Ontario Genomics

FOOD INNOVATION IN CANADA REPORT

An $18.8 Billion Opportunity in Precision Fermentation and Cultivated Foods

Ontario Genomics' follow-up to the 2021 Cellular Agriculture – Canada's $12.5 Billion Opportunity in Food Innovation Report

REPORT

March 2025

Food Innovation in Canada Report Online Version

Ontario Genomics' Cellular Agriculture Initiatives

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Executive Summary

As the global population accelerates toward 10 billion by 2100, the world faces unprecedented challenges, including climate change, geopolitical instability, and worsening food insecurity. Cellular agriculture, particularly precision fermentation and cultivated foods, offers an innovative solution to diversify and strengthen global food systems. By producing proteins, ingredients, and other food products in sustainable and scalable ways, this sector has the potential to redefine food production, complementing conventional methods while addressing global challenges.

Canada's Leadership Potential

Building on the 2021 landmark report, *Cellular Agriculture – Canada's $12.5 Billion Opportunity in Food Innovation*, this follow-up report, ***FOOD INNOVATION IN CANADA REPORT*** *- An $18.8 Billion Opportunity in Precision Fermentation and Cultivated Foods*, provides an updated global, national, and regional snapshot of the sector's evolution and Canada's progress on the initial recommendations. We reflect on global changes while readjusting our economic analysis and issuing a renewed call to action for advancing Canada's leadership in this high-potential growth market. In addition, we spotlight Ontario as a high-potential province through a detailed case study. The sector's projected economic impact in Canada could reach **CAD 18.8 billion**, creating over **125,000 jobs**, assuming optimal conditions and market share growth. However, seizing this opportunity requires urgent action and a nationally coordinated strategy.

Global Landscape and Developments

The international cellular agriculture industry is growing exponentially, with over 400 companies innovating in precision fermentation, cultivated foods, and supporting technologies. Leading jurisdictions like Singapore, the US, Israel, the Netherlands, and the UK, exemplify success through coordinated national strategies, efficient and transparent regulatory frameworks, and robust investments in companies and research. Global investments in food innovation, despite recent economic downturns, have grown by $1.6 billion since 2021, emphasizing the continued momentum in this sector. For Canada to stake its claim in this international opportunity, early success and a strong foundation are paramount to ensuring it carves out its share of the market and develops supply chain relationships.

Canada's Progress

Since 2021, the Canadian government has taken concrete steps to recognize the importance of the broader biomanufacturing sector through strategic partnerships and investments. Additionally, Canada has made strides in cellular agriculture, both nationally and regionally, including:

- Doubling the number of companies in the sector to 28, spanning precision fermentation, cultivated foods, and support industries.
- Regulatory progress, such as updates on Health Canada's website with information on regulatory considerations beyond novel food premarket requirements, as well as the recently authorized precision fermentation product, Remilk.
- Substantial progress is evident across various provinces, with regional initiatives and investments that support research, company creation, and scaling efforts.

To fully realize the economic potential of this sector, national coordination of regional capabilities must be prioritized moving forward.

Challenges and Opportunities

To maximize the economic potential of cellular agriculture, Canada must overcome key challenges:

1. **Scaling Infrastructure:** Developing large-scale production facilities to ensure cost-competitive outputs.
2. **Coordination:** Aligning regional strengths under a cohesive national strategy.
3. **Regulatory Agility:** Streamlining approval processes to remain globally competitive.

As cellular agriculture technologies, particularly precision fermentation, continue to mature, optimizing and reducing input costs becomes increasingly vital. Upcycling agricultural byproducts can enhance affordability and sustainability while supporting conventional farmers and processors. This alignment strengthens Canada's ability to be a trusted, sustainable supplier of high-quality agri-food products globally.

This level of cooperation from across the agri-food value chain remains paramount to the success of Canada's cellular agriculture sector and is well aligned with the 2019 Economic Strategy Table on Agri-Food's vision for Canada to be recognized as the most trusted, competitive and reliable supplier of safe, sustainable, high-quality agri-food products, an innovator in value-added products to feed the dynamic global consumer, and favoured protein provider globally.

Recommendations

To position Canada as a global leader in cellular agriculture, the following steps are critical:

1. Prioritize a National Vision and Strategy for a Canadian Cellular Agriculture Industry in the Near Term.
2. Take Proactive Evolution Toward a Clear, Transparent, and Agile Regulatory Framework for Cellular Agriculture Products in Canada.
3. Provide Additional Supporting Mechanisms for Research and Commercial Development, Building on the Foundation Already in Place.

Changes from the 2021 Report's Recommendations have been underlined above.

Conclusion

Canada has the tools and expertise to lead the global cellular agriculture revolution. Our revised forecast suggests the Canadian industry could reach CAD 18.8 billion, creating over 125,000 jobs, representing the upper end of the potential, assuming optimal conditions globally and regarding Canada's market share. By acting decisively and fostering collaboration across regions and industries, the country can capitalize on the economic and sustainability benefits of this transformative sector. The time to act is now—failure to prioritize this opportunity risks Canada's competitive edge in the growing global market.



Introduction

CELLULAR AGRICULTURE encompasses several innovative approaches that use cell cultures, tissue engineering, or precision fermentation to make food products or other materials. Cellular agriculture can also be referred to as food biomanufacturing and can be used to create products commonly made through conventional agriculture. For the purpose of this report, cellular agriculture refers to both precision fermented and cultivated products.

As of 2024, there are 8.2 billion people on the planet with the global population expected to reach 9 billion by 2050 and 10 billion by 2100 [1]. The accelerating climate crisis, evolving consumer preferences, world events, and worsening global food insecurity present immense global challenges. Cellular agriculture – the biomanufacturing of precision fermented and cultivated foods – has emerged in recent years as an alternative and compelling route to produce proteins, ingredients and other food products, presenting the opportunity to diversify and augment current global food systems by adapting millennia-old technologies to make both existing and new food products.

There have been remarkable technological advances around the world in recent years to develop the nascent cellular agriculture industry, with precision fermented foods or ingredients already on the market and readily available in some jurisdictions [2]. Cultivated products also achieved regulatory clearance, albeit with restricted availability, with some products on the market at a smaller scale or as hybrid products. Continued efforts and support are required to enable the various food products that could be produced by cellular agriculture, with slower growth expected in these early years in order to lay the foundation of future success and allow this industry to reach its full potential as widely available and readily accepted.

To explore the potential for Canada in this burgeoning industry, in 2021, Ontario Genomics and its partners[a] conducted extensive stakeholder engagement, a literature review, and an economics analysis[b] culminating in the landmark report, *Cellular Agriculture – Canada's $12.5 Billion Opportunity in Food Innovation*.

[a] The 2021 report, *Cellular Agriculture – Canada's $12.5 Billion Opportunity in Food Innovation*, was funded by Ontario Genomics and Agriculture and Agri-Food Canada (AAFC), and researched and written by Ontario Genomics in partnership with the Food and Agriculture Institute (FAI) at the University of the Fraser Valley. The economic analysis was carried out by Dr. Michael von Massow of the University of Guelph.

[b] The 2021 report's detailed economic analysis indicates a $7.5 billion a year industry and up to 86,000 jobs created by 2030, with higher longer-term revenues of up to $12.5 billion per year with the creation of up to 142,000 jobs; this is achievable and aligned with Canada's current share of the global market for the agriculture/food (ag/food) sector.

For Canada to capitalize on this rapidly expanding and high-potential global market of foods and ingredients production and retain – or even surpass – our current role as a leading and trusted food and agriculture exporter, the three interconnected actionable opportunities from the 2021 report must continue to be acted on to support development and achieve the potential of this sector.

1. ***Develop a National Vision and Strategy for a Canadian Cellular Agriculture Industry in the Near Term.*** *This is foundational to enable a growing domestic ecosystem and fully realize the benefits presented by this industry. An outcomes-driven national vision and strategy should be developed collaboratively, be inclusive of stakeholder requirements and include a clear plan for implementation in the short-, medium- and long-term.*
2. ***Establish a Clear and Transparent Regulatory Framework for Cellular Agriculture Products in Canada.*** *Canada is encouraged to proactively develop an agile, iterative, and innovative regulatory framework by building on existing processes to support the evaluation and approval of cellular agriculture products in a timely manner, in alignment with Canada's current rigorous regulatory process and excellent food safety standards.*
3. ***Provide Supporting Mechanisms for Research and Commercial Development.*** *Incentivization, through public and private investment and partnerships, and outcomes-driven networks, is critical for a thriving domestic cellular agriculture industry, with infrastructure support for research and development, training, company creation, scale-up and growth, leading to made-in-Canada product commercialization.*

Summarized above, the full actionable opportunities from the original report are included in **Appendix B**.

We're now revisiting these themes, including Canada's progress against the above-mentioned actionable opportunities both nationally and regionally, as well as a renewal of the economic analysis. We also consider changes in the global landscape and provide a renewed call to action for the continued advancement of Canada's leadership in this high-growth potential market.

Since the release of Ontario Genomics' 2021 report, several national and international groups have published their perspectives and outlined recommendations for specific focus areas that intersect with cellular agriculture. Most notably, several common themes emerged nationally that align with the three actionable opportunities highlighted in our 2021 report.

The ***first broad pillar*** highlights the necessity of a nationally coordinated strategy, ideally supported by a federal government funding body that understands the interdisciplinary nature of such innovations and can coalesce the ecosystem around a shared national vision in a cohesive and coordinated manner and leverage each region's strengths [3-6]. Related to this pillar is the call for an interconnected and collaborative network that can work synergistically to troubleshoot challenges and streamline solutions for innovators in this space.

The ***second broad pillar*** expands on the call for clear and transparent regulatory frameworks for novel technologies and products by highlighting jurisdictions where regulations have been streamlined to enable innovation commercialization in a timely and competitive manner, and illustrate the advantages derived by these jurisdictions who took this approach [5-7].

As a new food production system, cellular agriculture presents an alternative and compelling route to produce proteins, ingredients, and other food products. In addition to food ingredients (such as proteins, enzymes, flavour molecules, vitamins, pigments and fats) that can be incorporated with existing products to create value-added hybrid goods, fermented products include dairy, eggs, chocolate, honey and coffee, while cellular/cultivated products comprise red meat, poultry, seafood, foie gras and pet food. Non-food cellular agriculture products cover textiles such as leather, wool, silk and cotton.

The ***third broad pillar*** reiterates the need for supporting mechanisms to enable growth of innovative industries, including cellular agriculture. There is no one-size-fits-all solution, and support must come from the public and private sectors and cover training and talent development, research and development (R&D), start-up support, funding mechanisms, and scale-up infrastructure. Such supporting mechanisms can be dedicated to a single industry, or, more cost-effectively, be broadly applied across related technologies [3-7]. An interconnected hub model would enable regions to efficiently utilize their underlying advantages and account for Canada's vast geography and local differences.

The ***fourth broad pillar*** explores the far-reaching implications of such innovations, including cellular agriculture, in consumer attitudes, sustainability metrics, and the conventional agriculture and food (ag/food) sector, which is a substantial contributor to Canada's Gross Domestic Product (GDP). Several reports indicate that to allay any potential hesitancy and concern from consumers and conventional producers alike, there must be deliberate co-development and growth of both the technical and societal aspects of the Canadian cellular agriculture ecosystem [6-8].

There is a clear consensus on the sizable opportunity for innovation in multi-disciplinary and cross-sectoral biomanufacturing in Canada. Most activity at the national level thus far has been in the health biomanufacturing sphere, particularly since the recent COVID-19 pandemic. Still, there is the opportunity to actively and collaboratively incentivize and invest in the biomanufacturing space across the food and cleantech sectors. At a regional level, activity is accelerating across the country with new research, start-ups, funding, infrastructure and more. Building on the investments and progress that has already been made, Canada must continue to act on these shared recommendations, and it's important to consider how we are going to make this a reality.

HOT OFF THE PRESS

Meatly cultivated dog treats on sale in UK

February 7, 2025 – Meatly cultivated chicken hit UK shelves in Chick Bites dog treats produced in collaboration with vegan dog food company, THE PACK. This milestone marks the first sale of cultivated meat in the UK and in Europe, and the first cultivated pet food on the market globally. *REFERENCE*



Global: Updates and Initiatives

Top Three Global Initiatives

International attention and growth continue, with noteworthy global developments including:

- In 2022 (Israel) [9] and 2023 (China) [10], the Food and Agriculture Organization of the United Nations (FAO) held expert consultations and roundtable meetings centred around cellular agriculture food safety. The third meeting in the series [11], and the first in North America, happened in collaboration with Agriculture and Agri-Food Canada (AAFC), the federal ministry responsible for regulating the country's agricultural business. It took place October 10th, 2024, in Toronto, Canada and captured a snapshot of the current status of cell-based food production and precision fermentation, with all the latest developments in technologies and techniques. The event brought together 25 presenters from various parts of the world, and ~60 participants, including representatives from various departments and agencies of the Government of Canada. The meeting encouraged continued multidisciplinary and multisectoral exchanges to further transnational collaboration to assure safety standards for food derived from cell-based production and precision fermentation.
- Recently, the Bezos Earth Fund has committed $30 million each to three Sustainable Protein Centers. The first at North Carolina State University [12] is a centre of excellence to create a biomanufacturing hub, the second at Imperial College London [13] has a focus on bioengineering, and the third at National University of Singapore [14] is focusing on precision and biomass fermentation. These centres form a global network dedicated to advancing sustainable protein research, and mark the first significant investment by a foundation in this space so far, which is a sign of continued support for the industry.
- The first extensive discussions on sustainable agriculture and resilient food systems at the COP28 UN Climate Change Conference in Dubai, took place in late 2023 [15]. Topics included cellular agriculture technologies and their role in climate action, with more than 150 countries committing to include food and agriculture in their plans to address climate change.

Global Industry – Cellular Agriculture on the Rise

The number of companies focused on this space has exploded around the world over the last few years, with hundreds of companies being created or coming out of stealth mode, including many business-to-business (B2B) and some business-to-consumer (B2C) companies[c]. The estimated 400+ companies worldwide include those focused on three categories: (1) precision fermentation; (2) cultivated foods; (3) support.

Figure 1 presents these categories with a further breakdown by product and product category and includes both B2Bs and B2Cs. Worldwide, these three categories are evenly distributed. A wide variety of products or ingredients are being produced and support is being provided across the pipeline for continued growth of the space. There are companies creating precision fermentation products, those creating cultivated products, and support companies which are helping the others. Support can be a variety of things including media, cells, scaffolding, artificial intelligence (AI), other tools, etc.

A deeper examination of the changes in the number of companies from 2021 to 2024, as **Figure 2** shows, demonstrates growth in certain key products or areas including beef, fish, dairy and other protein ingredients, as well as in various support companies. This is consistent with what was predicted in our 2021 report, in that a variety of B2B companies would form the next wave in cellular agriculture to offer support along the production pipeline, rather than the continued establishment of the fully verticalized companies that originally launched the broader industry just over a decade ago.

It is worth noting that there has been significant growth in the number of support companies – some dedicated to cellular agriculture and others that are cross-platform – working across the sub-categories of cell culture inputs and cell line optimization, scaffolds, bioprocess design and optimization, bioprocessing infrastructure and equipment, and contract manufacturing/processing. The cross-platform nature of some of the companies, which also service other sectors including health and cleantech, demonstrates the multi-sectoral nature of engineering (synthetic) biology and biomanufacturing more broadly. The number of support companies, as well as the breadth of their services across the production pipeline, is indicative of the growth and continuing maturation of the industry as a whole.

HOT OFF THE PRESS

Netherlands Launches Two New Cellular Agriculture Facilities to Boost R&D and Production

January 15, 2025 – Two new cellular agriculture facilities have been launched in the Netherlands, backed by the National Growth Fund with €25M Investment. These facilities aim to strengthen the country's position in the sector by providing critical infrastructure for scaling R&D and production. One focuses on precision fermentation, while the other, Cultivate at Scale, specializes in cell culture bioprocessing *REFERENCE*

[c] The list of companies was obtained through various publicly available sources, including the Good Food Institute, but is not an exhaustive list. A stringent process of refinement was then conducted to focus on companies producing foods or food ingredients specifically, or companies developing technologies that directly support precision fermentation or cultivation of foods.

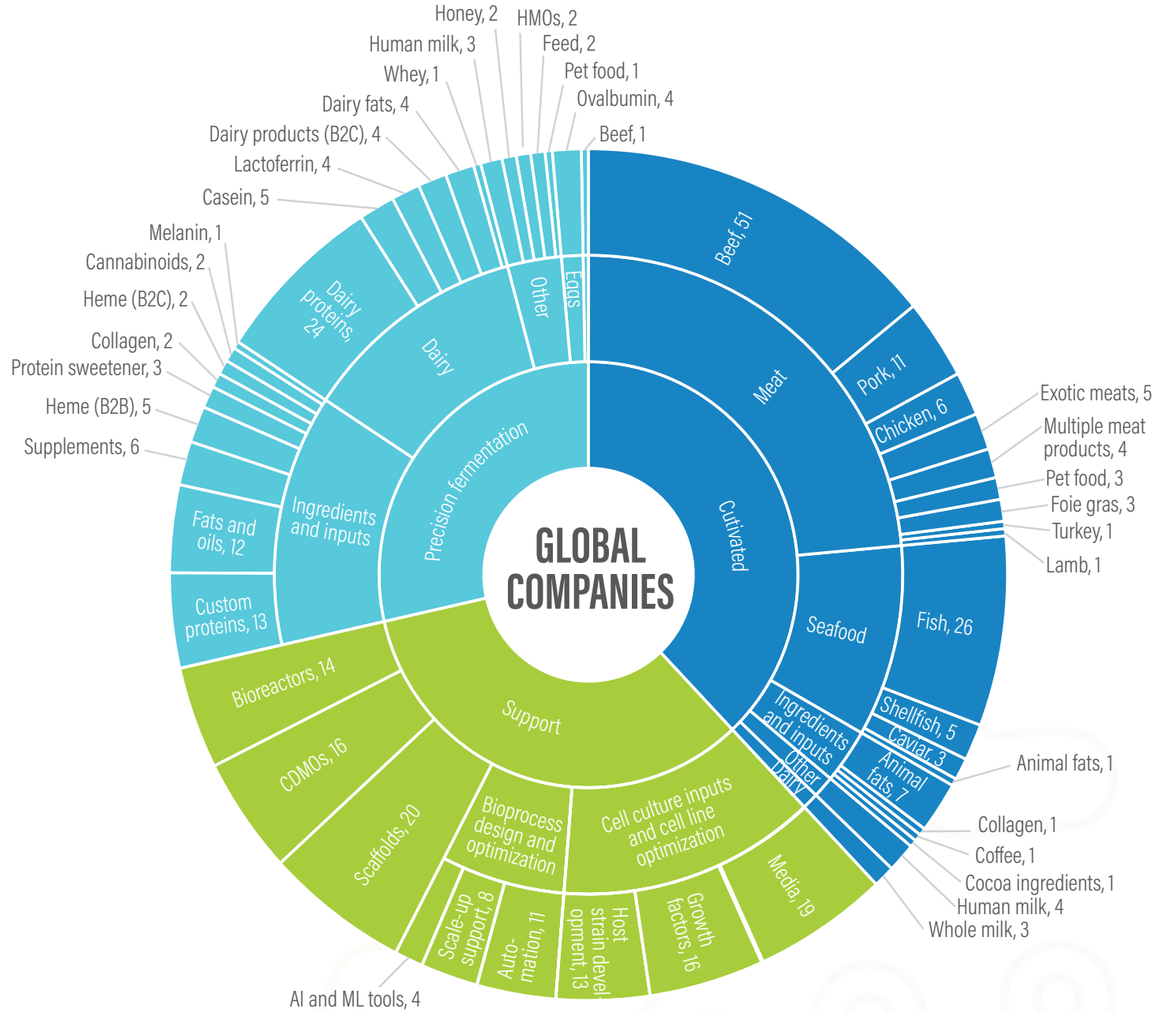


Figure 1: Global companies in Cellular Agriculture (2024)

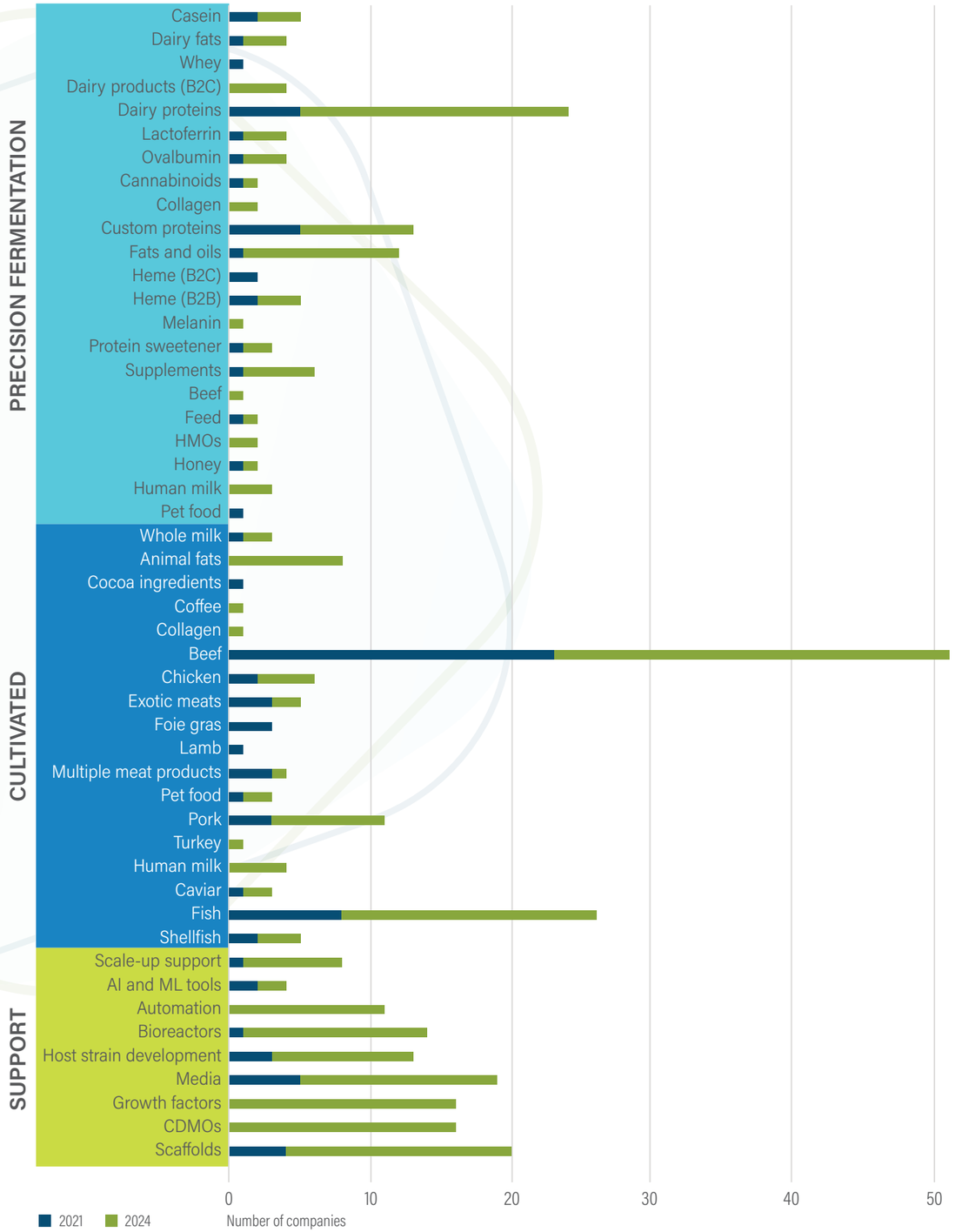


Figure 2: Comparison of 2021 (blue) to 2024 (green) companies, and their products.
Note: The scope is limited to food innovations, rather than other products that could be produced through biomanufacturing e.g. silk, wool etc.

Leading Jurisdictions

National Visions

As was the case in 2021, Singapore, the United States (US), Israel and the Netherlands continue to be leaders in this sector, with a second wave of countries and regions quickly rising to join this leading group, including the United Kingdom (UK) and Australia. While drivers for the industry tend to be country- or region-specific, broad commonalities that help propel these dominant jurisdictions forward include timely, transparent regulatory processes, investment in companies and research, as well as infrastructure and collaborations throughout the development pipeline.

Government investment and incentivization in these leading jurisdictions have also been key and their ensuing advancement has increased the urgency for Canada to make progress. Timing is of the essence, and **inaction could result in reduced market share or an inability to catch up**, thus lowering the achievable potential. Examples of global leadership include:

- Netherlands - a powerhouse in the ag/food space - announcing the world's largest public investment in cellular agriculture [16];
- US [17] and UK's [18] bold cross-sectoral biomanufacturing strategies and multi-billion-dollar investments to support the industry, including a flurry of creative support in infrastructure and hubs.
- Australia's updated engineering biology strategy [19];
- Singapore's continued incentivization through various mechanisms, including continuously evolving and competitive regulatory mechanisms, and high levels of investment in foreign companies to set up operations and seek regulatory approval [20].

The US and UK have outlined ambitious bioeconomy and biomanufacturing strategies to drive innovation, economic growth, and sustainability. The US focuses on advancing biotech manufacturing in health, agriculture, and clean energy, with significant investments in infrastructure and R&D to ensure a resilient supply chain and global leadership in biomanufacturing. The UK emphasizes strengthening its biotech ecosystem by fostering cross-sectoral health, food, and cleantech innovations, with targeted investments in sustainable manufacturing and regulatory frameworks to enhance competitiveness. Both countries aim to capitalize on the bioeconomy's potential to address global challenges and promote green, high-tech growth.

In Sept 2024, the US Food and Drug Administration (FDA), the US Environmental Protection Agency (EPA), and the US Department of Agriculture (USDA) have released a new, web-based tool for companies that develop microbial biotechnology products to better understand the regulatory requirements for biotechnology products including plants, animals, and microorganisms developed through genetic engineering or the targeted manipulation of genetic information.

Regulations

Following 2020's leading regulatory approval of cultivated meat products in Singapore, the past three years have seen various achievements in this space.

- There were approvals of cultivated products in the US (Upside and GOOD Meats chicken, 2023) [21], and the first approval of cultivated beef in Israel (Aleph Farms, 2024) [22].
- Australia/New Zealand's joint food safety authority have designated Vow's quail meat as "Safe To Eat", a step within their regulatory process, which was swiftly followed by full regulatory approval in Singapore [23-24] and Hong Kong.
- In July 2024, the UK made their, and Europe's, first regulatory approval of a cultivated product, with Meatly's cultivated chicken being cleared for use in pet food [25]. 2024 also saw the first EU tastings[d] of cultivated meat, by Meatable and Mosa Meat, both in the Netherlands [26-27].
- Notably, the comparative cost of cultivated products is still a concern, with initial releases

The South Korean government has indicated strong support for the domestic industry, investing $14.4 million to create a Cell-Cultivated Foods Regulatory-Free Special Zone, to help 10 cultivated meat companies to develop their processes and products with minimal regulatory obstacles.

[d] Tastings of cultivated meat in the Netherlands mark a significant step toward commercialization, providing a real-world test for consumer acceptance and culinary appeal. These events help validate the technology's taste and texture, and gather crucial feedback to refine the product. Specific government approvals were still required, even though these were for public demonstration purposes rather than for commercial sales.

being confined to high-end restaurants. However, in 2024 GOOD Meat released GOOD Meat 3 plant-chicken hybrid products in a specialty grocery store in Singapore [28]. Containing just 3% cultivated chicken, the intent is to make cultivated meat available to more consumers, and at a reasonable price point.

Across jurisdictions, the precision fermentation sector also continues to grow, with regulatory approvals and product launches.

- In the dairy space with Remilk [29], TurtleTree [30] (and partnership [31]), Imagindairy [32], and Vivici [33].
- Non-dairy ingredient launches include The EVERY Company's first whole liquid egg product (2023) [34], and Oobli's sweet protein, brazzein-53 (2024) [35].
- Demonstrating the interest of multinationals in this space, large corporations have continued to form B2B partnerships with precision fermentation companies, including Unilever with Perfect Day [36] and The EVERY Company (through The Vegetarian Butcher brand) [37], and Grupo Bimbo with Oobli [38].
- In July 2024, Danone announced the opening of the Biotech Open Platform in France, an advanced fermentation centre with a particular focus on precision fermentation [39]. The platform marks a new endeavour with strategic partners to support the development of biosolutions on a larger scale, including food products.
- New Zealand's dairy co-operative, Fonterra, has partnered with precision fermentation company Nourish Ingredients and biomass fermentation company Superbrewed Foods to explore ingredient production via fermentation, with plans to develop proteins, fats, and lipids [40].

In contrast to the overall position of the European Union (EU) and the US, and the many countries and jurisdictions that are advancing and investing in food innovation, a smaller number are raising challenges targeted specifically at the cultivated meat industry. These include Italy [41], France, and some US states [42], including Alabama and Florida. The industry is contesting this as "unconstitutional." For example Upside Foods filing a lawsuit against the state of Florida over its ban [43]. More details below (see Canadian Economic Case)

In addition, some of the first wave of fully verticalized companies, including Upside Foods [44] and JUST Foods/GOOD Meat [45], have altered or slowed their proposed scaling plans. Other pivots include Perfect Day's evolved business model to focus on B2B and their subsidiary nthBio [46], providing their expertise to the broader industry. More recently, Motif FoodWorks, a high-profile precision fermentation company best known for its focus on heme, closed. The company had also engaged in a costly IP battle with Impossible Foods, which has been resolved [47].

Nomenclature, Alternative Proteins, and Supporting Mechanisms

While there are still different nomenclatures in use in this space, "cellular agriculture" (or the abbreviation "cell ag") is widely accepted in the industry to describe the broad biomanufacturing of food and other agriculture products, although there is still confusion outside of the core industry (i.e., especially in the public and the media), with some associating the term with cultivated products only.

There are several different labels in use for cellular agriculture meat and seafood products, in particular, once again, in non-scientific and mainstream media, but within the industry, consensus is growing that "cultivated" is the label of choice, backed up by Good Food Institute research [48] and an MOU [49] between Asia-Pacific (APAC) stakeholders. More widely accepted already, the term "Precision Fermentation" has recently been refined to ensure clarity by an international collaboration between Precision Fermentation Alliance and Food Fermentation Europe [50].

The not-for-profit Cellular Agriculture Australia has produced a language guide for the industry in alignment with the above [51]. Joining this consensus, Health Canada also uses this definition [52] (i.e., cellular agriculture including both precision fermentation derived or cultivated foods) on their website*. There has been little research into consumer perceptions of the nomenclature but it's worth exploring to understand its impact on product acceptance which is important for industry growth.

Footnote*: Please note that Canada has not adopted a formal regulatory definition for cellular agriculture, or the subtypes of products this term can include.

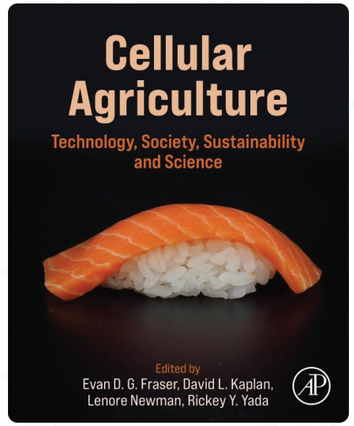
MYCELIUM:	PLANT MOLECULAR FARMING:	ALGAE:
Maia Farms, Canada	Moolec Science, UK	Smallfood, Canada
Meati, US	ORF Genetics, Iceland	Alver World, Switzerland
Libre Foods, Spain	Miruku, New Zealand	Zivo Bioscience, US
MushLabs, Germany		

Additional novel alternative protein and food production processes, outside of cellular agriculture, but within the fermentation space more broadly, are being developed around the world, some with large investments and products in the market. Examples include biomass production of mycelium, algae, and plant molecular farming with a snapshot captured here[e], with much more activity happening globally.

Educational Spotlight

There have been several cellular agriculture-focused educational initiatives in the last few years, including:

- Launched in 2023, Tufts University's Undergraduate Minor in Cellular Agriculture is the first dedicated undergraduate degree program in the field [53].
- The same year saw the publication of the first cellular agriculture textbook, *Cellular Agriculture: Technology, Society, Sustainability and Science*, with three of the four editors hailing from institutions in Canada, including British Columbia and Ontario [54].
- Other training opportunities include introductory online courses, such as those offered by Cell Agri [55] and Cellular Agriculture Australia [56].
- Just recently, Wageningen University & Research launched Europe's first cultivated meat and seafood course [57].



These all contain explicit ties to cellular agriculture in education, but it is worth noting that there are many courses and programs that are preparing people to contribute to this industry (e.g., biology, food science, genomics, engineering (synthetic) biology, biomanufacturing, artificial intelligence, computer science, tissue engineering, bioprocessing, etc.), reflecting the cross-sectoral and multi-disciplinary nature of this industry.

Investments – Worldwide

Since the release of our original report during the investment boom of 2021, there has been a downward shift in investment across all industrial sectors, with year-on-year global venture funding down by 35% in 2022 and another 42% in 2023 [58]. Despite this, investment in cellular agriculture companies has continued, albeit more slowly, but still with some large investments. This includes $400 million to UPSIDE Foods in 2022 [59], $35 million to Meatable in 2023 [60] and $40 million to Onego Bio in Q2 of 2024 [61].

In our 2021 report, we calculated the total investment in cellular agriculture to be US$9.7 billion. At that time, there were approximately 100 companies working in the space, and this calculation included all those companies for which investment data were publicly available[f]. In addition to companies producing food and ingredients, it included those creating materials such as leather, cotton and wool.

[e] The companies listed here are by no means exhaustive and were included simply to indicate the global interest in these food production methods.
[f] Investments were calculated from publicly available data, with limitations to what was accessible. Investment data is indicative of a trend, rather than the total investments made to date.

The landscape is now more complex, with more than 400 companies operating in the sector, ranging from start-ups dedicated to niche cellular agriculture solutions to multi-national corporations who focus on the sector as one part of much broader portfolios, and various players in between. For this reason, we have restricted the current investment data in this update report to cultivation and precision fermentation companies directly involved in the biomanufacturing of food and ingredients, which, as of mid-July 2024, sits at **$8.1 billion globally**.

The global investment by country is provided in (**Figure 3**), with a breakdown by product and product category. Based on this, the US and Israel are leading, followed by the Netherlands and the UK. Applying the same analysis to the 2021 companies (i.e., precision fermentation and cultivated food companies only) would result in an estimated $6.5 billion investment by 2021, indicating over ~$1.6 billion of new investments in this space in the last three years, even with the global investment downturn. The decision was made to remove support companies from the investment analysis in this updated report as there are limitations to the publicly available investment data. In addition, this category also includes cross-sectoral multi-nationals and the investments directed to their cellular agriculture activities are difficult to separate from their support of other sectors.

Global private investment funding, coupled with increasing government incentivization and investments in various countries, form the expected and necessary path of growth for any new industry. There is also growing interest from global foundations, as highlighted earlier, in support of this sector.

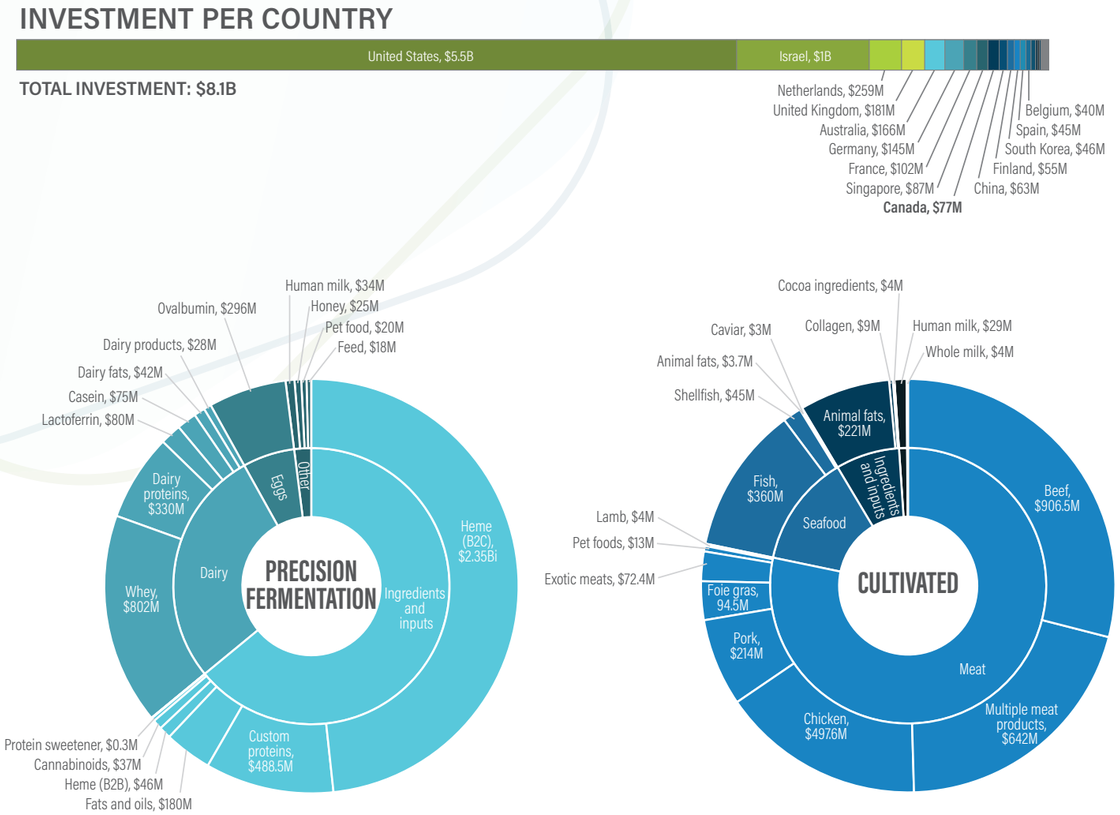


Figure 3: Global Investment in companies by country (2024).



Canada: Progress To Date

Canada – Progress Since 2021 Recommendations

Measured against the three key opportunities in the original 2021 report, there has been both direct and peripheral progress at the national level, as well as regional levels (see Regional Updates) (**Figure 4**).

First Recommendation

Considering the first actionable recommendation, Canada has made some progress, and although not as complete as the White House's Bold Goals [17], or the UK's $2 billion bioeconomy strategy [18], concrete steps have been taken by the Canadian government towards recognizing the importance of the broader biomanufacturing sector. While there has been significant activity on cellular agriculture across various regions, and a recognition of its importance, we have not seen the potential within this for boosting Canada's food security and sovereignty, or the development of a coordinated and integrated vision and strategy for Canada to serve as a touchstone for evaluating initiatives and benchmarking progress.

Innovation, Science, and Economic Development (ISED) Canada consulted the Canadian ecosystem in 2022 to support development of a $400 million Canadian Genomics Strategy (CGS) [4] focus on commercialization and adoption of genomics innovations. The resulting summary, "*What We Heard*", indicated the potential of engineering (synthetic) biology across disciplines, including food production, and noted that additional investments were needed. The key suggestions in the CGS summary mirror the opportunities in the 2021 cellular agriculture report, indicating that addressing gaps in the broader genomics and engineering biology ecosystem may lead to growth in cellular agriculture, and vice versa, due to common challenges and opportunities.

More peripherally, the $2.2 billion Canadian Biomanufacturing and Life Sciences Strategy (2021) [62] will help broaden transferable skills in infrastructure design, fermentation, and training. As part of this strategy to enhance domestic biomanufacturing capacity, the



NOVEL INITIATIVES AND CAPACITY IN THE CANADIAN CELLULAR AGRICULTURE LANDSCAPE

THE YUKON

The Social Implications Agri-Genomics: Ensuring a Just Transition to a Climate-resilient Agricultural and Food systems in Canada

FUNDED PROJECT | SOCIETY

Genome Canada | Royal Roads University | Genome British Columbia | University of the Fraser Valley

Cellular Agriculture Futures: A Survey of Public Perceptions in the Lower Mainland, British Columbia

SOCIETY

Royal Roads University | University of the Fraser Valley | The University of British Columbia

NORTHWEST TERRITORIES

Institute for Cellular Agriculture

CAPACITY | COMPANY SUPPORT | TECH DEV

Cult Food Science | New Harvest | University of Alberta

Scaling-up Capacity & Expertise

CAPACITY | COMPANY SUPPORT | TECH DEV

InnoTech Alberta

Creative Destruction Lab – Rockies

COMPANY SUPPORT

Edmonton

NUNAVUT

GIFS' Engineering Biology Facility

CAPACITY | COMPANY SUPPORT | TECH DEV

GIFS Global Institute for Food Security | PrairiesCan

Advanced Food Ingredients Centre

CAPACITY | COMPANY SUPPORT | TECH DEV

Food Centre – Saskatchewan Food Industry Development Centre Inc.

Ag-Tech Accelerator

COMPANY SUPPORT | FUNDING/INVESTMENT

GAAP Global Agri-Food Advancement Partnership | Cultivator powered by Conexus | Conexus Credit Union

BRITISH COLUMBIA

3 COMPANIES

Vancouver

ALBERTA

2 COMPANIES

Calgary

SASKATCHEWAN

Saskatoon

1 COMPANY

MANITOBA

Winnipeg

Lab Capacity

CAPACITY | TECH DEV | COMPANY SUPPORT

SPECLABS | SPINUP | n!Biomachines | CATALYST | VELOCITY

Scale-up Capacity & Expertise

CAPACITY | TECH DEV | COMPANY SUPPORT

Ontario Genomics | n!Biomachines | BioZone | Lambton College | La Cité

Talent Development

TALENT

University of Toronto | University of Waterloo | McMaster University | La Cité | University of Guelph | Lambton College

Micro-credentials

TALENT

Ontario Genomics | University of Toronto | Lambton College

Accelerator Program

COMPANY SUPPORT | FUNDING/INVESTMENT

BioCreate | Ontario Genomics | Canada

Upcycling

TECH DEV | COMPANY SUPPORT | FUNDED PROJECT

WASTECANCREATE | Ontario Genomics | Agriculture and Agri-Food Canada

Scale-up Capacity & Expertise

CAPACITY | COMPANY SUPPORT | TECH DEV

D3 District3 | zone agtech | AVANCE Biosciences

Talent Development

CAPACITY | TALENT | TECH DEV

Concordia Genome Foundry | Concordia Bioprocessing

Scale-up Capacity & Expertise (NS)

CAPACITY | COMPANY SUPPORT | TECH DEV

Verschuren Centre

Perceived Value of Cultured Proteins as Novel Food in Canada: Generation Z consumers in a cross-generational perspective

SOCIETY

Dalhousie University | Harvest Insights

Talent Development (PEI)

TALENT

CASTL | Upskill Canada

Global Seafood Association (NS)

QUEBEC

4 COMPANIES

Sainte-Anne-de-la-Pocatière | Quebec City | Saint-Hyacinthe | Montreal

PEI

Sydney | Charlottetown

NEW BRUNSWICK

NOVA SCOTIA

Halifax

2 COMPANIES

ONTARIO

16 COMPANIES

Ottawa | Waterloo | Guelph | Toronto | Burlington | Hamilton | Sarnia

CANADIAN INVESTORS

emerald | Ontario Teachers' Pension Plan | Arctern Ventures | Amplify Capital | builders | Loyal | Nadarra Ventures | consecon foundation | W | Cult Food Science | Eat Beyond | CPP Investment Board

SUPPORT ORGANIZATIONS

Ontario Genomics | Toronto Global | Agriculture and Agri-Food Canada | Genome Canada | Canadian Food Innovation Network | MaRS | Women in CleanTech Accelerator | RBC | Protein Industries Canada | New Harvest | Cellular Agriculture Canada | NPC Natural Products Canada

MAJOR FUNDED PROJECTS

NATIONAL

Largest Canadian Investment in Cellular Agriculture to date:

Omics-guided technologies for scalable production of cell-cultivated meat

McMaster University | University of Toronto | University of Guelph | La Cité

FUNDED PROJECT | TALENT | TECH DEV

POWERED BY: Ontario Genomics | Genome Canada

NATIONAL

Canadian cultured foods: Environment, scale-up, safety, nutrition and food processing

Ontario Genomics | Avance Biosciences | New Harvest | Concordia University | ARC-CARC | University of Saskatchewan

FUNDED PROJECT | TALENT | TECH DEV

POWERED BY: Agriculture and Agri-Food Canada

INTL.

The **ALT PROTEIN** Projects at: University of Toronto | McMaster University | University of Waterloo

TALENT | TECH DEV

POWERED BY: gfi Good Food Institute

NOTABLE PROGRAMS & INITIATIVES

ONTARIO

Canada's first regional cellular agriculture competition (2021)

ACCELERATE-ON Food Innovation with Cellular Agriculture

COMPANY SUPPORT | FUNDING/INVESTMENT

POWERED BY: Ontario Genomics | Canadian Food Innovation Network

NATIONAL

Webpage: General framework and guidance for regulation and safety assessment of cellular agriculture products (2023)

SOCIETY

POWERED BY: Government of Canada

NATIONAL

Canada's first national cellular agriculture competition (2023)

COMPANY SUPPORT | FUNDING/INVESTMENT

Food innovation challenge: Cultivating a resilient food future

POWERED BY: Canadian Food Innovation Network

LEGEND

- CAPACITY — Infrastructure (lab space, bioreactors)
- COMPANY SUPPORT — Entrepreneurship Support & Mentorship
- FUNDED PROJECT — Noteworthy Project Consortium
- FUNDING/INVESTMENT — Financial Support
- SOCIETY — Initiative Applicable to or Surveying the Broader Public
- TALENT — Educational Programs for Relevant Skills and Expertise
- TECH DEV — Technology Development: Innovation and Commercialization

Scale-up Infrastructure (Bioreactor Facility) | Academic Program (College or University)

Figure 4: Canadian Cellular Agriculture Innovation Ecosystem

Figure 4: Canadian Cellular Agriculture Innovation Ecosystem

Canadian government and National Research Council (NRC) built the Biologics Manufacturing Centre in Quebec in 2022 [63]. The Centre is focused on biomedical applications but serves as a training ground for much-needed highly qualified personnel (HQP) in biomanufacturing more generally.

In addition, investments by the Canada Foundation of Innovation in Vaccine and Infectious Disease Organization (VIDO) enabled the facility to include BSL4 and the Licensed Biologics Manufacturing Facility [64]. Following that, in 2024, there was nearly $574 million in funding across Canada to further grow the domestic biomanufacturing and life sciences sector with a focus on future health emergencies and capacity building [65].

Second Recommendation

Considering the second actionable recommendation, a much needed and important stride forward for cellular agriculture was made in 2023 when Health Canada described general frameworks and guidance for regulation and safety assessment of cellular agriculture products on their website. These products, whether produced by precision fermentation or cultivation, will be assessed as novel foods, with the current expected completion of safety assessments within approximately 410 days. Before being approved for sale in Canada, and depending on the end use, additional regulations may apply beyond pre-market food safety considerations. Products containing cellular agriculture ingredients may undergo additional, comprehensive pre-market safety assessments by Health Canada, the Canadian Food Inspection Agency (CFIA) and Environment and Climate Change Canada (ECCC), as appropriate. While this is a step in the right direction, if the regulatory process is not as competitive or agile as other jurisdictions, companies could view other jurisdictions as a more favourable and competitive landscape to locate.

In early 2024, Israeli company Remilk, announced they had achieved "No Objection" clearance from Health Canada for their beta-lactoglobulin protein, making this only the third approved precision fermentation ingredient in Canada, after Impossible Foods' soy leghemoglobin and an oligosaccharide that can be used in infant formula for term infants [66-67]. Over time and as products become more familiar, the 2021 report consultations recommend that Canada's regulatory framework should become more agile with reduced assessment time, as modeled by Singapore's competitive and frequently updated regulatory process [68].

Third Recommendation

This recommendation has seen the most activity, both nationally and particularly regionally (see Regional Updates) as evidenced by the various initiatives and organizations now active in incentivizing and supporting this space. This includes public and private investment and partnerships, outcomes-driven networks, infrastructure support for research and development, training, company creation, scale-up and growth, all of which are critical for a thriving domestic cellular agriculture industry and highlighted in the original 2021 report as needed for Canada to capture market share within this global sector.

Canadian Companies

The number of Canadian cellular agriculture companies has grown from 13 in 2021 to **a total of 28**, as can be seen in **Figures 5 and 6**. These range from companies dedicated to the biomanufacturing of both precision fermented and cultivated food and ingredient products, to multisectoral companies that support different sectors, including cellular agriculture, as shown in (**Figure 7**). The pipeline of Canada's cellular agriculture industry today ranges from feedstock supply to cell design to scale-up facilities. This maturing and specializing value chain demonstrates the capacity, drive and promise within the country's entrepreneurs to make this a compelling and lucrative industry for Canada.

3D BioFibR — HALIFAX, NS	Producing collagen fibres for use in tissue engineering, including scaffolding for cultivated meats	ardra — TORONTO, ON	Using precision fermentation to sustainably create both natural and novel ingredients
TORONTO, ON	Engineering yeasts to produce nature- identical animal proteins, including casein for animal-free cheese	Alterna Technologies — ESTRIE, QC	Producing cost-effective media supplements for cell culture for applications in cellular agriculture
BIOFECT INNOVATIONS — TORONTO, ON	Producing protein ingredients through precision fermentation for the food & beverage industry	BIOBOOST SYNBIO — P. COQUITLAM, BC	Using precision fermentation to produce cosmetics and functional foods. Offers recombinant molecule biosynthesis CRO service
ERGO — SASKATOON, SK	Creating and producing organoleptically identical animal proteins by plant cell precision fermentation	EVOLVED MEATS — WATERLOO, ON	Creating scaffold-free tissues for cultivated meat production and regenerative medicine
ferma FARMS — CALGARY, AB	Utilizing industry side-streams and precision fermentation to create sustainable, value added products	FUTURE FIELDS — EDMONTON, AB	Using engineering biology to make growth factors for cellular agriculture
genuine taste — TORONTO, ON	Producing cultivated animal fats to enhance flavour of alternative meats	HARVEST MOON — OTTAWA, ON	Using microbial fermentation to produce next-gen dairy inputs
hyasynth — MONTREAL, QC	Producing cannabinoids using yeast precision fermentation	Kulture Rebellion — TORONTO, ON	Re-inventing social drinks for healthy lives & a sustainable future with AI-enabled precision fermentation
LIVEN — TORONTO, ON	Producing protein ingredients through precision fermentation to enhance plant-based foods	MARA — DARTMOUTH, NS	Using algal biotechnologies for human nutrition and related industries
MATERIAL FUTURES — TORONTO, ON	Turning microorganisms into miniature dye factories	meatleo — ST. BRUNO DE MONTARVILLE, QC	Producing cultivated beef by cell culture and a unique manufacturing bioprocess

Figure 5: 2024 Canadian cellular agriculture companies.

MYO PALATE TORONTO, ON	Producing cultivated meats, including pork	n!Biomachines BURLINGTON, ON	Developing and manufacturing bioreactors for next-gen bioprocessing, to support the food, supplement and cosmetic industries
opalia™ A NEW ERA OF DAIRY MONTREAL, QC	Using cultivated mammary cells to produce dairy proteins	PreFer Industries BURLINGTON, ON	Producing smart ingredients and high-quality formulations through precision fermentation, photobioreactors, or greenhouses
RENAISSANCE BIOSCIENCE VANCOUVER, BC	Designing and producing customized cells lines for use in different industries, including cellular agriculture	TERRA BIOINDUSTRIES TORONTO, ON	Decarbonizing supply chains with upcycled ingredients, including production of a sugar-rich precision fermentation feedstock
The Better BUTCHERS CULTIVATED MEAT VANCOUVER, BC	Offering plant and mushroom protein meat alternatives with research into cultivated meat for future product development	Cultivated B BURLINGTON, ON	Solving key challenges of scalable alternative protein production and provides solutions as physical goods or licensable know-how
WHITEBOARD FOODS™ OTTAWA, ON	Producing a plant-based scaffold for use in plant-based and cultivated meats	YEX TORONTO, ON	Creating next generation growth media to support the cellular agriculture and biotech industries

Figure 5: 2024 Canadian cellular agriculture companies.

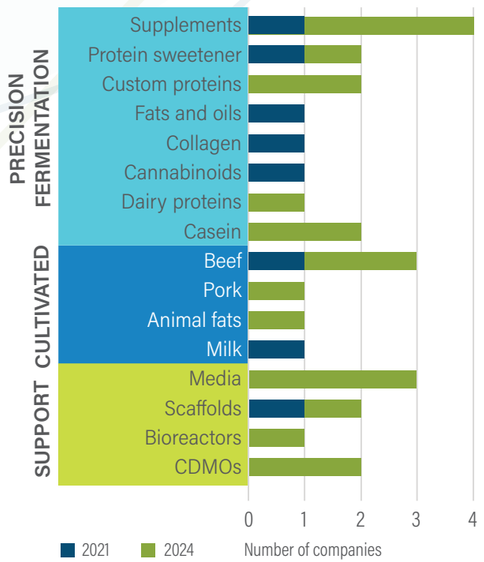


Figure 6: Changes in Canadian companies. Blue indicates companies noted in 2021 that are still active in Canada, green is an updated company list since the last report



Figure 7: Cellular Agriculture Companies in Canada

Upcycling Opportunities

As cellular agriculture technologies continue to mature, especially in the evolving precision fermentation space, work on optimizing and reducing the cost of inputs is becoming increasingly important. Herein lies a great opportunity for conventional agriculture and cellular agriculture to support one another. By using sidestreams or byproducts of traditional commodities as inputs, we can further improve the affordability and environmental impact of precision fermentation-derived ingredients or products, while providing new revenue streams for existing farmers, processors, and retailers.

A 2023 report from the Good Food Institute identified high-value crop sidestreams with high upcycling potential, including many relevant to Canadian production, as a source of protein hydrolysate, or lignocellulosic sugars [69], while a 2022 report from Vineland Research & Innovation described upcycling of byproducts streams from the Canadian horticulture value chain [70]. This level of cooperation from across the agri-food value chain remains paramount to the success of Canada's cellular agriculture sector and is well aligned with the 2018 Economic Strategy Table on Agri-Food's Vision for Canada's goals of A) being recognized as the most trusted, competitive and reliable supplier of safe, sustainable, high-quality agri-food products. B) being an innovator in value-added products to feed the dynamic global consumer. And C) being a favoured protein provider globally [71].

Byproducts/sidestreams with high upcycling potential:
This includes crops from conventional agriculture; spent grains from ethanol production; unused sugars from beverage processing, dairy byproducts, etc.

Sidestreams:
- Protein hydrolysate (soy meal, corn DDGS, canola meal, brewer's spent grain, and corn gluten meal)
- Lignocellulosic sugars (corn stover, soy straw, sugarcane trash/ bagasse, and barley straw/husks)
- Canadian horticulture byproducts (apple pomace, onion and potato skins, corn juice)
- Dairy byproducts (lactose, whey)

National Players

Various federal (listed alphabetically below) and regional organizations (see Regional Updates) in Canada support cellular agriculture companies, research, and initiatives, with many organizations now providing much needed and varied support, as recommended in the original report.

Agriculture and Agri-Food Canada (AAFC), supports cellular agriculture through their Strategic Plan for Science, [72]. This plan promotes the development of new agricultural technology, contributing to the mission of advancing circular economy and developing value-added opportunities to meet market opportunities. Of note, AAFC is also supporting a national project – *Canadian Cultured Foods: Environment, Scale-up, Safety, Nutrition and Food Processing* – involving research and development centres in various provinces, as well as academic and not-for-profits partners, to better understand the scientific implications associated with this new technology and potentially assist this emerging field with public data (see **Figure 4**).

The Canadian Food Innovation Network (CFIN) is a national network for food and beverage professionals focused on collaboration to develop new products and processes in the Canadian food-tech industry. CFIN has invested in cellular agriculture companies through various programs, including partnerships with Ontario Genomics on AcCELLerate-ON in 2021 (see Regional Updates) [73]; a targeted national cellular agriculture funding program in 2023 [74]; and their series of informational videos and communications collaborations with New Harvest and leading Canadian academics.

The Canadian Genomics Enterprise, a pan-Canadian network comprising Genome Canada and six independent regional Genome Centres including Ontario Genomics, supports the adoption and implementation of genomics technology through collaboration and funding programs. In 2023, there was funding of a large-scale project led out of McMaster University seeking to overcome the technological and social challenges facing the cultivated meat industry [75]. Further, a social sciences project led out of the University of the Fraser Valley is working to enable an inclusive and equitable transition as technological advances change the agriculture and food landscape in Canada [8, 6].

MaRS Discovery District partners with RBC to run the RBC MaRS Women in Cleantech Accelerator, to promote the work of women entrepreneurs working in clean tech through a two-year intensive program, which has supported several companies in the cellular agriculture space e.g., Liven Proteins, Genuine Taste, and Opalia [76].

Natural Products Canada, a not-for-profit organization focused on Canadian natural product innovations that can replace synthetic products, supports their mission through advisory and commercialization programs, and has backed several cellular agriculture companies, e.g. Aux Labs and Opalia.

New Harvest was established in 2004 and is the world's longest-running organization dedicated to advancing the field of cellular agriculture. Just over 15 years later, New Harvest Canada (2020) evolved with a dedicated focus on Canada, as well as representation in the Netherlands. In 2023, Cellular Agriculture Canada (originally founded in 2019) became an initiative within New Harvest Canada to collaboratively advance Canada's cellular agriculture ecosystem.

Protein Industries Canada, one of Canada's five Global Innovation Clusters, is an industry-led, not-for-profit organization created to accelerate innovation and position Canada as a global source of high-quality plant protein and ingredients. They have funded a collaboration between Ontario-based companies New School Foods (plant-based), precision fermentation start-up Liven Proteins, and BC-based NuWave Research [77].

Support also comes through the Natural Sciences and Engineering Research Council of Canada (NSERC), which offers funding to entrepreneurs and innovators researching and developing scientific and technical breakthroughs that will benefit Canada.

NRC's Industrial Research Assistance Program (NRC IRAP), offers small- and medium-sized Canadian businesses advice, access to connections, and funding to help them innovate and bring products to market. A new report by the Council of Canadian Academies (CCA) titled *The Next Course* was sponsored by NRC and focuses on innovative atypical food production methods and discusses cellular agriculture [78].

Education and Training

Educational and training opportunities are expanding with research and applied opportunities across many of Canada's post-secondary academic institutes. This ensures that the next generation of talent is ready for the new jobs that will be created in cellular agriculture and the biomanufacturing sector [79].

As cellular agriculture and biomanufacturing continue to grow more broadly, fit-for-purpose applied research capacity needs to grow alongside it. Canada's colleges support technology development across economic sectors and geographies, and there is currently a significant shift towards biomanufacturing capacity at these institutions. Tech-Access Canada is a national, not-for-profit organization that supports 67 NSERC-funded Technology Access Centres (TACs) that make their R&D support services accessible to all entrepreneurs and innovators across Canada, contributing to a more inclusive innovation economy. Collège La Cité in Ottawa offers support to start-ups in this space through TAC in Bio-Innovation (TAC–B) and its collaborations and facilities are fundamental to the Genome Canada-funded cellular agriculture research project above. Others, including Lambton College (ON), Loyalist College (ON), Cégep de Trois-Rivières (QC), Lethbridge Polytechnic (AB), Seneca College (ON), and more are currently expanding their capabilities in biomanufacturing to support private and public sector research and development. Leveraging the applied research knowledge of these institutions, as well as college-specific funding, to **de-risk technology development** and training the next generation of skilled workers, will contribute to Canada's ability to achieve and maintain leadership in the cellular agriculture space for decades to come [79].

In addition, four Canadian universities were funded by the Good Food Institute's Alt Protein Project, a global student movement dedicated to turning universities into engines for alternative protein education, research, and innovation, involving more than 50 universities around the world [80]. Of those four, three remain active including The Waterloo Alt Protein Project (founded 2022), the McMaster Alt Protein Project (founded 2023), and the University of Toronto Alt Protein Project (founded 2024).

Consumer Engagement

In 2024, New Harvest, District 3 Innovation Centre (QC) and AAFC co-hosted a series of virtual events designed to spark connections and innovation within the cellular agriculture community in Canada. CFIN worked with New Harvest and CULT Food Science on food innovation communications initiatives focused on familiarizing the Canadian ecosystem with this space. Various consumer engagement studies have also been conducted, including a consumer readiness survey with inhabitants of the Metro Vancouver region that assessed public perceptions of dairy products made using cellular agriculture [8], as well as a national study by Dalhousie University and Harvest Insights involving over 10,000 cross-generational perspectives on alternative proteins [81].

Canadian Investors

There has also been steady growth in the number of Canadian Investors and venture capital with a focus on agriculture, food, and climate. Some investments have been made in precision fermentation, cultivation, or support companies through pension funds, cellular agriculture-focused investment firms (CULT Food Science, Eat & Beyond), venture capitalists (e.g. Amplify Capital, ArcTern Ventures, Builders VC, Emerald Technology Ventures, Loyal VC, Wittington Ventures), angel investors, and foundations (e.g., the Consecon Foundation) already involved or aligned with this space. While some are still primarily investing internationally, there has been growth in Canadian firms, as well as in those whose investment portfolios are well suited to cellular agriculture and the ag/food space more broadly (see a more comprehensive list in Appendix C). These will play an important role in the growth of the Canadian cellular agriculture sector.



Regional Updates

An impressive amount of progress can be seen across various provinces aligning with actionable recommendation 3 – *Provide Supporting Mechanisms for Research and Commercial Development*. Although too widespread to detail, it is worth noting that regional governments provide support through various grants, funding programs, and initiatives aimed at fostering innovation, as well as the support of research and development efforts of start-ups, small and medium enterprises (SMEs), and academics across the country. Beyond government support, we have highlighted some of the key progress and initiatives happening across the country below.[9]

Atlantic Canada benefits from a focus on biotechnology, specifically precision fermentation, with the Verschuren Centre in **Nova Scotia**. Having offered fermentation capacity for several years, the centre recently received funding from the Atlantic Canada Opportunities Agency and from CFIN to add 10,000L and 15,000L bioreactors to the facility [82].

Future Ocean Foods, based in Halifax, is a new global alternative seafood association dedicated to supporting and accelerating the alternative seafood industry (plant-based fermentation and cultivated food and technology). Launched in late 2023, it has an impressive inaugural membership base of 36 companies across 14 countries.

The **PEI**-headquartered Canadian Alliance for Skills and Training in Life Sciences (CASTL) has partnered with Upskills Canada to deliver specialized training nationally in biomanufacturing and skills development to post-secondary students and industry employees.

Central Canada includes the country's most populous provinces, Quebec and Ontario, which are making strides to advance the biomanufacturing ecosystem.

[9] The list is not exhaustive, but it highlights some of the critical progress and initiatives happening regionally across Canada and indicates the growing interest in these food production methods.

In **Quebec**, District3 has announced the launch of a new initiative, AvanceBio, which is building a multi-sectoral regional centre of excellence for training, biomanufacturing capacity, and policy advising. Further building on existing capacity, in 2024, the Genome Foundry at Concordia University received $5 million of funding for infrastructure [83], including small- and large-scale fermentation equipment, to help move cross-sectoral engineering biology and biomanufacturing projects from bench to scale-up.

To drive startup acceleration, the Quebec government has invested $42 million in the AgTech incubator [84], Zone AgTech, for the development of an innovation centre in L'Assomption, QC. The new centre will focus on innovative solutions in response to challenges faced in agriculture and food production.

Ontario is also home to a wide range of new initiatives in or supporting the sector, many driven by Ontario Genomics' ambition to achieve the province's unparalleled opportunity in this space. Our collaborative initiatives include support of companies through:

- Co-launching with CFIN the first regional cellular agriculture-focused funding program, AcCELLerate-ON, which supports a variety of start-ups as well as an academic-industry partnership;
- Implementation of BioCreate with funding from the Federal Economic Development Agency for Southern Ontario and Ontario Genomics. The $11.6 million in-house accelerator program is for small- and medium-sized enterprises and has funded seven cellular agriculture-focused companies in the first five (of seven) cohorts [85];
- Co-leading with Global Affairs Canada, the co-organization of a 20+ Canadian cellular agriculture company delegation to the Netherlands in 2023 to promote engagement, which resulted in partnerships and investments with the Dutch ecosystem [86];
- Investing in fit-for-purpose bioreactors, some housed in the Bioengineering Hub, located at n!Biomachines new manufacturing facility in Burlington.

Funding of innovative industry-academic research and social sciences:

- Genome Canada through Ontario Genomics funded an Ontario-led $10-million cultivated meat project, the largest investment in cellular agriculture in Canada to date, with McMaster University, University of Guelph, University of Toronto, Collège La Cité, various industry partners, and nonprofits [75].
- In parallel, Ontario Genomics has led the creation of the wasteCANcreate upcycling consortium, a national program investing in bioconversion-based technologies, including precision fermentation, that can upcycle agricultural or food byproducts into high-value products like ingredients, proteins, or other products (e.g., biodegradable plastics, upcycled textiles, etc.).

Support of the next generation of talent:

- Training programs are also being expanded in the province, with biomanufacturing micro-credentials being offered by various groups including BioZone at the University of Toronto, Lambton College (in partnership with Ontario Genomics), Algonquin College, and others in the pipeline [87].

Recent new lab capacity has been established within the province e.g. SpinUp at UTM Mississauga, the Bioengineering Hub at n!Biomachines in Burlington, and SPEC Labs in Mississauga, as well as expanded capacity at Velocity Incubator in Waterloo, and the Catalyst at 77 Wade in development, all offering support to multi-sectoral life sciences and biotech companies in the province.

In **Western Canada**, the Global Institute for Food Security (GIFS), **Saskatchewan**, received $9.2 million in funding [88] from federal and provincial sources for a new Engineering Biology facility. This facility will be dedicated to delivering biomanufacturing services to support the agri-food and biotechnology sectors. Additionally, the Saskatchewan Food Industry Development Centre (the Food Centre) is building more capacity with their new Advanced Food Ingredients Centre soon to be offering full-scale contract research and manufacturing services in fermentation (up to 15,000L capacity), bioengineering, and downstream bioprocessing.

The Global Agri-Food Advancement Partnership (GAAP), a new entity resulting from collaboration between Ag-West Bio, GIFS, the Food Centre, Innovation Place, and private sector partners, is a privately operated agri-food investment incubator supporting early and rapid growth stage companies within all areas of agriculture and food. Ag-West Bio and the GAAP have made investments attracting foreign companies such as Ergo Biosciences in the precision fermentation of food ingredients to Canada [89].

Cultivator, located in Regina, SK, is Canada's first credit union-led tech incubator providing programming, resources, mentorship, funding, and space for founders to accelerate the growth of local tech startups.

In **Alberta**, the Institute of Cellular Agriculture is under development at the University of Alberta. In collaboration with New Harvest Canada and CULT Food Science, this will provide infrastructure, support, and funding for researchers and innovators [90], which will be in strategic proximity to InnoTech's fermentation capacity of up to 15,000L, and their downstream processing equipment. Central to the Institute will be Canada's first tenured professorship in cellular agriculture, with the recent announcement of the successful recruitment of the first Assistant Professor to the Institute [91].

Calgary-based Creative Destruction Lab (CDL) – Rockies CDL-Ag Stream helps founders from across Canada and the world rapidly scale and commercialize their science- or technology-based startup, including various cellular agriculture companies across Canada.

In **British Columbia**, the University of the Fraser Valley (UFV) has been investing substantial resources in advancing the field, led by Dr. Lenore Newman, the director of UFV's Food and Agriculture Institute (FAI). Recent initiatives include the Genome Canada-funded, UFV-led project mentioned above, which addresses how Canada can ensure an inclusive and equitable transition with emerging agri-genomics technologies, including cellular agriculture [6, 8].

Since 2021, much progress has been made across regions, capitalizing on provincial strengths, priorities, and ambition, and boosting awareness and growth of the industry across Canada. However, to realize the full economic opportunity and potential in this space, **national coordination of regional capacity must be prioritized** going forward. Cellular agriculture provides an opportunity to enhance, diversify and produce more food sustainably, complementing conventional methods of production, while also offering new opportunities across the value-chain, from farm to fork, as this sector grows and aims to scale competitively.



Canadian Economic Case

The Ontario Genomics report *Cellular Agriculture – Canada's $12.5 Billion Opportunity in Food Innovation*, forecasted that the Canadian cellular agriculture industry could be worth $7.5 billion by 2030 (and 86,000 jobs) and $12.5 billion in the long term (and 142,000 jobs).

> The Canadian cellular agriculture industry could reach $7.5 billion/year and create up to 40,000 jobs by 2030, and up to $18.8 billion/year and create as many as 125,000 jobs over a longer time frame.

This update report provides a perspective on the progress towards this potential since the original publication of the estimates. While there has been significant post-hype pessimism about the growth of the cellular agriculture industry, particularly as it relates to cultivated meat products, it is important to realize that the expectation in the early stages is for slower growth as the foundation for future success is laid [92, 93]. There have been some advances in fermentation products, with three products approved in Canada and significant growth globally. The focus on cultivated meat alone can actually cause observers to understate the development in the cellular agriculture space.

Our revised forecast suggests that the Canadian industry could be as large as **$18.8 billion CAD representing over 125,000 jobs** (see **Table 1, Appendix A**). That is the top end of potential if everything goes perfectly, both in the global industry and the Canadian market share.

The total size of the Canadian market depends on overall growth in the global market, but that is not to say Canada will automatically get a share of it. Canada will contribute to the growth of the global market both in terms of technical capacity and through demand. The overall size of the global market will be affected by technological capacity (can we do it?) and demand for the products as they come to the market (do they want it?).

Estimates for medium-term (2050 – 2070) size of the global market range from $11 billion to $275 billion CAD. Canada's contribution to this economic activity could range from as little as $75 million to as much as $19 billion CAD if the market meets maximum potential.

Canada has a lot at stake in taking advantage of the opportunity both in terms of jobs and economic activity. If the high-end global growth is achieved, Canada's contribution could range from a low of less than $2 billion (estimated 13,000 jobs) to a high of almost $19 billion (estimated 125,000 jobs). At the moderate level the difference is a market of just over half a billion (4,000 jobs) to over $5 billion (39,000 jobs).

Share differences could be driven not only by the number of firms that are participating in this space, but also by the types of things these companies produce. Research and development drives jobs but not high levels of economic activity – jobs per unit of activity are high. Later in the process when we are making commercialized products (either inputs or consumer products), the jobs per unit of output are lower.

Canadian Share of Global Market (CDN)			
Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 75,342,466	$ 301,369,863	$ 753,424,658
27,500,000,000	$ 188,356,164	$ 753,424,658	$ 1,883,561,644
82,500,000,000	$ 565,068,493	$ 2,260,273,973	$ 5,650,684,932
165,000,000,000	$ 1,130,136,986	$ 4,520,547,945	$ 11,301,369,863
275,000,000,000	$ 1,883,561,644	$ 7,534,246,575	$ 18,835,616,438

Table 1: Size of Cellular Agriculture Global Market and Canada's Potential Share

Job creation depends on the amount and type of activity in the Canadian industry. Based on Statistics Canada industry estimates, **food processing jobs are created at a rate of approximately one job for every $400,000 of output whereas biotechnology creates a job for every $90,000 of output** [94, 95]. This reflects the role of R&D in the biotechnology industry and earlier stage development. We estimate job creation based on a blend of both types of jobs in a mature market, so early job growth will be proportionally higher as they tend to be more technical and lay the foundation for the industry. Given that, the number of jobs created in Canada's cellular agriculture industry could range from a low of less than 1,000 to more than 125,000 in the medium term. These estimates differ slightly from those in the first report as we reflected a more conservative estimate given the job-to-activity numbers in food processing. **The opportunity for both jobs and economic activity is significant if Canada is successful in growing the domestic industry**.

We also estimated the market potential in the short term. The size of the industry in 2030 depends on both the growth of the global industry and Canada's ability to capture a larger share of the global growth. If the global industry grows quickly (achieving 40% of the estimated long-term potential by 2030) and Canada captures the higher end share of 5%, cellular agriculture could represent $7.5 billion in economic activity and more than 40,000 jobs by 2030. On the other hand, if global growth is slower (10% of the estimated long-term potential by 2030) and Canada captures only 0.5% of that market, cellular agriculture will represent less than $10 million in economic activity and few jobs. It is clear that the stakes are high for establishing Canada's cellular agriculture industry quickly.

Action in cellular agriculture today will affect the trajectory as well as the size of the industry. If our growth lags, there is a real potential that the resulting size of the industry will be smaller. Staking a claim to the market is important and early successes will have an advantage in terms of market share and supply chain relationships. **The timing and the rate of growth depend on the foundation being built now**. The difference is stark. The worst-case scenario would see Canada have a small number of firms involved in cellular agriculture in the context of the global industry, which may be difficult to sustain due to the lack of supporting infrastructure.

By Dr. Michael von Massow

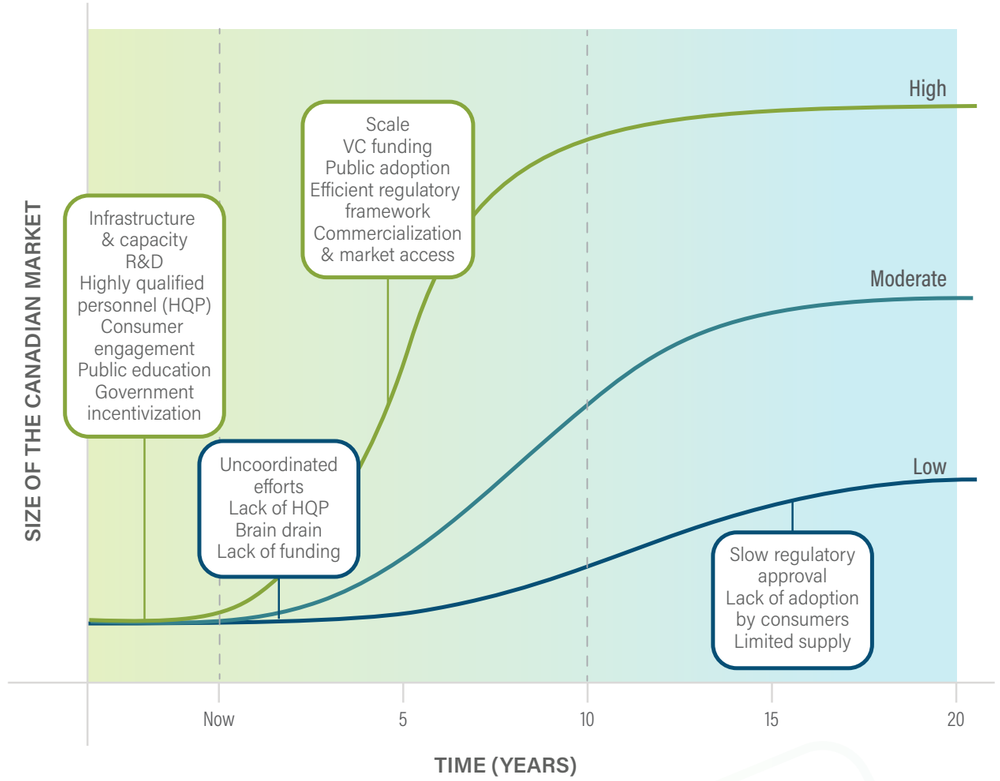


Figure 8: Growth Paths for Cellular Agriculture in Canada

Capturing a share of the market early is critical to achieving higher levels of economic activity. The performance in the next decade will be a major determinant of the potential overall level of activity in the medium and long-term. If the overall global growth (both demand and development) is slow, we would forecast that Canada's cellular agriculture activity would be from $7 million to over $75 million by 2030. The $75 million number would suggest that Canada has been a key player in the growth of the market and is well positioned for the optimistic medium- and long-term levels ($750 million to $18.8 billion). If the level of economic activity is lower, Canada will either have to catch up or will lag behind on the growth of the industry. The extent of which would be representative of the growth in the total global market for cellular agriculture products. If global growth is larger in the next decade, Canada's cellular agriculture industry could represent from almost $1 billion to $7.5 billion by 2030. These levels of activity would set a much more optimistic frame for the longer-term growth of the industry in Canada.

These scenarios are reflected in the stylized growth curves in **Figure 9**.

- ***Line A*** reflects the scenario where Canada is at $7 million by 2030. This reflects slower global growth and also slow growth in Canada. This is the pessimistic scenario with slower global growth and slow growth in Canada meaning a smaller share of the global market. In this lower bound scenario, Canada's total in the medium term would reach a maximum of $1.9 billion and it would be much more difficult for Canada to catch up should growth accelerate, and the maximum number (approaching $19 billion) would likely be out of reach.
- ***Line B*** reflects slow global growth but better performance for Canada. In that scenario, Canada achieves a $75 million industry by 2030 with a climb to $1.8 billion in the medium term (2050) and delayed growth to the maximum forecast of $18.8 billion.

- *Line C* reflects more rapid global growth with Canada lagging in the near term. This would see Canada achieve a market of $75 million by 2030 but make it difficult for Canada to reach its full potential because of lagging activity. In this scenario, Canada would grow to $1.8 billion more quickly than in the previous one but have more limited potential for growth in the long term.
- In the final scenario, *Line D*, both the global and Canadian markets grow quickly with Canada reaching $7.5 billion by 2030 and the total of $18.8 billion in the medium term. These scenarios present a range of estimates (A-D) and come with uncertainty but illustrate both the potential and the impetus for immediate action.

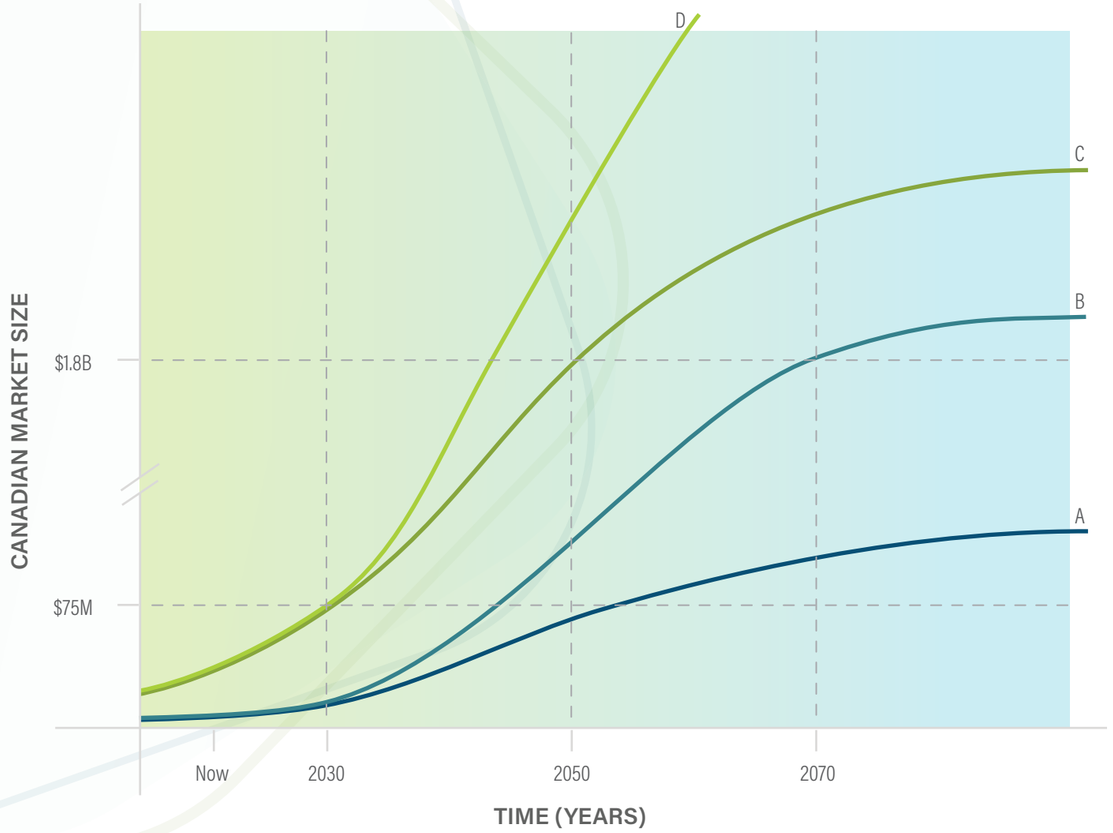


FIGURE 9: Canadian Market Size Over Time

The differences in the 2030 forecasts would represent less than 100 jobs at the low end to more than 10,000 at the high end. A more detailed discussion of these differences is available in **Appendix A**.

The estimates of market potential have grown. There are several factors that have contributed to this growth based on changing conditions, highlighted below.

What Has Changed?

There have been three significant developments in the time since the publication of the original report. We have seen generational levels of food price inflation across the world in all products, including proteins. See **Figure 10**.

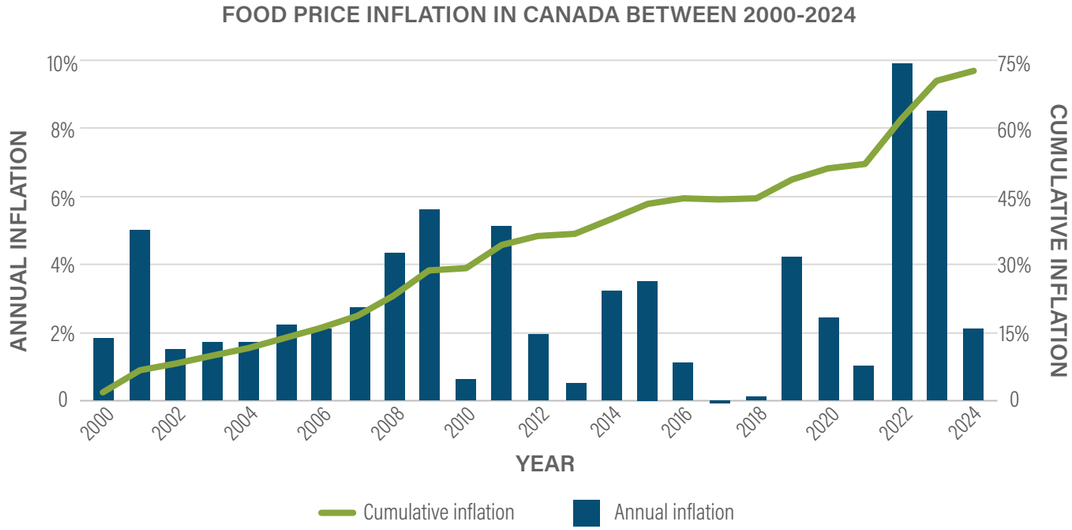


Figure 10: Food Price Inflation in Canada 2000 – 2024.

The price of food has risen substantially in the last 24 years, with food being more than 70% more expensive than it was in the year 2000. The last three years have seen more than 20% of that growth [96].

Inflation has been driven by a wide variety of factors, including (but not limited to):

1. Wars in Ukraine and the Middle East [97];
2. Increased potential for future armed conflicts in Europe, the Middle East and other areas;
3. Extreme weather events and diseases largely driven by climate change [98];
4. Exchange rate differences;

While the COVID-19 pandemic is often blamed for price increases, the pandemic itself did not contribute significantly to price inflation. The first three points above are important to cellular agriculture for two reasons.

Firstly, higher food prices will allow cellular agriculture products to be price-competitive sooner, which could accelerate the growth and value of the industry. It needs to be acknowledged that the value of inputs for cellular agriculture products will also have risen, but the relative price changes and sustained food price levels should provide a price competitive advantage in the medium term. This also creates an even larger opportunity for upcycling sidestreams from agricultural and natural resource extraction activities to supplement feedstock supply chains.

Secondly, the production variability caused by extreme weather events and other climate-driven factors will challenge the resiliency of food supply chains. The COVID-19 pandemic has brought a focus on the localization of food value chains. The risk of localization is that the food supply is more susceptible to production losses due to extreme weather events and other climate-driven disruptions.

A large part of the motivation for cellular agriculture is to augment conventional production to help meet global needs. While feedstocks will continue to depend on conventional production, cellular agriculture production will be much less susceptible to extreme weather events. Canada has an abundant supply of feedstocks in comparison to some of the other countries that are developing cellular agriculture industries, which will also bring stability to the industry.

By Dr. Michael von Massow

Cellular agriculture can bring stability to global and local production and help build resilience. This will also help to accelerate the timeline and increase the total potential for cellular agriculture in Canada and globally. Beyond the value of the economic activity due to cellular agriculture, there is also a consumer benefit of the growth of the industry. We are seeing increased price variability (the last ten years have statistically significantly more variability in food prices than the previous ten; **Figure 10**), which creates uncertainty and difficulty for consumers.

Other Perspectives

As discussed prior, there have been initiatives in some US states to ban cellular agriculture products generally or "lab-grown" meat products specifically [99]. This is largely motivated by protectionism towards conventional agricultural production, which was explicitly acknowledged in the legislation in Florida. There have also been some bans in European countries, most notably Italy [100]. While countries like the UK and the Netherlands have been determinedly developing the industry, it is not universal in Europe and can provide an opening in Canada.

It is unlikely that these bans will survive in the long term and there are many jurisdictions with large populations who are open to and encouraging the development of these products. It is also worth noting that the bans are more focused on cultivated meat than on precision fermentation products. While this may be as much due to the issue of awareness, there has not been the same focus on precision fermentation products. In fact, early fermentation products are already on the market in the US, and some specifically in the markets where cultured meat products are banned. Fermentation products may displace some traditionally produced ingredients and thus draw the attention of protectionist legislators, too.

Progress on Recommendations

There has been some progress on the recommendations from the original report. This is critical to ensuring that Canada gets its share of the growing total cellular agriculture pie.

The Government of Canada has released an informative webpage on applicable regulations in Canada for products of cellular agriculture which includes key considerations for developers, and this is an important step forward. Regulatory clarity is important for bringing investment and establishing manufacturing of cellular agriculture products, and transparency in oversight contributes to public trust in novel products. Canada presents a relatively small total market, and the absence of domestic market potential may discourage local research, development and production. It is, therefore, **critical to have an investment and regulatory environment that is favourable to the development of the industry** to provide a competitive advantage for Canada with opportunities to attract foreign investment, as well as growth of domestic players. Canada has numerous advantages given its proximity to, and established trade agreements with the US and Asian markets, as well as an abundance of feedstock. Canada also has free trade agreements covering 60% of global GDP.

Training can also give Canada an advantage by developing top-notch technical talent. While the current Canadian regulatory framework does provide some clarity, there are some questions about whether the framework sets a higher hurdle for regulatory approval than other countries [101, 102, 103]. Nevertheless, there are three precision fermentation products approved in Canada already. An agile approval process is vital to positioning Canada as a favourable market for cellular agriculture production. Regardless, there is some clarity to the regulatory requirements in Canada which is positive. The evolution of the regulatory environment both here and globally will be a significant factor in the growth of the Canadian industry.

There have been many initiatives in support of the cellular agriculture industry in Canada. These run from R&D funding, training and support of companies through to access to lab space and research bioreactors, and more. While these are important, it is less clear that the efforts have been aligned under a national strategy that brings different levels of government together to coordinate activities for maximum leverage.



Global Bird's Eye View

Much has happened in the last three years with some global jurisdictions leading the charge with bold national visions and strategies often focused on multi-cross-sectoral biomanufacturing opportunities. Others are leading with their agile and competitive regulatory frameworks. Direct support of companies, R&D, investments in infrastructure and training, and integration of social sciences are flourishing, culminating in precision fermentation hitting various markets worldwide. These include precision fermentation-derived ingredients or whole products and cultivated products as hybrid products in select locations and at a smaller scale.

Activity across continents, countries, regions, and provinces has built the initial foundation on which food innovation can continue to grow. As Canada looks globally to leading countries and regions, a modified "traffic light" assessment was created to compare various countries on their progress against the three recommendations from our 2021 report has been created (**Figure 11**). It is clear that **Canada has work to do to maintain the highest potential for the domestic cellular agriculture industry**.



Figure 11: Global Innovation Landscape

Taking the three recommendations from our 2021 report, elements of which can be recognized in the models being developed by leading countries or regions, we examined how Canada and these leading countries ranked against achievements relative to these recommendations and each other. This qualitative 'traffic-light' ranking is based on the snapshot of key updates within the report and by no means captures all achievements within each country. Considering the impressive strides certain countries and governments have made towards some of these three recommendations, they receive a star* ranking, including the US and the UK for their bold national visions, strategies, and recent $billion+ investments into cross-sectoral biomanufacturing (recommendation 1); Singapore for their innovative, iterative and modern regulatory structure (recommendation 2); and the US for their continued (some cases long-term) investments in innovation, support of companies, infrastructure, commercialization, and training (recommendation 3). This by no means minimizes the achievements of other countries in the cellular agriculture sector, including some other leading countries, such as the bell-weather for ag/food - the Netherlands, or the start-up nation of Israel.

Figure 11: Global Innovation Landscape



What's Next for Canada?

Canada is a recognized leader in the agriculture and food sector, has extensive free trade agreements, a wealth of domestic expertise, and many ingredients to be one of the world's leaders in cellular agriculture and the creation of precision fermentation-derived and cultivated food products. Canada is also a recognized leader in life sciences more broadly and in the health-focused bioeconomy.

Three years ago, the protein sector was at a crossroads. Since then, there has been an explosion of innovation, companies, research, and investments, and the tipping point of government funding worldwide has nurtured the current global leaders. The Canadian regional ecosystem is rallying, with companies being created nationwide and academic research developing much-needed solutions to help this industry overcome challenges towards scaling. Various parties are providing much-needed infrastructure, support and funding, although more is needed – especially for commercial scaling. While Canada has some capacity across regions, a lack of facilities for pilot/demonstration scale-up and at the commercial scale is still considered the most significant bottleneck globally. Innovations in design, efficiency, adaptation, or **increased investments in infrastructure will be necessary to help scale in Canada, as well as globally**.

Our world-class universities and colleges are striving to ensure the talent and workforce are ready for this exciting new opportunity. This talent will come from and apply to many disciplines and sectors, particularly platform technologies like genomics and engineering biology, biomanufacturing, artificial intelligence, computer science, stem cell and tissue engineering, food science, and social sciences. Given the multi-disciplinary nature of the talent and sectors involved, **a coordinated approach to training would be critical for maximum impact**.

Social sciences and communication will be imperative to tell this story as the industry grows and more products land on the market. The Canadian conventional agriculture and food sector is actively looking at involvement opportunities, especially around upcycling opportunities, where it can play an increasingly important role and benefit in the near term. Opportunities include new markets for raw materials (feedstock), enhancing current products (various products, including plant-based), creating new product categories and diversifying product offerings, offering food security solutions, and exploring new business opportunities in the emerging industry.

More international collaboration opportunities are developing, which will enhance the overall growth of this industry, including partnership and investment opportunities. **There is also a need to proactively establish international trade opportunities for the growing Canadian sector, which is paramount if a Canadian-based industry is to establish and grow**. With our extensive free trade agreements worldwide, this sector offers Canada an exciting export opportunity and a landing site for international companies. There are already evolving interests from global companies looking for North American market access, and regions across Canada are taking notice.

Time is of the essence and the size of the cellular agriculture leadership opportunity is Canada's for the making. By taking *further and concrete* action on the priorities outlined in this report, both regionally and, more importantly, at a national level, Canada can diversify its food and agriculture sector, become a leader in the new global biomanufacturing landscape, meet sustainability and food security goals, and reap the benefits from new economic markets. It is essential to look back at the original report's three recommendations (**Appendix 2**), holistically measure what we have achieved, done well, or need to do more of (**Figure 12**), and establish a ***renewed call to action***.

To achieve success, Canada must:

1. *Prioritize a National Vision and Strategy for a Canadian Cellular Agriculture Industry in the Near Term.*
2. *Take Proactive Evolution Towards a Clear, Transparent, and Agile Regulatory Framework for Cellular Agriculture Products in Canada.*
3. *Provide Additional Supporting Mechanisms for Research and Commercial Development, Building on the Foundation already in Place.*

Changes from the 2021 Report's Recommendations have been underlined above

An active, inclusive engagement strategy with the relevant stakeholders across Canada, is essential to build support for the sector. This includes existing industry players, all the way to the consumer, and all other stakeholders across the value chain.

A national vision and strategy that brings different levels of government together to coordinate activities would enable maximum leverage and impact. These could include things like investment in shared national infrastructure, trans-Canadian research investment, roadmap development, further regulatory modernization, connectivity across regional efforts, and coordinated recruitment of investment and talent. This can also reduce the duplication of efforts across the country. There are clearly jurisdictional questions, which make some efforts difficult, but a well-articulated national strategy with a commitment for coordination would accelerate the progress to fulfill Canada's potential as a leader in this space. A national strategy also requires a champion. The right strategy and champion(s) can help Canada be a true leader in cellular agriculture. Without these, Canada risks slow and disjointed investment and development. **A timely and coordinated national vision and strategy can help Canada be a true leader in cellular agriculture**.

Organizations Endorsing a Renewed Call to Action

BIOFECT™ INNOVATIONS
CANADIAN FOOD INNOVATION NETWORK
consecon foundation
Cultivated B
ESCARPMENT LABORATORIES
Food centre Saskatchewan Food Industry Development Centre Inc.
GIFS | GLOBAL INSTITUTE FOR FOOD SECURITY
Griffith FOODS
Ingredion
MSE
Kulture Rebellion
CENTRE D'ACCÈS À LA TECHNOLOGIE EN BIO-INNOVATION | LA CITÉ LE COLLÈGE D'ARTS APPLIQUÉS ET DE TECHNOLOGIE
Lipiferm Scientific
MATERIAL CUTTERS
MYO PALATE
NPC NATURAL PRODUCTS CANADA
NEW HARVEST
TERRA BIOINDUSTRIES
UNIVERSITY OF THE FRASER VALLEY FOOD AND AGRICULTURE INSTITUTE
UNIVERSITY of GUELPH
WPL
Genome Alberta | Genome Atlantic | Genome Prairie

Canada's $18.8 Billion Opportunity in Food Innovation: Precision Fermented and Cultivated Foods

CALL TO ACTION 1
National Vision and Strategy in the Near Term

GOOD PROGRESS

Continued **government incentivization** and support; public **policy** to support the sector

SOME PROGRESS

Continued support needs to include substantial and **sustained funding**, across the value chain and pipeline through to **commercial production**

Broad **communication** and outreach are integral in parallel to tech development to create further **understanding** and **interest** in these products

LITTLE PROGRESS

National **strategy**, based on a strong rationale and Canada's **unique advantages** and worldwide leadership potential, while examining **models** from leading countries to inform the development and **coordination** of the sector

Action plan framework, with short, medium and long-term steps, **value proposition**, and success **metrics**; developed and coordinated through a systems approach, with **national** and **regional** participation and strengths outlined

Define the **role** for cell ag in Canadian Food System, including **integration** of new production systems with conventional ones is critical, as well as continued discussions on **complementarity**, diversification and new product categories

CALL TO ACTION 2
Competitive, Clear, and Transparent Regulatory Framework

GOOD PROGRESS

Continued regulatory **clarity** and guidance, with a **transparent** regulatory framework

SOME PROGRESS

Continued improvements of timelines, **modernizing** regulatory review processes

Continued **early engagement** between regulators and companies

Cross assessment of regulatory processes with other jurisdictions should continue

LITTLE PROGRESS

Ongoing, clear, and comprehensive **communication** between the industry and regulators, as well as broad dissemination of positive engagements and **success stories**

Timely, flexible, **iterative**, and **competitive** transparent regulatory environment

Models from leading countries (e.g., Singapore) to examine their approach

Support for companies through the regulatory process e.g., concierges

CALL TO ACTION 3
Supporting Mechanisms for Research and Commercial Development

Research and Training the Next Generation of Skilled Workers

GOOD PROGRESS

Highly qualified personnel (HQP) for the sector, including raising awareness in existing **talent** from **complementary** disciplines

Continued high-value contribution from **colleges** across the country to enable **industry-driven** research and critical **workforce** development

SOME PROGRESS

Continued support for fundamental and industry-driven **research**; open science; continued **alignment** with **government priorities**, incl. Grand Challenges

LITTLE PROGRESS

Strategies and investment in the **platform biomanufacturing technologies** underpinning cellular agriculture, in particular engineering biology, omics, AI, and food sciences

Consumer acceptance and perception continues to be essential with **social sciences** research playing a critical role, as well as LCAs, TEAs and other analyses in due time, that are objective and independent

Growing the Economy: Start-up Support, Partnerships, Networks

GOOD PROGRESS

Investment in public and private sector-partnered **innovation hubs**, including incubators and accelerators, to support **start-ups** and SMEs, and access to expertise, **mentorship**, and **investment** opportunities

SOME PROGRESS

More outcome-driven **networks** to bring diverse groups together, **incentivizing** public-private partnerships and multi-cross and trans-disciplinary expertise, platforms, and sectors

Continued **public/private-private partnerships**, bridging the gap between research and translation, access to **infrastructure**, and linkages and entry routes into the **supply chain** for B2B companies

LITTLE PROGRESS

A concerted focus is needed to provide **facilities** for pilot/demonstration stage **scale-up**, as well as at a commercial scale. The lack of access to such facilities is still viewed as the most significant bottleneck globally

Canadian and international investors should be incentivized to invest in Canadian companies, including targeted government programs to attract, de-risk, or **leverage** private investment

Figure 12: Canada's Actionable Opportunities and Progress for a Thriving Cellular Agriculture Ecosystem.

FOOD INNOVATION IN CANADA REPORT

An $18.8 Billion Opportunity in Precision Fermentation and Cultivated Foods



Conclusion

Cellular agriculture presents Canada with a transformative opportunity to address critical challenges and reshape global food systems. With its unique advantages and advancements in precision fermentation and cultivated food technologies over the last three years, Canada is well-positioned to lead this emerging sector while complementing traditional food production methods. The industry's projected economic impact of CAD 18.8 billion and the creation of over 125,000 jobs demonstrate its immense potential. However, to fully realize these benefits, Canada must act with urgency. A unified national strategy, clear and agile regulatory frameworks, and investments in scalable infrastructure are crucial to fostering growth and ensuring global competitiveness.

As other nations accelerate their advancements, Canada risks falling behind if it does not prioritize and coordinate efforts. By building on regional strengths and progress, fostering international trade, and integrating cellular agriculture into its broader food and biomanufacturing strategies, Canada can secure its place as a global leader. The time to act is now—failure to seize this opportunity could jeopardize Canada's competitive edge in the growing global market, leaving it behind in the race to lead in sustainable and innovative food production.

Ontario Case Study

Introduction

This case study examines Ontario's substantial leadership opportunity in cellular agriculture within Canada, building on the foundational core strengths and sectors existing within the province, and highlights some short-term next steps to build on the momentum in this high-potential economic sector.

In the past three years, there has been a flurry of research and innovation, strategic investments, and focus on food innovation in cellular agriculture across Canada, with the most activity, support and traction occurring in Ontario (see earlier section, Canada: Progress To Date, for a complete cross-Canada breakdown). With space remaining in the market and because of existing core regional strengths (see **Figure 13**), and industries that broadly align with this sector (**Figures 14-17**), **Ontario has an unprecedented opportunity and is exceptionally well-positioned to play a leading role in this emerging food innovation sector**.

Ontario has many unique and diverse advantages on which this sector can build. The province has abundant human and natural resources, a diversified economy, world-class academic institutions (resulting in a hub for research talent and highly skilled labour force) (**Figure 14**), strong manufacturing sector(s), stable institutions and political systems.

Ontario is Canada's most populous province and already a leader in many industries tangential to cellular agriculture, including a world-leading life sciences sector and Canada's largest life sciences jurisdiction (**Figure 15**) (and the subsequent cross-sectoral expertise), that are broadly aligned with the cellular agriculture sector and well-positioned to translate that expertise to this new opportunity in food innovation.

Ontario is home to a strong and vibrant biotech sector, Canada's largest (by GDP) agriculture and food production and processing sectors (**Figure 16**) along with world-leading artificial intelligence (AI) and cleantech sectors, which all intrinsically connect and can impact and benefit from this new and evolving industry.

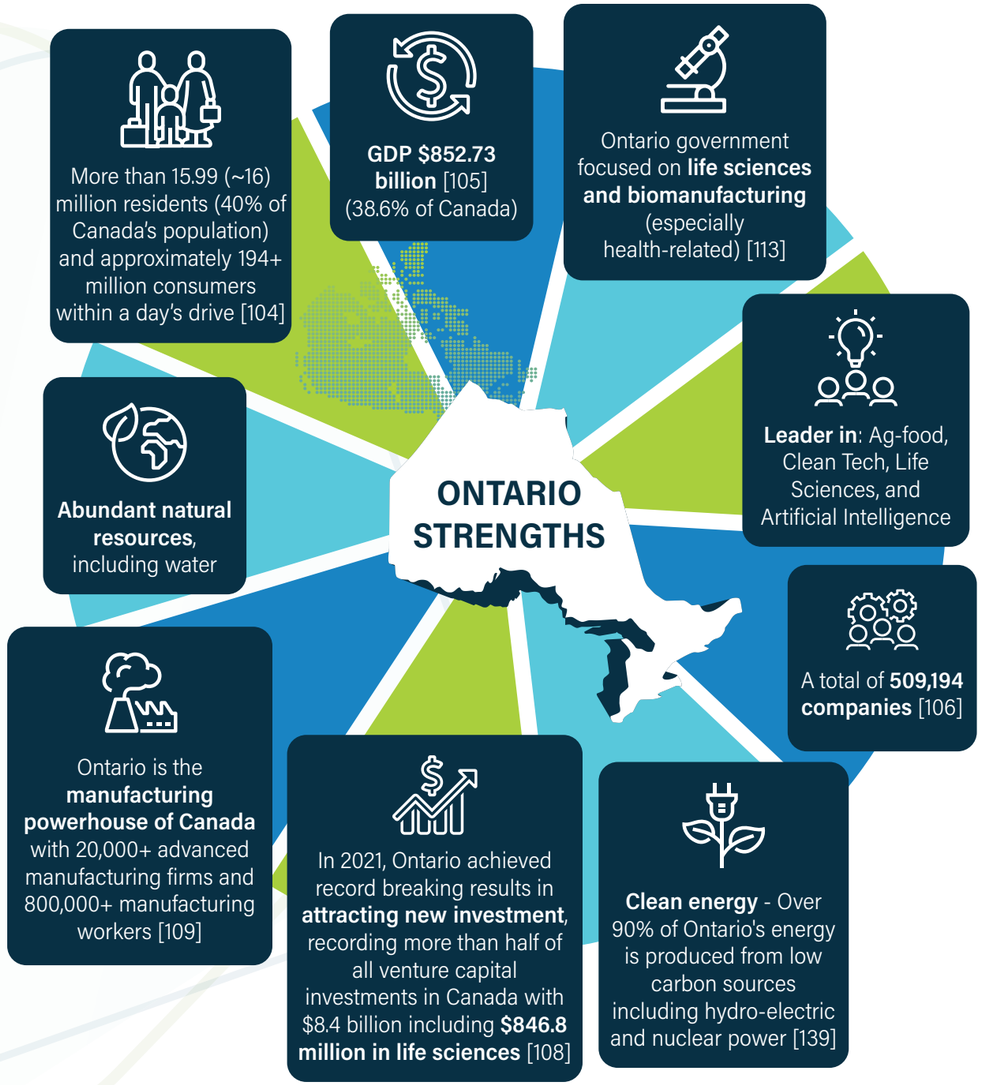


Figure 13: Core Ontario Strengths

Ontario also has a geographic advantage in North American markets, an exceptionally 'clean' energy grid, and many high-value economic factors such as businesses, investors, and academic institutions to help support and drive the success of this industry. Ontario has access to a large and diverse consumer base, creating opportunities for manufacturing food and beverages and new products that appeal to a wide range of people.

However, **it is critical to foster an environment that supports research and product development, investments, and infrastructure support that will allow the cellular agriculture industry to grow and flourish, enabling homegrown commercialization**. This support can have broad benefits including to the B2B and B2C cellular agriculture companies (precision fermentation, cultivated, support), Ontario's talent and workforce, and the broader biomanufacturing sector. There will also be benefits to the conventional ag/food sector with demand for feedstocks and valorization of sidestreams (**Figure 17**), creating innovative approaches for incorporating primary producers into emerging bioeconomy value chains.

In addition, by also supporting a competitive food processing sector, we can provide new opportunities to enhance and diversify our product offerings (including plant-based or new product categories) and reap economic and other benefits that this new sector has to offer.



Figure 14: Ontario's Leading Talent

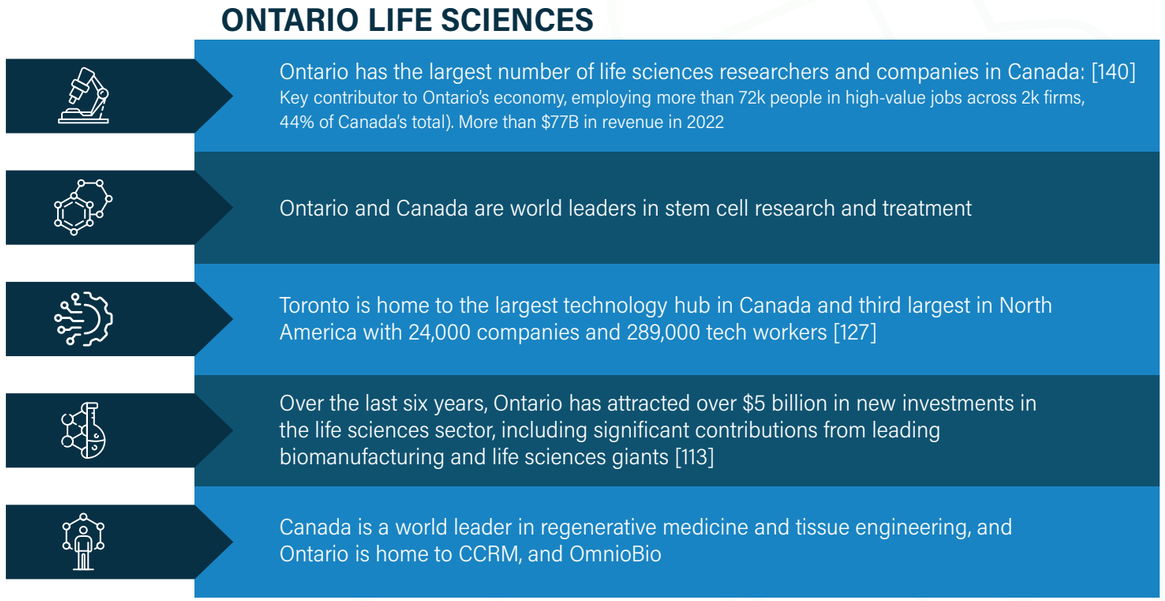


Figure 15: Ontario's World Leading Life Sciences Industry

ONTARIO AGRICULTURE & FOOD SECTOR

- Diverse and large Ontario agriculture and food sector accounts for one-third of the Canadian Ag/Food GDP (34%) [107]
- The third largest food and beverage industry in North America [116, 117]
  Generates $64B in revenue and $19.5B in exports/year, with 4,500+ food and beverage companies and 120k direct jobs
- The largest greenhouse vegetable sector in Canada with $2.7B in sales and $129M in exports [115, 118]
- Generated more than $50B for the Ontario economy (5.9% of GDP) [119, 121]
- Generates one out of every ten jobs in Ontario (employing 871,883 people) [120]

Figure 16: Ontario's Vibrant and Diverse Agriculture and Food Industry

ONTARIO IS RICH IN DIVERSE & TOP CANDIDATE FEEDSTOCKS FOR UPCYCLING

- 48,000+ farms, accounting for ~25.5% of the farms across Canada [122]
- Greenhouse byproducts, largest greenhouse producer in Canada [114]
  -Ontario greenhouse vegetables represent 71.8% of Canada's greenhouse vegetable industry
  -Ontario greenhouses grow over 575,000 tonnes of produce/year
- Dairy byproducts (whey, lactose) - Ontario is home to the second largest dairy processing sectors in Canada [122]
  -Contributes $8.1B to GDP and $267M in exports/year
  -Ontario produces 2.5B litres of milk/year
- Brewery industry and byproducts [69]
  -Brewers spent grain - ~16M kgs/yr (vast majority are landfilled)
  -Distillers' grains (bioethanol waste) - >100M kg/yr (majority used for low-cost animal feed)
- Top crops in Ontario: [123, 124, 125, 126]
  -Soybeans: # 1 national producer, over half (54.4%) of Canada's soybean acreage
  -Wheat: #4 national producer, 83.9% of Canada's winter wheat and 7.4% of Canada's total wheat
  -Corn: #1 national producer, 59.9% of Canada's total corn for grain area

Figure 17: Ontario's Upcycling Opportunity

Focus on Ontario – Economic Case

It is estimated that Ontario could achieve between 30% and 70% of the Canadian market. That means at the top end of the potential, cellular agriculture could be a $13 billion industry in Ontario and with more than 91,000 jobs. However, **what Ontario achieves is going to be relative to the effort Ontario puts in**, and if Ontario wants to achieve the higher end of these estimates, and capitalize on our leading advantage, we need to be strategic and deliberate in our actions to advance and support the promise that this sector has to offer.

Ontario's economic opportunity: $13 billion industry with more than 91,000 jobs.

The economic case for Canada in this update report focuses on the value of nationally coordinated activity, but it is worth exploring the potential in the province of Ontario to highlight some of the factors that could affect the growth of Canada's industry and the value of coordinated activity. The factors in Ontario that may offer an advantage and give it the potential to capture a disproportionate share of Canada's total industry are discussed below, as well as some counterpoints.

Training and HQP
Ontario is a leader in highly qualified personnel (HQP) and training in technical areas related to cellular agriculture. There are excellent universities and colleges across the country, but Ontario has a significant cluster of top-notch training institutions that are already active in the space and that will generate a higher volume of HQP and talent than other regions. This is already demonstrated by Toronto being home to Canada's largest technology hub, third largest in North America, with 24,000 companies and 289,000 tech workers [127]. There is room for migration to jobs but there is some inertia against movement. However, the cost of living in Ontario relative to other provinces may make HQP more outwardly mobile.

Share of Population and Economy
Ontario boasts a strong and vibrant conventional agriculture and food sector, including a leading dairy sector and diverse field and greenhouse crop production. In addition to the expectation that conventional agriculture will continue at a similar rate, cellular agriculture can create new business opportunities within the sector, such as generating feedstocks from primary production or valorizing sidestreams or by-products. The existing industry also provides routes to B2B and B2C market access for cellular agriculture products.

Infrastructure
Ontario has the largest proportion of the Canadian population of any province and hosts the leading food and beverage sector in Canada - the third largest in North America - including many multinationals. This means there is a concentration of demand for both food production and for food processing. **Many cellular agriculture products will be ingredients in food processing rather than fully formed final products. Access to both consumer and manufacturing demand and capacity will create a gravitational pull to Ontario**. While there will have to be an export market for cellular agriculture products, a larger local market for early production will be an advantage relative to other Canadian provinces.

Energy
Electrical energy that yields a lower carbon footprint may be a significant differentiator for cellular agriculture products. In 2021, 91% of Ontario's electricity was from zero carbon production, which could provide an advantage relative to some provinces – some still largely reliant on fossil fuels. Provinces like Quebec and Manitoba use largely (99%) zero carbon hydro-electric power which is an advantage relative to Ontario.

The higher cost Ontario economy (e.g., wages, real estate, etc.) could be a disadvantage relative to some other provinces, but it is expected this will be outweighed by the central location and critical mass of demand in the province. It is also worth noting that costs are not as high outside of major urban areas. Facilities will be established in places that balance cost, access to customers and inputs, transportation, and other factors.

There has been significant investment in supporting infrastructure and strategic development in the province. Ontario Genomics has championed the industry while also investing in pilot scale precision fermentation infrastructure and various partnerships to help support early-stage cellular agriculture companies on their journey to commercialization and training of talent to help grow this industry.

Table 2 presents the long-term projections for the Ontario industry in the case where the province achieves a higher share of the Canadian market. **Table 3** presents the forecast in the case that Ontario achieves a smaller share of the Canadian market.

Ontario's Potential in Global Cellular Agriculture Market: Higher Share			
Size of Global Market	Low	Medium	High
11,000,000,000	$ 52,739,726.03	$ 210,958,904.11	$ 527,397,260.27
27,500,000,000	$ 131,849,315.07	$ 527,397,260.27	$ 1,318,493,150.68
82,500,000,000	$ 395,547,945.21	$ 1,582,191,780.82	$ 3,955,479,452.05
165,000,000,000	$ 791,095,890.41	$ 3,164,383,561.64	$ 7,910,958,904.11
275,000,000,000	$ 1,318,493,150.68	$ 5,273,972,602.74	$ 13,184,931,506.85

Table 2: Ontario's Potential in Global Cellular Agriculture Market: Higher Share

Ontario's Potential in Global Cellular Agriculture Market: Lower Share			
Size of Global Market	Low	Medium	High
11,000,000,000	$ 22,602,739.73	$ 90,410,958.90	$ 226,027,397.26
27,500,000,000	$ 56,506,849.32	$ 226,027,397.26	$ 565,068,493.15
82,500,000,000	$ 169,520,547.95	$ 678,082,191.78	$ 1,695,205,479.45
165,000,000,000	$ 339,041,095.89	$ 1,356,164,383.56	$ 3,390,410,958.90
275,000,000,000	$ 565,068,493.15	$ 2,260,273,972.60	$ 5,650,684,931.51

Table 3: Ontario's Potential in Global Cellular Agriculture Market: Lower Share

There is a dramatic difference between the maximum potential if Ontario leads or follows in the market for cellular agriculture. In the optimistic scenario the industry has the potential to represent more than $13 billion in economic activity versus about $5.6 billion in the more pessimistic scenario. The top end of the optimistic scenario sees almost 91,000 jobs in Ontario whereas the top end of the pessimistic scenario is almost 39,000 jobs. There is clearly a lot at stake with respect to taking action in support of industry development. Ontario has some clear advantages as outlined earlier but those inherent advantages will only carry it so far.

The timing of the action is also critical to not only the total potential but also how quickly Ontario reaches that potential. If the industry, both globally and in Canada, experiences rapid growth and the Ontario industry is proactive in driving share of that growth, it could result in an industry with $5.3 billion in economic activity and more than 28,000 jobs by 2030. On the other hand, if industry growth is slower and Ontario lags behind, the highest forecasted level of economic activity would be just over a half a billion dollars and approximately 3,000 jobs by 2030.

There are clearly elements that are out of Ontario's control relative to building the cellular agriculture industry. The regulatory framework is in the hands of the federal government (tied to Actionable Recommendation 2 from the 2021 report). A national cellular agriculture strategy would include Ontario but not be regionally limited (tied to Actionable Recommendation 1 from the 2021 report). Maximizing the inherent advantages in the province requires focused and timely action, and if a national strategy is not quickly forthcoming there would be a benefit to an Ontario-focused strategy, which could then be further leveraged by integration into or forming the basis of a national strategy. In either case, there needs to be quick development of an Ontario strategy.

Ontario Innovation Ecosystem Supporting Cellular Agriculture

As outlined earlier, there has been an impressive amount of progress across various provinces aligning with actionable recommendation 3, and Ontario is a leading example of this progress (see Canada – Progress Since 2021 Recommendations). Ontario is home to over half (16 of the 28) of Canada's cellular agriculture companies, working across precision fermentation, cultivation, and support. Some of which have landed in Ontario as subsidiaries of international companies (**Figure 18**).

ardra — TORONTO, ON	Using precision fermentation to sustainably create both natural and novel ingredients	TORONTO, ON	Engineering yeasts to produce nature- identical animal proteins, including casein for animal-free cheese
BIOFECT INNOVATIONS — TORONTO, ON	Producing protein ingredients through precision fermentation for the food & beverage industry	EVOLVED MEATS — WATERLOO, ON	Creating scaffold-free tissues for cultivated meat production and regenerative medicine
genuine taste — TORONTO, ON	Producing cultivated animal fats to enhance flavour of alternative meats	HARVEST MOON — OTTAWA, ON	Using microbial fermentation to produce next-gen dairy inputs
Kulture Rebellion — TORONTO, ON	Re-inventing social drinks for healthy lives & a sustainable future with AI-enabled precision fermentation	LIVEN — TORONTO, ON	Producing protein ingredients through precision fermentation to enhance plant-based foods
MATERIAL FUTURES — TORONTO, ON	Turning microorganisms into miniature dye factories	MYO PALATE — TORONTO, ON	Producing cultivated meats, including pork
n!Biomachines — BURLINGTON, ON	Developing and manufacturing bioreactors for next-gen bioprocessing, to support the food, supplement and cosmetic industries	PreFer Industries — BURLINGTON, ON	Producing smart ingredients and high-quality formulations through precision fermentation, photobioreactors, or greenhouses
TERRA BIOINDUSTRIES — TORONTO, ON	Decarbonizing supply chains with upcycled ingredients, including production of a sugar-rich precision fermentation feedstock	Cultivated B — BURLINGTON, ON	Solving key challenges of scalable alternative protein production and provides solutions as physical goods or licensable know-how
WHITEBOARD FOODS™ — OTTAWA, ON	Producing a plant-based scaffold for use in plant-based and cultivated meats	YEX — TORONTO, ON	Creating next generation growth media to support the cellular agriculture and biotech industries

Figure 18: 2024 Ontario cellular agriculture companies

Ontario is also home to a wide range of new initiatives in, or supporting, the sector, many driven by Ontario Genomics' aim to achieve the province's unparalleled opportunity in this space (**Figure 18**).

Ontario Genomics' collaborative initiatives include support of companies through:

- Co-launching with Canadian Food Innovation Network (CFIN) the first regional cellular agriculture-focused funding program, AcCELLerate-ON, which supports a variety of start-ups as well as an academic-industry partnership;
- Implementation of the BioCreate program with funding from the Federal Economic Development Agency for Southern Ontario and Ontario Genomics. The $11.6 million in-house accelerator program is for small- and medium-sized enterprises and has funded seven cellular agriculture-focused companies in the first five (of seven) cohorts [85];
- Co-leading with Global Affairs Canada, the co-organization of a 20+ Canadian cellular agriculture company delegation to the Netherlands in 2023 to promote engagement, which resulted in partnerships and investments with the Dutch ecosystem [86];
- Investing in fit-for-purpose bioreactors, some housed in the bioengineering hub, located at n!Biomachines' new manufacturing facility in Burlington.

Funding of innovative industry-academic research and social sciences, including:

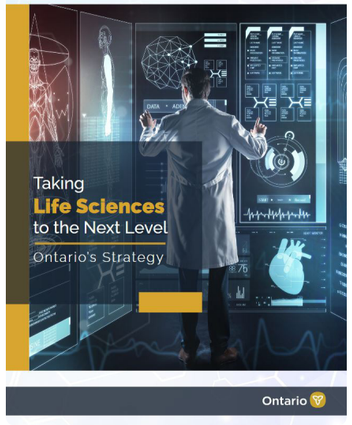
- Funding, with Genome Canada, an Ontario-led $10-million cultivated meat project, the largest investment in cellular agriculture in Canada to date, with McMaster University, University of Guelph, University of Toronto, Collège La Cité, and various industry partners [75];
- In parallel, Ontario Genomics has led the creation of the wasteCANcreate upcycling consortium, a national program which is investing in bioconversion-based technologies, including precision fermentation, that can upcycle agricultural or food byproducts into high-value products like ingredients, proteins, or other products (e.g., biodegradable plastics, upcycled textiles, etc.).

Support of the next generation of talent:

- Training programs are also being expanded in the province, with biomanufacturing micro-credentials being offered by various groups including BioZone at the University of Toronto, Lambton College (in partnership with Ontario Genomics), Algonquin College, and others in the pipeline [87].

Recent new lab capacity has been established within the province e.g. SpinUp at UTM Mississauga, the Bioengineering Hub at n!Biomachines in Burlington, and SPEC Labs in Mississauga, as well as expanded capacity at Velocity Incubator in Waterloo, and the Catalyst at 77 Wade in development, all offering support to multi-sectoral life sciences and biotech companies in the province.

Ontario - A Global Biomanufacturing and Life Sciences Hub



There has been strong support, investments and strategies for the biomanufacturing and fermentation industries more broadly, through various new and strategic investments by and within the province. These include:

- Ontario's Life Sciences Strategy – *Taking Life Sciences to the Next Level – Ontario's strategy* (2022), with a vision to establish Ontario as a global biomanufacturing and life sciences hub leading in the development, commercialization and early adoption of innovative health products and services [113].
- Phase 2 of the Life Sciences Strategy, launched October 2024, includes an investment of $146 million towards infrastructure and wet lab space, scale-up funding and venture capital funds aimed at establishing Ontario as a global biomanufacturing and life sciences hub [113].
- This includes an additional $40 million from the Venture Ontario Fund to invest in venture capital funds that will help Ontario-based life sciences companies and biomanufacturers innovate and grow, with a specific focus on in-demand, high-growth areas where Ontario demonstrates a competitive advantage.



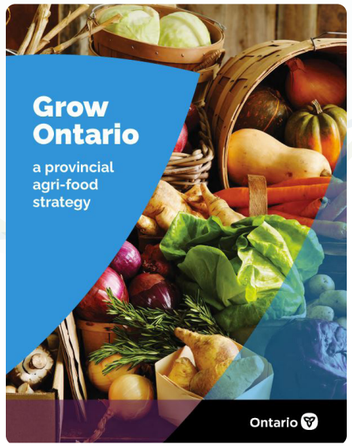
Figure 19: Ontario Cellular Agriculture Innovation Ecosystem

- Expanding the eligible priority sectors, including to agricultural and food technology, for Intellectual Property Ontario (IPON) to provide more comprehensive support to Ontario-based innovators and researchers and help capitalize on the commercial potential of the research coming out of the life sciences sector, and opportunity for more investments [128].
- Attracting international companies to locate to Canada through various mechanisms including:
  - Collaborative efforts by Toronto Global and Invest in Canada, bolstered by Ontario Genomics' 2021 report – attracted German company, The Cultivated B, to set up their first North American site in Ontario [129];
  - Invest Ontario, the province's dedicated investment attraction agency, with a focus on advanced manufacturing, life sciences, and technology;
  - Invest Ontario is supporting a $200 million investment by Jungbunzlauer (2024), a leading producer of high-quality, sustainable ingredients, including from natural sources, to build Canada's first xanthan gum manufacturing facility in Port Colborne, including large-scale fermentation capacity [130];
  - Over the last six years, Ontario has attracted over $5 billion in new investments in the life sciences sector, including significant contributions from leading biomanufacturing and life sciences giants [131].

Ontario's Food Innovation Opportunity

Ontario is recognized as a leading life science and biomanufacturing hub. Ontario is uniquely positioned in Canada to become a leader in food biomanufacturing (or cellular agriculture) by capitalizing on its research, innovation, and foundational strengths and extending beyond biomanufacturing in the health sector to include food, the convergence of which has become increasingly evident in recent years [132].

The province's strategic advantages—ranging from its world-class educational institutions and skilled workforce to its vibrant biotech, conventional ag-food, food processing, life sciences and manufacturing sectors—give it a solid foundation to drive growth in this high-potential industry. Food biomanufacturing would have its own unique needs and challenges, but it's with these clear foundational strengths, Ontario currently has a leading advantage at its fingertips.



Ontario is an agriculture and food powerhouse, strengthened by the Ontario Ministry of Agriculture, Food and Agribusiness (OMAFA) and a long standing and successful collaboration with the University of Guelph through the Ontario Agri-Food Innovation Alliance [133]. Together with Agricultural Research and Innovation Ontario (ARIO), they work to advance research and innovation that contributes to the success and competitiveness of the province's agri-food sector [134]. In addition, OMAFA's strategic report, Grow Ontario: a provincial agri-food strategy (2022) [135], outlines a plan to strengthen the agri-food sector, support economic growth, and ensure an efficient, reliable and responsive food supply for Ontarians. Grow Ontario outlines overarching priorities to strengthen supply chains, increase technology adoption, growth of talent, and 2032 goals, which are well aligned with the food innovation opportunities that precision fermentation and cultivated foods have to offer.

However, to unlock the full economic potential, Ontario must take decisive and coordinated action to foster innovation, secure investment, and develop supportive infrastructure and ecosystem. **With a concerted effort, Ontario could capture a significant share of the cellular agriculture market, creating thousands of high-quality jobs and generating billions of dollars in economic activity while also playing a pivotal role in global food innovation, benefiting our core foundational sectors and strengths.**

Ontario could achieve between 30% - 70% of the Canadian market.

Calculations in this report estimate that Ontario could achieve between 30% and 70% of the Canadian market. Estimations vary based on actions, and if we want to secure the highest opportunity of what this growing sector has to offer - a $13 billion industry in Ontario and the creation of 91,000 jobs - the time for action is now. **Strategic and deliberate movement is needed to advance and sustain the promise this sector has to offer, and the next steps should include the development of short-, medium-, and long-term goals and strategies towards sustained support and funding in the longer term.**

In the short term, there are benefits to coalesce and engage the community and broader ecosystem, including sectors intersecting with cellular agriculture and creating working groups or advisory councils towards developing a regional strategy. **Engagement with industry and private sector to invest and explore opportunities is key, as are the alignment opportunities with the conventional ag/food sector community to develop innovative multi-stakeholder value chains.** It is also crucial to engage with the provincial government around policy considerations and support, align on the next steps in Ontario, and look toward mechanisms of engagement and the next steps nationally.

Ontario could be the leading province in Canada, which aligns with Ontario's plans in the broader biomanufacturing and life sciences, and our goals for the growth of the province's agriculture and food sector. In the near term, **precision fermentation-derived ingredients and foods can help diversify and create new product categories in Ontario or strengthen existing ones for domestic and international markets, supporting home-grown company creation and Ontario intellectual property generation, as well as an opportunity to address food security concerns in Canada and globally.** In the longer term, these can be supplemented by additional cellular agriculture products, cementing Ontario's position as the sector leader.

Conclusion

As outlined in this report, Ontario possesses numerous strengths, resources, and the talent necessary to become a global leader in cellular agriculture. Food innovation has the potential to further diversify and enhance Ontario's dynamic agriculture and food industry, supporting other related sectors, including biomanufacturing, while contributing to global food security. However, as we have detailed in the previous pages, the time to take meaningful action is now for Ontario to unlock the maximum potential this exciting sector offers and make the $13 billion and 91,000 job opportunity a reality.

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APPENDICES

Appendix A: Development of the Economic Case

This appendix provides background and additional information on the economic forecasts presented earlier in the report. The first part of this appendix is replicated from the first Ontario Genomics report as it serves as the foundation for the numbers in this report [1]. There is some repetition from both the first report and this one, but we feel it is an important context within which to present the detailed numbers below.

The appendix is broken into three sections:
1. An overview of the original approach to the forecasts.
2. The approach to revising the forecasts.
3. Forecasts for the Ontario case study.

Appendix A.1 The Original Cellular Agriculture Forecasts

Our estimates of the potential of cellular agriculture for Canada were based on three key steps:
1. Estimating the size of the cellular agriculture market worldwide;
2. Estimating the size of Canada's share of that market; and
3. Estimating job creation in similar industries at similar levels of development.

There is little doubt that cellular agriculture has huge potential globally. There remains considerable uncertainty about both the rate of growth of the market and Canada's ability to carve out a share of that market. Progress on the recommendations from the previous report are critical to establishing a beachhead in cellular agriculture from which the Canadian industry can build. A proactive approach is critical. This uncertainty could be reduced if Canada was more proactive and developed a plan for supporting and fostering the industry. We develop projections based on a number of assumptions outlined in this appendix. We also outline some of the uncertainties associated with these assumptions to contextualize the projections and the range of potential outcomes. We highlight that there is likely greater uncertainty with respect to when specific market revenues are achieved as compared to the potential size of those markets.

The Market for Cellular Agriculture Products

Cellular agriculture covers a wide range of products. The primary focus of analysts to date has been on meat and dairy proteins. Many of the estimates of market size are based exclusively on lab grown meat rather than on the broader potential which includes cultured non-protein food products like chocolate and many fermentation products as ingredients. An example of this is heme which is used in some plant based proteins to mimic real meat proteins [2].makes estimation of the potential size of the market more difficult. There will be growth in existing products but there will be new products still in early development that will drive substantial growth in cellular agriculture as they are commercially scaled and come to market. There is little debate that there will be substantial growth in the cellular agriculture market. There is less consensus on the pace of that growth and when the market will meet certain revenue milestones.

We collected a broad range of estimates of the size of the cellular market generally or cultured meat specifically. This Delphi approach integrates a broad range of perspectives to provide insight into the potential for cellular agriculture products. The Delphi approach is a well-accepted tool in developing forecasts for products/segments for which there is no significant history.

We choose to evaluate a range of market sizes. Rather than assign a specific dollar value to a year (as many of the other estimates did) we specified numbers on a growth path. There is less debate on the eventual size of the market than there is as to when we will hit those milestones. Our low value of $10 billion reflects a significant market but incorporates the lower estimates of global market size with an adjustment to include all cellular agriculture products when only cultured meats were estimated. We also extended estimates before 2030 out to 2030. This represents a reasonable time horizon for growth and development both globally and in Canada and allows for some of the exponential growth one would expect in a market such as this. The midpoint of $75 billion is below some of the estimates for 2030 but represents a conservative forecast reflecting some of the more pessimistic forecasts for the next decade. We would reiterate that there is little doubt that the market will reach $75 billion and beyond globally but it might happen a bit later than 2030. The most optimistic forecast ($250 billion) is included to highlight the potential market size twenty or thirty years down the line.

There are several factors that will affect the size and growth rate of the cellular agriculture market that bring some uncertainty as to the timing of specific revenue milestones. These should be acknowledged as contributing uncertainty for both the total market size and the share attributable to Canada. These include:
- The pace of discovery and product development for individual products. Many products are still in the early development phase and even more in the discovery phase. The ability to bring these products to market and scale them depends on financing, infrastructure, and other factors.
- Consumer acceptance of these products. There is evidence that consumers are open to these products. Plant based products such as the Impossible Burger include the cellular agriculture product heme and are experiencing significant growth. Cultured chicken is on the market in Singapore. Perfect Day is selling frozen dessert and cream cheese with cultured dairy proteins, and the EVERY Company has launched an egg white-equivalent protein.
- Regulatory frameworks will be important for bringing products to the market.
- The availability of investment to drive product development and scale up will factor into the rate of growth.
- Infrastructure in support of scaling product is also critical to market growth.

It is also worth noting that much of the expertise and infrastructure to succeed in the cellular agriculture market will be applicable beyond food and ingredients. Chiu et al. estimate that the market for biological based innovation will reach $3.0-$5.1 trillion by 2050 with $0.8 -$1.2 trillion of that in agriculture and food [3]. Fostering the cellular agriculture market will provide an opportunity to develop a critical mass of highly qualified personnel and infrastructure to facilitate growth in the broader field of bio-innovation.

The Canadian Share of the Cellular Agriculture Market

There is considerable uncertainty related to the share of the total market that Canada could reach. As outlined above, factors such as availability of investment, supporting infrastructure for scaling, regulation, and Canadian based discovery and development will influence whether Canada plays a significant role in this industry going forward. Canada may also be dependent on other markets for growth. It is often the case that the cost of regulatory approvals for the relatively small Canadian market leads companies to prioritize limited resources for approvals to larger markets. The pace of approval also matters but Smyth (2017) highlights that the approval of GM Apples in Canada proceeded such that approvals came very quickly after they did in the United States [4].

Darby and Sewell (2021) also highlight a number of other factors that can influence a country's competitive position in new technology development. They suggest that governments need to be proactive in helping companies bring products to commercial success, particularly early investment where the private sector may not step up [5].

Canada represents approximately 0.5% of the world's population. Our conservative estimate of share reflects the case if Canada achieves a share of the market only equal to double its share of population [1]. We use double because Canada is a developed country and is further ahead in technology and food processing than many developing economies.

The World Bank estimated global GDP in 2019 at USD $87.6 trillion and that agriculture and food represent approximately 10% of that total [6]. We use 2019 as 2020 GDP was lower due to the pandemic and should be expected to return to pre-pandemic levels eventually. Canadians spent almost CDN $210 billion on food in 2019 with approximately CDN $130 billion in food stores [7] and another $78.5 billion in food service [8]. That means that Canada represents approximately almost 2% of the global food expenditure when exchange rates are considered. We use this as the midpoint for Canada's potential share of the total cellular agriculture market.

Canada is a major producer and exporter of agriculture and food products reaching almost $74 billion in 2020 [9]. This represents approximately 5% of the world trade in food and agriculture products of $1.5 trillion [10]. We use this as the aggressive target for Canada's share of the cellular agriculture market. If Canada can compete in cellular agriculture as it does in global exports generally, this is an achievable target.

Job Creation

Predicting job creation is difficult and forecasts are confounded by the maturity of the market. Jobs are a larger proportion of revenues early in the development of a market as there are many skilled individuals working on product and process discovery and development in advance of a mature market. As markets grow, the rate of job creation decreases.

Canada's gross domestic product (GDP) was almost $1.7 trillion in 2019 [11]. That represents an average of slightly more than $89,000 of GDP per job.

Canada's food processing sector produces approximately $104 billion in annual revenue with employment of approximately 250,000 jobs [12]. This makes sense in comparison to the Canadian number as the lower number for Canada reflects a significant number of service jobs where labour costs are a bigger component of output.

Canada's biotechnology sector represents almost $90 billion in revenue and one million jobs [13]. This gives a revenue per job ratio of almost $90,000. This reflects an industry in its infancy and the requirement to invest in development to grow sales.
We use the biotechnology number for an upper bound for cellular agriculture jobs and the food processing industry ratio for the lower bound. This reflects that job creation is highest early in a market's development before sales grow. It is positive that the jobs are created early in the development of an industry.

Projections
Based on the parameters outlined above we developed projections for the size of the Canadian cellular agriculture industry presented in the 2021 report.

Table A4: Market Potential for Cellular Agriculture in Canada

	Canada's Share (CDN)		
Size of Global Market	1%	2%	5%
10,000,000,000	$ 50,000,000	$ 200,000,000	$ 500,000,000
25,00,000,000	$ 125,000,000	$ 500,000,000	$ 1,250,000,000
75,000,000,000	$ 375,000,000	$ 1,500,000,000	$ 3,750,000,000
150,000,000,000	$ 750,000,000	$ 3,000,000,000	$ 7,500,000,000
250,000,000,000	$ 1,250,000,000	$ 5,000,000,000	$ 12,500,000,000

Table A5: Canada'sShort term Jobs: Slow Growth

	Share		
Early Market ($)	Low	Middle	High
10,000,000,000	568	2,274	5,684
25,000,000,000	1,421	5,684	14,210
75,000,000,000	4,263	17,052	42,629
150,000,000,000	8,526	34,103	85,259
250,000,000,000	14,210	56,839	142,98
	Share		
Mature Market ($)	Low	Middle	High
10,000,000,000	120	481	1,202
25,000,000,000	300	1,202	3,005
75,000,000,000	901	3,606	9,014
150,000,000,000	1,803	7,212	18,029
250,000,000,000	3,005	12,019	30,048

A1.2 Updating the Forecasts

There are several factors that have contributed to this growth based on changing conditions, highlighted below.

What has Changed?
There have been three significant developments in the time since the original publication of the original report. We have seen generational levels of food price inflation across the world in all products, including proteins (Figure A1) [14].

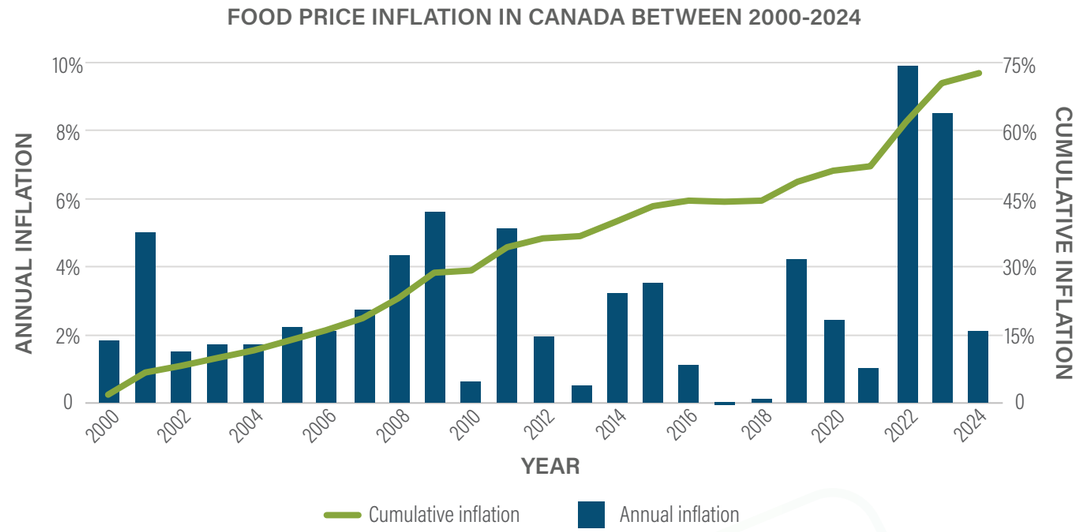


Figure A1: Food Price Inflation in Canada between 2000 – 2024.

The price of food has risen substantially in the last twenty-four years, with food being more than 70% more expensive than it was in the year 2000. The last three years have seen more than 20% of that growth [14].

Inflation has been driven by a wide variety of factors including:
1. **wars in Ukraine and the Middle East** [15];
2. **increased potential for future armed conflicts in Europe, the Middle East and other areas**;
3. **extreme weather events and diseases largely driven by climate change** [16];
4. exchange rate differences;

While the COVID pandemic is often blamed for price increases, the pandemic itself did not contribute significantly to price inflation. The first three points above are important for cellular agriculture for two reasons. First, higher food prices will allow cellular agriculture products to be price-competitive sooner, which could accelerate the growth and value of the industry. It needs to be acknowledged that the value of inputs for cellular agriculture products will also have risen but the relative price changes and sustained food price levels should provide a price competitive advantage in the medium-term. This also creates an even larger opportunity for upcycling sidestreams from agricultural and natural resource extraction activities to supplement feedstock supply chains.

Secondly, the production variability caused by extreme weather events and other climate-driven factors will challenge the resiliency of food supply chains. The COVID-19 pandemic has brought a focus on the localization of food value chains. The risk of localization is that the food supply is more susceptible to production losses due to extreme weather events and other climate-driven disruptions. A large part of the motivation for cellular agriculture is to augment conventional production to help meet global needs. While feedstocks will continue to depend on conventional production, cellular agriculture production will be

much less susceptible to extreme weather events. Canada has an abundant supply of feedstocks in comparison to some of the other countries that are developing cellular agriculture industries which will also bring stability to the domestic industry. Cellular agriculture can bring stability to global and local production and help build resilience. This will also help to accelerate the timeline and increase the total potential for cellular agriculture in Canada and globally. Beyond the value of the economic activity due to cellular agriculture, there is also a consumer benefit of the growth of the industry. We are seeing increased price variability (the last ten years have statistically significantly more variability in food prices than the previous ten) which creates uncertainty and difficulty for consumers.

There have been initiatives in several US states to ban cellular agriculture products generally or lab-grown meat products specifically [17]. This is largely motivated by protectionism towards conventional agricultural production, which was explicitly acknowledged in the legislation in Florida. There have also been some bans in European countries, most notably Italy [18]. While countries like the UK and the Netherlands have been aggressive in developing the industry, it is not universal in Europe and can provide an opening in Canada. It is unlikely these bans will survive in the long term, and many jurisdictions with large populations are open to and encouraging the development of these products. It is also worth noting that the bans are more focused on cultivated meat than on precision fermentation products. While this may be as much due to the issue of awareness, there has not been the same focus on precision fermentation products. In fact, some early fermentation products are already on the market in the US, specifically in the markets where cultured meat products are banned. Fermentation products may displace some traditionally produced ingredients and thus draw the attention of protectionist legislators, too.

Progress on Recommendations

There has been some progress on the recommendations from the original report. This is critical to ensuring that Canada gets its share of the growing total cellular agriculture pie.

The Government of Canada has released an informative webpage on applicable regulations in Canada for products of cellular agriculture which includes key considerations for developers, and this is an important step forward. Regulatory clarity is important for bringing investment and establishing manufacturing of cellular agriculture products, and transparency in oversight contributes to public trust in novel products. While Canada itself presents a relatively small total market and the absence of domestic market potential may discourage local research, development and production. It is, therefore, critical to have an investment and regulatory environment that is favourable to the development of the industry, to provide a completive advantage for Canada, with opportunities to attract foreign investment, as well as growth of domestic players. Canada has an advantage due to its proximity to, and established trade agreements with, the US and Asian markets and an abundance of feedstock. Canada also has free trade agreements covering 60% of the global GDP. Training can also give Canada an advantage by developing top-notch technical talent. While the current Canadian regulatory framework does provide some clarity, there are some questions about whether the framework sets a higher hurdle for regulatory approval than other countries [19, 20, 21] Nevertheless, there are three precision fermentation products approved in Canada already. The speed of approval is critical to positioning Canada as a favourable market for cellular agriculture production. Regardless, there is some clarity to the regulatory requirements in Canada which is positive. The evolution of the regulatory environment both here and globally will be a significant factor in the growth of the Canadian industry.

There have been many initiatives in support of the cellular agriculture industry in Canada. These run from R&D funding, training, support of companies, through to access to lab space and research bioreactors, and others. These are important. It is, however, less clear that the efforts have been coordinated under a national strategy that brings different levels of government together to coordinate activities for maximum leverage. These could include things like investment in shared national infrastructure, trans-Canadian research investment, roadmap development, further regulatory modernization, connectivity across regional efforts, and coordinated recruitment of investment and talent. This can also reduce the duplication of effort. There are clearly jurisdictional questions, which make some efforts difficult, but a well-articulated national strategy with a commitment for coordination would accelerate the progress to fulfilling Canada's potential as a leader in this space. A national strategy also requires a champion. The right strategy and champion(s) can help Canada to be a true leader in cellular agriculture. The alternative is slower and disjointed investment and development.

Given these changes and the passage of time, we raised our estimates of the long-term potential of the cellular agriculture. Although there is some evidence of Canada lagging behind other large players (see main report figure 11) we have maintained our original range regarding the share of the global industry taken by Canada. There is still time to catch up and, therefore, we believe that the upper bound of opportunity still exists.

Table A1 shows the forecasted range of opportunity for the Canadian industry in the medium to long-term (20-30 years). The figure of approximately $75 million (all numbers in Canadian dollars) In the upper left corner reflects both limited growth of the global industry and a smaller share for Canada. On the other hand, the $18 billion figure in the bottom right corner reflects a vibrant global industry with Canada holding a share of 5%. The range from low to high is significant and is driven by first by the size of the global market and secondly by Canada's success in garnering a share of that global market. We would suggest that the question of the overall size of the global market is one of timing – it will grow significantly but it may take a longer time to get there. Thus it is critical for Canada to stake a claim to a share of that market now so that the $18 billion market size is achievable versus the smaller $1.9 billion share of the larger market.

Table A1: Canadian Share of Global Market (CDN)

Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 75,342,466	$ 301,369,863	$ 753,424,658
27,500,000,000	$ 188,356,164	$ 753,424,658	$ 1,883,561,644
82,500,000,000	$ 565,068,493	$ 2,260,273,973	$ 5,650,684,932
165,000,000,000	$ 1,130,136,986	$ 4,520,547,945	$ 11,301,369,863
275,000,000,000	$ 1,883,561,644	$ 7,534,246,575	$ 18,835,616,438

Table A2 shows the job numbers associated with each level of market size in the Canadian industry. These are developed the same way that the previous ones were with a blend of biotech and food processing job outputs.

Table A2: Canadian Jobs by Market Potential

Size of Global Market	0.5%	2%	5%
11,000,000,000	518.80	2,075.18	5,187.95
27,500,000,000	1,296.99	5,187.95	12,969.89
82,500,000,000	3,890.97	15,563.86	38,909.66
165,000,000,000	7,781.93	31,127.73	77,819.32
275,000,000,000	12,969.89	51,879.55	129,698.87

There is also significant interest in the more short-term economic opportunity presented by cellular agriculture. To project the potential size of the market we looked at a slow growth scenario (10% of long-term potential) and a quick growth scenario (40% of long term potential). **Table A3** gives the quick growth scenario and **Table A4** gives the slow growth scenario.

Table A3: Canada's Short-Term Share of Global Market: Slow Growth

Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 30,136,986.30	$ 120,547,945.21	$ 301,369,863.01
27,500,000,000	$ 75,342,465.75	$ 301,369,863.01	$ 753,424,657.53
82,500,000,000	$ 226,027,397.26	$ 904,109,589.04	$ 2,260,273,972.60
165,000,000,000	$ 452,054,794.52	$ 1,808,219,178.08	$ 4,520,547,945.21
275,000,000,000	$ 753,424,657.53	$ 3,013,698,630.14	$ 7,534,246,575.34

Table A4: Canada's Share of Global Market: Fast Growth

Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 7,534,246.58	$ 30,136,986.30	$ 75,342,465.75
27,500,000,000	$ 18,835,616.44	$ 75,342,465.75	$ 188,356,164.38
82,500,000,000	$ 56,506,849.32	$ 226,027,397.26	$ 565,068,493.15
165,000,000,000	$ 113,013,698.63	$ 452,054,794.52	$ 1,130,136,986.30
275,000,000,000	$ 188,356,164.38	$ 753,424,657.53	$ 1,883,561,643.84

In both cases the difference between the low share and the high share is stark. The performance in the next five to six years sets the foundation for the long-term potential. If, for example, Canada lags behind in the quick growth scenario achieving less than $1 billion in economic activity by 2030 (approximately 4,000 jobs) it will be difficult to catch up and make it to the $18 billion dollar long-term opportunity. On the other hand, if Canada is proactive in taking action, we can achieve almost $2 billion in cellular agriculture market size (and more than 100,000 jobs) even if global growth is slow.

Tables A5 and A6 present the 2030 job numbers associated with quick and slow growth scenarios.

Table A5: Canada's Short Term Jobs: Slow Growth			
Size of Global Market	Low	Medium	High
11,000,000,000	161.69	646.79	1,616.98
27,500,000,000	404.24	1,616.98	4,042.46
82,500,000,000	1,212.74	4,850.96	12,127.40
165,000,000,000	2,425.48	9,701.92	24,254.81
275,000,000,000	4,042.46	16,169.87	40,424.68

Table A6: Canada's Short Term Jobs: Fast growth			
Size of Global Market	Low	Medium	High
11,000,000,000	40.42	161.69	404.24
27,500,000,000	101.06	404.24	1,010.61
82,500,000,000	303.18	1,212.74	3,031.85
165,000,000,000	606.37	2,425.48	6,063.70
275,000,000,000	1,010.61	4,042.46	10,106.17

Appendix A.3 Ontario Forecasts

This appendix provides a greater depth of detail with respect to the forecasts for Ontario specifically and augment the Ontario case study presented earlier.

The earlier section highlighted many of the strengths of Ontario relative to other regions in Canada. Ontario's share of the Canadian market will be driving by differences in investment, policy, research progress, and strategic decisions made by companies. Predicting growth in Ontario involves some subjective evaluation of the total potential. We use some broad shares to set a range of potential for the Ontario share of the total Canadian market. For example, Ontario represents approximately 42% of Canada's food and beverage GDP [22]. Ontario has a specific biotechnology growth strategy and represents more than 50% of the biotech companies in Canada today [23]. Early shares can expand as momentum and critical mass grows [24].

Based on these qualitative assessments, we propose a share range of 30% (pessimistic) to 70% (optimistic) for the Ontario cellular agriculture industry. That provides the foundation for the estimates derived from the Canadian economic activity numbers provided previously.

Tables AO1 and AO2 present medium term numbers for both dollar value and jobs respectively, for Ontario in the scenario that Ontario achieves a 70% of the Canadian market. **Tables AO3 and AO4** presents those numbers in a low share scenario. In a high share scenario, Ontario could reach more than $13 billion in economic activity and 91,000 jobs. This clearly represents a significant opportunity. In the case where the global industry doesn't grow quick or substantially, and Canada gets a smaller share of the total (the upper left cell in **Table AO1**, Ontario's industry would be small ($53 million with less that 400 jobs) even if it achieves the high share. The foundation in Ontario could drive growth of the entire Canadian industry but there remains a significant first mover opportunity to carve out a larger share of the value of the industry.

If Ontario only achieves 30% of the Canadian industry (the pessimistic projection), there is still a potential for $5.6 billion in activity and almost 40,000 jobs. While both numbers ($13 billion and $5.6 billion) are substantial, there is considerable motivation for building momentum early and driving both the growth of the Canadian market and Ontario's share of that market.

Tables AO7 through AO12 provide perspectives on short term potential for Ontario's industry (2030). We take the numbers from appendix A and apply the two share scenarios for Ontario's industry. The 2030 numbers range from a low of $2 million (very unlikely) to a high of $5.6 billion. The actual industry will likely be somewhere in between the floor and ceiling presented.

Table AO1: Ontario Short Term Market Size: High Share			
Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 52,739,726.03	$ 210,958,904.11	$ 527,397,260.27
27,500,000,000	$ 131,849,315.07	$ 527,397,260.27	$ 1,318,493,150.68
82,500,000,000	$ 395,547,945.21	$ 1,582,191,780.82	$ 3,955,479,452.05
165,000,000,000	$ 791,095,890.41	$ 3,164,383,561.64	$ 7,910,958,904.11
275,000,000,000	$ 1,318,493,150.68	$ 5,273,972,602.74	$ 13,184,931,506.85

Table AO2: Ontario Short Term Jobs: High Share			
Size of Global Market	Low	Medium	High
11,000,000,000	363.16	1,452.63	3,631.57
27,500,000,000	907.89	3,631.57	9,078.92
82,500,000,000	2,723.68	10,894.71	27,236.76
165,000,000,000	5,447.35	21,789.41	54,473.53
275,000,000,000	9,078.92	36,315.68	90,789.21

Table AO3: Ontario Short Term Market Size: Low Share			
Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 22,602,739.73	$ 90,410,958.90	$ 226,027,397.26
27,500,000,000	$ 56,506,849.32	$ 226,027,397.26	$ 565,068,493.15
82,500,000,000	$ 169,520,547.95	$ 678,082,191.78	$ 1,695,205,479.45
165,000,000,000	$ 339,041,095.89	$ 1,356,164,383.56	$ 3,390,410,958.90
275,000,000,000	$ 565,068,493.15	$ 2,260,273,972.60	$ 5,650,684,931.51

Table AO4: Ontario Short Term Jobs: Low Share			
Size of Global Market	Low	Medium	High
11,000,000,000	155.64	622.55	1,556.39
27,500,000,000	389.10	1,556.39	3,890.97
82,500,000,000	1,167.29	4,669.16	11,672.90
165,000,000,000	2,334.58	9,338.32	23,345.80
275,000,000,000	3,890.97	15,563.86	38,909.66

Table AO5: Ontario Market Share: High Share, Fast Growth			
Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 21,095,890.41	$ 84,383,561.64	$ 210,958,904.11
27,500,000,000	$ 52,739,726.03	$ 210,958,904.11	$ 527,397,260.27
82,500,000,000	$ 158,219,178.08	$ 632,876,712.33	$ 1,582,191,780.82
165,000,000,000	$ 316,438,356.16	$ 1,265,753,424.66	$ 3,164,383,561.64
275,000,000,000	$ 527,397,260.27	$ 2,109,589,041.10	$ 5,273,972,602.74

AO6: Ontario Jobs: High Share, Fast Growth			
Size of Global Market	Low	Medium	High
11,000,000,000	113.18	452.75	1,131.89
27,500,000,000	282.97	1,131.89	2,829.72
82,500,000,000	848.91	3,395.67	8,489.18
165,000,000,000	1,97.83	6,791.34	16,978.37
275,000,000,000	2,829.72	11,318.91	28,297.28

AO7: Ontario Market Share: Low Share, Fast Growth			
Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 9,041,095.89	$ 36,164,383.56	$ 90,410,958.90
27,500,000,000	$ 22,602,739.73	$ 90,410,958.90	$ 226,027,397.26
82,500,000,000	$ 67,808,219.18	$ 271,232,876.71	$ 678,082,191.78
165,000,000,000	$ 135,616,438.36	$ 542,465,753.42	$ 1,356,164,383.56
275,000,000,000	$ 226,027,397.26	$ 904,109,589.04	$ 2,260,273,972.60

AO8: Ontario Jobs: Low Share, Fast Growth			
Size of Global Market	Low	Medium	High
11,000,000,000	48.50	194.03	485.09
27,500,000,000	1,131.89	485.09	1,212.74
82,500,000,000	363.82	1,455.28	3,638.22
165,000,000,000	727.64	2,910.57	7,276.44
275,000,000,000	1,212.74	4,850.96	12,127.40

AO9: Ontario Market Share: High Share, Slow Growth			
Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 5,273,972.60	$ 21,095,890.41	$ 52,739,726.03
27,500,000,000	$ 13,184,931.51	$ 52,739,726.03	$ 131,849,315.07
82,500,000,000	$ 39,554,794.52	$ 158,219,178.08	$ 395,547,945.21
165,000,000,000	$ 79,109,589.04	$ 316,438,356.16	$ 791,095,890.41
275,000,000,000	$ 131,849,315.07	$ 527,397,260.27	$ 1,318,493,150.68

AO10: Ontario Jobs: High Share, Slow Growth			
Size of Global Market	Low	Medium	High
11,000,000,000	28.29	113.18	282.97
27,500,000,000	70.74	282.97	707.43
82,500,000,000	212.22	848.91	2,122.29
165,000,000,000	424.45	1,697.83	4,244.59
275,000,000,000	707.43	2,829.72	7,074.32

AO11: Ontario Market Share: Low Share, Slow Growth			
Size of Global Market	0.5%	2%	5%
11,000,000,000	$ 2,260,273.97	$ 9,041,095.89	$ 22,602,739.73
27,500,000,000	$ 5,650,684.93	$ 22,602,739.73	$ 56,506,849.32
82,500,000,000	$ 16,952,054.79	$ 67,808,219.18	$ 169,520,547.95
165,000,000,000	$ 33,904,109.59	$ 135,616,438.36	$ 339,041,095.89
275,000,000,000	$ 56,506,849.32	$ 226,027,397.26	$ 565,068,493.15

AO12: Ontario Jobs: Low Share, Slow Growth			
Size of Global Market	Low	Medium	High
11,000,000,000	12.13	48.51	121.27
27,500,000,000	30.32	121.27	303.19
82,500,000,000	90.96	363.82	909.56
165,000,000,000	181.91	727.64	1,819.11
275,000,000,000	303.19	1,212.74	3,031.85

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Appendix B: The Actionable Opportunities from the 2021 Report - CELLULAR AGRICULTURE: CANADA'S $12.5 BILLION OPPORTUNITY IN FOOD INNOVATION



Canada's Actionable Opportunities for a Thriving Cellular Agriculture Ecosystem

Based on the input from our stakeholder consultations, along with a review of literature and other publicly available information, we articulate the inter-connected actionable opportunities to inform a policy framework and implementation plan for a thriving Canadian cellular agriculture industry worth up to $12.5 billion a year and creating up to 142,000 jobs.

1. Develop a National Vision and Strategy for a Canadian Cellular Agriculture Industry in the Near Term to enable a domestic ecosystem that fully realizes the benefits presented by this industry. Founded on a clear value proposition and rationale, this strategy should be national in scope and developed collaboratively and cohesively by federal, provincial and territorial governments, industry (including large corporates, start-ups and conventional agriculture), academic and research institutions, not-for-profits, regulatory agencies, and policymakers.

The strategy should define a framework with concrete steps for implementing an action plan in the short, medium and long-term and have clear success metrics. Considerations for the value proposition and rationale include economic and export opportunities, environmental and ethical concerns, current and future domestic and global protein requirements, trade considerations, the changing food and agriculture employment landscape, opportunities in the sector, food security, resiliency in the face of climate change or other shocks, and alignment with Canada's strengths and priorities. In addition, promoting the integration of new production systems with existing conventional ones is critical, with ongoing monitoring to prevent undue disruption to either sector. The framework should include the strategy for government incentivization at both federal and regional levels. In the development of this Canadian-specific framework, models from currently leading cellular agriculture countries should inform pathways for incentivization and funding mechanisms that leverage government support for private sector investment.

Taking the value proposition into account, the action plan should specifically include steps for:

- Substantial and sustained investment in cellular agriculture for dedicated research and development;
- Support for start-up creation and growth through pilot scale-up to commercial-level production;
- Building a talent development pipeline.

The action plan should ensure coordination of and access to essential and existing infrastructure. Upfront investment is necessary to help Canada catch up with other jurisdictions currently ahead in this sector.

Broad communication and outreach are integral to the success of a national strategy. This needs to occur in parallel with technology development to ensure widespread uptake of cellular agriculture products and optimal return on investment. Critical consideration is required to understand consumer perspectives and use for appropriate messaging to reach various people across different demographics - from children to the elderly, as well as those facing food insecurity - to articulate benefits, address concerns, and overcome potential barriers early.

2. Establish a Clear and Transparent Regulatory Framework for Cellular Agriculture Products in Canada. Canada is encouraged to develop an agile, iterative, and innovative regulatory framework by building on existing processes. The framework should be informed as early as possible by engaging industry stakeholders and other experts with the relevant regulatory departments and agencies (e.g., AAFC, CFIA, Health Canada and Environment and Climate Change Canada), and including cellular agriculture subject matter experts within regulatory bodies. This will ensure that any new policies and regulations have expert input and consider the perspectives of both regulatory agencies and the ultimate end users, and would help simplify and strengthen the Canadian process. A timely, reasonably priced and predictable regulatory process, and a smooth and transparent evaluation process with high approval confidence, can be achieved through an iterative approach. Early engagement between regulators and companies also allows issues to be flagged and addressed promptly. This will be crucial to attract and retain cellular agriculture companies in Canada while ensuring the domestic industry remains globally competitive under Canada's rigorous regulatory process and food safety standards. This process can be further fostered through continuous, clear, and comprehensive communication between the industry and regulators, as well as broad dissemination of positive engagements and success stories. A delineated regulatory pathway that is aligned with the industry's needs has shown much success in Singapore, the most advanced jurisdiction in regard to approvals of cellular agriculture product offerings.

To aid companies in navigating the regulatory process, a government program that appoints industry liaisons or "concierges" could be established. This would particularly benefit start-ups and early-stage companies that are navigating the process for the first time. It is anticipated that, before seeking regulatory approval, standardized safety testing of cellular agriculture food products could provide confirmation of product composition, nutritional profile, and (lack of) toxicity profile. Consideration should be given to an expedited review of products that have already been "passed" by an accredited, external standardized test. As the global cellular agriculture industry grows and matures, Canada will need to ensure its cellular agriculture standards align with emerging international standards to maintain its reputation as a producer of safe, high-quality foods and not impede exports. Currently, this is an underdeveloped area, and being an early mover in standardized safety testing will allow Canada to have substantial input into international standards as they progress. Cross assessment of regulatory processes with other jurisdictions (e.g., Singapore, Australia and New Zealand) should be continued and expanded, as appropriate.

Early development of regulatory guidance for the labelling of these products is also essential for transparency and to empower consumers to make informed choices. Cellular agriculture product labelling should be descriptive, communicate the nature of the product in clear and relatable language, while maintaining appeal as a food item. Labelling should differentiate cellular agriculture products from those in the traditional protein market while creating a positive impression and ensuring both types of products are on a level playing field and competitive in consumer markets.

3. Provide Supporting Mechanisms for Research and Commercial Development. Incentivization, through both public and private investment and partnerships, and outcomes-driven networks, is critical for a thriving domestic cellular agriculture industry, with infrastructure support for R&D, training, company creation, scale-up, and growth leading to made-in-Canada product commercialization.

<u>Research and training the next generation of skilled workers</u>
Early government investment would catalyze invention, help de-risk opportunities, and attract private sector investment while incentivizing innovation and driving company creation and entrepreneurship within Canada. Funding could support:

- Both fundamental and industry-driven research to ensure that the necessary and foundational tools and technologies are in place and that research is directed to industry needs.
- Open science to reduce redundancy and speed up product development.
- Alignment with strategic government focus areas or grand challenges, such as climate action, to encourage industry growth through sustainable practices and innovations.
- Key areas of multi, cross- and trans-disciplinary research (e.g., 'omics, engineering biology, AI, food sciences and others) for advancing cellular agriculture technologies that are also applicable to other business verticals (e.g., health, low carbon economy).
- LCAs, TEAs and other analyses that are objective and independent.
- Social sciences research playing a critical role in driving consumer engagement, addressing risk perception and public trust, and developing appropriate communication strategies.

New training programs that offer targeted and cross-disciplinary opportunities and industry placements related to cellular agriculture and engineering biology are critical. There are also opportunities to train and up-skill those with related expertise in other sectors. This would ensure that a domestic talent pipeline of skilled High-Quality Personnel (HQP) could fill the high-quality jobs that the cellular agriculture industry will create.

<u>Growing the economy through start-up support, public private partnerships, and networks</u>
Early start-ups require support in the form of lab space, facilities, and infrastructure, but also public and private seed funding for initial company growth. Canadian and international investors should be incentivized to invest in Canadian companies through clear and well-publicized government support for the industry. As seen in leading cellular agriculture jurisdictions, investment in public and private sector- partnered innovation hubs, including incubators and accelerators, can effectively support companies in their early stages. In addition to physical facilities, these hubs would need to include access to expertise, mentorship, and investment opportunities. While Canada has some capacity in Nova Scotia and New Brunswick, a lack of facilities for pilot/demonstration scale-up and at commercial scale is viewed as the most significant bottleneck globally, and is a primary reason for companies to leave Canada for other jurisdictions, such as the United States or Europe. The initial outlay to establish domestic scale-up capacity in localized ecosystems would be high, but fee-for-service operations could provide a global leadership opportunity to Canada, with potential to attract foreign companies. Such infrastructure can also be adaptable to serve different industries, such as to the production of vaccines in a health emergency or to bypass disruptions in the supply chain of critical materials to support a low carbon economy.

Supporting applied research and commercial development through industry and research collaboration is valuable to ensure the success of the domestic cellular agriculture industry. Partnerships between established companies and start-ups/academics (public-private partnerships) bridge the gap between research and translation, provide access to infrastructure, and create linkages and entry routes into the supply chain for B2B companies. The larger partner benefits from priority access to innovations, diversification and the creation of new product categories with strong market pull. Effective industry partnerships are vital to inform and drive policy and regulation and advocate with a common voice for a clear path to market for Canadian companies. On a larger scale, outcomes-driven networks are crucial to bringing together diverse stakeholders from industry, academia, government, and non-governmental organizations. Such networks should include diverse fields of multi-, cross-, and trans-disciplinary expertise and platforms and include regional, national, and international partnerships for interdisciplinary cross-pollination of ideas to breakdown silos between sectors and geographic regions and facilitate dialogue between disciplines. Network participants can benefit from and provide benefits to other sectors (e.g., health, low carbon economy) through knowledge exchange and parallel applications of novel technologies. These networks must include representation from the food production and conventional agriculture industries to foster mutually beneficial relationships, and transition or expansion to new food products market.

Appendix C: Canadian Investors

Canadian investors with a focus on agriculture, food, and climate investments, with some investments in precision fermented, cultivated, or support companies (indicated).

Who	Location	Description/Investment Portfolio
Pension Funds		
Canadian Pension Plan Investment Board	Toronto, ON	The governing body for the Canadian Pension Plan Fund managing the investment portfolio. Investment in Perfect Day (pre-2021 report)
Ontario Teachers' Pension Plan Board	Toronto, ON	The governing body for the Ontario Teachers' Pension Plan Fund managing the investment portfolio. Investment in Motif Foodworks (pre-2021 report)
Cellular Agriculture and Food-Tech Focused Funds		
CULT Food Science	Vancouver, BC	CULT Food Science, an investment platform based in Vancouver, is focused on investment and commercialization of cell-based food. Portfolio of 18 cellular agriculture companies, including Quebec-based Opalia.
Eat & Beyond	Vancouver, BC	Private equity and venture capital firm that focuses on investments in plant-based protein and meat alternative food industry. Portfolio of a variety of alternative protein companies.
Venture Capital		
Amplify Capital	Toronto, ON	A spin out from the MaRS Discovery District investing in early-stage companies in areas of health, education and environmental sustainability. Investment in a wide variety of companies, including Alberta-based Future Fields.
Arc Tern Ventures	Toronto, ON	With a focus on climate and sustainability, one of their six sectors for investment is food systems includes plant-based food inputs and cellular meats. Investment in a wide variety of companies across these industries, including in Mosa Meat (pre-2021 report).
Builders VC	Calgary, AB, USA	Investing in companies to promote innovation within existing industries including healthcare, real estate & construction, and agriculture, including alternative proteins and precision agriculture. Portfolio includes Future Fields (Alberta), and Upside Foods.
Emerald Technology Ventures	Toronto, ON	Toronto based venture fund supporting investments in sustainable industrial innovation, with dedicated funds for investment in water, energy decarbonization, and packaging. Investments include cultivated (Believer Meats), and precision fermentation (ImaginDairy) companies.
Farm Credit Canada	Regina, SK	Support entrepreneurs and believe in the future of agriculture and food. From start-ups to mature enterprises, they partner with businesses and entrepreneurs to help them reach their full potential, providing financing for primary producers, businesses in agriculture, and in the food industry.
Loyal VC	Toronto, ON	A highly diversified global investment firm focusing on individual entrepreneurs and companies rather any particular industry or sector. Investment in various companies, including Avant (cultivated).
Nadarra Ventures	Halifax, NS	An early-stage venture fund focusing on agriculture, food, and materials who have raised their first fund to invest, supporting leading ag biotechnology companies in Canada.
RHA Ventures	London, ON	Focused on the growth of early-stage companies, their 519 Growth Fund II will be invested in those companies engaged in the agriculture, agri-food, and technology enabling sectors.
Thrive Canada Accelerator by SVG Ventures	Canada	Supports early-stage agrifood tech startups across the entire value chain, focusing on technologies that promote a more efficient, sustainable, and secure agricultural future. SVG Ventures supports start-ups and founders, from ideation stage through Series A and beyond.
Tall Grass Ventures	Calgary, AB	A venture capital firm investing in the future of agriculture and food, that supports the transformational entrepreneurs who are changing our world's relationship with its food, fuels and fibers.
The 51	Calgary, AB	The 51's Food & AgTech Fund makes investment in women led and gender diverse early-stage companies across the agricultural biotechnology, automation, farm innovation, and food innovation sectors.
Waterpoint Lane	Toronto, ON	Focused on the agrifoodtech sector, by investing in growth stage enterprises to improve the sustainability of food systems across areas of soil health, water consumption, food waste, and greenhouse gas emissions.
Wittington Ventures	Toronto, ON	Investing in North American tech companies in the climate, commerce, food, and health sectors. Varied portfolio across climate, commerce, food, and healthcare, including investments in Motif and Arcaea.
Foundations		
Consecon Foundation	Prince Edward County, ON	A private foundation focused on distributing grants to Canadian organizations working within four broad categories including accelerating the protein transition, carbon management, biodiversity protection, and environmental education. Within cellular agriculture, grants given include New Harvest and Ontario Genomics.

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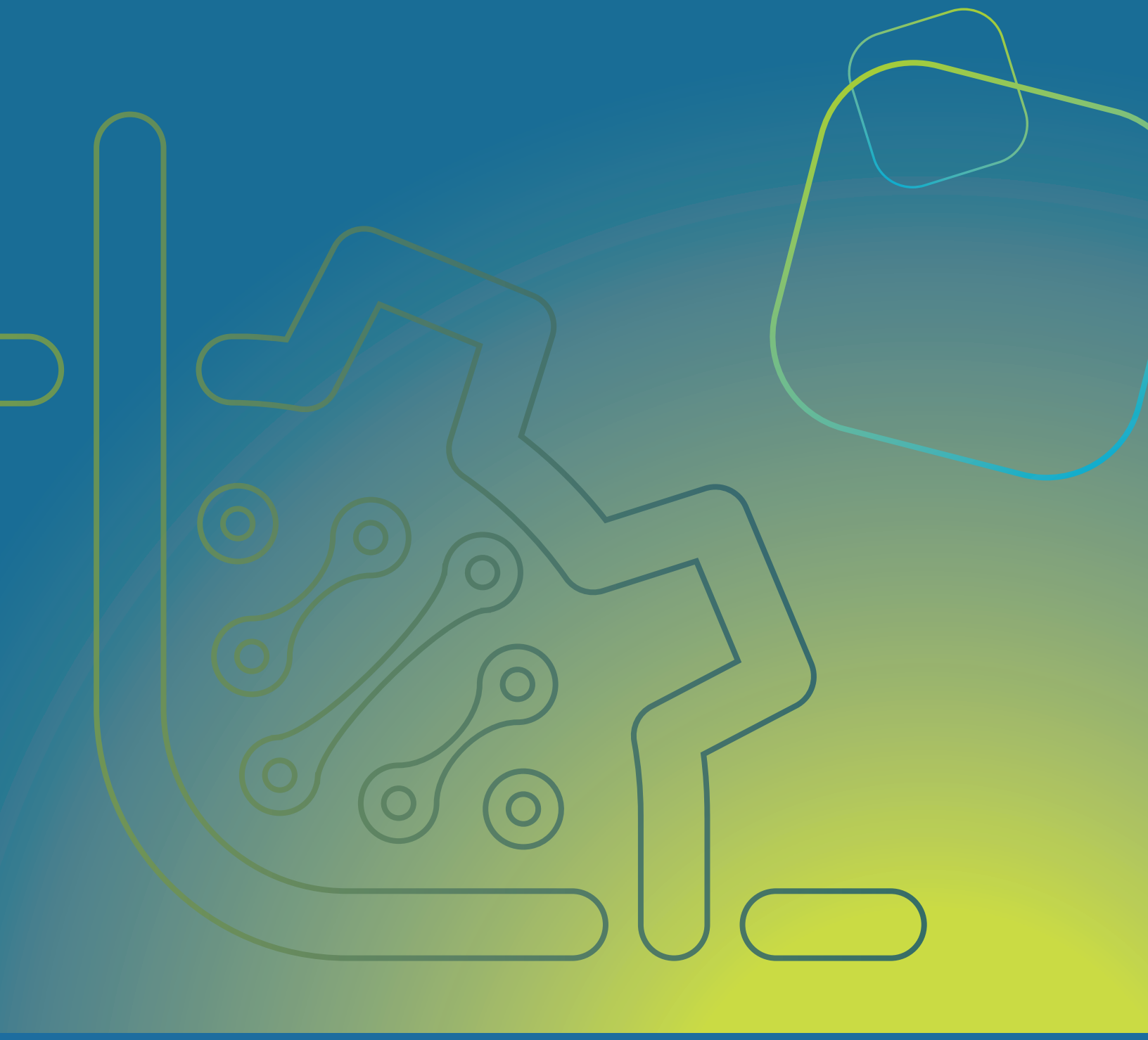
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For more information:

Elaine Corbett, PhD
Ontario Genomics
Director, Strategic Partnerships
ecorbett@ontariogenomics.ca

Food Innovation in Canada Report Online Version

Ontario Genomics' Cellular Agriculture Initiatives



Ontario Genomics

Ontario Genomics
661 University Avenue, Suite 490
Toronto, ON M5G 1M1
CANADA

Phone: 416-977-9582
Fax: 416-977-8342
E-mail: info@ontariogenomics.ca