GenomeAlberta

TOWARD 2050

A genomics pathway for Albertans, our health, economy and the environment

VISION

To inspire and catalyze omics solutions that benefit Albertans and the world.

MISSION

Genome Alberta supports genomics-based innovation for the needs and benefit of society through excellent science, technology development and application, fostering collaborations and partnerships, and promoting our impact and relevance through effective communication.

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EXECUTIVE SUMMARY

Genomics is a revolutionary science with the power to improve lives, transform sectors and grow economies. It brings together biology, genetics, and computer science in powerful new ways to give us incredible insights on how every living thing works and interacts with its environment.

Genomics technologies bring cost-savings, increased efficiencies, improved productivity and targeted solutions to a vast number of areas ranging from human health to biodiversity conservation to biomanufacturing to agri-food to new digital products and knowledge economy services. It's estimated that bio-based innovation could "contribute between $2 trillion and $4 trillion to the global economy by 2030" (McKinsey & Company, May 2020) and Alberta will benefit by seizing the opportunity to become a leader with a strong digital and bio-based economy.

Genomics can be a key technology driver in realizing Alberta's ambitious vision to become an internationally recognized technology and innovation hub.

Offering game-changing technologies and powerful new knowledge, genomics can deliver solutions to key sector challenges, drive economic growth, diversification, and prosperity for the province. As part *Alberta's Technology and Innovation Strategy* investing in genomics, capitalizes on growth in the life sciences sector, and postions Alberta as a serious global competitor in the bio revolution.

Using genomics solutions to address our priorities and challenges, Alberta can be a jurisdiction that attracts leading innovators and investors. Genome Alberta is proposing a focused and strategic direction for investment that capitalizes on Alberta's foundational strengths to drive results in **three key areas**;

- **Improving patient outcomes and health care delivery** through adoption of precision medicine and genomics technologies for faster and more effective diagnosis and treatment;
- **Improving productivity and competitiveness of agriculture producers** in changing global markets with healthier, more resilient, and climate-adaptable livestock and crops;
- **Enhancing Alberta's reputation for environmental stewardship and natural resource management** through increased application of genomic tools for biodiversity conservation, resilient ecosystems and continued economic opportunities in a sustainable, low carbon economy.

Over the past 18 years Genome Alberta has become an integral partner in Alberta's innovation ecosystem, working together with government departments, agencies and innovation organizations to develop and deploy genomics solutions in key sectors of our economy.

Working with all levels of government, we have secured significant investments that enable Alberta-focused research that includes more than **$550M** in genomics research with **$120M** of federal research funds helping to create **20** spin-off companies and **thousands of jobs** in Alberta.

Working closely with the Alberta government on a shared path forward, Genome Alberta is laying out a renewed vision for Alberta to expand its economic potential as part of the global bio revolution in the coming years. *Toward 2050, a genomics pathway for Albertans, our health, economy and the environment* describes how and where genomics can be a driver for Alberta's future prosperity with a strategic investment to deliver results.

Potential global economic impact next 10-20 years:

$2-4 trillion USD

with 70% driven by bio-innovation in health and agriculture/agri-food

(McKinsey Global Institute)

THE CHALLENGE

Alberta has an ambitious vision to become an internationally recognized technology and innovation hub. To remain competitive, our economy needs to maintain a strong agricultural sector, sustainable forests, an energy industry that continues to remain a leader in a low-carbon economy, and an accessible and affordable health care system. **As we continue to tackle significant challenges at home, we must harness the power of technology to transform the world and drive our economy forward.**

Alberta has what it takes to become a significant player in the growing digital and bio revolutions, however, we need to be intentional about embracing this challenge in order to gain competitive advantage and ensure sustainable growth. A report published in May 2020 by McKinsey & Company (*The Bio Revolution: Innovations Transforming Economies, Societies, and Our Lives*) highlights the significant impact of advances in biological sciences on various sectors, from health care and agriculture to consumer goods and energy.

- 60% of physical inputs used across the global economy could ultimately be produced through biological means,
- 45% of existing global disease burden could be addressed using today's innovations, and
- 30% of private-sector R&D investments are spent in biology-related industries.
- Genomics underpins innovations in engineering biology including biomolecules, biosystems, biomachines, and biocomputing which are driving economic and societal impacts.

The report estimates that the bio revolution has the potential to drive substantial economic growth, with estimates suggesting it could contribute between $2 trillion and $4 trillion to the global economy by 2030, with 70% driven by bio-innovation in the health care and agriculture/agri-food sectors alone.

THE OPPORTUNITY

Genomics is a pathway to improve lives, transform sectors, and power prosperity well into the future. Large-scale advancements in genomics, big data, AI and bioinformatics over the past 20 years are transforming the trajectories of advancements in critical areas – from health care and biomanufacturing to nature-based climate solutions.

Through its Biomanufacturing and Life Sciences Strategy, the Government of Canada is fostering growth across the country with a focus on national strength, coordinated governance, talent pipeline, public capacity, and world class regulation that enables a thriving innovation system. The opportunities for genomics in this strategy are strong. Additionally, by investing in the Canadian Genomics Strategy, Canada is showing the world its commitment to genomics and its readiness to capitalize on the bio revolution.

> **Other provinces are also working to attract Canada's innovation leaders and the federal dollars to drive their research and development forward.**

In 2022, Ontario Genomics established the BioCreate program, providing seed funding and support to assist Ontario-based genomics SMEs in the health, food and agriculture, and cleantech sectors to bring new products and technologies to market.

In 2018, Genome BC and Genome Canada invested $3 million in a $6.5 million University of British Columbia / Abcellera Project to discover, test, and develop therapeutic antibodies for the treatment of Duchenne Muscular Dystrophy-associated fibrosis. Today Abcellera is a $4 billion company and building a $701 million biotech campus including a new preclinical antibody development facility on UBC campus.

ALBERTA IS READY

Biotechnology is expected to significantly change the competitive landscape in a wide range of industries. With the promise of increased efficiencies, productivity and targeted solutions being made more affordable, global innovators are looking to gain advantage in the bio revolution. Alberta already has several foundational strengths that we can build upon, including Canada's top post-secondary institutions and leading researchers in agriculture and agri-foods, health sciences, and natural resources. We also have the ingenuity and entrepreneurial spirit that has built our key economic sectors today and will continue to drive them into the future. *The Alberta Technology and Innovation Strategy* is setting us up to enhance our position in the technology and innovation sector and Alberta is working hard to establish our reputation as a globally recognized technology and innovation centre.

Genomics innovation is leading to solutions to tackle both Alberta's, and some of the world's, greatest challenges. Now is the time to seize the opportunity with an investment that can shift Alberta to the forefront of this rapidly evolving field and position ourselves for economic growth and prosperity in the global bio-based economy. We can be a leader on the world stage in the implementation of precision medicine, environmental performance, precision agriculture and much more. **Genome Alberta is paving the way to make this opportunity a reality**.

THE ROLE OF GENOME ALBERTA

For over 18 years, Genome Alberta has driven the development and deployment of genomics-enabled solutions that are yielding significant impacts for Alberta. We are a key contributor to Alberta's innovation ecosystem, partnering closely with industry and government stakeholders, and research and innovation leaders to enable the creation and adoption of genomics solutions.

Genome Alberta is both a champion of provincial priorities and a conduit to leverage national funding, through Genome Canada and other federal programs.

As a not-for-profit research funding organization in a province that is home to top ranked research institutions, Genome Alberta adds significant value to the provincial life sciences innovation ecosystem by:

- Advancing development of novel technologies and their applications in key economic sectors,
- Capitalizing on connections across Canada to ensure Alberta benefits from the national innovation ecosystem,
- Managing milestone-driven research programs that yield tangible socioeconomic benefits and economic growth,
- Securing significant federal funds for Alberta-led research, to capture additional innovation support for our provincial priorities,
- Bringing together interdisciplinary teams to address ethical, legal, environmental, and economic barriers to ensure responsible technology development and use.

Working together on a shared pathway forward with the Government of Alberta and other innovation partners, Genome Alberta will be a trusted partner in providing leadership and investment coordination for impactful genomics innovation. We will focus our efforts on the impact areas Alberta needs for our future prosperity.

THE PATHWAY

Genomics provides game-changing technologies to deliver solutions to Alberta's key challenges, while driving economic growth, diversification, and prosperity for the province. However, a coordinated and strategic approach to maximize the return on provincial investment is needed. With a deep knowledge of the potential in genomic technologies, connections to the national and international genomics community, and thorough understanding of Alberta's challenges and priorites, Genome Alberta has identified three key areas where we can focus efforts, maximize impact and move forward on a pathway towards capturing valuable economic returns as part of the global bio and digital innovation economy.

IMPACT AREAS:

Since the launch of the human genome sequencing project over three decades ago, we have seen remarkable advances in genomic technologies, as well as the range of potential applications. These tools and technologies are already providing cheaper, faster, smarter, greener solutions in virtually all bio-based sectors. There is a huge opportunity to not only expand the use and applications towards addressing Alberta's challenges, but to also create new made-in-Alberta technology products and services.

These three critical impact areas describe where Alberta can gain advantage at home and compete globally:

Improving patient outcomes and health care delivery by adopting precision medicine and genomics technologies for faster and more effective diagnosis and treatment.

Improving productivity and competitiveness of agriculture producers in changing global markets with healthier, more resilient, and climate-adaptable livestock and crops.

Enhancing Alberta's reputation for environmental stewardship and natural resource management through increased application of genomic tools for biodiversity conservation, resilient ecosystems and continued economic opportunities in a sustainable, low carbon economy.

TABLE 1: How impact areas align with Government of Alberta strategies and business plans, and link to desired results.

IMPACT AREA 1: Improving Patient Outcomes and Health Care Delivery

ALIGNMENT WITH ALBERTA'S OUTCOMES AND GOALS

Ministry Business Plan 2023-26 - Health

Health Care Action Plan

Alberta Technology and Innovation Strategy

Alberta 2030: Building Skills for Jobs

Advancing Commercialization and Talent in Research

Health Quality Council of Alberta

ALBERTA PRIORITY OUTCOMES

1.1 Expanding diagnostic services

1.2 Reduce burden of disease by providing increased access to rapid and effective diagnosis for rare diseases

1.3 Reduce ER wait times

1.4 Better information for decision makers for monitoring emerging viral or pathogenic threats

DESIRED RESULTS FROM GENOMIC SOLUTIONS

- Improved patient outcomes through faster diagnosis enabled by expanded genome sequencing capacity
- Early diagnosis and intervention through expanded newborn screening options
- Optimization of treatments and minimized adverse drug reactions that will reduce ER wait times
- Predict the spread of emerging threats and pathogens to plan public health approaches accordingly through genomics enabled surveillance tools

CROSS-CUTTING PRIORITIES, INITIATIVES, AND ACTIVITIES

Data Technology Infrastructure and Development

Talent and Skills

Technology Transfer and knowledge sharing

Employing a One Health approach

Policy and regulatory environment

IMPACT AREA 2: Improving Productivity and Competitiveness of Agriculture Producers

Ministry Business Plan 2023-26 - Agriculture and Irrigation

Ministry Business Plan 2023-26 - Health

Alberta Technology and Innovation Strategy

Alberta 2030: Building Skills for Jobs

Advancing Commercialization and Talent in Research

2.1 Enhanced productivity and sustainable agriculture and agri-food

2.2 Disease resilience for livestock and crops

2.3 Targeted surveillance to protect crop and animal health and reduce threat of antimicrobial resistance

- Increased productivity and economic returns through genomics informed breeding and selection approaches
- Protect economically important exports and reduce any loss through advanced vaccination solutions for livestock
- Protect elite crop varieties against infectious diseases and yield loss by introducing heightened resilience
- Increased surveillance and safety testing of food-borne illness to avoid health catastrophes and economic loss through genomics and omics-based diagnostics

IMPACT AREA 3: Enhancing Environmental Stewardship and Natural Resource Management

Emissions Reduction and Energy Development Plan

Ministry Business Plan 2023-26 - Forestry and Parks

Ministry Business Plan 2023-26 – Environment and Protected Areas

Hydrogen Roadmap

Alberta Technology and Innovation Strategy

Alberta 2030: Building Skills for Jobs

Advancing Commercialization and Talent in Research

3.1 Improve natural resource management and environmental reclamation efforts

3.2 Sustainable forest management and maintenance of forest health

3.3 Effective biodiversity monitoring and conservation approaches

3.4 Enabling clean technology through genomics assessments for safe and secure storage of alternative energy sources

- Cost-effective nature based solutions for remediation and reclamation in the oil sands region
- Productive and healthy forests resilient to threats
- Informed biodiversity and conservation policies through environmental eDNA monitoring tools and programs
- De-risk hydrogen storage and maximize production through commercialization of bioassays
- Reduction of methane emissions through capture and conversion into less harmful bioproducts

IMPACT AREA 1:

Improving patient outcomes and health care delivery by adopting precision medicine and genomics technologies for faster and more effective diagnosis and treatment.

Albertans need and deserve access to an effective, efficient, and state-of-the art health care system that is there when they need it most. However, the cost of high-quality health care is substantial. In Budget 2023, the Government of Alberta is forecasting health operating expenses will cost the province $24.5 billion, a 4.1% increase over the 2022-23 forecast. Genomics technologies and precision medicine have the promise to add value, efficiency and cost-effectiveness to our health care system. Genomics is already incorporated as standard practice for select clinical methods, such as cancer and newborn screening and rare disease diagnosis. Accelerating deployment of genomics across our health care system for prevention, screening, diagnosis, and treatment is critical to ensuring the long-term health and wellness of Albertans along with minimizing the burden (physical and financial) on our health care system.

Alberta's integrated health care system is uniquely positioned to evolve quicker, relative to other jurisdictions, by nimbly responding to these developments. As well, enhancing safe and responsible access to health and genomics information will help our doctors and community-based medical professionals make the best possible health care decisions for Albertans.

As a catalyst for genomics innovation in the health care space, and with our regional and federal connections, Genome Alberta is able to strategically target new funding opportunities to advance precision medicine approaches that will improve patient outcomes by enabling effective treatment and monitoring.

1.1 EXPANDING DIAGNOSTIC SERVICES

To fully realize the benefits of precision medicine, data sharing and genome sequencing infrastructure need to be in place. Alberta is unable to handle demands of genetic testing and currently outsources many genetic tests. Expanding capacity in the province through public and private laboratories can significantly impact patient care. Performing testing within Alberta through genomics-solutions will result in:

- reduced time to return genetic testing results to the patient,
- patient data is generated in and stays in Alberta,
- health care dollars are spent in Alberta, and
- attraction and employment of the future talent needed to drive genomic diagnostic services.

1.2 REDUCE THE BURDEN OF DISEASE by providing increased access to rapid and effective diagnosis for rare diseases

While Alberta's newborn screening program currently detects 22 treatable conditions by screening for biochemical indicators that results in early diagnosis and life-saving treatment, capacity is limited. Genome Alberta will capitalize on existing investments (e.g. All for One precision health initiative) to accelerate the incorporation of additional testing for improved health outcomes for more children. Expanding newborn screening in addition to screening for other diseases including cancer and hundreds of rare diseases, will increase our ability to identify health issues and intervene at the earliest possible stages.

1.3 REDUCE EMERGENCY ROOM WAIT TIMES

Reducing emergency room (ER) wait times is a priority in Alberta. A study reported that one in nine emergency room visits are medication-related, with adverse drug reactions and ineffective drug treatments as leading contributors. Pharmacogenetic testing reduces adverse drug reactions and optimizes treatment selection by predicting an individual's response based on their genetics for a wide range of conditions including cancer, cardiovascular disease, mental health disorders including depression, pain management, and asthma.

Currently, doctors prescribe antidepressant medication based on a trial-and-error process with less than 40% of patients achieving remission during their first attempt. Pharmacogenomic testing increases remission rates by nearly two-fold in patients with major depression. Despite the evidence for improved clinical outcomes from pharmacogenomic testing, challenges remain related to information management, practical implementation issues, and reimbursement decisions. These will need to be addressed before any benefits to the patient and health care system are realized. Understanding and overcoming these barriers is key to implementing pharmacogenomic testing in the province which will:

- reduce the burden on our health care system through decreased ER wait times, and
- improve patient outcomes.

1.4 BETTER INFORMATION for decision makers for monitoring emerging viral or pathogenic threats

The COVID-19 pandemic caught the globe unprepared, devastating the global economy and forcing reactive decision-making at the expense of evaluating their potential social, ethical, and legal consequences. This highlights the importance of tracking pathogens to identify the next threat before it happens. While emergent pathogens are a priority for public health agencies globally, the risk of mortality and morbidity from antimicrobial resistance in bacterial pathogens cannot be overlooked.

Jurisdictions across the world are expanding their capacity to perform genomic pathogen sequencing and digitalization of surveillance infrastructure as part of public health policy. Considering 75% of emerging infections in humans are transmitted from animals, it is critically important to ensure infrastructure and data sharing policies are in places across human health, agricultural, and environmental sectors to collaboratively monitor known and yet-to-emerge pathogens through a One Health, integrated surveillance lens. Genomics provides a broad-spectrum pathogen surveillance option that requires no prior knowledge of the pathogen sequence, lending itself to:

- identifying new pathogens and variants of concern,
- tracking pathogen population dynamics locally and broadly, and
- surveying the spread of antimicrobial resistance and guiding decision making.

The Power and Promise of Precision Medicine

"Precision medicine offers the opportunity to tailor disease treatment to a specific person, by taking into account their genetic and biological make-up, the environment in which they live, and how they live their life. Fourth Industrial Revolution technological advances – such as **increased computational capacity, sophisticated digital information platforms and large amounts of genetic and biological data** – are changing the players involved and the way in which health and healthcare systems function... …Governments, industry, academics, civil society and patient groups need to collaborate to ensure that the whole of society is able to benefit from rapid advances in technology and precision medicine."

World Economic Forum, Precision Medicine Program

IMPACT AREA 2:

Improving productivity and competitiveness of agriculture producers in changing global markets with healthier, more resilient, and climate-adaptable livestock and crops.

Agriculture remains a major economic driver in Alberta, contributing $10.3 billion to Alberta's GDP, and employing 69,000 Albertans in 2022[1]. Sustainability and productivity of this important sector face challenges from changing climate conditions, disease outbreaks which can be devastating for both livestock and crop producers, along with the growing threat of antimicrobial resistance.

To ensure the agriculture sector remains a key economic engine, Alberta needs to meet these challenges with innovative solutions.

Increased use of genomics solutions will provide realistic, achievable strategies for a steady market access amidst shifting and uncertain environmental conditions and pre-empt economic losses. The transformative potential of genomics enables key, Alberta-made solutions such that:

- producers are protected from market turbulence and are empowered to make informed choices towards optimal management practices,
- animal welfare and environmental integrity are prioritized without a loss of productivity, sustainability, or resiliency, and
- local, and global, consumers enjoy a constant supply of safe and healthy Alberta-produced foods.

With our extensive genomics expertise and knowledge, Genome Alberta will continue to elevate Alberta's global leadership in adaptable and sustainable agriculture.

2.1 PRODUCTIVITY AND SUSTAINABILITY

Genomics allows us to explore and utilize the diversity present in plants and animals, by helping us understand the specific traits that impact productivity in our agriculture commodities. Knowing these traits allows us to use existing and novel breeding approaches to maximize productivity without sacrificing quality. As environmental conditions shift year to year, this knowledge can be critical for producers to enhance profits which in turn creates economic growth for the province.

Accelerated implementation of genomics knowledge and tools enables us to mitigate and address some of the heightened threats from climate change, such as droughts, heat, and pest outbreaks. Genomics is also helping realize the potential in Agriculture for producing climate solutions through emissions reductions and increased sequestration. Through genomics there is game-changing potential to:

- uphold competitiveness and reduce environmental concerns by enhancing selective breeding, increasing feed efficiency while decreasing methane production;
- generate value-added crop varieties more resilient to drought, profitable for producers and beneficial for the environment; and
- enhance livestock grazing practices by understanding how soil microbes interact to enhance soil carbon sequestration. This will allow us to maximize the carbon sink potential of our native grasslands, which currently store 31.8 million tonnes of carbon, with a value of $4.23 billion.

[1]https://www.alberta.ca/agri-food-investment-and-growth-strategy.aspx#:~:text=Alberta's%20agri%2Dfood%20industries%20are,support%20and%20grow%20the%20industry

2.2 DISEASE RESILIENCE

Genomics is unique in its ability to offer key insights into the underlying cause of infectious diseases, and ongoing threats to the production of animals, and crops. Generating data on both host and pathogen, genomics offers solutions that address challenges in all aspects of agriculture. Being proactive in our adoption of genomics tools will allow:

- Deployment of crop varieties with enhanced natural resistance to the key pests and pathogens through trait integration into commercial lines. For example, wheat midges cause over $300 million worth of damage and yield loss to the Canadian prairies annually.
- Development of vaccines that safeguard livestock against a variety of pathogens. For example, shielding cattle from Bovine Respiratory Disease, which contributes to 80% of morbidities and 50% of mortalities within Alberta's herds.
- Integration of resistance mechanisms to ensure continued productivity of economically important crops like canola and potato. Key examples include blackleg disease in potato (contributes $2.87 billion to Canadian economy) and clubroot disease in canola (contributed $12 billion to Canadian economy).

2.3 SURVEILLANCE

Staying ahead of industry-crippling disease outbreaks that result from either known or emerging sources requires a proactive strategy, and genomic-based surveillance can serve as our foremost defense. Genomics uniquely provides rapid testing options for detecting emerging threats early while allowing detailed transmission tracking such as:

- Serious fungal infections like *Fusarium* head blight (FHB) in wheat, protecting yields and ensuring food security.
- Livestock pathogen surveillance to protect access to international export markets by reducing the potential of recurrence of costly events like the 2003 Bovine Spongiform Encephalopathy (BSE) outbreak and the 2015 Avian flu in Alberta.
- Emergence of antimicrobial resistant pathogens from agricultural production settings with the potential to transition across environments and to human settings (a One Health approach). For example, monitoring of water sources to ensure optimal use of Alberta's water resources to meet a variety of needs and values.

Alberta is leading the way on new solutions for carbon sequestration in rangeland grazing systems and for high-protein, low carbon footprint alternative crops for global markets. With new investments announced under the **Climate-Smart Agriculture and Food Systems initiative, over $13.1M is going towards innovative solutions** to help meet net-zero emissions targets by 2050 and elevate Alberta to a global leadership position in sustainable grazing and climate smart cropping systems.

IMPACT AREA 3:

Enhancing Alberta's reputation for environmental stewardship and natural resource management through increased application of genomic tools for biodiversity conservation, resilient ecosystems and continued economic opportunities in a sustainable, low carbon economy.

Alberta has long been a leader in environmental conservation and protection while supporting economic prosperity and quality of life for Albertans. Alberta is demonstrating our commitment to Environmental Social Governance (ESG) performance through the *Jurisdictional ESG Framework* to communicate our progress and results to the public, business community and others. Genomics innovation can contribute to advancing the performance in several ESG categories including Emissions, Air Quality and Climate Risk, Biodiversity, Energy Resources, Natural Capital Protection, Remediation and Reclamation and Innovation and Technology Export and Adoption.

Genomics innovations are already underway, and can further enhance environmental reclamation efforts, increase resiliency in Alberta's forests, provide better tools for biodiversity monitoring and conservation goals, and enable the adoption of clean technology and renewable energy. Continued investment in these innovations, infrastructure, expertise, and deployment opportunities are needed to maximize growth and productivity of Alberta's natural resources sector in a sustainable, low-carbon economy.

3.1 IMPROVE NATURAL RESOURCE MANAGEMENT and environmental reclamation efforts

As a leader in energy, Alberta is committed to efficiency and quality. Genomics-focused solutions and collaborations will address challenges facing Alberta, and focus on:

- development of procedures to prevent pipeline corrosion and new extraction technologies for increased infrastructure integrity;
- improved environmental risk assessments with superior effluent clean up techniques and oil spill remediation for safer oil and natural gas exploration, development, production, and transportation; and
- cost-effective and eco-friendly remediation and reclamation of land after oil sands use that ensures safe ecosystem restoration pertaining to water quality, soil microbiome diversity and health, animal and human health resulting in a One Health approach to conservation.

3.2 SUSTAINABLE FOREST MANAGEMENT AND HEALTHY FORESTS

Genomic technologies can identify the traits for adaptations to uncertain changes in climatic conditions and pest outbreaks. These insights are needed for the development of new selective breeding models specific to planting regions to produce healthy, productive, and resilient forests. Implementation of genomic tools that accelerate tree breeding and reforestation will further support forest ecosystem resiliency and sustainability. Genomics technologies can revolutionize the forest sector by providing valuable insights into the behaviour of trees and their interacting environments by:

- identifying genetic markers associated with resilience to pests and disease for optimized seedlings, reducing losses and increasing sustainability,
- improving quality, growth, and yield to remain competitive in the global market and foster healthy environments for land, animal, and human values; and
- deploying tools for monitoring the health of forests that detect early signs of stress or disease, including invasive species allowing for early and timely intervention.

3.3 BIODIVERSITY MONITORING AND CONSERVATION

As genomics research and innovation in environmental DNA (eDNA) advances, a greater range of tools and techniques are becoming available to government, industry and NGO partners to advance biodiversity management and conservation objectives. New tools and techniques are offering more cost-effective, comprehensive and accurate alternatives to conventional monitoring activities. A variety of applications for eDNA tools are already being explored in Alberta through projects led by the Alberta Biodiversity Monitoring Institute (ABMI), such as methods to monitor rare species. Capacity for eDNA technologies is also being built up through Innotech Alberta, however, there is further untapped potential in this area where Alberta can stand out as a national leader. Expanded adoption of eDNA technology and tools will provide more effective solutions for:

- quickly and efficiently studying biodiversity and monitoring ecosystem-level changes including detecting invasive species,
- providing results rapidly and in real time with data that can inform ethical and environmental regulation and policy around habitat conservation, resource utilization and land use planning; and
- forecasting environmental challenges as they emerge that may threaten the health and success of the natural resources sector, the ecosystem, and humans (One Health approach).

3.4 ENABLE CLEAN TECHNOLOGY

Alberta is preparing for a carbon neutral economy by 2050 and looking to clean technology and innovation for solutions to help achieve this goal. With the strategic direction and principles set out in the *Emissions Reduction and Energy Development Plan* and the *Hydrogen Roadmap* to set the course for building the provincial hydrogen economy, genomics tools can support the development and scale-up of emerging hydrogen technologies by:

- offering accurate assessments of microbial communities that impact the safety and security of alternative energy sources, maximizing hydrogen production and de-risking storage; and
- identifying naturally occurring microorganisms that have the capacity to capture and/or convert methane into valuable products and optimizes them for industry utilization. These microorganisms will use methane to produce useful bio-based chemicals or materials such as biofuels and can contribute to reduced reliance on fossil fuels lowering greenhouse gas emissions.

Environmental DNA, or eDNA, is DNA that is left by organisms (e.g. animals, plants, insects, bacteria, fungi) in their environment which can be collected in samples of soil, water, snow or air and does not require direct sampling from an individual organism.

"The use of eDNA in biodiversity and ecosystem services research has become increasingly popular in recent years as a way to non-invasively survey and monitor populations of organisms. The advantages of eDNA include **cost-effectiveness and the ability to detect a wide range of species in a single sample."**

Ecosystem Services Working Group, GEOBON

STRATEGIC OBJECTIVES

The genomics pathway is a shared journey with the Government of Alberta, Genome Alberta and other key organizations within Aberta's innovation ecosystem, academia and industry. There are several strategies to guide our collective efforts and achieve results together.

These include provincial genomics leadership, using partnerships to deliver on Alberta's challenges, and focusing new resources on the adoption and commercialization of genomics innovations to yield economic returns across sectors.

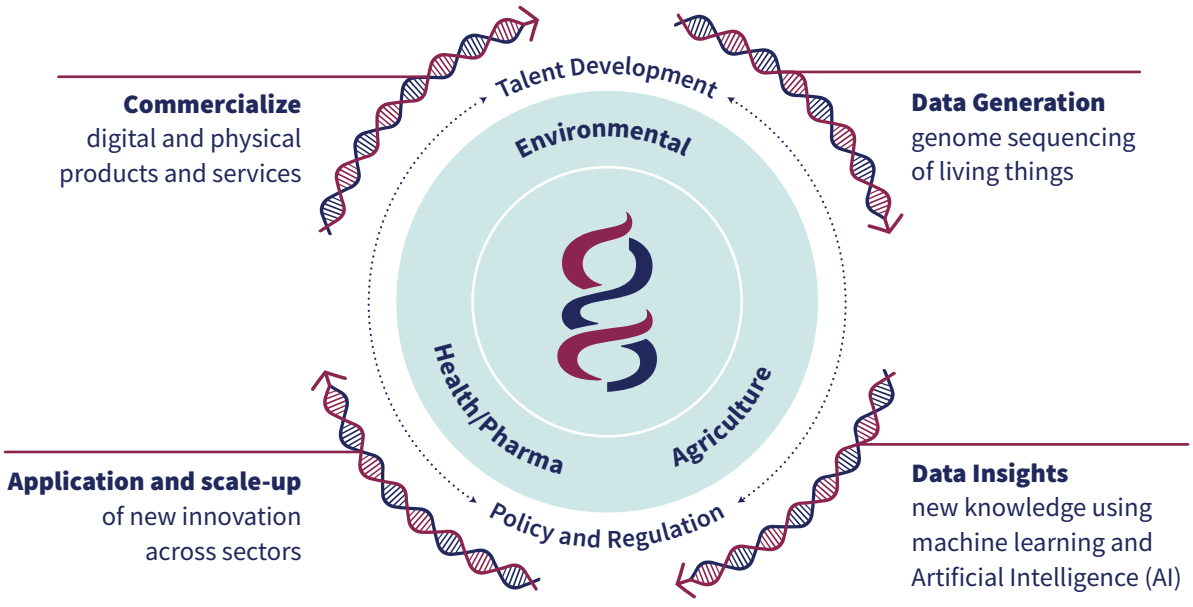
GENOMICS LEADERSHIP

OBJECTIVE: **Bring together Alberta's life sciences ecosystem through a strategy or framework to maximize value from coordinated investments across the molecular life sciences research and innovation community.**

For Alberta to fully realize economic impacts from the growing global bio-based economy, coordinated, and collaborative leadership for the province's life sciences ecosystem is critical. A number of other provinces have recently released new or updated Life Sciences Strategies (e.g., British Columbia June 2023, Ontario April 2022, Quebec June 2022) in order to position themselves globally. The diverse approaches of Alberta's industry, government, and academic communities can be harnessed into a collective effort that delivers the spectrum of benefits under a set of common goals for our province.

The Alberta government, through various ministries, continues to provide broad strategic direction for provincial innovation leaders to follow. Genome Alberta values this direction and fully supports additional efforts the government may undertake specific to the life sciences sector. In coordination with other life sciences partners, we are already working hard to advance the goals and objectives in these strategies through genomics-focused activities. We will continue to collaborate and coordinate investments that set Alberta up for success and impact. We would also value a provincial strategy dedicated to the life sciences sector which would allow ecosystem leadership to focus on driving critical near- and long-term solutions. Genomics will be a critical pillar of any life science framework and Genome Alberta is poised to contribute our genomics knowledge and leadership towards its development.

GENOMICS IN ALBERTA'S LIFE SCIENCES SECTOR



ADDRESS ALBERTA'S CHALLENGES

OBJECTIVE:

Use genomics to deliver solutions by generating higher value from large-scale genomics datasets, coordinating infrastructure deployment, and connecting the talent and expertise needed.

Genomics is a workhorse in the innovation toolkit that has untapped potential to address Alberta's challenges across sectors. Significant investments have been made over the past 20 years into earlier stage genomics research and innovation that are now readily available to the private and public sector as foundational genomics tools, assays, datasets, infrastructure and the talent pool of expertise.

The breadth of application of genomics innovation is diverse and continues to grow, both within and outside the province. Genome Alberta has seen the evolution of advances in technology and its applications and is taking a broader approach to engaging partners we know, and identifying novel ones, to connect solutions to challenges. To capitalize on our genomics investments and assets our approach will be:

- maximizing value from existing/future genomics datasets through coordination and accessibility,
- engaging partners directly to identify and accelerate the production of genomics innovations that are ready for adoption and/or commercialization,
- ensuring genomics technologies, services and infrastructure are ready to assist innovators while maximizing the leverage from key capital investments,
- accelerating training programs aimed at delivering the talent pool needed by industry and other partners to fully utilize genomics information; and
- to move innovations more quickly to the suite of partners that can deploy them.

ADOPT AND COMMERCIALIZE

OBJECTIVE:

Expand economic impacts, employment and commercialization opportunities derived from Alberta's genomics knowledge and biotechnology sector.

Since its creation in 2005, Genome Alberta has watched the evolution of investments into the field of genomics move up the Technology Readiness Level scale. While early investment was weighted heavily in the fundamental research and proof of concept and technology feasibility areas, the bulk of recent investments have shifted to applied research, demonstration/scale-up and standardization. More and more innovations are reaching technology transfer stages and are becoming ready for clinical trials and commercialization.

Adoption and commercialization of genomics innovation needs to support:

- new startup companies, with increased focus placed on building a more comprehensive and organized early-stage ecosystem to support new business creation and provide companies with the tools required to scale, both in early stage/seed funding and support services; and
- established or mature businesses, helping to diversify products, improve efficiency, lower costs or increase environmental performance.

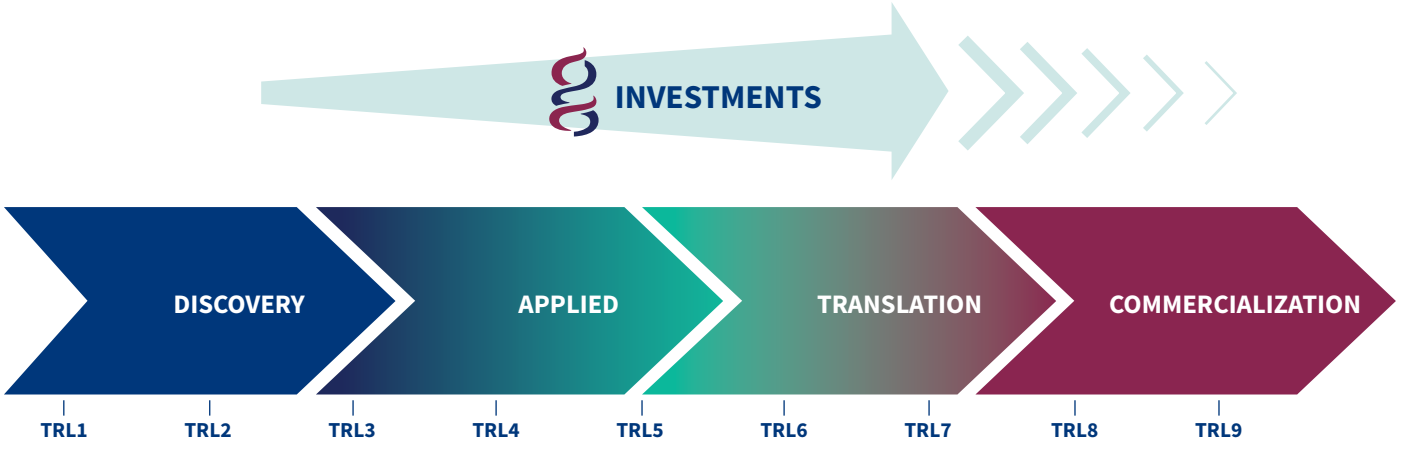
The report from the *Research and Commercialization Working Group* (RCWG), Advancing Commercialization and Talent in Research, identifies a number of ways to further advance research commercialization. Genome Alberta is positioned to address these priorities through expanding end-user driven initiatives focused on developing commercially viable genomics technologies. This would be done in partnership with for-profit industries in areas of critical importance to Alberta, such as big data analytics, health care, biomanufacturing, crops and livestock.

Alberta's life sciences ecosystem must work collaboratively so that commercially viable opportunities do not fall off the implementation pathway. To enhance the adoption and commercialization of genomics innovations, the following approaches are needed:

- support early partnerships between industry and genomics innovators for the co-creation of needed genomics solutions,
- target innovation funding opportunities to industry-identified gaps, further supporting genomics solutions that can be implemented within existing/novel business activities,
- ensure genomics-focused industry support programs that accelerate adoption and deployment of genomics solutions (e.g., Ontario Genomics BioCreate Program, Genome BC's Industry Innovation Program, and Genome Quebec's Genomics Integration Program),
- developing Alberta's regulatory and accessibility frameworks to enable responsible use of genomics datasets by industry, government, and other partners; and
- ensure industry has access to a skilled genomics, business development, and commercialization talent pool to help maximize opportunities and returns from genomics innovations.

Adoption and commercialization of genomics innovation is intended to nest within, and compliment, the broader efforts undertaken by the key players and commercialization supports already established as part of Alberta's innovation engine. Genome Alberta will continue to work closely with other innovation partners, agencies and organizations to make this happen.

INVESTMENT SHIFT IN GENOMICS INNOVATION ALONG THE TECHNOLOGY READINESS LEVELS



CROSS-CUTTING PRIORITIES, INITIATIVES, AND ACTIVITIES

A suite of critical, cross-cutting priorities and initiatives will require focused investment to deliver results in health, agriculture and natural resources and the environment. These priorities and initiatives are the foundation needed to advance innovation and include: (i) Data and technology infrastructure and development (ii) Talent and skills (iii) Technology transfer and knowledge sharing (iv) Employing a One Health approach and (v) Policy and regulatory environment.

DATA TECHNOLOGY INFRASTRUCTURE AND DEVELOPMENT

Data is transforming the way we view the world and how we drive new opportunities for growth and economic return. It is viewed by many as “the new oil” in its capacity to drive impact and profit globally. Genomics data provides a wealth of information that can be used to help navigate Alberta’s challenges across health, agriculture and agri-food, and natural resources and environment sectors. Through genome sequencing, metabolomic profiling, imaging, and other omics approaches, vast quantities of data are produced that require storage, analysis, and interpretation. The need for data management resources and digital technologies that allow broad access yet protect privacy where needed are critical to realize the full power of genomic data.

An approach that enables broader accessibility and sharing of data sets across partners will accelerate interpretation, resulting in the solutions needed to address Alberta’s priorities and create impact for the economy and society. This includes development of technologies and tools to sort through data and extrapolate information needed to make decisions. The talent and skills to put genomics to work through the management of data is also an important component of leveraging this information, and together life sciences leadership can ensure genomics talent is developed and available when we need it.

Coordination and management of genomics datasets requires an interdisciplinary approach and working together with stakeholders from industry, research institutions, government, funders, and other associations. Working with partners with vast knowledge in artificial intelligence and machine learning like Amii (Alberta Machine Intelligence Institute) will be instrumental in unlocking the potential of the data sets created by genome sequencing efforts.

> **Genome Alberta will work with Alberta’s research and data ecosystem to help enhance technologies and infrastructure that will support implementation and use of this data for socioeconomic impact.**

TALENT AND SKILLS

A highly-skilled, genomics-focused talent pool is critical to delivering on all impact areas and for all partners. To ensure Alberta has access to the skilled talent to match industry's needs and diversify the economy, we must invest in programs that develop and retain this talent. This can include:

- expansion of work-integrated learning opportunities to give students direct hands-on experience to build the skills, knowledge, and competencies required to be successful in their careers. This will provide avenues of innovation and skilled employees for industry's needs.
- upskill and cross-skill students in the life sciences with business skills needed for SMEs and large companies. Additionally, introduce business students to life sciences SMEs. This can be accomplished through work placement programs.
- continue to support students access to high quality opportunities for development through programmatic and project funding at post-secondary institutions.

The Alberta 2030: Building Skills Strategy developed by the Ministry of Advanced Education provides a framework to develop the highly skilled and competitive workforce that answers the needs of Alberta employers. Investment in programs that improve the student experience, develop skills for jobs, support innovation and commercialization, and improve sustainability and affordability are essential for a healthy economy. The intended outcome of the Alberta 2030 strategy is to ensure the province develops, attracts, and retains a future skilled workforce to diversify and grow the economy, while also securing capital and investment.

Genome Alberta and its partners will lead the way in creation of jobs and work placement positions that support genomics research, innovation, and commercialization.

These jobs include graduate students (PhD/MSc), research assistant/associates, technicians, post-doctoral fellows, undergraduate/co-op students, computer programmers, bioinformaticians, biostatisticians, project managers and coordinators, administrative staff, facility/lab managers, researchers, IT analysts, business development managers, end-users, genome analysts, financial analysts, consultants, visiting scholars, counsellors and physicians, general labourer, grant advisor, newsletter developer, and regional officers. Alongside growth of Alberta's genomics-based industry, jobs will be created that enable retention of this critical talent.

'One Health' Approach

The World Health Organization defines 'One Health' as an integrated unifying approach to optimize the health of people, animals and the environment. It is particularly important for food and water safety, control of diseases that spread between animals and humans, pollution management and combatting antimicrobial resistance.

Antimicrobial resistance (AMR) has been declared as one of the top 10 global public health threats facing humanity. AMR occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines. As a result, medicines become ineffective, and infections become increasingly difficult or impossible to treat. By some estimates, AMR may cause more deaths than cancer by 2050.

Genomics technology and tools offer cost-effective and comprehensive solutions for a One Health approach to addressing this pressing challenge.

TECHNOLOGY TRANSFER AND KNOWLEDGE SHARING

Technology transfer and knowledge sharing is essential to fully realize benefits, returns, and impacts from investments in genomics innovation. Genomics technologies must be transferred to the people and entities who will implement them. Expanding efforts to bring innovators, users, and prospective investors together at the earliest stages will enable co-development of projects that ensure users' needs are being met. Transfer of knowledge and research outcomes must be integral in the process to see more solution adoption and additional economic value through commercialization.

To increase access to commercialized research efforts, an increased focus will be placed on building a more comprehensive and organized early-stage ecosystem to support new business creation and intellectual property creation.

Companies need the tools to scale and the means to transfer technology and knowledge to industries that will facilitate their uptake. This gap is most evident for companies created within academic institutions, with many researchers struggling to find available initiatives and support systems to move their ideas out of the lab and turn them into an investible business.

Working across Alberta's life sciences ecosystem is key to ensuring that genomics knowledge and innovations can translate into real economic development outcomes for the province. Engagement with businesses (including SMEs and start-ups), economic development agencies, and commercialization entities will be integral to facilitating translation of genomic solutions developed from funded initiatives. Together, Genome Alberta and the life sciences ecosystem needs to drive development of investor-ready genomics innovations to ensure their uptake and commercialization for Alberta's economic growth.

EMPLOYING A ONE HEALTH APPROACH

Under a One Health approach, genomics acts as a unifying and cross-cutting technology that works to address the health of people, animals and their shared environments. Active surveillance of pathogens and diseases is critical to ensuring we are ready to act. Genomics provides a rapid, reliable, and cost-effective surveillance solution for the health and well-being of all.

This approach provides genomics solutions for Albertans through:

- prevention of disease outbreaks in animals and people through pathogen surveillance, yielding data that can inform relevant policy and regulations,
- monitoring spread of global pathogens to protect the health of Albertans,
- understanding the prevalence and impact of antibiotic resistant genes in the environment to target appropriate use of antibiotics, reduce the burden on the health care system, enhance animal welfare, and minimize environmental impact; and
- improved food safety and security through rapid and routine testing options.

The One Health approach cannot rely on any one sector alone. It requires integration, collaboration, and information sharing by experts across disciplines to solve these multi-faceted challenges. It depends on the development of genomics solutions, having partners ready to deploy them, and ensuring the workforce and talent are present to deliver them. In this way, One Health delivers against all impact areas critical to addressing Alberta's challenges while keeping Albertans and our key industries healthy and competitive. Genomics will drive One Health through the future.

POLICY AND REGULATORY ENVIRONMENT

For any new technology solution, the existing policy and regulatory environment plays a critical role in future uptake and broad application. Given the sensitive nature of genomics information and implications of its use, ensuring appropriate policy and regulatory frameworks that guide and support adoption and implementation of genomics innovations and datasets is vital. Barriers that may limit such implementation must be addressed in concert with innovation activities to ensure successful outcomes that will benefit society and the economy.

Through efficient knowledge and data sharing channels, research investments can support and inform the government's establishment of appropriate policies and regulations critical for impactful use of genomics innovations.

Data security and privacy regulations must be in place to ensure proper use of data, especially when pertaining to human health information. Ethical considerations around this sensitive information must guide how the data is managed from creation to interpretation. Regulations around commercialization will help manage property rights, licensing, and patents. They will also promote responsible, equitable access to data and solutions to ensure genomics innovations benefit the communities that need them most.

IMPLEMENTING THE VISION

In this document Genome Alberta has shared a renewed vision for Alberta to expand its economic potential as part of the global bio revolution in the coming years. *Toward 2050, a genomics pathway for Albertans, our health, economy and the environment* describes how and where genomics can be a driver for Alberta's future prosperity with a strategic, multi-year investment to deliver results.

Toward 2050 is a shared pathway to go forward together. Genome Alberta has worked closely with the provincial government since our inception in 2005, establishing ourselves as an integral partner in Alberta's innovation system. Genome Alberta occupies a key position to support genomics-based innovations **in all sectors of importance to Alberta** with the ability to directly leverage and secure federal investments through Genome Canada. We have built cooperative working relationships with other organizations in the innovation ecosystem to share ideas, investment and innovation priorities to ensure that there is minimal duplication and maximum synergy within the system.

With support from the Government of Alberta, this vision can become a reality for Albertans. Genome Alberta can enable the groundbreaking discoveries that will revolutionize medicine, agriculture, and environmental stewardship in our province that will touch every aspect of our lives, from personalized health care to sustainable and climate-smart food production. As we look towards 2050, the potential to unlock solutions to pressing, local, regional and global challenges have never been greater and Genome Alberta is ready to make it happen.