THE ROLE OF CELLULAR AGRICULTURE IN SUSTAINABLE, RESILIENT AND JUST FOOD SYSTEMS

An Action Agenda

JUNE 2023

Cautious and considered disruption of technology is paramount to ensure that trust and transparency is maintained in the innovations being achieved.

ACKNOWLEDGEMENTS

This report is the result of a collaboration across many lands and institutions. Our team is made up mostly of settlers and decedents of settlers, living on the ancestral territories of many Indigenous peoples across Turtle Island (also known as North America).

The Lead Authors collaborated on this project while affiliated with the Food and Agriculture Institute at the University of the Fraser Valley. The University of the Fraser Valley is situated on the sacred lands of the Stó:lō peoples. The Stó:lō have an intrinsic relationship with S'ólh Tém:éxw (Our Sacred Land), and we express our gratitude and respect for the honour of living and working in this territory.

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As well as many others from the public, private, academic sector and communities throughout the course of the project

CONTENTS

CONTENTS CONTINUED

INTRODUCTION

The need to transition toward a sustainable food and agriculture system is critical and widely recognized. The current food and agriculture system contributes to a multitude of sustainability issues and environmental pressures, including the production of greenhouse gases, water overconsumption, freshwater pollutants, and loss of habitat and biodiversity. Simultaneously, agriculture is highly vulnerable to the effects of these environmental issues, such as flooding, extreme heat, drought, and loss of soil quality. Such impacts have severe effects on the livelihoods and wellbeing of producers, their communities, and society at large. As diets change and the global population grows, there is a clear need for exploring new ways of producing and distributing food in ways that contribute to sustainable and resilient futures.

"Cellular agriculture" could be a potential piece of the sustainable food systems puzzle. Cellular agriculture consists of a suite of technologies and techniques for producing equivalent or near-equivalent agricultural products without the use (or minimal use) of livestock, instead using tissue cell culturing (i.e., growing and propagating mammalian cells) or fermentation (i.e., altering a microorganism to produce organic molecules such as animal proteins or flavours) techniques.[1] Cellular agriculture holds great promise for contributing to transitions to sustainable food systems, as it could potentially address some of the major issues associated with conventional agriculture systems, such as land use, freshwater overconsumption, greenhouse gas production, and others. Additionally, being a technology-driven and indoor food production method, cellular agriculture can be developed in a variety of different types of environments, thereby opening new opportunities for urban farming and local economic development.

Despite cellular agriculture's promise, the development of a technology alone is not a silver bullet for the current issues associated with agriculture. Depending on how the technology is implemented and the industry develops, cellular agriculture could be highly beneficial to communities or societies, or it could reproduce a number of the social issues, economic inequities, and environmental impacts experienced with our current agriculture system.[2] Therefore, as this technology and industry emerge and grow, it is important to ask:

What are the key considerations and actions needed for guiding the trajectory of cellular agriculture toward sustainable, resilient, and just food systems?

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1 Cellular agriculture and food systems priorities. *Nature Food 3*, 781 (2022). https://doi.org/10.1038/s43016-022-00628-2

2 Newman, L., Newell, R., Dring, C., Glaros, A., Fraser, E., Mendly-Zambo, Z., Green, A. G., & KC, K. B. (2023). Agriculture for the Anthropocene: Novel applications of technology and the future of food. *Food Security 15*, 613–627. https://doi.org/10.1007/s12571-023-01356-6

To explore this question, the Food and Agriculture Institute at the University of the Fraser Valley, in collaboration with New Harvest Canada, led a two-year research effort: *Emerging Agricultural Technologies and the Future of Food*. The aim of the project was to explore the opportunities, challenges, and key considerations for developing a cellular agriculture industry in British Columbia (and broadly Canada) in ways that support transitions to sustainable food futures. The research involved a wide range of activities, including stakeholder interviews, a public survey, land-use modelling, feedstock studies, a learning exchange on the social implications of the technology, supply chain mapping, and public communications. More information on the project can be found on its website:

www.ufv.ca/food-agriculture-institute/the-research/cellular-agriculture

The research culminated in a final workshop, where collaborators and participants shared their key learnings from their work in the project and/or involvement in the industry, as well as the implications of these learnings for policy and action. This document captures the outcomes from the final workshop, and it is organized into multiple sections. The following section provides details on the workshop process and activities. Then, key considerations are presented on the opportunities, challenges, and potential role of cellular agriculture in food systems. The final section provides a series of recommendations for designing and implementing policies, programs, strategies, and actions that can guide the development of the cellular agriculture industry toward sustainable, resilient, and just food systems in British Columbia, Canada, and beyond.

THE WORKSHOP

The purpose of the final workshop in the *Emerging Agricultural Technologies and the Future of Food* project was to capture learnings from the variety of activities conducted in the research and to identify recommendations for policy- and decision-makers. To this end, the workshop gathered students, researchers, startup innovators, and non-profit leaders who engaged in the research at some stage throughout the two-year duration of the project to share their insights and lessons for orienting the development of the cellular agriculture industry toward sustainable food futures. To this end, a key question guiding the workshop was:

What are the policies, programs, strategies, or actions needed to ensure that cellular agriculture contributes to environmentally, socially, and economically sustainable food futures?

The three-hour workshop was held online by Zoom in April 2023, and its activities were facilitated using CoLabS,[3] an online collaboration platform. The workshop began with a presentation that summarized the main objectives and components of the research project, as well as outlined the purpose and activities of the workshop. Then, each participant introduced themselves and gave a brief description of their involvement in the project and/or the emerging cellular agriculture industry.

Following participant introductions, the group engaged in an activity that involved posting two to three comments in CoLabS on key learnings from their work, which serve as useful considerations for thinking about ways of guiding the development of an emerging cellular agriculture industry in British Columbia. Participants were given time to review all the posts, and then, a second round of posting was done. The second round involved participants sharing thoughts on the implications of (and recommendations based on) the key learnings with respect to developing policies, programs, strategies, or actions geared toward cellular agriculture contributing to an environmentally, socially, and economically sustainable food future. Following the posting activities, the group engaged in a discussion guided by (but not limited to) the questions:

- *What key policy, program, strategy, or action recommendations (or implications for recommendations) did you identify or stood out to you?*
- *What themes or major policy/action areas do you see emerging through this workshop (which recommendations align with one another)?*
- *What key policies, programs, strategies, or actions were not identified through the breakout session and are missing here?*

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3 Jost, F., Newell, R., & Dale, A. (2021). CoLabS: A collaborative space for transdisciplinary work in sustainable community development. *Heliyon 7*(2), e05997. https://doi.org/10.1016/j.heliyon.2021.e05997

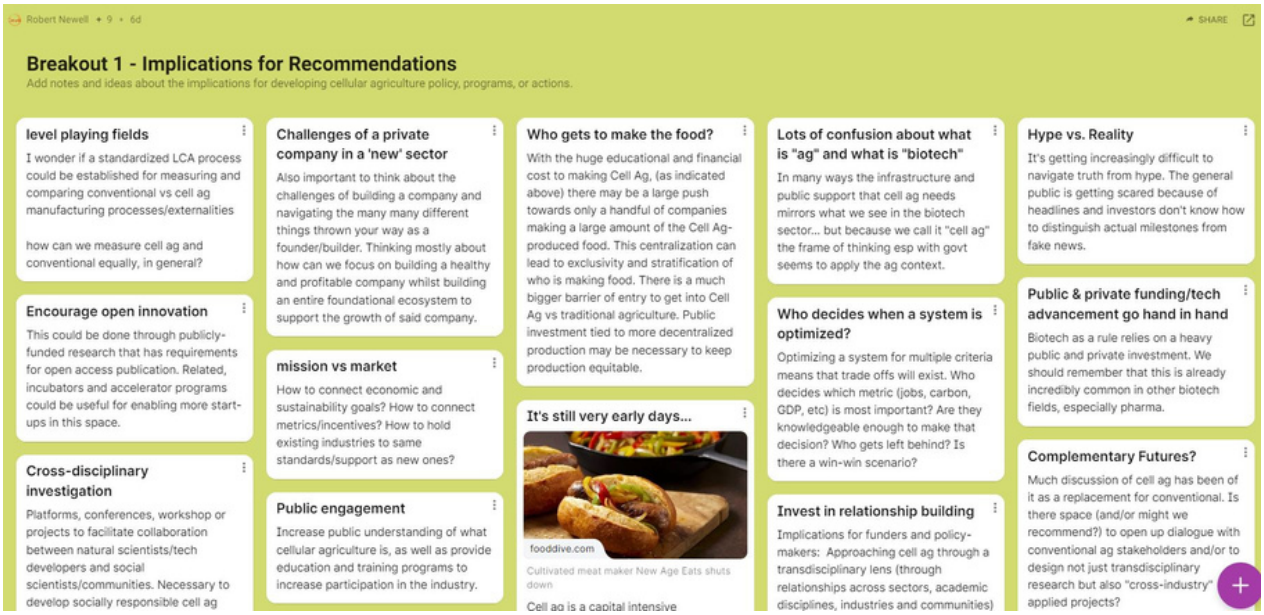

Figure 1. Image of CoLabS platform

The group discussions were transcribed after the workshop, and all workshop data (i.e., CoLabS posts, messages in the Zoom chat, and thoughts from discussion transcripts) were organized and synthesized into a series of coherent themes. The themes fell under one of two categories: (1) key considerations for designing policies, programs, strategies, or actions directed toward guiding the trajectory of the emerging cellular agriculture industry, and (2) recommendations for policies, programs, strategies, or actions. These considerations and recommendations are presented in the following sections.

CONSIDERATIONS

A just transition of the protein industry (including the development of cellular agriculture industry) requires increased and meaningful engagement between industry, academia, government, and local communities.

1. ENGAGEMENT AND RELATIONSHIPS

1.1 Building relationships and trust. Cellular agriculture is a novel technology that can benefit and impact communities and groups in different ways. Community and stakeholder engagement and collaboration are critical for ensuring that the technology is implemented through a just transitions [4] approach. However, such engagement and collaboration require strong relationship building to avoid previous issues related to the distrust and tensions produced from shallow engagement and extractive research approaches. This is a particularly important consideration for Indigenous communities and members of marginalized groups that historically have been disproportionally impacted by the harms of conventional industrial food systems. Relationship building takes time, and researchers and startups working in this space should ensure appropriate time and resources are allocated to training in protocols for engagement and to team reflection. Researchers and startups should also disclose their interests and positionalities to whomever they engage to ensure transparency and enable trust building. This process of relationship building is often more complex than anticipated, and it is critical to for those who want to embark on this work to do so with humility and following principles of reciprocity, consent, accountability and trust.[5]

1.2 Tensions with and opportunities for conventional agriculture. The emergence of cellular agriculture can result in significant fear and anxiety for those working in the conventional agriculture industry, and it is important to be sensitive to these concerns. Outside of Canada in places such as Europe and the United States, some companies have embraced the technology to "future proof" their businesses, and such opportunities for including conventional producers in the industry should be explored.

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4 International Labour Organization (2015). *Guidelines for a just transition towards environmentally sustainable economies and societies for all*. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_432859.pdf

5 Whyte, K. (2020). Too late for indigenous climate justice: Ecological and relational tipping points. *WIREs Climate Change, 11*(1), e603. https://doi.org/10.1002/wcc.603

These opportunities could involve exploring the production of hybrid products, where cellular agriculture produces ingredients for foods that also consist of conventionally farmed/raised products. Complete buy-in will likely never be possible, and resistance toward cellular agriculture will continue to exist from various actors and interest groups (e.g., such as seen with plant-based proteins). However, resistance among the entire conventional agricultural industry is not inevitable, and strategic engagement with interested parties in conventional agriculture could result in important bridges between the two industries.

1.3 Transdisciplinary collaborations. Transdisciplinary research that involves and engages industries in key questions around the role and challenges cellular agriculture can play in sustainable food systems can help move the conversation beyond solely the academic sector into practice. Such initiatives could potentially serve to foster companies that include social- and environmental-consciousness in their missions and visions.

1.4 Framing cellular agriculture as "agriculture". Identifying the key stakeholders and government agencies that need to collaborate in shaping the cellular agriculture industry can be a confusing challenge. Framing this emerging food production method as "agriculture" raises questions about what the nature of agriculture is in the modern day. Cellular agriculture is a food production method that also firmly exists within the realm of biotechnology, and the emerging industry requires the same level of investment, infrastructure, and support as the biotechnology sector for it to flourish. The confusion around where cellular agriculture exists with respect to its sector can create challenges for government agencies: under whose purview should the industry lie?

Figure 2. Discussion at the Social Implications of Cellular Agriculture Learning Exchange

There is a need for transparent communication strategies to educate the public regarding cellular agriculture, recognizing that diverse communities may have values that are in line and/or in tension with this technology.

2. PUBLIC KNOWLEDGE AND TRANSPARENCY

2.1 Source and nature of public communications. As the industry grows, public education and engagement is important to improve literacy and inclusion in the industry. Equally important is to consider who engages the public and the reasons for their communication campaigns. For example, there may be special interest groups and lobbyists that have strong interests in maintaining a particular narrative and lack of transparency around cellular agriculture. Additionally, confusion can exist due to the "media hype" around cellular agriculture, making it difficult (and potentially creating anxieties) among the public and investors with respect to how immediately this "disruptive technology" will be commonplace within food production systems.

2.2 Public knowledge and understanding. Although cellular agriculture has received more attention in the media as of late, there is still relatively little public understanding and familiarity with the food production method. Current media communications perhaps provide an oversimplified impression of the product, with many knowing it simply as "lab-grown meat". The widespread lack of literacy and transparency regarding the science and techniques used in this field may impact potential consumers and producers as they work to make informed decisions in the marketplace or working in the protein industry. Such knowledge gaps can result in the public regarding the products negatively, such as being "unnatural" and "unhealthy", despite their potential benefits. Conversely, people may view the technology as wholly beneficial due to the media hype, despite key considerations and potential concerns about how it may be implemented and how the industry may develop.

2.3 Public values surrounding food futures. Cellular agriculture could gain public acceptance if it contributes to food systems in a beneficial way. A survey study[6] done in the Lower Mainland, British Columbia, revealed that most people do not have differing opinions around the type of product created through cellular agriculture (i.e., cultured beef, cultured chicken, cultured salmon, and fermentation-based dairy); however, they held favourable views of the technology if it could contribute to accessible foods with respect to low cost and high availability, as well as the proliferation of local businesses. Such responses reflect values for creating more local and regional food systems, and it is worthwhile to explore how the cellular agriculture industry can develop in such a manner.

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6 Glaros, A., Newell, R., Ruder, S.-L., Mukiri, J., & Pizzirani, S. (2023). *Cellular Agriculture Futures: A survey of public perceptions in the Lower Mainland, British Columbia*. Food and Agriculture Institute, University of the Fraser Valley. https://doi.org/10.13140/RG.2.2.31248.58889

2.4 Social-cultural differences in attitudes and perspectives. When engaging the public and improving knowledge and transparency around cellular agriculture, it is important to recognize that social and cultural differences exist with respect to consumer interest in and acceptance of the food production method. For example, the aforementioned survey study[7] revealed that residents who identify as having East Asian and South Asian heritage were on average more open to the idea of having the industry and products in their local region and grocery stores. Similarly, those reporting a higher household income were more likely to be willing buy cellular agriculture products than those reporting a lower household income.

2.5 Indigenous relationships with food and ecosystems. It is also critical to invite ethical dialogues with Indigenous communities to understand how this technology fits within their food systems values and rights. Cellular agriculture decouples people from animal foods which may conflict with the interdependence at the centre of many Indigenous ontologies. For example, in the Lower Mainland area of British Columbia, First Nations communities have deep traditional and spiritual relationships with wild salmon, which raises questions about whether cellular agriculture technologies have a place in the struggle for Indigenous food sovereignty and resurgence of Indigenous foodways in the region. This includes questions about whether cellular agriculture could be strategically implemented to contribute to the protection of these species in the wild, or whether it may further entrench current trends of the industrial food system.

Figure 3. Image of Abbotsford, British Columbia (Newell, R. [photographer], 2021)

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7 Howard, P. H. (2022). Cellular agriculture will reinforce power asymmetries in food systems. *Nature Food 3*(10), 798–800. https://doi.org/10.1038/s43016-022-00609-5

Canada is a new player in the global cellular agriculture industry. Without increased public support in the form of interdisciplinary training, funding, and incentives for open innovation and knowledge sharing, there is limited potential for the industry to develop in inclusive and holistic ways.

3. INDUSTRY DEVELOPMENT AND GROWTH

3.1 Interdisciplinary training and inclusion in the industry. It is important to develop training opportunities for developing new practitioners in the industry. Currently, few post-secondary students know much about what cellular agriculture is, let alone how to enter the industry. Increasing opportunities for education and training across all levels of education (college, undergraduate, graduate, certificate programs) is important for broadening involvement in the industry and diversifying the practitioner base. It is also important to note that, as a technology-driven form of food production, the early innovators and practitioners in the emerging cellular agriculture are entering the nascent industry through STEM (science, technology, engineering, and mathematics) training. Such training can foster a results-driven culture, where the goal is to bring an innovation into the public sphere without considering the complex social-cultural implications of said technology. The development of interdisciplinary educational and training opportunities is necessary to engage students and future practitioners in the social, cultural, and political considerations around cellular agriculture (along with the technological and economic considerations). Such comprehensive training will result in practitioners that think and can anticipate the unintended consequences of their technological innovations. Furthermore, current focus on training for cellular agriculture is concentrated in universities, emphasizing biotechnology, food science, and engineering for research and development. However, once the industry scales up, broader training will be required to manage, operate, and regulate facilities which will likely come from a combination of colleges, polytechnic schools, and universities.

3.2 Access to technology. Access to information (or lack thereof) is a major challenge in the emerging cellular agriculture industry. Currently, technological development is primarily driven by the private sector, with many of the lessons and knowledge around the technology being protected as intellectual property. Cellular agriculture for most people is opaque and difficult to understand, and a more open approach to the development of this food production industry is required. Adopting open innovation models in cellular agriculture research and development could help contribute to a more transparent and inclusive industry.

3.3 Centralization versus decentralization. A large risk exists that the cellular agriculture industry will become highly centralized and operated by only a few large firms, with less opportunity for competition or broad-based public participation. This would lead to the technologies and intellectual property primarily remaining solely within the domain of these larger firms. Such trends have been seen elsewhere in the food and agriculture sector, such as with plant-based proteins. High centralization can result in issues around exclusivity; that is, who gets to produce the food?

***3.4 Economic and technical viability to grow the industry*.** At this stage in cellular agriculture's development as an industry, there are no companies in this space with long-term economic viability, and it is reasonable to expect many of the current startups working in this space will no longer exist in the upcoming years. Cellular agriculture companies that are exploring analogues to relatively inexpensive animal products, such as chicken, experience particularly large challenges with respect to long-term viability, as it is difficult to compete with the economics of conventional livestock. Scaling up production is necessary for economic viability, which requires several hundred million dollars of capital to support. Further to this, many of the processes and equipment required for large-scale operation have yet to developed to achieve economies of scale. If cellular agriculture were to become a component of future food systems, it is important to consider from where the investment and funding will be sourced. The primary source of funding for the industry currently is venture capital, which is not ideal considering its lack of consistency, secrecy, and shorter-term return on investment cycles. This brings forward key questions about whether/how cellular agriculture can be supported by diverse forms of long-term funding, such as academic-industry grants and public investment into research and development hubs.

3.5 British Columbia's role in the emergence of the industry. As the cellular agriculture industry emerges, it is important to consider the timing around when British Columbia (and Canada) will engage in the industry. This is particularly important for British Columbia, where existing agricultural land constraints as well as supply chain concerns (as observed during the 2021 flooding) are top-of-mind. Depending on its timing and level of engagement, the province could be a leader in the production of cellular agriculture products, as well as help define product standards related to greenhouse gas emissions, food safety, etc. Alternatively, the province could serve as a resource base for producing feedstock and other inputs for cellular agriculture production, including possibly through repurposing agricultural waste products.[8] Specific opportunities include developing strategic partnerships along the west coast of North America toward the concentration of startups in Silicon Valley, in addition to building upon the Lower Mainland's already robust agricultural research and innovation infrastructure and traditions.

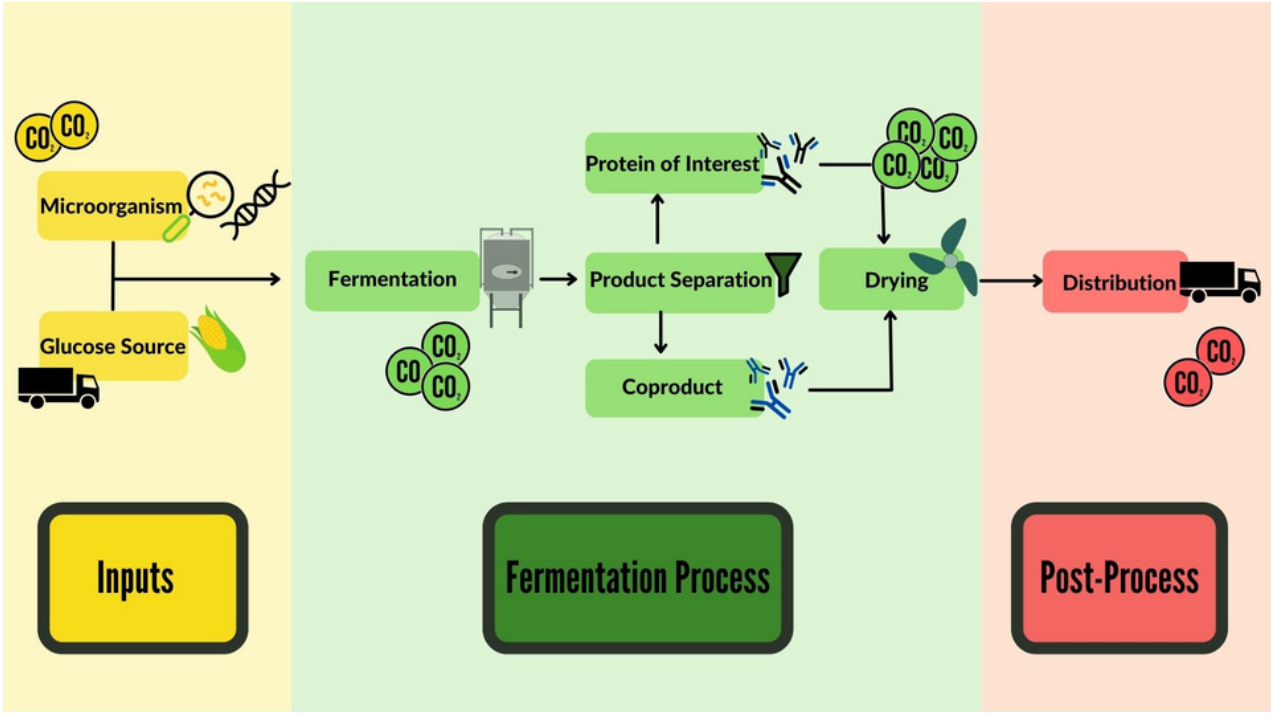

Figure 4. Cellular dairy supply chain

[8] Chowdhury, F. R., Kroeger, K., Naaz, A., Hidalgo, M. O., Sicheri, J. (2022). Towards Creating a Sustainable Cellular Agriculture Industry in the Fraser Valley. https://www.ufv.ca/media/assets/food-and-agriculture-institute/pdfs/TowardsSustainableCellularDairyIndustryFraserValley-Feb2022.pdf

Further research is required to enable cellular agriculture's maximal contribution to environmental sustainability, including the development of comprehensive environmental, social and governance (ESG) metrics, implementation with sustainable energy systems, and integration within circular economies.

4. FOOD SYSTEMS SUSTAINABILITY

4.1 Technology standards and metrics for success. It is important to consider what the goals of developing cellular agriculture are, and how we measure success toward said goals. Such a consideration more broadly requires defining metrics and indicators for transitions toward sustainable food systems, which should be done with careful and comprehensive thought toward social, environmental, and economic aspects. If measuring cellular agriculture with respect to solely (for example) economic efficiency and product pricing, cellular agriculture would underperform in comparison to conventional livestock agriculture. However, when measuring its value in terms of social impacts and environmental sustainability, cellular agriculture could have a role to play in sustainable food systems, and such metrics would help guide the development of the technologies and industry toward that role. Examples include metrics around whether a food production method is safe and environmentally sound, and incentives/subsidies for any form of food production that meet these measures would encourage beneficial technological development and agricultural transitions.[9]

4.2 Agriculture and ecological health. Cellular agriculture could possibly contribute to critical ecological sustainability objectives related to biodiversity and ecosystem health, but such benefits are not guaranteed from the technology. Cellular agriculture may require far less land than conventional agriculture, even when taking into account its production inputs such as feedstock. In turn, such "spared land" could be conserved or rewilded to regenerate habitat. Cellular agriculture may also be a strategy to adapt to climate change-related damages on farmland, by shifting food production to a more controlled and stable environment. However, the capacity for a technology or practice to spare land does not necessarily mean that said technology/practice will lead to increased land conservation. Therefore, it is important to consider how the technology can be implemented with complementary policies and programs for sparing land and habitat.

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9 Holmes, D., Humbird, D., Dutkiewicz, J., Tejeda-Saldana, Y., Duffy, B., & Datar, I. (2022). Cultured meat needs a race to mission not a race to market. *Nature Food 3*(10), 785–787. https://doi.org/10.1038/s43016-022-00586-9

4.3 Agriculture and climate change. Cellular agriculture could possibly contribute to climate change mitigation, but it does also present climate change concerns. Greenhouse gas emission concerns shift from the production of methane and nitrous oxide to the production of carbon dioxide when transitioning from conventional livestock to cellular agriculture. This is due to the carbon footprint associated with energy consumption in cellular agriculture for heating/cooling, transportation of inputs, production of media, etc. It is important to co-develop cellular agriculture with climate change mitigation innovations and policies, such as increased efficiencies and renewable energy sources associated with the production process.

4.4 Waste management and circular economy. Cellular agriculture presents unique opportunities for utilizing waste streams as feedstocks for developing products, such as the use of wood waste for fermentation-based dairy. As the industry emerges and grows, these opportunities can be harnessed in ways that enable a circular economy. However, such waste-to-feedstock opportunities are quite challenging and expensive, and considering the financial hurdles cellular agriculture already experiences with respect to scaling up, the incentives for exploring these opportunities are currently quite low.

4.5 Degree of decoupling from animal agriculture. Cellular agriculture bypasses the need to raise large amounts of livestock animals for human consumption, which in theory, should address environmental issues associated with livestock farming. However, as global demand for protein products grows, the degree to which cellular agriculture decouples society from livestock is yet to be determined. In addition, cellular agriculture could be developed as complementary to animal agriculture; therefore, cellular agriculture does not necessarily preclude the need to explore more environmentally-sound approaches to animal agriculture.

Figure 5. Image of Vancouver, British Columbia (Ruder, S.L. [photographer], 2023)

RECOMMENDATIONS

1. Meaningfully consult and collaborate with Indigenous communities and governments.

Indigenous communities in Canada have distinct rights that are recognized and affirmed in Section 35 of the Constitution Act (1982). In 2019, British Columbia passed into legislation the United Nations Declaration on the Rights of Indigenous Peoples Act that provides a framework for reconciliation, an important process that is outlined in the Truth and Reconciliation Commission (TRC) Calls to Action. Although cellular agriculture can have positive implications (e.g., progressing conservation strategies), there is potential for cellular agriculture to irreparably harm Indigenous communities, their sacred practices, and cultural protocols. Therefore, it is critically important to commit to collaborative consent and the co-development of options based on community input. Cellular agriculture can play a key role in authentic reconciliation by pursuing the engagement practices of respect, relevance, reciprocity, and relationship.

2. Increase public investment to support the cellular agriculture ecosystem and guide its trajectory.

Cellular agriculture is currently supported primarily through private investment, and considering the startup costs, this sole source of funding is inadequate for effectively allowing the industry to grow and become a part of the food system or to engage with communities. Diversifying funding through increased public investment would enable collective growth of the cellular agriculture industry and system, as well as open opportunities to guide the industry growth in a desirable manner. For example, public funding programs could mandate open innovation to enable broader inclusivity in the industry. Additionally, programs that support research and development could require the implementation of frameworks, such as Responsible Research and Innovation,[10] to guide technological development toward environmental and social objectives.

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10 European Commission, Directorate-General for Communication, Directorate-General for Research and Innovation (2013). *Responsible research and innovation (RRI), science and technology - Report*. Publications Office. https://data.europa.eu/doi/10.2777/45726

RECOMMENDATIONS

3. Develop an indicator system for evaluating success in the food production systems.

An indicator framework for assessing what makes for a "sustainable, responsible, resilient food production method" is essential for improving food and agriculture systems in British Columbia and Canada. Such a framework should be developed through transdisciplinary research efforts that consider a variety of social, economic, and environmental indicators. Applying this framework will be useful for determining where to direct funding and investment toward emerging food production methods (including cellular agriculture). The indicator system should also be applied to our current conventional agriculture practices to understand how new production methods may or may not contribute to sustainable food systems. Frameworks and approaches have already been developed for such indicator systems, such as the National Index on Agri-Food Performance,[11] and these types of frameworks can be adapted to the context of emerging food production methods in British Columbia.

4. Leverage the land sparing potential of cellular agriculture.

Cellular agriculture may possibly contribute to reducing agriculture expansion and contribute to habitat conservation; however, such benefits are not guaranteed simply through the development of the technology. To ensure that the land sparing potential of cellular agriculture is harnessed, complementary policies and programs should be put in place that (for example) compensate farmers and property owners for the establishment of easements and rewilding areas. Such programs could be facilitated through collaboration with land trust organizations that could serve as trusted intermediaries between governments and property owners.

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[11] National Index on Agri-Food Performance (2022). *Synthesis of results: Poised to showcase Canada's agriculture and food sustainability credentials.* Phase 2C Final Report - Part 1. https://www.agrifoodindex.ca/

RECOMMENDATIONS

5. Promote industry growth that contributes to food system resilience.

Climate change presents a clear and severe challenge for food systems in British Columbia, as evidenced by the heat dome and extreme flooding experienced in recent years. Cellular agriculture is not a panacea for these issues; however, it can be implemented to diversify food production, thereby increasing resilience. However, it is important to promote the growth of an industry that effectively contributes to resilience rather than furthers vulnerabilities. This includes zoning and incentive policies that encourage decentralized production and facilities outside of high-impact areas such as flood plains.

6. Convene diverse groups and stakeholders to bridge silos.

The role and potential effects of cellular agriculture in future food systems has social, economic, environment, cultural, and political implications. It is thus important to engage in transdisciplinary and cross-sectoral work that explores these complex implications and relationships. Convening (or supporting) meetings, conferences, and workshops that bring together researchers from different disciplines, government representatives from different agencies, and stakeholders from different aspects of the food system is critical for developing the relationships and capacity to examine the complex topics and questions around widespread adoption of cellular agriculture in British Columbia and beyond.

RECOMMENDATIONS

7. Develop a plan for strategic engagement using a systems lens.

Along with events that facilitate broader transdisciplinary and cross-sectoral discussions, it is important to develop an engagement plan that recognizes the different roles various groups play in the food system. For example, certain conventional agriculture stakeholders may be in position to cultivate feedstock crops for cellular agriculture products, and it is worth engaging these groups specifically to gauge interest and discuss these opportunities. Similarly, some communities may be interested in the technology and food production method for different reasons, such as cellular agriculture's potential roles in economic development in large urban centres and/or food security in remote communities. Mapping out the different stakeholders and communities associated or affected by a transition to cellular agriculture is important for understanding their different roles and stakes in the emerging food production approach, which will provide insight on how to develop an effective engagement strategy.

8. Invest in relationship building.

Building relationships is important, but often undervalued work, in the research and development of a new technology. As a disruptive technology, the emergence of cellular agriculture will elicit concern in a number of different communities and stakeholder groups. It is important to invest in projects that allocate the appropriate time for building trust and relationships among these communities and stakeholders. In particular, it should be emphasized that cellular agriculture is designed to augment, not replace, traditional agriculture in order to progress a resilient and reliable food system. Grant programs for inter-/transdisciplinary work in this space could include considerations around relationship building as key criteria for funding.

RECOMMENDATIONS

9. Support initiatives that facilitate knowledge mobilization and public discussion.

Cellular agriculture is mysterious and unfamiliar to much of the public, and the media communications around the technology have not served to adequately inform the public on its nature and potential opportunities and challenges. Initiatives that provide more transparency around cellular agriculture and a public platform for discussion on hopes and concerns surrounding the emerging industry are important for improving broader understanding of its potential role in local and regional food systems. Such initiatives can range from online public discussion forums to knowledge mobilization hubs that serve to support and coordinate communications and dissemination from diverse researchers working in this space.

10. Develop interdisciplinary education and training programs.

For cellular agriculture to be an inclusive industry in British Columbia, education and training programs need to be developed that expose students to the food production method and its possibilities. Such education should be interdisciplinary in nature so that emerging practitioners understand both the technical aspects and sociocultural implications of the emerging industry.