidating and institutionalizing the existing and emergent regional genomic research nodes.

In the case of question four, regarding when, how and why the regional centres were created, both Chapters Three and Four revealed that they were the byproducts of Genome Canada's Competition I at the turn of the millennium. Genome Canada's ability to access substantial resources from various funding sources made it possible for it to provide strategic direction in creating and structuring the regional centres.

In the case of question five regarding how the network was governed, Chapter three revealed that despite some minor differences, considerable similarity and symmetry has existed in the governance frameworks of Genome Canada and each of the regional centres. A few notable differences are evident in the precise configuration and composition of their respective governance and operational committees. The chapter also revealed that the research agenda of each regional centre focused on several general topic

areas, rather than a single specialized topic area. Nevertheless, each of the regional centres tend to have one or two areas of particular interest or specialization based on the economic, commercial and industrial bases of their respective regions or provinces.

The findings regarding question six on the research focus of each regional centre can be summarized as follows. Chapter Three revealed that the key stakeholders within the GCRN decided to establish a regionalized network within which each centre was free to conduct research on any topic or theme of interest, rather than a regionalized network approach within which each regional center would serve as a "center of excellence" for each research topic or theme. This decision was based on the following four key considerations:

1. Increasing collaborative elements.
2. Decreasing the risk of groupthink.
3. Increasing the number of nodes which keep bottlenecks from forming.
4. Enhancing the adaptive and flexible governance structure necessitated by a "moving target" cycle of adjustments in research themes and funding.

The first two points relate to concerns that establishing regional 'centers of excellence' each of which focused only on one major component of the research agenda would result in some problems. One such problem was the pooling of researchers with the same research interest into one center, thereby limiting access they would have to fellow researchers in their field but with different research interests. A regional network of centres that were not limited to a single research topic or theme would likely reduce the likelihood that this would happen by increasing contact among researchers across the GCRN. The third consideration relates to concerns regarding over reliance on rigid

hierarchical approaches to governance, management and in designing research agendas. The network approach promotes redundancy and works to bypass risks associated with bureaucratic bottlenecks or node failures. Finally, the organizational structure was useful in dealing with the "moving target" manner of establishing research agendas, research funding, and research governance discussed in previous chapters.

5.1.3 Summary and Analysis of Findings Related to Question 7

In the case of question seven regarding how the research network has been resourced, a quick summary of the competitions described in Chapter Four provides some important insights. Chapter Four revealed that funding resources for the GCRN has been derived from the governmental and non-governmental sectors domestically and internationally. Genome Canada has been very instrumental in distributing funds to the projects through the regional centres through a series of research funding competitions. Competition I involved the establishment of the five regional genome centers along with the creation of the first application process for funding of genomic research projects. This first Competition was very open, creating a glut of projects the institution had not anticipated, with less than a tenth of those making it through the process. Competition I provided professional management for the regional centers and allowed for the purchase of necessary research infrastructure and equipment. However, Competition I's model was inefficient considering the great number of rejected projects. Such an open model demonstrated it was necessary to establish more restrictive criteria for submissions in the future. In all, the "moving target" approach utilized in Competition I would form the foundation for future Genome Canada competitions.

Competition II is considered the first "true research" Competition. The number of projects selected for funding was twice that of Competition I. Competition II also added tighter restrictions to applicants utilizing a registration package method to preempt projects that fell outside Genome Canada's areas of interest. More importantly, the regional centers also became involved in insuring projects submitted would pass Genome Canada's eligibility criteria reinforcing the importance of the regional centers. Competition II approved twice as many projects for funding as Competition I in roughly the same amount of time, indicating the changes made increased the efficiency of the application process.

Competition III was the first Genome Canada competition where funding was not set up beforehand, requiring Genome Canada to caution that the Competition might have to be delayed if funding did not arrive. Due diligence thus became a far more important and intensive process in Competition III, and the need for clear commercialization potential in research projects contributed to a more streamlined and efficient application process. Greater focus on GE^3LS issues and international collaboration were hallmarks of Competition III. Compared to Competitions I and II, Competition III used the most sophisticated system, showing a general maturation within the network and introducing the need to see back-end commercialization from successful projects.

The Theme I/ABC Competition constituted a notable shift in Genome Canada's philosophy and direction regarding the organization, operation and funding of the GCRN. Devised by Industry Canada to identify strategic research themes, Theme I, followed by the ABC Competition, returned to Competition I's Letters of Intent model to determine themes to focus Canada's next round of genomic projects; two were eventually selected:

bio products and crops. The ABC Competition also had no funding available upfront. Consequently, Genome Canada had to submit a strategic review in order to be granted funding from Industry Canada. This showed a renewed interest in the Genome Canada system by Industry Canada, and brings up both a potential merit and flaw. The merit is that this was likely Industry Canada's way of indicating a preference to work with Genome Canada more intensively, thereby further empowering the government helix to continue supporting the network. In recent years, however, concerns have emerged that Industry Canada may be placing greater restrictions and recommendations on Genome Canada as a first step in reasserting some measure of authority over the institution. Whether this will result in positive or negative outcomes remains to be seen.

5.2 Importance of Continuing Federal Government Support for Genome Canada

One of the interesting questions regarding the future of Genome Canada is what would be the implications of the federal government discontinuing its support for Genome Canada. Indications are that it would be highly unlikely that the network could be financially sustained and maintained in its current form. The first loss under such a scenario would undoubtedly be Genome Atlantic. Having failed to secure any successes in recent research funding competitions and existing on backlog projects from Genome Prairie, Genome Atlantic would likely be the first loss to the genomic centers. How Genome Prairie and the Ontario Genomic Institute would fare depends largely on the response their provinces would have to a post-Genome Canada situation. Given there is no evidence to suggest provincial governments are willing to support these centers to the same extent other provincial governments do in other regions (see Genome BC and Alberta below) these regional centers would most likely revert to the more informal

entities they were during the pre-Genome Canada phase and continue as best they could on provincial and other funding. What is meant by reversion to an informal state is to remember the state of the network during the 1990s prior to the creation of Genome Canada. The creation of Genome Canada differentiates the informal from the formal period in that Genome Canada created a formal structure within which funding could be competed for in a much more established fashion then during the pre-Genome Canada period. As suggested the regional centers likely to survive such a post-Genome Canada period would Genome Quebec, Genome BC and Genome Alberta. Genome Quebec receives matched contributions dollar for dollar from the provincial and federal governments and has begun, like Genome BC, hosting smaller, more regional competitions of regional interest. Genome BC existed before Genome Canada and has maintained its practice of receiving more funding from its provincial government, thereby reducing its dependence on Genome Canada. It is likely Genome BC would become a relatively more powerful and influential player in a smaller Canadian genomic context with regional competitions hosted by Genome BC continuing where national competitions become fewer and fewer. Genome BC already has a history of hosting smaller, regional competitions with its own funding competitions.[98]

Genome Alberta could also continue to exist independently provided it could convince the Alberta provincial government to fund it to the same extent as the British Columbia provincial government funds Genome B.C. There is an important distinction to be made here. Genome Alberta did become independent from Genome Prairie because the Alberta provincial government wanted to make sure its provincial funding was going

[98] For examples of Genome BC`s regional competitions see http://www.genomebc.ca/portfolio/timeline/ and http://www.genomebc.ca/opportunities/current-funding-competitions/

to research in Alberta's interests. However, Genome Alberta is still reliant on Genome Canada funding to maintain its current efforts. Without Genome Canada funding the ability for Genome Alberta to survive independently in its current form would depend directly on whether the Alberta provincial government would be willing to adopt a more B.C. like approach and become the dominant funding source for the regional center. While the Alberta provincial government passed on such an opportunity previously, if Genome Canada were to lose federal funding it may become a more viable or necessary option for the provincial government especially if Alberta wishes to continue pursuing significant genomic research.

While this would by and large be a step backwards it could be argued this is simply an expression of another fiscal crisis. These centres would likely work to either keep Genome Canada afloat or return to lobbying the federal government directly, seeing such a setback as a temporary one that could be easily reversed once the economic conditions turn more favorable. What would be interesting to consider is a positive outcome in a post-Genome Canada environment in which the national agency (i.e., Genome Canada) would no longer exist. For this to occur, the remainder of the network consisting of just the regional centers will have to become sufficiently advanced that the need for a centralized authority becomes obsolete. An idealistic idea to be sure, as this would require the regional centers to overcome their dependence on Genome Canada for primary funding and the development of a research proposal funding process that insures a balanced selection of appropriate research projects. If they could deal with those two important issues, it is possible that a highly decentralized, self-sustaining network of

regional centers capable of surviving without direct federal and provincial funding could continue to exist.

One final scenario to consider is a Genome Canada independent of any government funding. This is unlikely to occur simply due to the extensive costs of the research being conducted and Genome Canada being a public corporation; the distinction between a public corporation and a Crown corporation is that Genome Canada is not tied to the governmental bureaucracy in any direct fashion other than funding. However, if some of their research projects developed sufficient commercial viability and Genome Canada effectively invested available capital with the intention of developing a self-sustaining fund, then Genome Canada could conduct competitions without any funding from government sources. There are two things to consider here. First, it would not grant Genome Canada absolute autonomy because the federal government would still maintain control over regulations regarding genomic research. Second, with regards to networked federalism theory this does not seem to be an ideal situation to aspire for, as it could hold the potential of eliminating a number of key nodes associated with government bureaucratic systems and networked federalism maintaining as many connections and nodes as possible is the ideal situation. Independence from governmental funding for future research competitions would be the only foreseeable benefit.

Hopefully the economic downturn of the past few years can be mitigated before it becomes a fiscal crisis. The 1990's clearly showed how lack of funding from the federal government carries the very real danger of hampering research initiatives and potentially

losing valuable scientific experts and laboratories to countries with governments that devote more financial resources to research such as the United States, Britain or China.

5.3 The Effects of Canadian Federalism on the Structure and Resourcing

As mentioned earlier two options existed for the structure of the network, one with regional centres and the other with centres of excellence, with the former being used over the latter. One of the reasons for this choice can be linked to Canada's federal structure. Regional bodies allowed provincial governments a clear indicator of where their research dollars were going and allowed the development of focused research interests that coincided with provincial research interests. A central body permitted a clear agent to deal with the federal government and oversee project funding, as well as allowing the central agent to deal with matters that would have taken time from research projects at the regional level. These factors led to the GCRN to use Canada's federal model as a framework upon which to create a network that would have obvious connections between regional centers-central agent, regional centers-provincial governments, central agent-federal government, etc.

The network also emphasized the need for government to work with research interests in a mutually beneficial manner. The creation of a network separate yet linked to Canada's federal system allowed the response time the GCRN was looking for while still granting federal and provincial governments influence over research interests that coincided with governments' interests. It also made Genome Canada the central authority in international collaborations with the GCRN, permitting the GCRN to become more involved in international projects. A system that harmonized the research network with government authorities further reduced possibilities for conflict and encouraged a more

inclusive environment. Basing Genome Canada around Canada's federal system allowed a stable network with clear associations and interests to form permitting Genome Canada to be best equipped to engage in research interests both domestic and global.

5.4 Potential Areas for Further Research

Given the novel nature of this research, there is a need for further research in at least four areas. The first comes out of what was introduced in the opening chapter that the focus of this thesis is on organizational evolution, not on the actions of individual actors that influenced said evolution. There is no question that policy entrepreneurs, acting individually and collectively, were responsible for achieving agreed upon objectives. Performing further research into whom these actors may have been and what roles they fulfilled during the creation and evolution of the processes during the pre-Genome Canada and Genome Canada periods would be valuable.

Second, further research could be done on whether the federal government chose the right model for research funding. This research would focus on the issue that arose just prior to Genome Canada's creation on whether the system should be based on a model whereby each centre specialized in one pre-determined areas, or a model whereby the precise research focus of each regional centre would be based on the focus of their research that succeeded in accessing funds through the funding competitions.

As suggested at the conclusion of Chapter Four a third interesting aspect of genomic research that merits further research is the precise focus of the research agenda of the GCRN. Some of that research agenda is reaching a point to where it is being considered an integral part in global spanning research projects, including, for example, human longevity research, stem cell and nanotechnology research, which has produced

an increasing array of articles and books indicating a growing interest in such research.[99] The example of life extension has fascinated humanity for centuries, and for the first time in recorded history there may actually be substantial scientific evidence to suggest such procedures could be commercially viable within the next generation.[100] Even the possibility of such research being scientifically feasible, let alone commercially viable, demands an examination of the various effects this sort of research might have on established laws, politics, morals, economics, practically every aspect of our society. If it were possible to grant the average human even an additional ten years of productive life, that little difference could mean substantial changes to the way society behaves, and yet it is likely such serious investigations could be bypassed until they are long overdue simply due to the traditional stance that high technology is farfetched. There are serious implications to such possibilities, and without proper consideration there could be extremely problematical effects on a society ill prepared for a future where such technologies are available and potentially commonplace.

Finally, to expand on the previous point but at a practical level the most obvious avenue for future research is that there are other high technology sectors that are beginning to become more important and might likewise benefit from governance and operational frameworks similar to Genome Canada. Analyses could be done on the feasibility of utilizing the Genome Canada model for these other sectors in an effort to mirror the successes Genome Canada amassed while potentially averting or mitigating the trial and error methods embodied in the moving target model used during Genome Canada's institutional evolution that were necessary for such a first time project. In just

[99] Aubrey De Grey, Ending Aging: the Rejuvenation Breakthroughs That Could Reverse Human Aging in Our Lifetime (St. Martin's Press: 2007)
[100] "How to Live Forever", Science & Technology: abolishing aging, The Economist (January 3rd, 2008)

over a decade Canada went from being inconsequential in the international genomic research agenda to being a leading player in a number of important sectors, clearly indicating that the process from pre-Genome Canada through Genome Canada's four thematic evolutions greatly increased the ability for technology sectors to advance. Could this system be applied to other technological sectors? If so, the results would be beneficial and worthy of consideration.

All such research would provide additional insights into Genome Canada, a fascinating institution that developed through a concerted effort at collaboration and coordination of multiple stakeholders for a common goal. The choices made during this institution's evolution were also well thought out with plenty of opportunity for feedback and flexibility, and the institution seems to fit as an ideal case study for the success of a networked federalized research system. Sometimes, politics is not the story of why 40,000 people took to the streets, but rather why they did not; this is the case with Genome Canada, with the right decisions being made and an excellent example being set. The system is not perfect, but seems adequately robust and flexible to adapt to some of the challenges that may emerge in the near future.

Bibliography

Abraham, C. (2009, January 29) Budget erases funding for key science agency. *The Globe and Mail*. Retrieved February 18, 2009 from http://v1.theglobeandmail.com/servlet/story/RTGAM.20090129.wbudgetscience29/BNStory/budget2009/home

Axelrod, A. and Phillips, C. (2007). *What Every American Should Know About American History.* Holbrook, Massachusetts: Adams Media Corporation.

Birch, A. (1955) *Federalism, Finance, and Social Legislation in Canada, Australia, and the United States.* Oxford: Clarendon Press.

Cairns, A. (1977, December) The Governments and Societies of Canadian Federalism, *Canadian Journal of Political Science*, Vol. 10, No.4

Cutler, F. and Menddolen, M. (2008). Canada. *Explaining Federalism: State, Society and Congruence in Austria, Belgium, Canada, Germany and Switzerland* edited by Erk, J. London; New York: Routledge.

De Grey, A. (2007). *Ending Aging: the Rejuvenation Breakthroughs That Could Reverse Human Aging in Our Lifetime.* St. Martin's Press.

Genome Alberta "Funding Partners": http://www.genomealberta.ca/about/partners/

Genome Atlantic "About Genome Atlantic": http://www.genomeatlantic.ca/aboutus

Genome Atlantic "History": http://www.genomeatlantic.ca/faq.php

Genome Atlantic "Projects": http://www.genomeatlantic.ca/projects/view/2-Atlantic_Medical_Genetics_and_Genomics_Initiative_AMGGI

Genome BC "Portfolio: Timeline": http://www.genomebc.ca/portfolio/timeline/

Genome BC 2008 Annual Report, available at http://www.genomebc.ca/aboutus/publications_resources/documents/GenomeBC2008AnnualReport.pdf

Genome Canada " Governance: Board of Directors": http://www.genomecanada.ca/en/about/governance/directors.aspx

Genome Canada "About Genome Canada": http://www.genomecanada.ca/en/about/

Genome Canada "Genome Financial Reporting System": http://genomereports.ca/section.php?Lang=En&ID=3&Nav=Section

Genome Canada "Governance: Committees: Audit Committee": http://www.genomecanada.ca/en/about/governance/committee/audit.aspx

Genome Canada "Governance: Committees: Compensation Committee": http://www.genomecanada.ca/en/about/governance/committee/compensation.aspx

Genome Canada "Governance: Committees: Corporate Governance Committee": http://www.genomecanada.ca/en/about/governance/committee/corporate.aspx

Genome Canada "Governance: Committees: Election Committee": http://www.genomecanada.ca/en/about/governance/committee/election.aspx

Genome Canada "Governance: Committees: Investment Committee": http://www.genomecanada.ca/en/about/governance/committee/investment.aspx

Genome Canada "Governance: Committees: Science Committee": http://www.genomecanada.ca/en/about/governance/committee/science.aspx

Genome Canada "Governance: Committees": http://www.genomecanada.ca/en/about/governance/committee/executive.aspx

Genome Canada "Interim Report" available at: http://www.genomecanada.ca/medias/PDF/EN/Five-year_Evaluation.pdf

Genome Canada "Media": http://www.genomecanada.ca/en/medias/news.aspx?i=2

Genome Canada, "Regional Centres": http://www.genomecanada.ca/en/centres/

Genome Canada, "Vision-Mission-Mandate": http://www.genomecanada.ca/en/about/vision.aspx

Genome Prairie "FAQ": http://www.genomeprairie.ca/NewsMedia/FAQ.aspx

Genome Prairie "Projects": http://www.genomeprairie.ca/portals/0/Projects%20List%20Updated%20January%202010.pdf

Genome Prairie 2009-2010 Annual Report, available at: http://www.genomeprairie.ca/LinkClick.aspx?fileticket=uOmERQd6ptA%3d&tabid=40

Genome Prairie Annual Reports available at http://www.genomeprairie.ca/about_genome_prairie.html

Genome Quebec Annual Report 2009-2010 Available at: http://www.genomequebec.com/v2009/gq/publications/publications/rapportAnnuel/GQ-AnnualReport-2009-2010-FINAL.pdf

Gross Stein, J. (2007). Networked Federalism. *Canada: The State of the Federation 2006/07 Transitions: Fiscal and Political Federalism in an Era of Change.*
Knoppers, B. and Scriver, C. (2003). *Genomics, Health and Society: Emerging Issues for Public Policy.* Retrieved August 29th, 2010 from http://www.policyresearch.gc.ca/doclib/IR_OTHER_genomicbook_e.pdf

Ministry Report (2002, January). *Genetics, Testing & Gene Patenting: Charting New Territory in Healthcare.* Retrieved August 29th, 2010, from http://www.health.gov.on.ca/english/public/pub/ministry_reports/geneticsrep02/report_e.pdf

Ontario Genomic Institute 2010 Annual Report Financial Statements, available at: http://www.ontariogenomics.ca/sites/default/files/OGI%20Annual%20Report%202010%20and%20Financials.pdf

Phillips, P. (2007). *Governing Transformative Technological Innovation: Who's in Charge?* Cheltenham, UK; Northampton, Mass.: Edward Elgar.

Science & Technology (2008, January 3). Abolishing Ageing: How to Live Forever. *The Economist.* Retrieved August 29th, 2010, from http://www.economist.com/node/10423439

Shreeve, J. (2004). *The Genome War.* New York: Ballantine Books.

Soucy, J and Wrobel, M. G. (2000, March 27). *Federal Spending: Changing Trends*. Retrieved August 29th, 2010, from http://dsp-psd.tpsgc.gc.ca/Collection-R/LoPBdP/CIR/872-e.htm#D. Federal Budgets of 1990, 1991 and 1992 and(txt)

Taleb, N. (2007) *The Black Swan: The Impact of the Highly Improbable.* Random House; New York, New York.

Warren and Phillips, *Working Paper on Guidelines and Evaluation Criteria for Funding Competitions: A Comparison of Structure*

Watts, R. (1986). The MacDonald Commission Report and Canadian Federalism, *Publius, Vol. 16, No. 3, The State of American Federalism, 1985 (Summer, 1986)*

Williams, T. and Science and Technology Division (2000, July 26). *The Human Genome Project and Its Ethical, Legal and Social Implications*. Retrieved August 29th, 2010 from http://dsp-psd.tpsgc.gc.ca/Collection-R/LoPBdP/BP/prb0008-e.htm