Canada's Digital Biology Advantage

Transforming Industries for a New Era of Prosperity and Self-Reliance

Genome Canada

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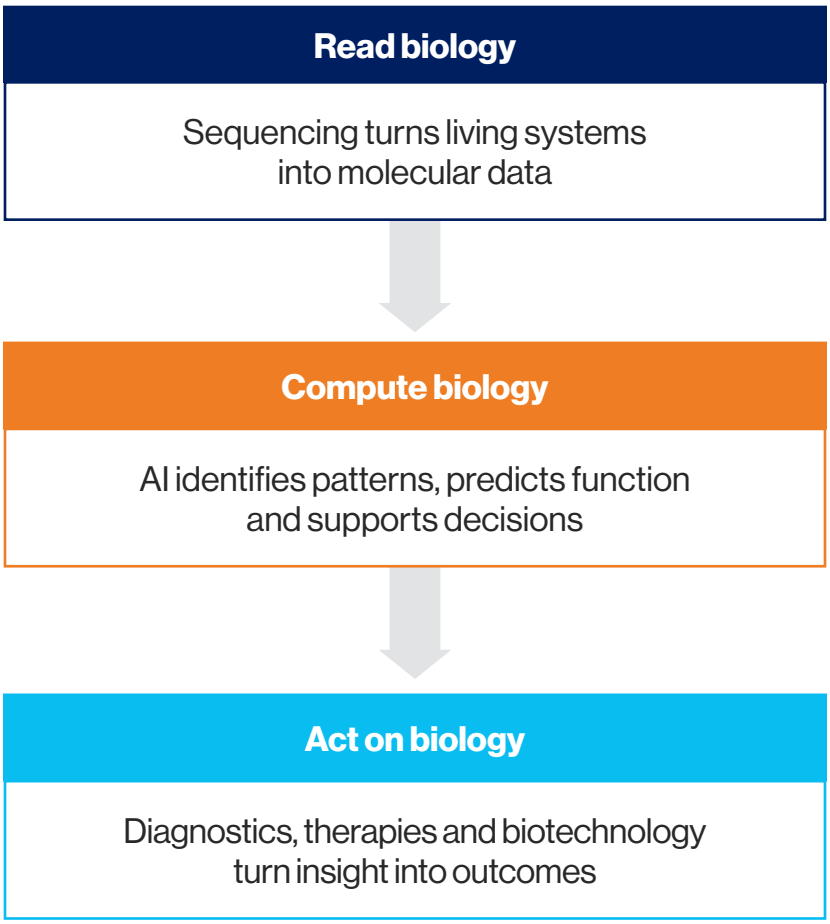
Digital biology: The engine of transformation

Biology is becoming increasingly readable, computable and engineerable



Genomics is the connective layer between biological systems, computational power and real-world innovation.

Executive summary

A new platform for prosperity

Genomics and related biotechnologies are reshaping how economies create value. By making biology readable and usable as data, they are driving a **digital biology revolution** that is transforming health care, enabling preparedness and resilience, and creating new sources of growth across the Canadian economy.

The economic impact of this "bio revolution" is already significant. New research conducted by Signal49 Research on behalf of Genome Canada sets out the scale of the genomics sector's economic impacts:

78K | Canada's genomics sector supports nearly 78,000 jobs	**$16.7B** | The sector contributes $16.7 billion to the GDP, as well as generating $8.9 billion in labour income and $4.5 billion in tax revenue.
151K | By 2035, genomics-related activity is projected to support more than 151,000 jobs.	**$42.6 billion** | By 2035, genomics-related activity is also projected to support more than $42.6 billion in GDP.

These figures capture only a fraction of the opportunity. Genomics and related biotechnologies are enabling new capabilities across every sector of the economy, from health and food production to natural resources and advanced manufacturing.

Climate-resilient crops and livestock	Protecting forests from pests and disease	Recovering value from mine waste and reducing pollution
Earlier detection and more precise treatments	Next-generation bio-based products	Detecting biological threats before they spread

The global bioeconomy

Canadian scientists have been key to pushing forward the frontier of genomics research, and Canadian entrepreneurs have staked out Canada's place in the growing bioeconomy, projected to be worth **US$30 trillion globally by 2050**.[1]

Technology with economy-wide impact

Genomics is improving the resilience and productivity of agriculture and aquaculture, helping protect Canada's natural resource industries from emerging threats, creating new biomanufacturing opportunities and transforming health care through earlier disease detection, more efficient drug development and new treatments for serious illnesses.

1 "Financing instruments and policy levers to harness biomanufacturing for climate, biodiversity and growth," *OECD*, 2025-12-02, https://www.oecd.org/en/publications/financing-instruments-and-policy-levers-to-harness-biomanufacturing-for-climate-biodiversity-and-growth_48bec995-en/full-report.html#a1zNat241

Genomics can also provide Canada with an early-warning system for emerging biological threats. Genomics-based surveillance can detect changes in pathogens and ecosystems before they become crises, while genomics-enabled tools translate that intelligence into new diagnostics, therapeutics and other critical products.

Together, these capabilities can strengthen Canadian industries and create new sources of economic and strategic advantage.

The foundation for self-reliance and security

The same biotechnology and biomanufacturing platforms that support commercial production can be rapidly adapted during emergencies to produce diagnostics, therapeutics and other critical supplies.

Building up these capabilities is not about turning away from global markets or scientific collaboration. It is about building the domestic capabilities Canada needs to reduce critical dependencies, respond to disruption and compete from a position of strength.

Realizing this potential will require Canada to retain and build value from the assets that underpin digital biology. The biological data generated by Canada's diverse populations, ecosystems and natural resources will be increasingly valuable to research, innovation and industry. Strong and trusted Canadian stewardship of this data—together with the infrastructure, talent and intellectual property needed to use it—will be essential to ensuring Canadian assets create lasting benefits in Canada.

Canada's choice

Canada enters this transformative period from a position of strength. Canadian researchers, entrepreneurs and innovators have helped establish the country as a global leader in genomics. But scientific leadership does not automatically translate into commercial leadership, domestic capacity or economic advantage.

The global bio revolution is already creating new sources of economic and strategic advantage. The question is whether Canada will capture its full value. Doing so means converting scientific strengths into national capabilities, strong companies and solutions that support prosperity and self-reliance. It also means ensuring that the data, infrastructure and intellectual property driving this transformation continue to create value for Canada.

We have the assets to lead. The opportunity now is to build on them in ways that strengthen Canadian capacity, scale Canadian companies and capture more value from Canadian discoveries. This paper shares a snapshot of the transformational opportunities ahead.

Understanding the economic impact of genomics

As of 2025, Canada's genomics sector supported nearly 78,000 jobs in Canada, contributing $16.7 billion to Canada's GDP, as well as generating $8.9 billion in labour income and $4.5 billion in tax revenue.[2]

This impact is set to grow significantly over the next decade. A conservative mid-point estimate projects that by 2035, genomics-related activity will support more than 151,000 jobs across the economy and generate over $42.6 billion in GDP.[3]

But genomics is not just another sector of the economy. Like electricity, computing and the internet before it, genomics and related biotechnologies are broad-use technologies whose impacts extend far beyond the sector itself, transforming industries across the economy.[4]

> *Genomics allows us to digitize biology, creating a connective layer between biological systems, computational power and real-world innovation. It allows us to understand living systems with greater precision and turn that knowledge into vastly improved, and brand new, products, processes and solutions.*
>
> *This makes biological data a strategic economic asset. Canada's diverse populations, ecosystems and natural resources generate data with enormous potential value. Ensuring this data is developed and used in Canada, under strong and trusted governance, will be critical to building domestic capability and capturing the economic benefits that flow from it.*

Genomics encompasses not only our biological bodies, what it takes to sustain us, and the diseases that can impact them, but also our food chains, our natural resources and the broader biodiversity of the world. It is the key to unlocking our understanding of the living world. And it enables the tools to precisely sculpt and edit living systems, opening vast new possibilities.

2 Zafer Sonmez and James Lannigan, "Canada's Genomics Advantage: The Economic Impact of Genomics in Canada," *Signal49 Research*, 2026-08, p. 14, https://www.signal49.ca/product/economic-impact-of-genomics-in-canada_sept2026/. These figures, and the following encompass the direct impact of the organizations conducting genomics R&D and genomics companies, as well as indirect supply-chain impacts and induced impacts

3 Zafer Sonmez and James Lannigan, "Canada's Genomics Advantage: The Economic Impact of Genomics in Canada," *Signal49 Research*, 2026-08, p. 16, https://www.signal49.ca/product/economic-impact-of-genomics-in-canada_sept2026/

4 "The Stanford Emerging Technology Review 2026," *Stanford University*, 2026-02, p. 39, https://setr.stanford.edu/sites/default/files/2026-02/SETR2026_web-260219.pdf

A small snapshot of the power of digitizing biology can be seen in research that does the opposite: making the digital realm biological. Traditional methods of data storage are reaching their limits in a world that is producing ever more vast quantities of data. To combat this problem, researchers at the University of British Columbia Okanagan are developing ways to harness the power of DNA as a data storage medium. DNA fits vastly more information in a much smaller space, uses 100 million times less energy than current storage methods, and can retain information for thousands to millions of years.[5]

DNA data storage is only a small part of what genomics makes possible. From protecting Canada from biothreats and strengthening food and agricultural systems to improving health outcomes and enabling new industries such as biomanufacturing, the impact of genomics over the coming decades will be hard to overstate.

Canada has played a leading role in bringing genomics to this point of revolutionary impact.

The initial creation of Genome Canada over two decades ago, and the subsequent $4 billion invested into genomics research—including $1.7 billion federal dollars and $2.3 billion in co-funding from provinces, public sector partners and industry— have helped make Canada a world leader in the field.[6]

Canadian scientists have been key to pushing forward the frontier of genomics research, and Canadian entrepreneurs have staked out Canada's place in the growing bioeconomy, projected to be worth US$30 trillion globally by 2050.[7]

With Canada holding the second largest repository of disclosed biological sequences in patent filings worldwide and ranking third among G7 countries in venture-capital backed genomics companies, the foundations are in place.[8]

5 "How Canada is at the forefront of unpacking the potential of DNA data storage," *Canada Foundation for Innovation*, 2025-03-18, https://www.innovation.ca/projects-results/research-stories/dna-data-storage

6 "Genome Canada: Canada's Genomics Ecosystem Leader," *Genome Canada*, 2022-05, https://genomecanada.ca/wp-content/uploads/2022/05/GC_2022_EN.pdf

7 "Financing instruments and policy levers to harness biomanufacturing for climate, biodiversity and growth," *OECD*, 2025-12-02, https://www.oecd.org/en/publications/financing-instruments-and-policy-levers-to-harness-biomanufacturing-for-climate-biodiversity-and-growth_48bec995-en/full-report.html#a1zNat241

8 Zafer Sonmez and James Lannigan, "Canada's Genomics Advantage: The Economic Impact of Genomics in Canada," *Signal49 Research*, 2026-08, p. 14, https://www.signal49.ca/product/economic-impact-of-genomics-in-canada_sept2026/

Strengthening the resilience and competitiveness of established industries

BOX 1 - Examples of current and emerging genomics use cases in three key Canadian sectors

Agri-food:

- Improving the disease and pest resistance of agricultural plants and animals, including through breeding healthier, higher quality livestock *(current use)*.
- Improving crop resistance to frost, drought and other environmental factors *(current use)*.
- Protecting the health of crop and pollinator species *(current use)*.
- Improving agricultural yields and enabling new food products *(current use)*.
- Protecting food safety, quality and traceability *(current use)*.[9]

Forestry:

- Identifying and combatting diseases and pests that threaten Canada's forests *(current use)*.
- Supporting reforestation after wildfires *(current use)*.
- Strengthening the climate resilience of Canadian forests through identifying fire and drought resistance genetic markers *(current use)*.[10]
- Creating opportunities to transform pulp and paper industry waste into bioproducts through biorefineries *(emerging use)*.[11]
- Enabling the identification and traceability of wood products, supporting forest certification for market access *(current use)*.[12]

Natural resources:

- Enabling deeper analysis of well and mine sites, including helping locate new hydrocarbon reservoirs and understand the environmental impact of projects *(current use)*.[13]
- Identifying organisms that can clean tailings water and stabilize contaminated soil *(emerging use)*.[14]
- Creating biomining opportunities that can extract valuable critical minerals out of waste as well as from low-grade or unconventional ores *(emerging use)*.[15]

Genomics holds transformational potential across many fronts. One of the most important is its contribution to key Canadian industries such as agriculture, aquaculture, forestry and oil and gas —in addition to critical contributions to Canadians' health and to the health care sector more broadly (explored further below).

9 "Agriculture & Food," *Ontario Genomics*, https://www.ontariogenomics.ca/sectors/agriculture-food/

10 "Keeping our forests resources resilient and healthy," *Genome British Columbia*, https://www.genomebc.ca/why-partner-with-us-genome-bc/genomics-and-forestry-2/

11 "A Genomics Strategy for British Columbia's Forestry Sector," *Genome British Columbia*, 2019, https://www.genomebc.ca/wp-content/uploads/2019/08/0112.001.003_Forestry-Sector-Strategy_FINAL.pdf

12 "Genomics supporting Canada's forestry sector," *Government of Canada*, 2024-06-27, https://grdi.canada.ca/en/success-stories/genomics-supporting-canadas-forestry-sector

13 "Genomics in Canada's Energy & Mining Sectors," *Genome Alberta*, 2019-12, https://genomealberta.ca/wp-content/uploads/2023/05/Energy_and_Mining_Sector_Report_v4_final.pdf

14 "Biocementation for Mining Waste Management," *Genome British Columbia*, https://www.genomebc.ca/projects/biocementation-for-mining-waste-management/

15 "Biological Solutions to Critical Mineral Production from Sulfide Ores," *Genome British Columbia*, https://www.genomebc.ca/projects/biological-solutions-to-critical-mineral-production-from-sulfide-ores/

Agriculture and agri-food

The agriculture and agri-food sector provides one of the clearest examples of the role genomics can play in supporting established industries. The sector generates $149.2 billion of Canada's GDP in 2024 (equivalent to 7%) and employs 2.3 million people.[16]

The selection of plants and animals for desirable traits has long been central to agriculture, helping increase yields and support a growing global population. Historically, the process was slow and imprecise, often introducing unwanted characteristics alongside beneficial ones. The development of genomics changed that.

Earlier waves of genomics have already transformed agriculture.

For example, the pioneering work of geneticist and agronomist Norman Borlaug to develop high-yield, disease-resistant wheat varieties has been credited with helping avert famine for hundreds of millions of people and significantly improving global food security.

BOX 2 - Deploying genomics in support of Canada's dairy industry

At a time of significant external stresses on the dairy sector, genomics is playing an important role in strengthening its competitiveness and resilience. Major global players, such as the Canadian-owned cattle genetics firm Semex and the Canadian her management firm Lactanet, are key industry partners in genomics projects that identify climate resilient cattle, future proofing Canada's $20 billion dairy industry. Other dairy industry-focused projects, funded through Genome Canada's Genomic Applications Partnership Program, include one between the University of Guelph and Gay Lea Foods to ensure the microbial safety and quality of dairy powders, helping reduce losses through poor quality, enhancing the competitiveness of the Canadian agri-food sector.

Modern genomic techniques are pushing the frontier of precision agriculture even further. They enable more precise identification of desirable and undesirable genetic traits, while dramatically lower costs have expanded their use across a wide range of crops and livestock. Building on Borlaug's legacy, Canadian researchers have played a key role in initiatives such as the International Wheat Genome Sequencing Consortium, which brought together more than 1,000 researchers to map the wheat genome, a genome five times larger than the human genome. This work has been complemented by genomic breeding initiatives at the University of Saskatchewan's Crop Development Centre, which use marker-assisted selection to develop wheat varieties with greater tolerance to cold and drought, and resistance to wheat rust and other pests and diseases.[17]

Work by Canadian scientists such as this not only boosts agricultural productivity, but also helps protect the sector against emerging threats, many of them intensified by climate change.

16 "Overview of the Canadian agri-food system," *Government of Canada*, 2025-07-03, https://agriculture.canada.ca/en/sector/canadian-food-system/overview-agri-food-system

17 "Cracking Wheat," *Genome Canada*, 2022-04-20, https://genomecanada.ca/cracking-wheat/

Genomics is helping secure the future of Canadian aquaculture.

Total Canadian aquaculture production in 2024—including finfish and shellfish such as oysters and mussels—was worth over $1.3 billion.[18] But the sector faces growing threats. Climate change is warming oceans, causing heat stress and creating conditions for new diseases to spread into Canadian waters.

Two such diseases, MSX and Dermo, have spread through Atlantic Canada in recent years, devastating oyster production.[19] According to Peter Warris, Executive Director of the PEI Aquaculture Alliance, these diseases, combined with restrictions under the Canadian Shellfish Sanitation Program, have had a major impact on growers and harvesters.

Heat stress, reduced food availability and disease have stunted oyster growth and increased mortality. In some locations, growers have experienced losses of 70 to 100 per cent, including younger oysters needed to sustain future harvests. As Warris notes, many growers have lost not only this year's market crop, but future harvests as well.[20]

> *Genomics is a powerful tool to counter these challenges. It is "100 per cent necessary research for the survival of the industry," says Warris.* [21]

Warris pointed to the US shellfish industry as a model worth Canada's consideration. Over time, U.S. growers complemented investments in productivity with significant investments in genomics, using genomic tools to monitor disease and develop more resilient broodstock. Institutions such as the Aquaculture Genetics & Breeding Technology Center have become central to the industry's resilience by providing high-performing broodstock adapted to changing conditions.[22]

Similar work is underway here to build the genomic capacity and infrastructure that will be essential for the ongoing survival of Canada's aquaculture and fisheries industries. These include significant investments into MSX and Dermo surveillance through Genome Canada's eDNA Surveillance Program and others.[23] Other key initiatives include industry projects to incorporate genomic marker technology into Salmon breeding programs[24] and the deployment of genomic insights to revive and sustain fisheries in British Columbia.[25] These investments are foundational to the long-term prosperity of these industries.

18 "Aquaculture production quantities and value, 2024," *Government of Canada*, 2026-01-14, https://www.dfo-mpo.gc.ca/stats/aqua/aqua24-eng.html

19 Seyitan Moritiwon, "Oyster diseases threaten Atlantic Canada's industry," *Hatchery International*, 2025-03-30, https://www.hatcheryinternational.com/oyster-diseases-threaten-atlantic-canadas-industry/

20 Research interview with Peter Warris, PEI Aquaculture Alliance.

21 Research interview with Peter Warris, PEI Aquaculture Alliance.

22 "Aquaculture Genetics & Breeding Technology Center (ABC)," *VIMS*, https://www.vims.edu/research/units/centerspartners/abc/

23 "Protecting oysters with early warning tools," *Genome Atlantic*, https://genomeatlantic.ca/project/protecting-oysters-with-early-warning-tools/

24 "Salmon and Chips," *Genome Atlantic*, https://genomeatlantic.ca/project/salmon-and-chips/

25 "Enhancing Production in Coho: Culture, Community, Catch (EPIC4)," *Genome Canada*, https://genomecanada.ca/project/enhancing-production-coho-culture-community-catch-epic4/

The Canadian honey bee industry is a powerful example of Canada's self-reliance challenge and the role genomics can play in addressing it.

Honey bees are critical to Canada's agricultural system. Many crops, including apples, blueberries and cucumbers depend heavily on honey bee pollination, while honey bees play an essential role in hybrid canola production—accounting for around half of pollination and supporting increased harvest quality and quantity. Agriculture and Agri-Food Canada estimates that honey bees contribute seven billion dollars annually in additional harvest value.[26]

Despite its importance, Canada's honey bee sector faces mounting challenges. Winter colony losses reached 39.3 per cent in 2025, well above the historical average.[27] At the same time, Canada remains heavily dependent on imported queen bees, with more than 360,000 imported in 2026, primarily from California and Hawaii.[28] This reliance exposes the sector to trade disruptions, disease risks and broader supply chain vulnerabilities. Honey bees also face ongoing threats from varroa mites, a pest that can devastate entire colonies if left untreated.[29]

> *Rod Scarlett, Executive Director of the Canadian Honey Council, notes that major threats like overwintering losses, varroa mites and other urgently require new research—and genomics is a critical part of the solution.*[30]
>
> *Genome Canada-funded research led by Dr. Pierre Giovenazzo at Université Laval is using genomic tools to identify the genetic traits associated with winter hardiness, disease resistance and productivity.*[31] *This work is the "first of its kind in North America," according to Dr. Giovenazzo, and builds on genomic selection approaches that have transformed Canada's dairy industry, helping breeders identify and propagate desirable traits with far greater precision.*[32]

By helping breeders develop more resilient and productive bee stocks, this work could reduce Canada's dependence on imported queen bees and strengthen domestic breeding capacity. As Dr. Giovenazzo notes, genomics offers a pathway to greater self-sufficiency for Canadian beekeepers while creating new business opportunities and keeping expertise and economic value in Canada.[33] It is a practical example of how digital biology can turn domestic research strength into greater self-reliance.

26 "Statistical Overview of the Canadian Honey and Bee Industry and the Economic Contribution of Honey Bee Pollination, 2021," *Government of Canada*, 2022-12-22, https://agriculture.canada.ca/en/sector/horticulture/reports/statistical-overview-canadian-honey-and-bee-industry-2021

27 "Statement on Honey Bee Wintering Losses and Diseases Management in Canada for 2025," *Canadian Association of Professional Apiculturists*, 2025, https://capabees.com/shared/CAPA-final-report-on-winter-losses-2025.pdf

28 Research interview with Pierre Giovenazzo, Université Laval; Brendan Daisley, "Importing Queen Bees Won't Solve Canada's Beekeeping Problems," *University of Guelph*, 2026-04-14, https://news.uoguelph.ca/2026/04/importing-queen-bees-wont-solve-canadas-beekeeping-problems-opinion/

29 "Varroa mites," *Government of Ontario*, 2026-01-09, https://www.ontario.ca/page/varroa-mites

30 Research interview with Rod Scarlett, Canadian Honey Council.

31 "ApiOmic, honeybee breeding using genomics," *Genome Canada*, https://genomecanada.ca/project/apiomic-honeybee-breeding-using-genomics/

32 Hannah Sweett, "Celebrating 15 Years of Genomic Selection," *Lactanet*, 2024-08-13, https://lactanet.ca/en/celebrating-15-years-of-genomic-selection/

33 Research interview with Pierre Giovenazzo, Université Laval.

Forestry, energy and mining

Genomics is an increasingly important technology in Canada's natural resource sectors. Forestry, energy and mining combined contribute over $161 billion to Canada's GDP, employ hundreds of thousands of Canadians, and power Canada's global trade.[34] These contributions make them crucial for Canada's economy, reflected in the federal government's investments in nation-building projects that help these industries get their products to market and realize Canada's potential as an energy superpower.[35] Across all of these sectors, genomics is playing an increasingly important role, helping to strengthen their resilience and competitiveness.

The contributions of genomics are particularly significant in the forestry sector.

Long one of Canada's most important and iconic industries, forestry has faced deep challenges over recent decades. Deep cyclical decline, structural changes in the world market—such as the shift to electronic rather than paper-based media—and the growing toll of climate change are all deep threats.[36] The latter, whether through more intense and more frequent wildfires, die-backs driven by drought stress, or ever more destructive insect and disease outbreaks, have the potential to be existential threats.[37]

Genomic tools are playing an important role in countering these threats. A wide range of projects are delivering solutions to strengthen the forestry sector.

+ Using eDNA and soil microbiome sequencing that shows where forests recover naturally and where they need help
+ Enabling foresters to identify and plant fire and drought resistant varieties
+ Building essential biosurveillance projects to help counter the devastating pine beetle infestation thanks to the 2013 sequencing of its genome[38]

These same tools are increasingly being used to monitor biodiversity and ecosystem health at scale, enabling earlier detection of environmental change and supporting more informed stewardship of Canada's natural assets.

34 "Overview of Canada's forest industry," *Government of Canada*, 2025-03-12, https://natural-resources.canada.ca/forests-forestry/forest-industry-trade/overview-canadas-forest-industry; "Minerals and the economy," *Government of Canada*, 2026-02-27, https://natural-resources.canada.ca/minerals-mining/mining-data-statistics-analysis/minerals-economy; "Energy and the Canadian Economy," *CAPP*, https://www.capp.ca/en/our-priorities/energy-and-the-canadian-economy/

35 "Prime Minister Carney announces second tranche of nation-building projects referred to the Major Projects Office," *Prime Minister of Canada*, 2025-11-13, https://www.pm.gc.ca/en/news/news-releases/2025/11/13/prime-minister-carney-announces-second-tranche-nation-building-projects

36 "Overview of Canada's forest industry," *Government of Canada*, 2025-03-12, https://natural-resources.canada.ca/forests-forestry/forest-industry-trade/overview-canadas-forest-industry

37 "Forests and Climate Change," *Climate Atlas of Canada*, https://climateatlas.ca/forests-and-climate-change; "Canada needs to get ready for a future fraught with fire: How can the forest sector respond?," *Canadian Climate Institute*, 2024-01-31, https://climateinstitute.ca/canada-fires-forest-sector/

38 Cindy Macdonald, "Mountain pine beetle genome decoded," *Pulp & Paper Canada*, 2013-04-02, https://www.pulpandpapercanada.com/mountain-pine-beetle-genome-decoded-1002191713/

Genomics is finding applications across the energy and mining value chain, demonstrating the breadth of its economic potential.

In exploration, research projects have validated the use of genomic data to identify and de-risk offshore oil and gas opportunities in Nova Scotia.[39] In extraction and remediation, genomics is enabling a new generation of biological tools.

> *One example is a collaboration between Genome British Columbia, The University of British Columbia and the Rio Tinto Centre for Future Materials to advance biomining, which uses microorganisms to extract metals from mineral ores and waste streams.*

These techniques can help recover valuable resources while treating tailings and polluted water that are difficult to address using conventional methods.[40] Biomining holds huge economic potential. As a recent study has concluded, "vast quantities of mine tailings in Canada represent a substantial and largely underutilized secondary resource for critical minerals."[41] Here, genomics is unlocking the value of resources while reducing environmental impacts and liabilities.

Similar opportunities exist in the energy sector. Canadian projects have explored the use of bioengineered microbes as biosensors to detect pollution in oilsands tailings ponds and as tools to accelerate remediation.[42] With oil sands remediation liabilities potentially as high as $130 billion, speeding up the clean up of tailings ponds has huge financial and environmental upside, as well as helping make new projects more viable.[43]

Protecting the health and security of Canadians

In addition to helping strengthen Canada's industries, genomics is also playing an essential role in protecting the health and wellbeing of Canadians, from both known diseases, such as cancer, and unknown and emerging threats, like pandemics and other invasive diseases. As research from Signal49 has shown, Canada is an international leader in health genomics, with the technology already "improving health care in tangible ways" (see Box 3).

39 "Saint Mary's part of new $6.5 million offshore de-risking project," *Saint Mary's University*, 2019-07-24, https://news.smu.ca/news/2019/7/24/saint-marys-part-of-new-65-million-offshore-de-risking-project

40 "Genome BC and UBC Launch Biomining Innovation Partnership to Transform Mining Practices," *Genome British Columbia*, 2026-01-27, https://www.genomebc.ca/blog/genome-bc-and-ubc-launch-biomining-innovation-partnership-to-transform-mining-practices/

41 Daowi Wang and Qi Liu, "Recovering critical minerals and metals from Canadian mine tailings for renewable energy transition: Resources potential and reprocessing challenges," *Hydrometallurgy*, 243, 106723, 2026-08, https://doi.org/10.1016/j.hydromet.2026.106723

42 "AU researcher engineers microbes to detect oilsands pollutants," *Athabasca University*, 2024-05-15, https://www.athabascau.ca/news/research-and-innovation/science-and-environment/au-researcher-engineers-microbes-to-detect-oilsands-pollutants.html

43 Rebecca Kauffman, "Tailings Pond Liabilities: Alberta's Looming Oil Sands Challenge (Part 1)," *Environmental Law Centre*, 2022-08-22, https://elc.ab.ca/post-library/tailings-pond-liabilities-albertas-looming-oil-sands-challenge-part-1/

Box 3 Genomics use cases in health care (Source: Signal49)

Earlier detection: Genomics supports precision diagnostics, such as non-invasive prenatal screening, carrier screening and blood tests that can detect certain cancers earlier.

Better identification of health risks: Risk can be determined more precisely, allowing clinicians to focus attention on patients and to target interventions.

More efficient drug development: Using genomics technologies, new medicines take less time to develop, can be designed more deliberately, and are more likely to work.

New treatments for serious diseases: Gene- and cell-based therapies are now being used to address the underlying causes of certain conditions rather than just treating symptoms, offering new hope for patients with inherited disorders, cancers and other complex illnesses.[44]

These applications are setting the stage for significant economic gains for Canada. Most notably, AbCellera, the Vancouver-based biotechnology firm that grew from Genome Canada and Genome British Columbia funded projects, has recently seen major stock market gains. A new treatment developed by them for hot flashes in menopausal women has proven more effective and has fewer side effects than existing therapeutics in clinical trials, resulting in some analysts forecasting annual sales of over $2 billion for AbCellera.[45]

While these kinds of potential sales would be transformational, cementing AbCellera's place among the global biotechnology giants, genomics is also reshaping patient care. This is particularly evident in the fight against cancer.

Genomics in the fight against cancer is a "game-changer for patients."

Cancer is Canada's leading cause of death,[46] with more than a quarter of a million Canadians expected to be diagnosed in 2026. Approximately 240 people a day will die from it.[47]

The human and economic costs are substantial. The Canadian Cancer Society estimates that cancer imposed $37.7 billion in societal costs in 2024, including $30.2 billion in direct health care costs, a figure expected to rise in the years ahead.[48]

Genomics is helping change that trajectory. According to Catalina Lopez-Correa, Executive Vice-President, Research, at the Canadian Cancer Society, "genomics is a game-changer for cancer patients." Genomic technologies are increasingly being used across the cancer journey, from risk assessment and early detection to diagnosis, treatment selection and prognosis.

44 Zafer Sonmez and James Lannigan, "Canada's Genomics Advantage: The Economic Impact of Genomics in Canada," Signal49 Research, 2026-08, p. 20, https://www.signal49.ca/product/economic-impact-of-genomics-in-canada_sept2026/

45 Siddhi Mahatole, "AbCellera's menopause drug cuts hot flashes in mid-stage trial, shares surge," Reuters, 2026-08-10, https://www.reuters.com/business/healthcare-pharmaceuticals/abcellera-menopause-drug-cuts-hot-flashes-mid-stage-trial-shares-rise-2026-08-10/

46 "Leading causes of death, total population, by age group," Statistics Canada, 2026-01-13, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310039401

47 "Cancer statistics at a glance," Canadian Cancer Society, https://cancer.ca/en/research/cancer-statistics/cancer-statistics-at-a-glance

48 "Canadian Cancer Statistics: A 2024 special report on the economic impact of cancer in Canada," Canadian Cancer Society, 2024-10, https://cdn.cancer.ca/-/media/files/research/cancer-statistics/2024-statistics/2024-special-report/2024_pdf_en.pdf

Genome Canada's landmark Canadian Precision Health Initiative (CPHI) will create Canada's largest-ever collection of human genomic data, laying the foundation for earlier cancer detection and more precise treatments.[49]

Early precision medicine research demonstrated substantial benefits for patients. Clinical trials that matched treatments to specific biomarkers achieved significantly higher response rates and longer progression-free survival than non-targeted approaches.[50]

More than one in four cancer patients can benefit from targeted therapies based on genomic analysis of their tumours, representing tens of thousands of Canadians each year.[51]

> *The benefits extend beyond patient outcomes. "Cancer is the area where genomics has the most tangible economic impact in health care," says Lopez-Correa. As cancer treatment costs continue to rise, the cost of genomic sequencing continues to fall. Sequencing costs at the Genome Sciences Centre declined 61 per cent between 2020 and 2024, making precision medicine increasingly accessible.*[52]

The greatest opportunity may lie in earlier detection. Emerging approaches such as circulating tumour DNA (ctDNA) testing can identify cancers through a simple blood test before they would otherwise be detected.[53] Earlier diagnosis improves outcomes for patients and can reduce the costs associated with treating advanced disease.[54] Canadian research has similarly concluded that comprehensive genomic profiling can deliver substantial clinical and economic benefits while becoming increasingly cost-effective as adoption expands."[55]

During the Cold War, radar helped us detect threats in the sky. In the future, genomics-based surveillance will help us detect threats in the environment before people get sick or industries feel serious impacts.

Genomics can help Canada detect biological threats earlier, understand how they are changing and respond before their consequences escalate. These capabilities are increasingly important to protecting Canadians, safeguarding key industries and strengthening national preparedness.

Canada faces a wide range of biological threats to human health and the natural environment. Their economic consequences can be significant. Invasive species and diseases affecting Canada's forests, for example, have cost hundreds of millions of dollars in lost revenue, prevention and control measures, and environmental mitigation.[56]

49 "Canadian Precision Health Initiative," *Genome Canada*, https://genomecanada.ca/challenge-areas/canadian-precision-health-initiative/

50 Paulina Krzyszczyk, et al., "The growing role of precision and personalized medicine for cancer treatment," *Technology (Singap World Sci)*, 2019-01-30, https://pmc.ncbi.nlm.nih.gov/articles/PMC6352312/

51 "Toward a national framework for clinical cancer genome profiling in Canadian hospitals," *Genome Canada*, https://genomecanada.ca/project/toward-national-framework-clinical-cancer-genome-profiling-canadian-hospitals/

52 Morgan Ehman et al., "The cost and cost trajectory of genome sequencing and bioinformatics analysis for Indigenous children with suspected rare diseases," *Genetics in Medicine*, (27), 101568, 2025-08-23, https://www.gimjournal.org/article/S1098-3600(25)00215-1/pdf

53 Research interview with Catalina Lopez-Correa, Canadian Cancer Society.

54 Anuraag R. Kansal et al., "Potential Economic Value of Multi-cancer Early Detection Testing Under Differential Cost Trends for Cancer Screening and Management," *Pharmacoecon Open*, 10(2): 275-287, 2025-12-23, https://doi.org/10.1007/s41669-025-00626-7

55 Stephanie Snow et al., "Life Years Gained and Healthcare Dollars Saved: National Economic Evidence Supporting Comprehensive Genomic Profiling as Standard of Care for Canadian Cancer Patients," *Current Oncology*, 33, 191, 2023-03-30, https://doi.org/10.3390/curroncol33040191

56 "Economic impacts," *Government of Canada*, 2025-09-10, https://natural-resources.canada.ca/forests-forestry/insects-disturbances/economic-impacts

Genomic biosurveillance tools provide a form of **biological radar**. Environmental DNA (eDNA) can be used to detect biological threats in wastewater, soil, air and deep-water ports, helping identify and respond to emerging risks before they become widespread.

The economic value of early detection is already clear. "Invasive species cost billions of dollars annually in lost ecosystem services, reduced resource sector productivity and management efforts," says Brittany Day, National Manager, Plant Research and Strategies, at the Canadian Food Inspection Agency. "Preventing an outbreak avoids huge costs in phytosanitary work, loss of trade and market access, tree removal and replacement."[57]

Biosurveillance also has important applications in agriculture and aquaculture. Peter Warris of the PEI Aquaculture Alliance points to the arrival of MSX and Dermo diseases in Atlantic Canada as evidence of the need for stronger genomic testing capacity. "We need to build the capacity of labs so we can do genomic testing to handle increased risks."[58]

The COVID-19 pandemic demonstrated the value of genomic surveillance on a national scale.[59] Through the Canadian COVID-19 Genomics Network (CanCOGeN), Genome Canada rapidly brought together genomic and public health capabilities to identify emerging variants and strengthen response efforts. The infrastructure developed through that work continues to support surveillance of other emerging pathogens.[60]

The biological threat landscape is also changing. Advances in artificial intelligence, biotechnology and bioengineering are lowering the barriers to designing and producing dangerous pathogens. Former White House Homeland Security Adviser and Deputy National Security Adviser Elizabeth Sherwood-Randall warns:

> *"In the foreseeable future, a terrorist group with minimal skills could access a jailbroken AI model (one that has evaded safety controls) trained on the world's most comprehensive biological data set. The group could use the model to design a new strain of H5N1 avian influenza that is more lethal and more easily spread from animals to humans than existing strains. Connecting remotely to one of the new generation of fully equipped, contract-for-service "cloud" labs, it could anonymously arrange for the virus to be built and tested and then sent to a biomanufacturing facility to be produced at scale. From there, the group could stealthily disperse the new strain through air-handling systems at major livestock farms across the United States.*

57 "New UBC Tool May Help Stop a Destructive Insect in Its Tracks," *University of British Columbia*, 2026-03-04, https://news.ubc.ca/2026/03/new-ubc-tool-may-help-stop-a-destructive-insect-in-its-tracks/

58 Research interview with Peter Warris, PEI Aquaculture Alliance.

59 Caroline Colijn et al., "The need for linked genomic surveillance of SARS-CoV-2," *Canada Communicable Disease Report*, 48-4, 2022-04, https://www.canada.ca/content/dam/phac-aspc/documents/services/reports-publications/canada-communicable-disease-report-ccdr/monthly-issue/2022-48/issue-4-april-2022/ccdrv48i04a03-eng.pdf

60 "CanCOGeN Update," *Genome Canada*, 2023-07, https://genomecanada.ca/wp-content/uploads/2023/07/GC-CanCOGeN_update_July-27-ACCESSIBLE-EN-.pdf

> *Before long, the American poultry, beef, and dairy industries would suffer massive losses. When the virus inevitably jumped to the human population, it would cause severe illness and could result in hundreds of thousands or even millions of deaths. The response from U.S. public and private institutions—lacking both an integrated strategy and adequate tools—would be too slow, too uncoordinated, too underresourced, and too overwhelmed to stop the spread and mitigate the consequences. And soon, the virus would also cross borders, triggering food insecurity, widespread sickness, and mass casualties around the world."*[61]

What once sounded like science fiction is increasingly being treated as a plausible risk. As political risk analyst and former Centre for International Governance Innovation (CIGI) fellow Kyle Volpi Hiebert notes, "the COVID-19 pandemic was mild in historical terms, yet was very disruptive globally. If a more dangerous pathogen is intentionally used in an attack then things will get out of hand fast. There will be very real consequences."[62]

A crucial shift in the bioterrorism landscape has been the way powerful new AI models have decentralized synthetic biological capabilities. While biological threats were previously managed on a state-to-state basis, Sherwood-Randall argues that "given technological changes at the intersection of AI, biotechnology, and bioengineering, changes that substantially lower the bar to lethal pathogen production and wide diffusion to uses beyond secret state laboratories, this doctrine is no longer fit for purpose, if it ever was."

These AI models now consistently demonstrate advanced capabilities that, in the view of the *International AI Safety Report*, allows them to "provide information relevant to various steps in creating biological and chemical weapons." Researchers have been able to bypass safeguards around harmful biological uses and have demonstrated that models outperform domain experts at troubleshooting virology lab protocols.[63]

The risks of these AI capabilities being utilized are not remote. "Nonstate actors—including lone wolves, terrorists and apocalyptic groups—have an unnerving track record of attempting biological attacks, but with limited success due to the intrinsic complexity of building and wielding such delicate capabilities," argue Bill Drexel and Caleb Withers for the Center for a New American Security. AI tools, combined with biotechnology advances, create "a new world of risks from the development of powerful bioweapons and biological accidents alike."[64]

61 Elizabeth Sherwood-Randall, "AI and the New Age of Bioweapons: Preparing for a World of Synthetic Pathogens," *Foreign Affairs*, 2026-08-18, https://www.foreignaffairs.com/united-states/ai-new-age-bioweapons-sherwood-randall

62 Research interview with Kyle Volpi Hiebert.

63 Y. Bengio, et al., "International AI Safety Report 2026," *DSIT*, 2026, https://internationalaisafetyreport.org/publication/international-ai-safety-report-2026

Both Sherwood-Randall and Volpi Hiebert agree that governments must do more to combat these threats. Volpi Hiebert points to both the Canadian Joint Incidence Response Unit within the Department of National Defence and the RCMP-led interdepartmental chemical, biological, radiological, nuclear, and explosive (CBRNE) threats response team as valuable initiatives that will need increased support to tackle large-scale incidents.

Looking internationally, Hiebert notes that the US Army's latest biodefence strategy, released in September 2026, seeks to incorporate lessons learned from the COVID-19 pandemic, including how pandemics tend to thrust the military into civilian support roles.[65] "It is important that kind of thinking and information is developed and articulated. And in the public domain," says Hiebert. "That way different levels of government, the private sector and civil society groups can be better prepared if a cascading sequence of negative events were to occur, something made more likely as a result of AI enabling bad actors." A safety report from Anthropic in September detailed five case studies of users attempting to harness its models to support biological weapons development.[66]

Biosurveillance is key to countering this threat. Sherwood-Randall stresses the need for "a nationwide monitoring system that can provide early warning of emerging pathogens, whether naturally occurring or synthetic." Canada has built the foundations of this kind of system through CanCOGeN. However, to be effective at detecting pathogens early enough to provide time to react effectively, continued investment in capabilities is required. For example, capabilities could include utilizing eDNA technologies in wastewater, soil, air, and deep-water port monitoring to detect, classify and respond to real time threats.

Synthetic pathogens may represent an emerging challenge, but the need for biosurveillance is already clear. From invasive species and agricultural diseases to future pandemics and biosecurity threats, early detection can reduce costs, protect critical industries and save lives. Genomics is poised to become a foundational capability for safeguarding Canada's health, economy and security in the decades ahead.

64 Bill Drexel and Caleb Withers, "AI and the Evolution of Biological National Security Risks," *Center for a New American Security*, 2024-08-13, https://www.cnas.org/publications/reports/ai-and-the-evolution-of-biological-national-security-risks

65 "Army Biodefense Strategy 2026," *United States Army*, 2026-09, https://admin.govexec.com/media/general/2026/9/2026_army_biodefense_strategy_signed_(2).pdf

66 "Detecting and countering misuse of AI: September 2026," *Anthropic*, 2026-09, https://www.anthropic.com/threat-intelligence-report-september-2026#biological-misuse-sep-26

Growing Canada's bioeconomy: Final thoughts

The potential of genomics is immense. While many technologies generate excitement but ultimately fail to deliver, genomics is already helping transform Canada's economy into a new bioeconomy.

Across a wide range of sectors, it is strengthening competitiveness, improving productivity and helping address emerging threats. It is also reshaping health care, improving patient outcomes while creating opportunities for a more sustainable health system.

In a rapidly changing and increasingly uncertain world, genomics is becoming an important source of resilience. From climate change and invasive species to emerging diseases and biological threats, genomics can help Canada anticipate risks, respond more effectively and strengthen its long-term security.

Realizing the full benefits of this transformation, however, will require deliberate action. Too often, Canadian scientists and public investments have played critical roles in developing world-changing technologies, while much of the resulting economic value has been captured elsewhere. Recent assessments of Canada's science, technology and innovation system suggest this remains the default outcome today.[67]

Canada has helped advance genomics through decades of investment in talent, research and infrastructure. Today, a growing ecosystem of researchers, companies, Genome Centres and public sector partners is working to translate those strengths into economic and societal value. Genome Canada's large-scale research and innovation missions, the *Canadian Genomics Strategy* and other national and provincial innovation strategies provide a strong foundation. The opportunity now is to build on these investments in targeted ways that strengthen Canada's capacity to commercialize innovation, scale companies and capture more of the value created by Canadian discoveries.

Canada has the assets to turn genomics leadership into enduring national capability.

67 "The State of Science, Technology, and Innovation in Canada 2025: Expert Panel Report," *Council of Canadian Academies*, 2025-11, https://cca-reports.ca/wp-content/uploads/2025/11/The-State-of-STI-in-Canada-2025_FINAL.pdf

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