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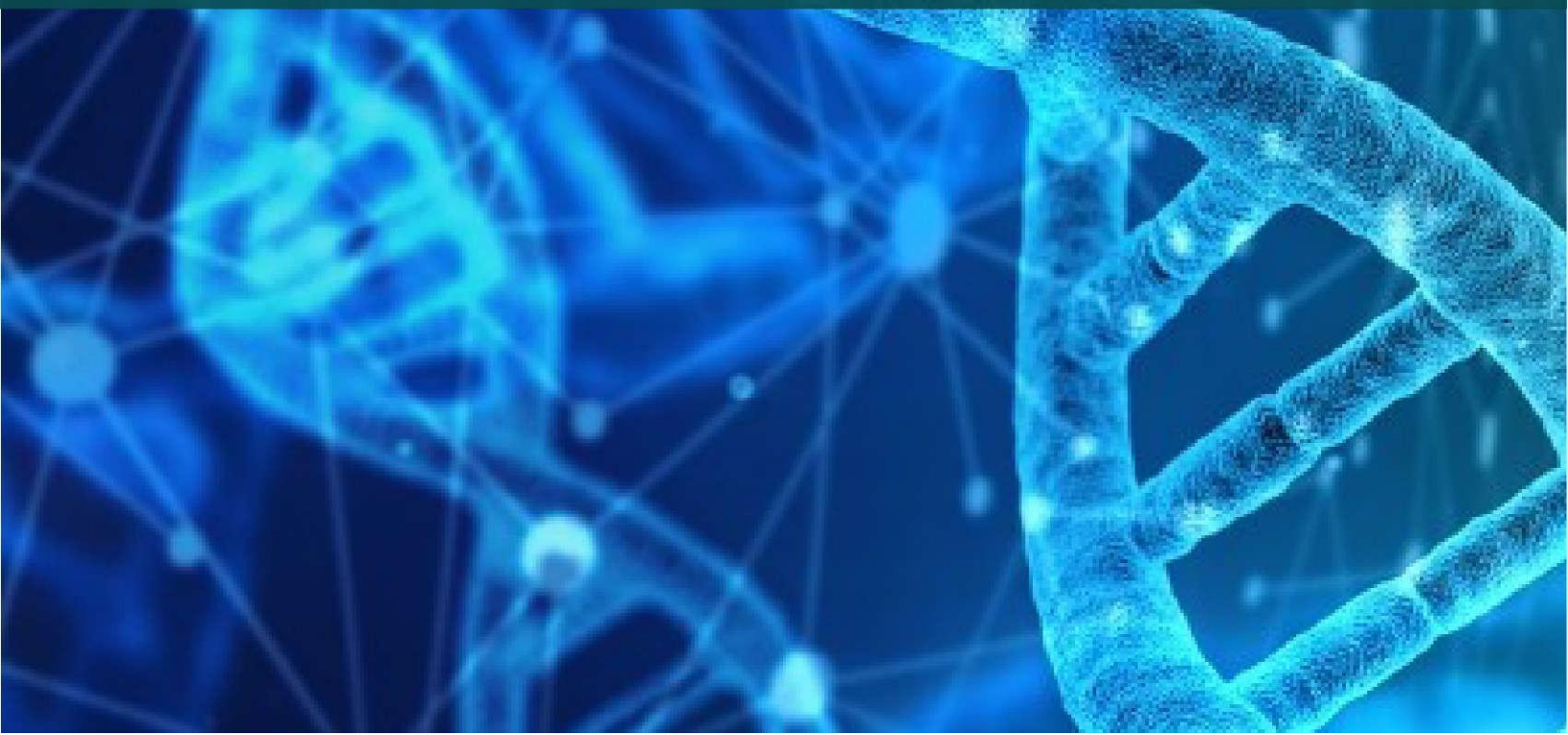
Canada

CANADIAN GENOMICS STRATEGY



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Executive Summary

Genomics is a powerful tool for addressing today's major global challenges, including climate change, environmental degradation, biosecurity, pandemic preparedness, agricultural productivity, and food security. Globally, the bioeconomy is projected to generate trillions of dollars in value, with genomics serving as a foundational technology that will drive innovation across agriculture, healthcare, energy, materials science, and beyond. The combination of genomics and AI, alongside rapidly developing bioengineering tools like CRISPR and mRNA technologies, will result in unprecedented acceleration of discoveries in medicine, agricultural productivity, environmental conservation, and critical national capabilities—from advanced health monitoring to adaptive agricultural systems and rapid response to biological threats.

The GoC has committed more than $1.6 billion over 20 years through Genome Canada's funding for large-scale applied and translational genomics; accordingly, Canada is among the world leaders in genomics research and its application in numerous sectors including health, food and agriculture, environment and natural resources. As technology advances and matures, there are increasing opportunities to translate these research advantages into real-world applications and commercial products. To supplement Canada's strong historic support for genomics research and translation and to help realize greater commercial impact, the Government of Canada will be allocating $175.1 million over 7 years starting in 2024-2025 to support the Canadian Genomics Strategy (CGS).

The genomics sector in Canada is currently characterized by start-ups or small and medium-sized enterprises. However, the significant growth and commercialization potential of genomics innovations presents opportunities to grow and scale made-in-Canada success stories. This Strategy aims to build on current momentum by supporting the scaling of promising firms and ensuring Canada's long-term success in the global bioeconomy. We will achieve this by strengthening the connection between research and commercialization, thereby enhancing the economic potential and widespread adoption of genomics innovations.

To inform the development of the CGS, the GoC consulted with key stakeholders. Input focused on four key areas: data access and management, talent development and retention, adoption and commercialization, and ecosystem coordination. A *What We Heard Report,* which can be found at: Pan-Canadian Genomics Strategy: What We Heard Report (canada.ca), summarizes the consultations.

Strategic Goals

The CGS aims to:

- Advance commercialization and adoption of genomics applications by Canadian businesses.
- Strengthen leadership of the genomic enterprise to foster collaboration and improve data accessibility across Canada's genomics ecosystem. This will involve collaborative networks and cross-sector partnerships with industry, academia, non-governmental organizations (NGOs) and the public sector. By promoting interdisciplinary cooperation, these efforts will facilitate greater data sharing, knowledge exchange, and innovation in genomics.
- Develop top-tier talent in Canada's genomics sector, cultivating a robust pipeline of highly qualified people to address critical workforce needs.

Approach

To enhance federal programming to meet these strategic goals, the GoC will set up an expert advisory council, reporting to the Deputy Minister of Innovation, Science and Economic Development (ISED), comprised of industry, academic and government experts to provide strategic guidance to the GoC on new and developing opportunities while ensuring the strategy continues to align with rapidly changing science.

Canadian Genomics Strategy

Genomics: A Strategic Opportunity

Genomics is an interdisciplinary field and we are considering the definition in the broadest and most inclusive sense. It is defined as a comprehensive study, using high throughput technologies, of the molecular information of a cell or organism and its functions (for example, DNA/RNA sequencing, proteomics and metabolomics). This technology holds transformative potential for addressing critical global challenges, including climate change, environmental degradation, biosecurity, pandemic preparedness, agricultural productivity and food security. It also has enormous potential to generate significant economic benefits.

Supported by significant research initiatives Canada has thriving R&D activities making significant contributions across multiple economic sectors in Canada, including[1]:

- **Health genomics**, ranging from research and development (R&D) for better treatments and therapeutics, to new processes for analyzing and incorporating a person's genome into diagnoses.

- **Agriculture and agri-food genomics developments**, such as improving crops and livestock practices to be able to weather the effects of climate change.

- **Forestry genomics**, including improved forest productivity and conservation through a better understanding of the genetic variation of species.

- **Fisheries and aquaculture genomics**, including the study of finfish and shellfish genomes to enhance breeding and farm conditions.

- **Environmental stewardship**, including the use of genomics tools to map biodiversity, improve an ecosystem's resistance to climate change, and develop new nature-based solutions to reduce emissions.

- **Energy**, where genomics can lead to innovations in fuel production and the cultivation of renewable resources.

- **Mining**, where genomics can help mitigate the environmental impact of projects and genetically enhanced microorganisms can assist in the non-toxic bioaccumulation of critical minerals.

Canadian companies are leveraging Canada's strong research foundation to use genomics for real-world applications. Examples of the application of genomics include:

- **Health applications**, ranging from better diagnostics for rare diseases, cancer, and chronic illness to novel therapeutics like mRNA vaccines and cell therapies to pandemic and biothreat surveillance.

- **Environmental applications** that play a key role in developing greener energy and new materials (such as, biodegradable plastics), and help minimize the environmental impact of Canada's natural resources sector; facilitate decontamination of polluted sites through bioremediation; and create sophisticated biosynthetic materials for advanced manufacturing industries.

[1] *Harnessing Genomics For Impact*, (Genome Canada Annual Report 2023-2024) online: <GC-AnnualReport-2023-24_EN_web.pdf (genomecanada.ca)> at 8.

- **Agriculture and agri-food applications**, including those to improve and increase livestock and eco-friendly crop production, and an expansion of high-protein shellfish production to address food insecurity.[2]

Canadian genomics is a thriving ecosystem with world class infrastructure, researchers, institutions, and companies working across sectors from Health to Agri-food to natural resources and the environment. Building on this strong foundation, this strategy will further encourage the development of genomics research into real-world applications in multiple sectors by emphasizing greater coordination across multiple parties. The CGS will support the continued translation of Canada's research knowledge into commercialization and adoption of new technologies and processes that will support sector advancement and growth. These efforts will ensure that Canada remains competitive in a global economy where other countries are ramping up efforts to develop genomics technologies.

Due to the far-reaching scientific and economic potential of genomics, global interest and investment is rapidly expanding. As such, the GoC is supporting a strategy that provides funding to support commercialization to capitalize on its transformative power to catalyze economic growth and deliver tangible health, social and environmental benefits to Canadians.

The Federal Funding Context

Recognizing the significant potential of genomics and the need for a coordinated national approach, Genome Canada was launched in 2000 with a mandate to establish a national genomics ecosystem in Canada and to position the country as an international leader in applied genomics.

Since 2000, Genome Canada has invested approximately $1.6 billion in federal funds in large-scale applied and translational genomics research in Canada. This investment has leveraged $2.4 billion in co-funding from provincial governments and other sources for a total investment of $4.0 billion.[3] Genome Canada's federated national approach involves **six regional genome centres** that ensure federal investments are aligned with regional needs, opportunities, and interests:

- Genome British Columbia
- Genome Alberta

[2] *Harnessing Genomics For Impact*, (Genome Canada Annual Report 2023-2024) online: <GC-AnnualReport-2023-24_EN_web.pdf (genomecanada.ca)> at 10.

[3] *Harnessing Genomics For Impact*, (Genome Canada Annual Report 2023-2024) online: <GC-AnnualReport-2023-24_EN_web.pdf (genomecanada.ca)> at 23.

- Genome Prairies (Manitoba and Saskatchewan)
- Ontario Genomics
- Génome Québec
- Genome Atlantic (all four Atlantic provinces)

Genomics research and development also occurs across various government departments and agencies, and is supported by multiple federal funding sources:

- Canada's **three federal granting agencies** support genomics research through grants and awards in both fundamental and applied research. They also bolster training, skills development, and innovation in Canadian postsecondary institutions. These agencies support small-to medium-sized research projects in the field:
    - Canadian Institutes of Health Research (CIHR)
    - Natural Sciences and Engineering Research Council (NSERC)
    - Social Sciences and Humanities Research Council (SSHRC)

- The Canada Foundation for Innovation (CFI) provides funding support for fundamental research infrastructure within the Canadian research community and together with Genome Canada, supports genomics technology platforms.

- **Federal support for downstream activities in innovation** (for example, commercialization and scale-up) for entities of all sizes is provided by:

    - National Research Council's Industrial Research Assistance Program (NRC IRAP)
    - Regional Development Agencies (RDAs)
    - ISED's Global Innovation Clusters (GIC)
    - Strategic Innovation Fund

- The Genomics Research and Development Initiative (GRDI) supports the Government of Canada's intramural[4] research activities in genomics with an annual budget of $20 million. Research areas for the GRDI include agriculture, environment, fisheries, forestry, and health. Participating GoC departments and agencies include:

    - Agriculture and Agri-Food Canada
    - Canadian Food Inspection Agency
    - Environment and Climate Change Canada
    - Fisheries and Oceans Canada
    - Health Canada
    - National Research Council of Canada
    - Natural Resources Canada
    - Public Health Agency of Canada

[4] Intramural research is conducted internally by a government department or agency.

Other significant actors in the genomics ecosystem include the National Microbiology Lab (NML), provincial and regional public health labs, research hospitals, universities, colleges, biobanks, population cohorts across the country, and a multitude of Canadian companies working in genomics.

Stakeholder Engagement

To inform the development of the CGS, the GoC consulted with key stakeholders in the genomics ecosystem. Participants included experts in genomics research, large and small businesses, industry associations, federal and provincial/territorial governments, not-for-profit organizations and universities and colleges from regions and sectors across Canada.

A total of 470 genomics experts, researchers, business leaders, and interested Canadians participated. Science-based departments and agencies were also engaged to ensure CGS alignment with existing federal programs and priorities. A *What We Heard* Report, summarizing the stakeholder input, can be found at: Pan-Canadian Genomics Strategy: What We Heard Report (canada.ca). The GoC will continue its ongoingengagement with industry leaders, expert stakeholders and provinces and territories as we go forward.

Key Policy Challenges

The engagement process identified several challenges that need to be overcome to ensure success:

a. **Canada needs to secure greater genomics-related commercialization.**

Canada has a reputation for undertaking high-calibre genomics research. The CGS provides an opportunity to improve domestic R&D intensity and genomics commercialization activities, accelerating innovation. As interest in genomics applications continues to grow, support may be needed to grow new genomics businesses and scale established ones.

b. **Canada's genomics ecosystem is fragmented and needs coordination**.

While genomics research funding is coordinated in part through Genome Canada and the federal granting agencies, outcomes from genomics research, and further applications are not. Access to data and the ability to combine and analyse genomics datasets are an important part of a successful national genomics ecosystem, and essential for advancing knowledge and catalyzing economic growth. Within Canada, genomics datasets are poorly coordinated and difficult to access due to institutional and jurisdictional silos. Enhancing

leadership of the genomic enterprise to facilitate collaboration and greater access to data within the national genomics ecosystem can aid in overcoming these challenges.

c. Canada faces significant labour shortages in the bioeconomy.

While science, technology, engineering, and mathematics (STEM) education is on the rise, a majority of STEM graduates do not stay within the field and find work in other occupations, contributing to labour shortages. According to BioTalent Canada,[5] Canada will require 65,000 additional workers by 2029. For Canada to address these skills gaps in genomics, a rich pool of highly qualified personnel (HQPs) must be developed and attracted. Genomics also needs to compete with other sectors of biotechnology to advance talent.

Strategic Goals

To respond to these key challenges, the CGS aims to strengthen the genomics ecosystem by fostering a strategic allocation of resources focused on three clear goals: advancing commercialization and adoption of genomics applications by Canadian businesses, strengthening leadership of the genomic enterprise to foster collaboration and improve data accessibility across Canada's genomics ecosystem, and developing top-tier talent in Canada's genomics sector, cultivating a robust pipeline of highly qualified people to address critical workforce needs.

Advance commercialization and adoption of genomics applications by Canadian businesses.

Commercialization of genomics research and innovation is a key driver for generating social and economic benefits for Canadians. The CGS underscores the pivotal role of Canadian businesses in developing potentially revolutionary new technologies across multiple sectors, from agriculture and food technology start-ups to novel green energy companies to established health technology firms.

While the commercial application of genomics research in health is increasingly well-established, significant opportunities also exist in the agriculture and environment sectors. CGS programming highlighted here aims to capitalize on early-stage discoveries in these and other areas and translate them into market-ready commercial products, both through targeted investments in applied research and partnerships and through the development of necessary skilled talent.

[5] The latest Labour Market input from Biotalent in 2021.

Genome Canada has been the mainstay for support of genomics research in Canada. As the science has evolved and the technology matured, Genome Canada has evolved its approach from supporting fundamental research to applied research and now to challenge-driven research with clear commercial impact. Similarly, a clear need has emerged for targeted policy approaches to accelerate technology commercialization and widespread adoption.

Genome Canada will support the CGS through its Genomic Applications Partnership Program (GAPP), delivered with the six regional genome centres. For a decade, GAPP has supported demand-driven genomics collaborations in agrifood, environment and health. Under the CGS, the program will continue to evolve with a greater focus on commercialization, adoption, and the scaling up of private firms. By working with the regional genome centres, GAPP will promote development and adoption of promising technologies based upon regional strengths.

As a complement to Genome Canada's programming, ISED's Global Innovation Clusters (GICs) program supports business-led innovation and collaboration in key areas of Canadian economic advantage. Dedicated funding to support collaborative projects that advance genomics commercialization as a component of the GIC program's activities will leverage the program's existing tools and expertise (such as commercialization support, IP creation, networking, and investment attraction) to advance genomics-related commercial objectives and develop talent.

ISED's Innovative Solutions Canada (ISC) program links R&D procurement spending with the scale-up, adoption and commercialization of early-stage research & development (in this case, genomics technology). Most departments fund ISC, so any innovation successful in the program's Challenge and Testing streams are then available across government (mostly science-based departments and agencies (SBDAs) and federal laboratories working on genomics research) for their procurement needs.

Strengthen leadership of the genomic enterprise to foster collaboration and improve data accessibility across Canada's genomics ecosystem.

Canada's genomics ecosystem includes universities, research hospitals, digital research infrastructure organizations, government labs, public health agencies, technology developers, and diverse private-sector businesses that gather, share, and use genomics data to improve their operations and provide new products.

Federal and provincial governments provide strategic investments to support the above organizations to conduct forward-thinking research and product development and establish collaborative networks and partnerships that bridge industry, academia, NGOs, and the public sector.

Genome Canada and the network of six independent regional genome centres are a critical component of the genomics ecosystem, working to align federal and provincial investments and to ensure national initiatives are built on regional strengths. The network employs a challenge-driven approach to genomics research and innovation, aiming to deliver tangible and equitable benefits for Canada. The regional genome centres provide regional and cross-sectoral knowledge, and build partnerships with researchers, industry, and end-users within the genomics ecosystem.

The CGS aims to create new national partnerships and initiatives to improve access and analysis of genomic data between government, post-secondary institutions, and private-sector organizations. The GoC is showing leadership in this area by establishing a funding arrangement with the Global Alliance for Genomics and Health (GA4GH). This Canadian-led international coalition is a global leader for human health genomics standards, formed to accelerate progress in genomic research by cultivating a common framework of standards and harmonized approaches.

Develop top-tier talent in Canada's genomics sector, cultivating a robust pipeline of highly qualified people to address critical workforce needs.

Canada faces significant labour shortages in the bioeconomy, including genomics. To address this challenge, Canada needs to develop and maintain a rich pool of highly qualified people (HQP).

The CGS aims to support the development of HQP in relevant fields. Federal programming can create linkages between early career researchers and firms that require multi-disciplinary skillsets for genomics, fostering innovative collaborations and leading to productive partnering and downstream commercial results.

NSERC's Collaborative Research and Training Research Program (CREATE) supports the training and mentoring of teams of highly qualified students and postdoctoral fellows from Canada and abroad through the development of innovative training programs. Through funding under the CGS, NSERC will facilitate the transition of genomics researchers and trainees into industry ready HQP across strategic sectors in Canada.

CIHR strives to ensure a solid foundation of future health research leaders by offering programs that increase the supply of highly qualified research personnel. Under the CGS, CIHR will fund training awards to support graduate students studying bioinformatics,

computational biology, and data sciences, responding to an identified shortage of talent that can limit downstream investments. Support to CIHR also includes resources that complement its new bioinformatics, computational biology, and health data sciences training platform (created to develop HQP) enabling the next generation of genomics researchers' greater access to these novel resources.

Governance and Coordination

To enhance federal programming to meet these strategic goals, the GoC will set up an expert advisory council, reporting to the Deputy Minister of ISED, comprised of industry, academic and government experts to provide strategic guidance to the GoC on new and developing opportunities, while ensuring the strategy continues to align with rapidly changing science.

Provincial and International Collaboration

With Canada's strong research base, harnessing innovation to further genomics applications requires partnerships and collaborations with research organizations and corporations from around the country and the world.

Federal-Provincial-Territorial (FPT) engagement will continue through activities undertaken by the CGS Secretariat and via programming identified in Annex A.

Genome Canada distributes funding to support operations, research, and innovation projects at the six independently incorporated regional genome centres located across Canada. The regional genome centres are then able to leverage federal support from Genome Canada to secure provincial co-funding to partner on projects.

As demonstrated by previous federal investments into the genomics ecosystem, the proposed approach will de-risk potential provincial investment in the uptake and commercialization of genomics innovation and encourage greater collaboration between the FPT governments to build synergies and work together to advance CGS goals.

International collaborations have always been a part of developing Canada's research excellence, allowing the domestic genomics ecosystem to link with innovative ideas globally, accelerate technology development, and gain a foothold in international markets. Canada will continue to engage with like-minded countries to create linkages, advance mutual interests, and foster opportunities and collaboration, including in the development of HQPs.

Next Steps

To enhance federal programming to meet these strategic goals, the GoC will set up an expert advisory council, of industry, academic and government experts to provide guidance to the GoC on new and developing opportunities while ensuring the strategy continues to align with this rapidly changing science.

Annex A: Programming by Strategic Goal

The GoC is allocating $175.1 million over 7 years, starting in 2024-2025, to support the Canadian Genomics Strategy (CGS).

Since 2000, Genome Canada has been a key convener of the national genomics ecosystem through high-impact challenge-driven genomics research and innovation that deliver tangible and equitable benefits to communities across Canada.[6] Genome Canada will continue to play a crucial role in raising awareness towards CGS objectives and programs, as well as convening discussion with national and international partners on the most pressing issues affecting genomics. It will also support technology advancement in genomics through national and international partnerships and offering funding competitions in pursuit of the most promising commercialization opportunities.

Strategic Goal 1: Advance commercialization and adoption of genomics applications by Canadian businesses.

Genome Canada's Genomic Applications Partnership Program (GAPP) ($96 million over 5 years)

- Funding opportunities through Genome Canada's GAPP will focus exclusively on commercialization, providing support to projects that help grow domestic firms which are ready to develop or adopt new genomics tools and products, thereby contributing to Canada's economic growth.

ISED programming: Global Innovation Clusters (GIC) ($20 million over 6 years)

- The GIC program is comprised of five clusters: Digital Technology, Protein Industries, Advanced Manufacturing, Scale AI, and Ocean.
- Dedicated genomics-related funding within the GIC program will expand cluster programming to advance genomics-specific initiatives.
- The GICs will support genomics firms with growth potential and facilitate research translation into commercialization opportunities. The program has relevant expertise and linkages with genomics, aligning cluster services (such as commercialization support, IP creation, networking, and investment attraction) with the needs of firms.
- The GIC program will initiate a selection process to allocate genomics-related funding among the Clusters in order to support collaborative projects that accelerate commercialization, scale-up and adoption of genomics technologies.

[6] Genome Canada, online: <Our approach - GenomeCanada>

ISED programming: Innovative Solutions Canada (ISC) ($15 million over 5 years)

- ISC will enable the government to partner with eligible Canadian small businesses and facilitate the early development, testing and validation of prototypes, and will help make the GoC a first adopter in the genomics space.
- Participation in the program provides Canadian companies, in particular SMEs, an opportunity to develop innovative solutions to meet the GoC's operational need and priorities and inject innovative ideas into the federal science and technology ecosystem.

Strategic Goal 2: Strengthen leadership of the genomic enterprise to foster collaboration and improve data accessibility across Canada's genomics ecosystem.

Genome Canada, the regional genome centers and the Global Alliance for Genomics and Health will support the CGS goal of strengthening leadership of the genomic enterprise to foster collaboration and improve data accessibility across Canada's genomics ecosystem.

Genome Canada and Regional Genome Centers ($20 million over 4 years)

- The CGS provides operating funding for the regional network of six regional Genome Centres (Genome British Columbia, Genome Alberta, Genome Prairie, Ontario Genomics, Génome Québec and Genome Atlantic) to greater assist private sector firms through their specialized knowledge and expertise and through the implementation of the CGS-supported GAPP. This Genome Canada-led regional network ensures the CGS will provide opportunities for economic development across the country, building national capacity and impact through regionally optimized initiatives.

Genome Canada will advance Canadian data management under the CGS ($2.5 million over 5 years)

- Genome Canada will work closely with the federal government and other key partners to advance work on data, including to convene and coordinate a national alliance dedicated to mapping existing infrastructure, identifying gaps, setting objectives, and building a plan for large-scale national data assets.

CIHR support to the Global Alliance for Genomics and Health ($4 million over 4 years)

- The Global Alliance for Genomics and Health (GA4GH) allotment creates a funding arrangement between the federal government and GA4GH. The GA4GH is an international alliance formed to create a common framework of standards in genomics and develops technical standards and policy frameworks and tools that expand the responsible, voluntary, and secure use of genomic and other related health data. This support enables Canada to host the GA4GH secretariat ensuring Canada maintains its global leadership in this field. Genome Canada already has an ongoing relationship with GA4GH, including as co-partners in various data-related initiatives.

Strategic Goal 3: Develop top-tier talent in Canada's genomics sector, cultivating a robust pipeline of highly qualified people to address critical workforce needs

The Natural Sciences and Engineering Research Council Collaborative Research and Training Experience (CREATE) program ($9 million over 7 years)

- NSERC CREATE supports the training and mentoring of teams of highly qualified students and postdoctoral fellows from Canada and abroad through the development of innovative training programs. It will facilitate the transition of genomics researchers and trainees into industry ready HQP across strategic sectors in Canada.

The Canadian Institutes of Health Research Training Awards ($6 million over 6 years)

- CIHR strives to ensure a solid foundation of future health research leaders and is committed to offering programs that increase the supply of highly qualified research personnel.