



Advancing Solutions for Alternative Proteins Project Report:

A Systematic Analysis of the Plant Protein, Fermentation, and Cultivated Meat Industries

July 31, 2020

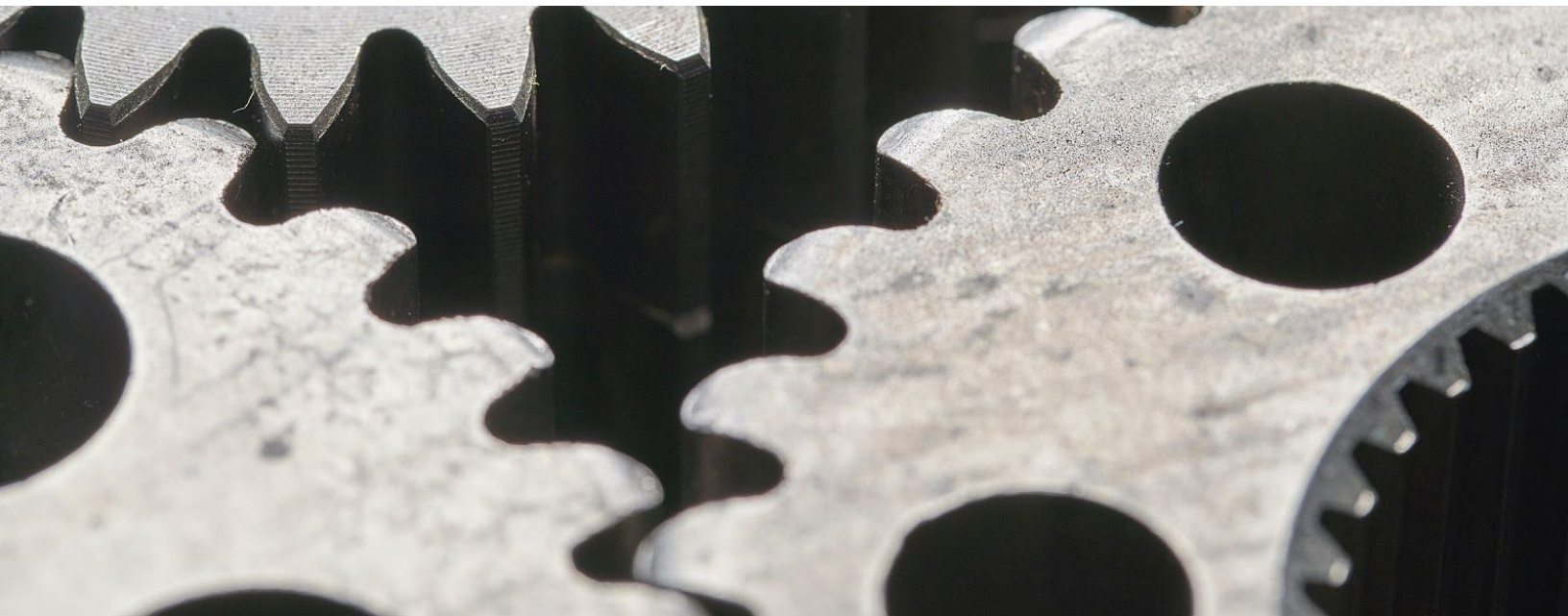


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About The Good Food Institute

As a nonprofit whose mission is to accelerate the growth of the alternative protein industry, The Good Food Institute has a unique and vital role to play in transforming each step of the value chain more quickly and on a larger scale than conventional market forces would dictate. GFI is working to accelerate this transition toward a better food system by surfacing the most pressing problems and most needed solutions in the alternative protein market. By offering recommendations for building a resilient and sustainable alternative protein industry, GFI helps businesses, investors, nonprofits, academic researchers, and governments prioritize efforts supporting the alternative protein industry and ensure that resources are channeled effectively.

The Advancing Solutions for Alternative Proteins initiative and corresponding deliverables—all open-access and free of charge—were made possible by GFI’s generous donors. If you’d like to support our open-access research and efforts to catalyze the alternative protein industry, please contact philanthropy@gfi.org.

Introduction to Advancing Solutions for Alternative Proteins

The problems of industrialized animal agriculture are well known, with many well-documented examples of negative environmental, nutritional, public health, and animal welfare outcomes. Animal agriculture is a major contributor to many global issues, including climate change, deforestation, pollution, biodiversity loss, soil erosion and degradation, antibiotic resistance, water overuse, and zoonotic diseases. Alternative proteins sourced from [plants](#), microbial fermentation, and [animal cell culture](#) have the potential to create food products that are healthier and more ecologically sustainable.

While the alternative protein industry has made impressive technological advances and demonstrated product-market fit through the rapid commercialization of plant-based meat, egg, and dairy products, diversifying our food supply to be unreliant on animal proteins is no small feat. Feeding billions of humans and tens of billions of farmed animals is among the world’s greatest logistical challenges. Transformative technologies, including in food tech, often wish to draw parallels to the rate of consumer adoption of modern phenomena such as social media and digital communication platforms. But unlike digital technology—whereby billions of users download applications nearly instantaneously with incredibly low distribution, transaction, and marginal costs via digital interfaces—food is tangible, real-world stuff that needs to be grown, stored, transported, processed, and distributed in almost every corner of the globe.

Food system transformation entails complex infrastructure, labor, and supply chain realignments that demand time, human resources, specialized knowledge, and substantial capital. Transitioning from animal protein will require changing the crops on billions of farmed acres; reorienting millions of tons of processing, storage, and transportation capacity; reordering supply chains and commodity markets; retraining farmers and food industry workers; reformulating final

products; and expanding or retrofitting manufacturing capacity through capital-intensive efforts. The [recent growth of the plant-based sector](#) has been impressive, and market research projects that this [rapid demand growth](#) will continue. But limitations govern the speed at which the supply side of the equation can shift to meet this rising demand. These limitations include the construction rate for new production capacity; the time required to develop critical technological innovations; the conservative moves of cautious or risk-averse market players; and even biological factors, such as seasonal crop cycles.

The monumental complexity and scale of such a food-system transformation inspired GFI to launch this Advancing Solutions for Alternative Proteins initiative. As a knowledge hub, community connector, and consultative resource to the alternative protein industry, GFI works toward a global system optimum that maximizes alternative protein market share. This usually aligns with, but is distinct from, the local optima pursued by individual industry actors, who are understandably incentivized to maximize their own profit rather than the size of the industry as a whole.

While few companies are incentivized to publicize information or resources that would benefit competitors faced with similar problems, GFI can add value by alleviating shared challenges and coordinating activities across stakeholders throughout the entire market ecosystem. A high degree of public, private, and nonprofit sector participation can accelerate the success of the alternative protein industry. Governments, investors, NGOs, academic institutions, and private companies can use their purchasing power, financing, influence, and expertise to accelerate the industry.

To identify the most impactful interventions needed to build a successful alternative protein industry, GFI conducted an in-depth market-shaping¹ analysis, adapting a framework developed in the public health sector by organizations such as USAID; the Bill & Melinda Gates Foundation; and Gavi, the Vaccine Alliance, to create robust markets for vaccines and essential medical supplies.

Market shaping can accelerate market growth via [catalytic interventions](#) that achieve lasting results. This involves identifying ways that the current market deviates from the ideal, determining the root causes of these market shortcomings, analyzing potential interventions, identifying effective partners, and—once solutions are implemented—evaluating and monitoring impact. Market interventions are designed for counterfactual impact: Their purpose is to accelerate important market shifts that otherwise would have occurred too slowly or not at all and to ensure these changes occur on a larger scale than conventional market forces would dictate.

¹ A note on terminology: While we borrowed quite heavily from market-shaping frameworks to inspire and guide this initiative, we decided to coin the term “Advancing Solutions for Alternative Proteins” for this project and its associated deliverables. We made this choice to provide more clarity to readers about the nature of the report and deliverables, but we hope that this report will be considered part of the broader market-shaping literature.

Market shaping often uses three levers:

1. Reducing transaction costs by lowering structural hurdles to market interactions—making it faster and easier to find needed partners, simplifying ordering, creating market trust, providing transparency about product or service quality and market fit, and developing more efficient delivery and payment mechanisms.
2. Increasing market information flow—generating new data, aligning existing analyses, or improving the accessibility and usability of available data to reduce information asymmetries. Increased information transparency reduces transaction costs and operational risks, supporting the other levers.
3. Balancing supplier and buyer risks—offsetting financial risks borne by suppliers and buyers and structuring partnerships to make market engagement more attractive. This draws in new market players and entices existing suppliers to operate more actively.

As to the third lever, farmers, for example, often lack insight into demand and thus cannot justify growing a novel crop. More information about forecasted demand reduces uncertainty and de-risks the decision to move from more established crops. Similarly, alternative protein companies may struggle to prove the scalability of their technology due to the lack of pilot- and demonstration-scale production facilities. Building more of these facilities and making them more accessible will help these companies hit their technological milestones sooner and focus their capital more effectively. Other interventions might relate to unanswered scientific or technical questions or industry white spaces that a commercial venture would best fill.

Needed interventions include the following:

- Awarding grants or prize incentives for supply chain or technology solutions that address a potential bottleneck that may be years away (and thus provides little economic incentive to begin the prerequisite R&D).
- Aggregating and forecasting demand across multiple companies to increase market efficiency relative to responding to disaggregated, real-time demand.
- De-risking investment activity at scales much larger than are conventionally tolerable due to market uncertainty.
- Supporting early-stage production resources to pave the way toward economies of scale and provide track records of success for future fundraising.

For the Advancing Solutions for Alternative Proteins initiative, GFI spent several months conducting extensive research, holding ideation sessions, and interviewing more than 120 experts throughout the alternative protein value chain to identify the existing challenges, future bottlenecks, and potential solutions. The resulting deliverables are designed to serve as a roadmap for businesses, investors, nonprofits, academic researchers, and governments who are building a resilient and sustainable alternative protein industry.

Explore More from the Advancing Solutions for Alternative Proteins Initiative:

[Innovation Priorities](#)

- Provides an overview of the key challenges limiting the growth of alternative proteins.
- Explores the bottlenecks at every step of the supply chain, which will be continually updated as the industry evolves and grows.
- Elucidates needs for research, investment, business solutions, and ecosystem-level interventions.

[Solutions Database](#)

- Provides a repository of concrete, actionable solutions to support the growth of alternative proteins.
- Serves as a living resource that will continue to grow through contributions from GFI's team and from external stakeholders.
- Encompasses solutions suitable for companies, governments, entrepreneurs, investors, researchers, academic institutions, and nongovernmental organizations, including research projects; commercial opportunities; and ecosystem-level interventions, such as policy and regulatory solutions.

[Advancing Solutions for Alternative Proteins \(ASAP\) Executive Summary](#)

- Provides an overview of the rationale, methodology, and key findings.
- Links readers to all the deliverables and resources generated by the ASAP initiative.

[Future-Proofing Alternative Proteins: Advancing Solutions for Long-Term Resiliency](#)

- Presents the key findings from our premortem analysis of potential threats to the widespread adoption of alternative proteins and strategies for avoiding or mitigating the most pressing risks.
- Provides recommendations for positioning the alternative protein ecosystem for long-term growth.

[Futures Wheels as Tools for Elucidating Non-obvious Opportunities and Challenges for Industry Growth](#)

- Explores possibilities of future-growth scenarios for alternative proteins, supporting better decision-making in the present.
- Provides recommendations for conducting future exercises to surface additional strategic insights.

Methodology

Step 1: Develop Strategic Approach

The industry analysis began with a review of existing market-shaping strategies and best practices, as well as decision-analysis frameworks used in public health and agriculture. Rigorous decision-analysis modeling maximizes impact and reduces risk in intervention planning. However, data gaps in the alternative protein industry and the fast pace of change make implementing some analytical tools more difficult. GFI conducted a series of 13 process interviews with decision-analysis and scenario-planning experts to better understand the frameworks, tools, and methodologies used to assess strategic interventions in other fields—to pressure-test their applicability to alternative proteins. Insights from these conversations underpinned the framework for the first generation of analysis and solutions.

Step 2: Conduct Internal Analysis

GFI assessed the current health of the industry, identified market shortcomings, and mapped root causes. Next, we identified potential solutions that would directly affect one or more of the shortcomings or root causes. Finally, we mapped relationships to indicate causal direction

between shortcomings and solutions along impact pathways. Our influence diagram visually describes and simplifies this network of relationships.

Known also as causal maps, Bayesian networks, Ishikawa (fishbone) diagrams, cause-and-effect diagrams, and issue or opportunity trees, influence diagrams decompose problems, find non-intuitive root causes, identify critical control points, guide risk management and risk mitigation efforts, make assumptions explicit, determine and communicate optimal strategy, and reveal the fundamental causal relationships in complex systems. They should include all major risks and potential decisions, as well as indicate the relationships among them with arrows. Building the influence diagram generated new insights about significant relationships throughout the value chain and illuminated gaps that could yield opportunities for intervention. A key remaining question is how to prioritize interrelated solutions in a portfolio to most effectively alleviate challenges and maximize impact.

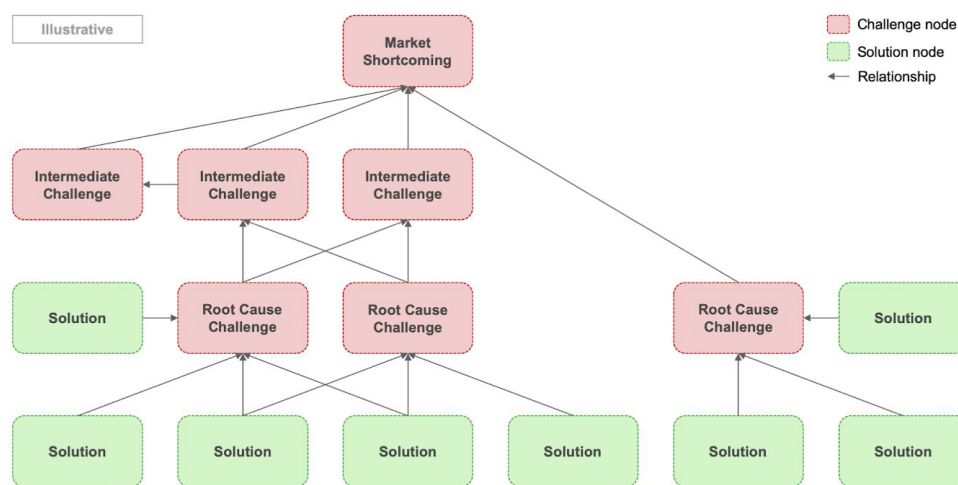
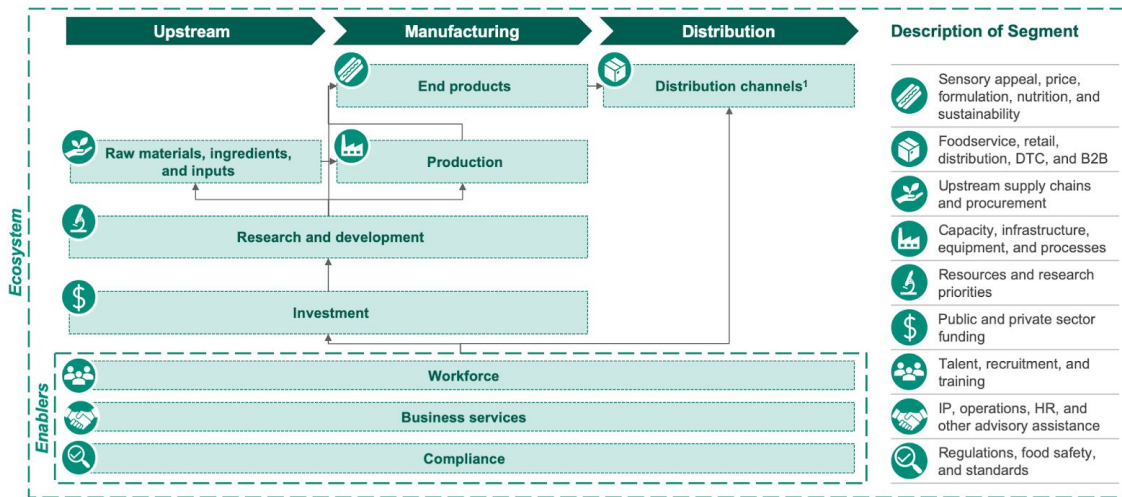


Figure 1. Illustrative schematic of a conceptual influence diagram. Major market shortcomings and their root causes are represented by red boxes and clustered by the area of the value chain impacted. Potential solutions are represented by green boxes.

Step 3: Conduct Expert Research and Refinement

GFI used a simplified version of the influence diagram to create a high-level value-chain segmentation of the industry to structure the analysis and guide the external stakeholder interviews and surveys. The first iteration focused on six critical components of the value chain: distribution channels, end products, production, raw materials, ingredients and inputs, research and development, and investment. We subsequently identified workforce, business services, and compliance as key areas that undergird all aspects of the value chain. Because of GFI's expertise in and belief in the power of the alternative protein industry's supply side, we did not extensively investigate the demand side of the value chain in this first generation of analysis.



1. For plant-based products or end products derived from fermentation

Figure 2. Value-chain segmentation. This conceptual value-chain segmentation served as the basis for the expert interviews and surveys. Note that distribution channels were not discussed in the context of cultivated meat, as this product is not yet on the market or in distribution.

Expert Stakeholder Selection

The experts interviewed include scientists (academic and industry), entrepreneurs, investors, consultants, and industry leaders from established life science, food, and technology companies. GFI selected stakeholders with an eye toward gathering diverse perspectives across each area of the value chain and providing equal coverage of the primary production modalities for alternative proteins: plant-based formulation, microbial fermentation, and meat cultivation.



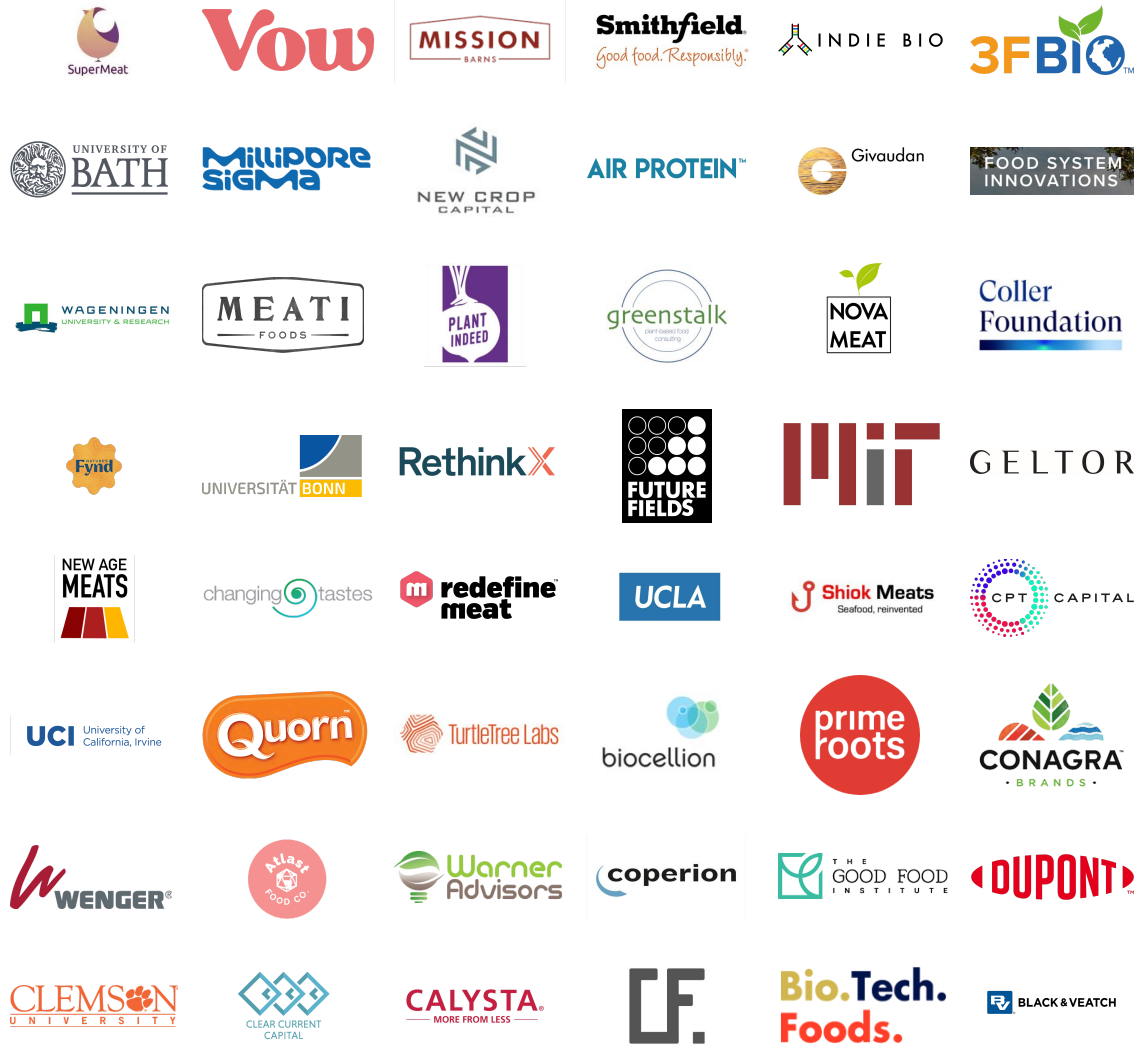


Figure 3. Companies represented among the expert interviewees. These logos represent the majority of our expert interviewees, although some participants declined to be publicly listed. A full list of all interviewees who agreed to be named is located in Appendix 3.

To ensure a holistic view of the industry and avoid blind spots, overlooked opportunities and risks, or unexpected consequences, we split the research into two separate workstreams with different methodologies.

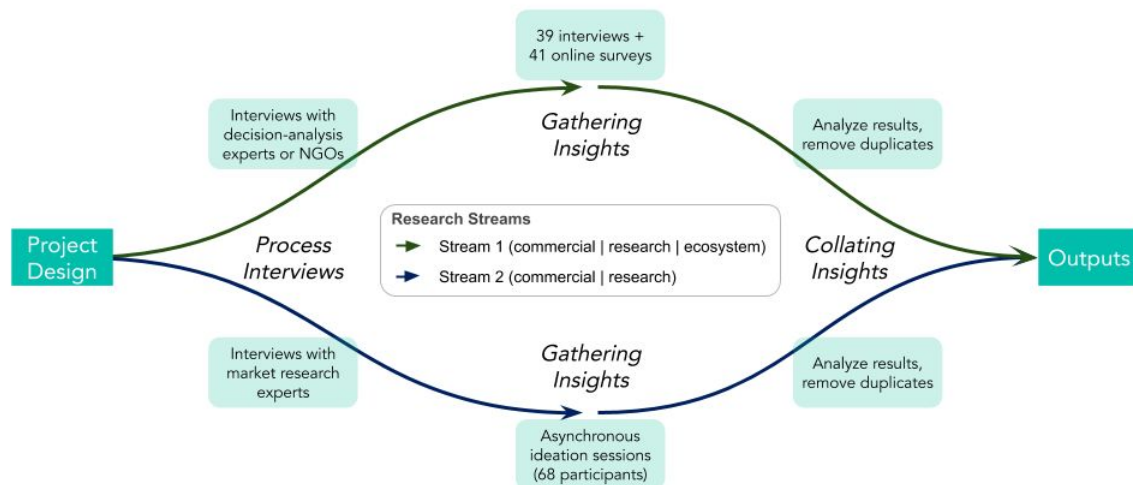


Figure 4. Stakeholder insights gathered through two process streams. Both workstreams relied on distinct methodologies for canvassing insights and perspectives on the alternative protein industry, but GFI ultimately collated these insights into a single database of major challenges and high-priority solutions.

Stream 1: Interviews and Surveys

The first workstream consisted of 39 telephone or video interviews and 41 online surveys with experts from around the globe. We scheduled each telephone or video interview for one hour, but several participants allowed for extended interviews or requested follow-up sessions to continue sharing ideas and providing feedback. Using the value-chain segmentation for reference, each expert could choose one or two of the six areas for a deep dive. In the context of the selected value-chain segment, we asked participants to discuss the most significant bottlenecks, brainstorm solutions, and quantitatively rate the relative impact of a series of GFI-generated solutions.

Stream 2: Asynchronous Brainwriting

The second workstream captured insights via a week-long “asynchronous ideation” session for each of the three production platforms, using a “brainwriting” framework developed by [Brad Barbera](#). The sessions, conducted through Google Sheets, focused predominantly on commercial and research challenges and allowed participants to respond to questions such as, “What is the biggest bottleneck in the production of plant-based meat today?” Participants provided feedback and built on the submitted ideas of other participants, thus generating insights that one-on-one interviews would not have elicited. Participants represented all three production platforms approximately equally, with 22 participants contributing ideas for the cultivated platform, 17 for the fermentation-derived platform, and 29 for the plant-based platform.

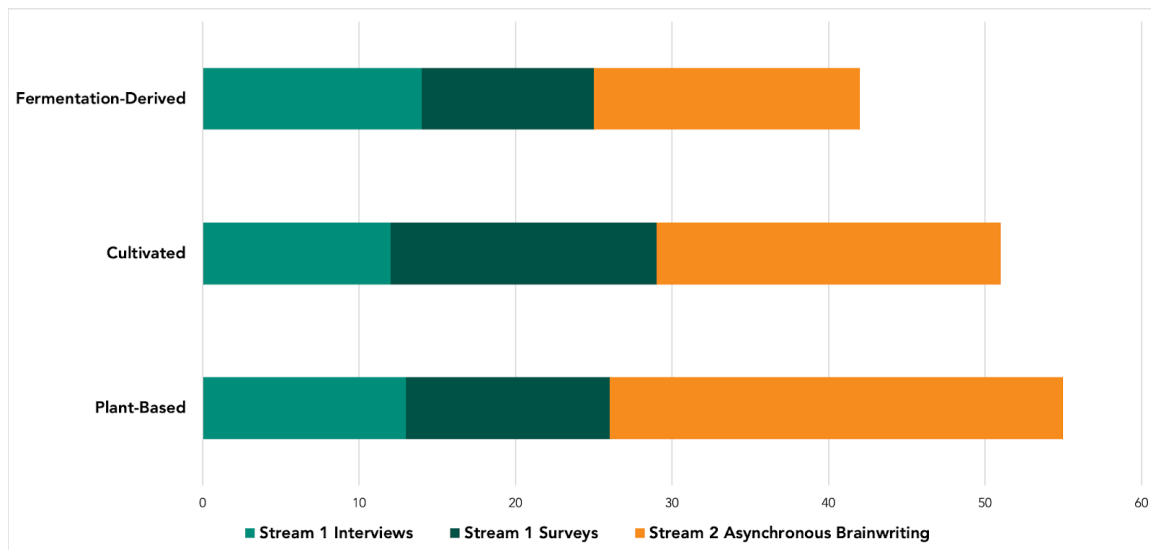


Figure 5. Respondents by production platform and mode of participation (telephone or video interview vs. online survey). Expert stakeholders were approximately equally distributed across all three production platforms of the alternative protein industry.

Step 4: Consolidate Findings and Prioritize Solutions and Challenges

GFI combined responses from both workstreams into a database of all potential solutions that targeted one or more of the identified shortcomings. After consolidation, we developed a tiered prioritization system based on qualitative and quantitative feedback. We characterized each solution by the intervention category, impacted area of the value chain, production platform (plant-based, fermentation-derived, or cultivated), technology sector, type of actor relevant to implementing the solution, and anticipated impact (which GFI probed quantitatively via the interviews and surveys for a subset of solutions that we had articulated in advance).

Using these criteria overlaid with qualitative analysis, we categorized solutions as one of three levels. Level 1 solutions merit launching to the publicly hosted solutions database, accompanied by a brief description and tags that indicate their position in the value-chain and technology segmentation framework. Level 2 solutions are more thoroughly articulated, each taking the form of a one-page concept note that outlines the challenge it seeks to address, the proposed solution, and the anticipated impact. Level 3 solutions merit additional feasibility assessments or will launch directly into project execution, depending on the nature of the opportunity. The vision of this framework is to matriculate ideas through this pipeline—from high-level concept to concrete proposed solutions to detailed project roadmaps or proposals and, ultimately, to project execution. Projects may take the form of launching a new company or product line, coordinating activity in the market using a new platform or policy, or conducting a research project to fill a key knowledge gap.

Table 1
Criteria for Tagging and Prioritizing Opportunities

Category	Value chain location	Production platform	Technology sector	Actor type
<ul style="list-style-type: none"> ● Ecosystem: systems-level or structural reforms that reduce transaction costs, increase market information, or balance risks between market participants ● Commercial: unmet needs that will require unique skills and resources to address and consequently areas in which entrepreneurs or industry players might innovate ● Research: critical scientific or technological questions that require either public or private sector research and development to solve 	<ul style="list-style-type: none"> ● End products ● Raw materials, ingredients, and inputs ● Production ● R&D ● Investment ● Distribution channels ● Workforce ● Business services ● Compliance ● Demand generation 	Plant-based	<ul style="list-style-type: none"> ● Crop development ● Ingredient optimization ● End product formulation and manufacturing 	<ul style="list-style-type: none"> ● GFI ● NGOs ● Entrepreneurs / startups ● Established industry ● Investors ● Policymakers ● Academic researchers
		Cultivated	<ul style="list-style-type: none"> ● Cell line development ● Cell culture media ● Scaffolding ● Bioprocess design ● End product formulation and manufacturing 	
		Fermentation-derived	<ul style="list-style-type: none"> ● Target molecule selection ● Host strain development ● Feedstocks ● Bioprocess design ● End product formulation & manufacturing 	

Key Findings: How to Accelerate the Alternative Protein Industry

Industry Health: Identifying Key Performance Indicators and Metrics

Our analysis focused on understanding current market health by identifying the most important market characteristics; identifying desired outcomes in an ideal market; and listing key performance indicators, challenges, root causes, and opportunities. GFI's goal is to create a healthy, just, and sustainable food system, and our analysis aims to create concrete targets to reach that goal.

Table 2
Characteristics of a Healthy Alternative Protein Market

	Market characteristic	Desired market outcomes	Example market challenges	Example root causes	Example interventions	Key performance indicators	Relevant measurement tools
Product attributes	Quality and functionality	<ul style="list-style-type: none"> ● Delicious and appealing ● Functional for all applications ● Convenient and easy to use ● Versatile ● Easy to store 	<ul style="list-style-type: none"> ● Texture issues ● Functionality that does not match animal product functionality ● Difficult cooking and preparation; unfamiliar user experience 	<ul style="list-style-type: none"> ● Unoptimized ingredients ● Lack of product variety ● Poor product formulation 	<ul style="list-style-type: none"> ● Ingredient optimization ● Better end product formulation ● Development of better functional inputs 	<ul style="list-style-type: none"> ● Consumer perceptions ● Buyer (B2B) perceptions ● Taste comparisons to animal products ● Market segment penetration 	<ul style="list-style-type: none"> ● Product quality analysis ● Quality assurance assessment ● Sensory panels

Supply attributes	Affordability	<ul style="list-style-type: none"> • Low prices for consumers • Producer profitability • Costs similar to or lower than those of animal protein products 	<ul style="list-style-type: none"> • High prices relative to those of conventional animal products • High price variance • High price volatility 	<ul style="list-style-type: none"> • Expensive inputs • Inefficient production processes • Ineffective demand forecasting 	<ul style="list-style-type: none"> • Production scaled to unlock economies of scale • Ingredient and process innovations • Subsidies 	<ul style="list-style-type: none"> • Prices high enough to incentivize suppliers but low enough to promote widespread adoption • Prices lower than those of animal counterparts 	<ul style="list-style-type: none"> • Cost of goods sold analysis • Price analysis • Consumer research studies
	Variety	<ul style="list-style-type: none"> • Products available to suit all consumers and needs • Products relevant to all cuisines and cultures 	<ul style="list-style-type: none"> • Products suitable only for some dietary patterns • Irrelevance to various cuisines 	<ul style="list-style-type: none"> • Too few producers • Diversity of products constrained by lack of scale required for quality or cost savings • Hard-to-create formats, flavors, or analogs 	<ul style="list-style-type: none"> • Startup support • Investment in increased capacity • Creation of competitive small-scale production paradigms 	<ul style="list-style-type: none"> • Variety that matches or exceeds animal product ranges • Representation of diverse cuisines and culinary styles 	<ul style="list-style-type: none"> • Supplier landscape assessment • Market data, broken down by product segment and SKUs • Cultural and cuisine gap analysis
	Health and safety	<ul style="list-style-type: none"> • Nutritious • Free from contamination • Free from allergenicity • Safe • Qualified for clean label options (for some in the early-adopter segment) 	<ul style="list-style-type: none"> • Use of unhealthy inputs for easier replication of animal products • Unclear guidance on safety requirements for inputs and new ingredients 	<ul style="list-style-type: none"> • Lack of ingredient innovation • Issuance of regulatory guidance handicapped by lack of technological maturity or clarity 	<ul style="list-style-type: none"> • Ingredient and input innovation • R&D into improved processing methods • Collaboration with industry and regulators for consensus standards • Rigorous food safety protocols 	<ul style="list-style-type: none"> • Consumer rating as healthy and safe • Outperformance of animal products in nutritional studies • Few or no food safety incidents, such as recalls 	<ul style="list-style-type: none"> • Nutritional studies • Safety testing and QA • Consumer research • Buyer (B2B) surveys • FSMA incident tracking
	Availability	<ul style="list-style-type: none"> • Equitable and consistent accessibility for all consumers • Capacity and stability of global supply to meet present and future demand 	<ul style="list-style-type: none"> • Supplier exits or failures • Supply volatility, such as shortages or gluts • Consumers unable to find the products they want 	<ul style="list-style-type: none"> • Insufficient product variety • Production capacity constraints, such as too few co-manufacturers • Lack of key inputs in sufficient quantities 	<ul style="list-style-type: none"> • Demand forecasting for both end products and inputs • Encouraging more startup and product launches • Sharing product-availability gap analysis with food industry 	<ul style="list-style-type: none"> • Alternative proteins equally or more widely available than animal proteins 	<ul style="list-style-type: none"> • Menu penetration analysis • Retail availability analysis • Market research • Supplier landscape assessment • Product-availability gap analysis
	Secure and resilient supply chain	<ul style="list-style-type: none"> • Production, processing, and raw material capacity that meet demand • Capacity diversified among many suppliers • Low transaction costs, healthy information flow, and balanced risks and returns 	<ul style="list-style-type: none"> • Demand faster-growing than supply or latent demand unsatisfied • Supplier monopolies or oligopolies • Difficulty for buyers or suppliers to locate one another or arrange partnerships 	<ul style="list-style-type: none"> • Lack of effective marketplaces and exchanges • Lack of contract and dedicated production capacity • Too few companies pursuing opportunities in each segment of the supply chain 	<ul style="list-style-type: none"> • Creation of marketplaces, exchange platforms, brokers, events, and online communities to connect buyers and sellers • Financial and technical assistance for contract manufacturers seeking to scale 	<ul style="list-style-type: none"> • Alternative protein supply chains more resilient to risks than animal protein supply chains • Global processing and production capacity comparable to that of animal proteins 	<ul style="list-style-type: none"> • Demand forecasting • Production and processing capacity analysis • Supplier landscape assessment • Scenario analysis • Wargaming • Futures analysis

R&D innovation	<ul style="list-style-type: none"> • Robust pipeline of new products and services available to producers and suppliers • Rapid market introduction of superior products • Pre-competitive, non-duplicative open-access research 	<ul style="list-style-type: none"> • Difficult and rare product launches • Few technology providers that offer solutions tailored to alternative protein applications • Confidentiality of most company R&D 	<ul style="list-style-type: none"> • Chronically underfunded foundational research • Redundant efforts due to silos and poor communication • Technology providers unaware of opportunity in the alternative protein field 	<ul style="list-style-type: none"> • Increased government R&D funding • Philanthropic research grant program • Industry-academic collaborative research centers 	<ul style="list-style-type: none"> • Total government funding (federal, state, local, international) allocated to R&D • Launches of products or services to support researchers • Publications 	<ul style="list-style-type: none"> • Research funding database and analysis • Publication analysis • Surveys of technology developers regarding awareness and interest in alternative protein applications
Investment	<ul style="list-style-type: none"> • Abundant capital to ensure that supply can meet existing and future demand • Diverse active investors (public and private, equity and debt, venture and corporate, etc.) • Investors that bring genuine strategic value 	<ul style="list-style-type: none"> • Alternative protein companies struggling to raise specific types of capital, such as seed rounds or debt financing • Alternative protein companies unable to find strategic investment partners • Lack of investment in large-scale production capacity 	<ul style="list-style-type: none"> • Narrowly focused or small investor pool • Lack of connections between the startup community and established industry • View of banks, venture debt providers, and strategic partners that alternative protein companies are too risky 	<ul style="list-style-type: none"> • Investor outreach and education • Events, consultants, online communities, and brokers to foster connections • Creation of funds or guarantees to de-risk debt investments for capital providers 	<ul style="list-style-type: none"> • Amount of total investment into alternative protein companies, R&D, marketing, infrastructure, etc. • Venture capital and private equity deals 	<ul style="list-style-type: none"> • Investment analysis • Financing analysis • Surveys of alternative protein companies about their experience with investors
Just and fair employment	<ul style="list-style-type: none"> • Equity and justice for all participants • Meaningful and appropriately compensated work • Equitable access to work across income, geography, social status, and other factors 	<ul style="list-style-type: none"> • Insufficient profits for farmers growing alternative protein inputs • Candidates drawn from limited pools or compensation uncompetitive 	<ul style="list-style-type: none"> • Raw material commodity traders and ingredient companies not effectively communicating demand • Geographically clustered alternative protein companies that lack diverse skill sets and experienced management 	<ul style="list-style-type: none"> • Support for marketplaces and mechanisms for manufacturers to contract directly with farmers • Support for democratized and distributed production of alternative proteins 	<ul style="list-style-type: none"> • Profitability per acre compared with animal protein inputs • Ingredient usage rates • Supplier counts and landscape • Alternative protein industry revenue • Alternative protein workforce diversity 	<ul style="list-style-type: none"> • Ingredient usage data and forecasting • Industry workforce surveys
Ecological sustainability	<ul style="list-style-type: none"> • Minimal environmental impact: climate, pollution, energy use, water use, land use, etc. • Integration within a circular bioeconomy—leveraged waste streams or side streams • Minimal use of disposable materials 	<ul style="list-style-type: none"> • Water- and land-intensive alternative protein inputs • Significant waste generation or underutilized biomass fractions 	<ul style="list-style-type: none"> • Alternative protein inputs not bred or optimized for sustainability • Unused side streams and lack of processing methods to make them more useful 	<ul style="list-style-type: none"> • Support for R&D to find better inputs and optimize existing inputs • Support for marketplaces, brokers, consultants, processors, and exchange mechanisms that can valorize side streams 	<ul style="list-style-type: none"> • GHG emissions, pollution, energy usage, water usage, and land usage • All resource usage levels below those of animal protein production 	<ul style="list-style-type: none"> • Techno-economic analysis of alternative protein side streams • Life cycle assessments

	Talent and workforce development	<ul style="list-style-type: none"> Highly skilled workers throughout value chain, gained through robust training, talent, and labor pipelines Displaced workers and farmers in new, valuable roles 	<ul style="list-style-type: none"> Alternative protein companies struggling to find needed talent Alternative protein companies struggling to integrate talent with animal protein supply chain experience 	<ul style="list-style-type: none"> Lack of educational resources to train people for careers in alternative proteins Lack of training to help workers transition to careers in alternative proteins 	<ul style="list-style-type: none"> University and trade school outreach to build talent pipeline and expand educational opportunities Creation of better hiring, training, and worker support protocols for the industry 	<ul style="list-style-type: none"> Number of university courses, student groups, and research centers Amount of relevant academic research Worker hiring and retention rates 	<ul style="list-style-type: none"> Workforce surveys and assessments Educational landscape analysis
Demand attributes	High demand and positive awareness	<ul style="list-style-type: none"> Strong demand for alternative proteins across geographies and consumer demographics Accurate and positive consumer view of alternative proteins Accurate and positive B2B-buyer view of alternative proteins 	<ul style="list-style-type: none"> Low awareness of alternative protein products Misinformation about alternative proteins common among consumers or food industry 	<ul style="list-style-type: none"> Consumer or B2B buyer needs unmet Competitor-spread misinformation about alternative proteins 	<ul style="list-style-type: none"> Product and market research to identify most desired product attributes Partnering with companies, media, governments, NGOs, and other institutions to counter misinformation 	<ul style="list-style-type: none"> Repeat purchase rates and customer loyalty Consumer and buyer awareness and perception ratings Awareness and positive perception higher for alternative proteins than for animal proteins 	<ul style="list-style-type: none"> Demand segmentation Demand stakeholder analysis Consumer behavior analysis Consumer research Buyer surveys
	Effective promotion	<ul style="list-style-type: none"> Widespread promotion of alternative proteins through cost-effective earned and paid media 	<ul style="list-style-type: none"> Frequent use of unappealing nomenclature or ineffective positioning in advertising efforts 	<ul style="list-style-type: none"> Retailers, producers, and restaurants unaware of what consumers look for in alternative protein products 	<ul style="list-style-type: none"> Improved marketing through supplier-sales partner collaborations Research to determine most effective promotional approaches 	<ul style="list-style-type: none"> Amount of marketing investment Earned media coverage Word-of-mouth promotion rate and Net Promoter Scores 	<ul style="list-style-type: none"> Social media analysis Consumer research Marketing research and testing
	Cultural integration	<ul style="list-style-type: none"> Alternative proteins accepted and supported in all global cultures Social, political, religious, nonprofit, and media influencer acceptance or support for alternative proteins Alternative proteins integrated into major global cuisines 	<ul style="list-style-type: none"> Alternative proteins partisanized or appeal limited to niche audiences Alternative proteins unsuitable for common cuisines Alternative proteins adopted by some countries and cultures but not others 	<ul style="list-style-type: none"> Alternative protein production too geographically clustered and lacking in global diversity Products poorly positioned to meet unique needs of different cultural contexts Lack of local alternative protein production 	<ul style="list-style-type: none"> Kosher and halal certification Coordinated outreach to media, NGOs, and governments supporting alternative proteins R&D and investment to support democratized and distributed means of production 	<ul style="list-style-type: none"> Market penetration and market share compared to animal proteins New product launches segmented by region 	<ul style="list-style-type: none"> Cultural analysis Market data with international and demographic granularity New product development data
Ecosystem attributes	Fair and effective regulation	<ul style="list-style-type: none"> No prohibitive regulatory scrutiny or onerous regulatory requirements Alternative proteins 	<ul style="list-style-type: none"> Uneconomical inspection or approval requirements Unfair label censorship requirements 	<ul style="list-style-type: none"> Competitors lobbying governments to place undue and anti-competitive restrictions on alternative proteins 	<ul style="list-style-type: none"> Lobbying by trade groups and alternative protein companies Creating model legislation and regulatory 	<ul style="list-style-type: none"> Political and regulatory equity when compared with animal proteins 	<ul style="list-style-type: none"> Policy and regulatory analysis Statutory analysis (by state / province / country / region)

governed by fair and effectual regulations

- Alternative proteins difficult to understand or unfamiliar for regulators

- frameworks
- Ensuring the industry builds relationships with the public sector

Inspired by Table 6 of the [USAID primer](#), page 7 of [Dahlberg's analysis](#), and page 4 of [Global Fund's report](#).

Future iterations of the analysis will drive toward increasingly quantitative targets and articulate how these objectives intersect with widely adopted frameworks, such as the U.N.'s Sustainable Development Goals.

Comparing the current market with the vision of the ideal market is the first step to identifying the most pressing challenges and their root causes. For example, high prices could stem from expensive inputs, high operational or labor costs, high supplier margins, high transaction costs, demand volatility, or a combination of factors. A cost of goods sold analysis is a relevant tool for locating the biggest cost drivers. Identifying the most significant root causes ensures that the industry focuses on interventions that most effectively target market shortcomings.

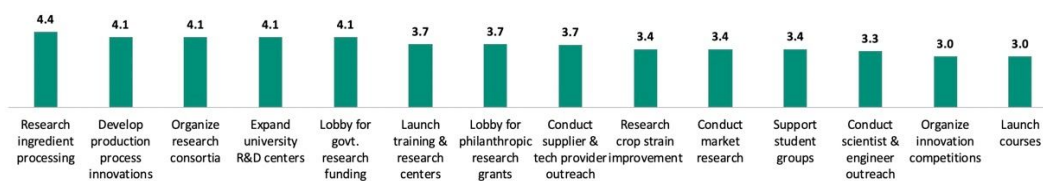
Aggregating Impact Assessment Scores for Opportunities Across the Value Chain

During Stream 1 of the research process, GFI presented lists of specific solutions and interventions to expert interviewees and asked them to rank these activities by expected impact, on a scale from 1 (low impact) through 5 (high impact). We segmented the results by production platform (plant-based, cultivated, and fermentation-derived) and value-chain segment.

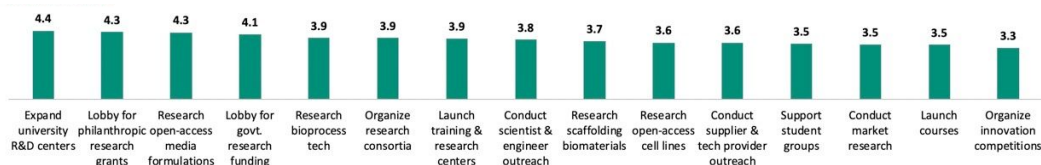
Note that these rankings do not encompass the breadth of proposed solutions in the database, as this resource is populated with internal GFI insights, as well as suggestions and ideas contributed by external experts during both streams of research. Please visit our [solutions database](#) to view the full menu of solutions.

Research and Development

Plant-Based



Cultivated



Fermentation-Derived

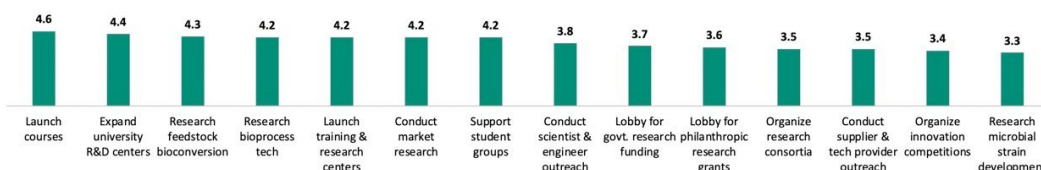


Figure 6. Research and development solutions for each production platform, ranked by impact scores.

Table 3

Research and Development Intervention Descriptions

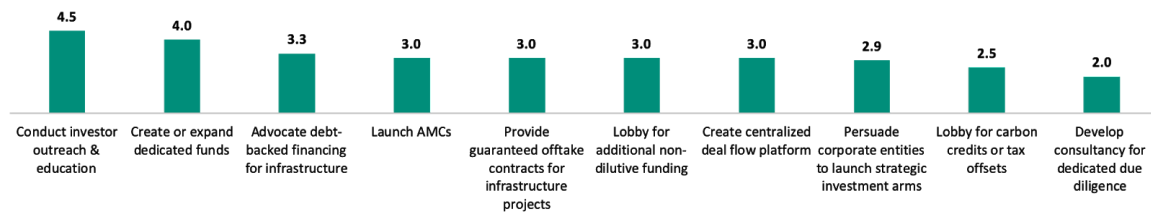
Plant-based	Cultivated	Fermentation-derived	Shared across all platforms
<ul style="list-style-type: none"> • Improve ingredient processing and functionality. • Develop and commercialize production process innovations (e.g., alternatives to extrusion for texturization). • Improve crop strains. 	<ul style="list-style-type: none"> • Optimize open-access cell culture media formulations. • Direct concerted research efforts toward bioprocess technology solutions that enable greater efficiency (continuous bioprocessing, contamination control strategies, novel harvesting methods, etc.). • Direct concerted research efforts toward biomaterials for scaffolding solutions. • Develop open-access cell lines. 	<ul style="list-style-type: none"> • Expand the availability of inputs through feedstock conversion methods. • Enable greater efficiency through bioprocess technology solutions (continuous bioprocessing, contamination control strategies, novel harvesting methods, etc.). • Direct concerted research efforts toward microbial strain development. 	<ul style="list-style-type: none"> • Launch or expand R&D centers at universities focused on plant-based, cultivated, or fermentation-derived proteins. • Launch and support university or online courses about the alternative protein field. • Organize public innovation competitions to develop new technology solutions, feedstock or input solutions, and end product formulations. • Launch and operate model manufacturing facilities for training and research. • Conduct coordinated scientist and engineer outreach to expand the technical talent pipeline. • Launch and support university student groups focused on the alternative protein field. • Conduct supplier and technology provider outreach to increase awareness of needs and opportunities in the alternative protein field. • Organize industry research consortia for collaborative efforts to develop solutions for shared challenges. • Advocate grants for research in the alternative protein field. • Conduct market research on product attributes and the extent to which existing alternative protein products fulfill specific organoleptic properties. • Lobby for government research funding.

Averaged across production platforms, creating and expanding university R&D centers rated as the most impactful R&D-related intervention. The highest-rated specific research areas were cell

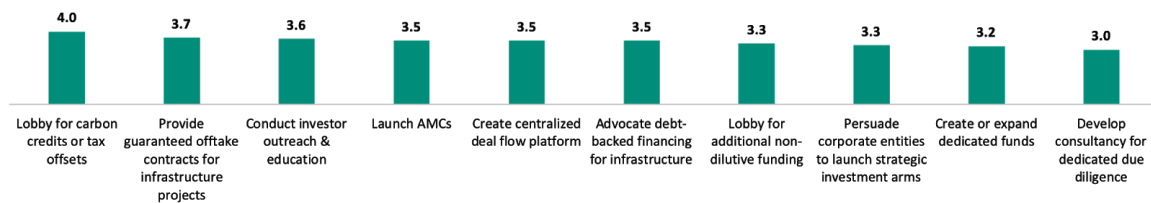
culture media formulations; feedstock bioconversion methods; ingredient processing innovations for improved functionality; and plant-based production process innovations, such as alternatives to extrusion for protein texturization. Finally, interventions that would increase funding for R&D—including government support, [philanthropic grants](#), and research partnerships—were regarded as medium- to high-impact.

Investment

Plant-Based



Cultivated



Fermentation-Derived

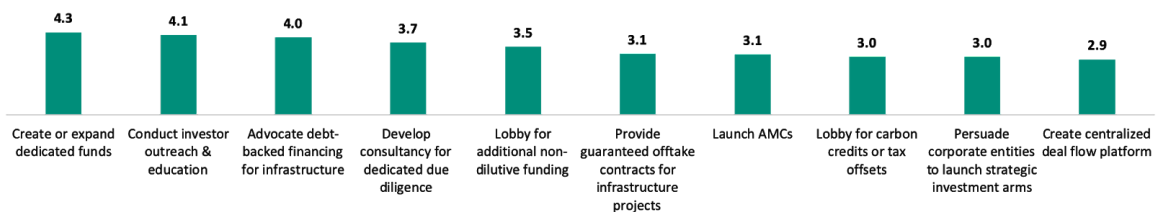


Figure 7. Investment solutions for each production platform, ranked by impact scores.

Investment Intervention Descriptions

Shared across all platforms

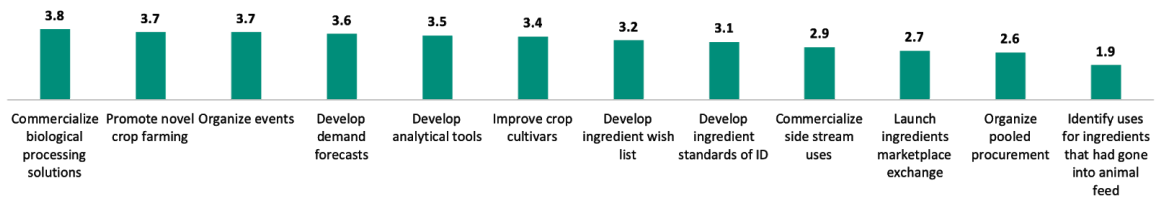
- Conduct coordinated investor outreach and education to bring new investors into the alternative protein industry.
- Create or expand investment funds dedicated to investments in the sector.
- Advocate/lobby for directing resources toward enabling large-scale, debt-backed financing for production infrastructure projects.
- Launch advance market commitments to guarantee the market for acceptable new alternative protein products.
- Provide guaranteed offtake contracts for substantial production infrastructure projects as required by many large-scale lenders.

- Advocate/lobby for expanding mechanisms of non-dilutive funding (such as loans with favorable terms or low interest) offered by government.
- Create a centralized platform for facilitating deal flow between pre-seed (incubators and accelerators), seed or early-stage, and growth or later-stage investors.
- Persuade additional established corporate entities in the sector to develop strategic corporate investment arms with alternative proteins as a priority area.
- Lobby for carbon credits or tax offsets for alternative protein production.
- Develop a dedicated consultancy that offers technical due diligence specifically in the alternative protein industry.

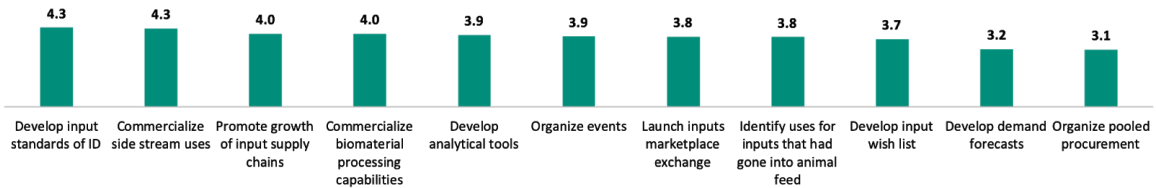
Respondents from all three production platforms (plant-based, cultivated, and fermentation-derived) ranked the impact of investor outreach highly, particularly attracting new types of investors and capital providers into the industry. They indicated a strong interest in the creation and expansion of investment funds dedicated to alternative proteins. Many respondents highly rated attracting providers of non-dilutive (non-equity-based) funding, including debt-backed financing for infrastructure projects and venture loans.

Raw Materials, Ingredients, and Inputs

Plant-Based



Cultivated



Fermentation-Derived

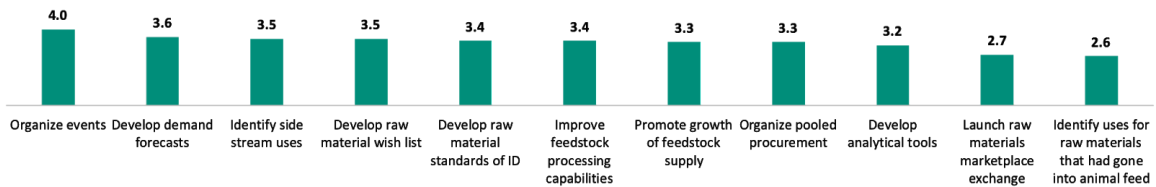


Figure 8. Raw material, ingredient, and input solutions for each production platform, ranked by impact scores.

Table 5
Raw Material, Ingredient, and Input Intervention Descriptions

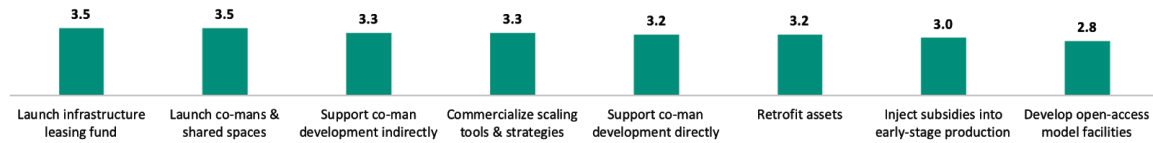
Plant-based	Cultivated	Fermentation-derived	Shared across all platforms
<ul style="list-style-type: none"> Commercialize new biological processing solutions (enzymes or fermentation) to improve ingredient functionality. Promote novel crop farming directly (e.g., investment and resources) and indirectly (e.g., education) to align with plant-based platform needs. Improve and commercialize novel crop cultivars (via breeding or engineering) to align with plant-based platform needs. 	<ul style="list-style-type: none"> Promote growth of cultivated meat input supply chains directly (e.g., investment and resources) and indirectly (e.g., education). Improve and commercialize media component and scaffolding biomaterial processing capabilities to align with cultivated platform needs. 	<ul style="list-style-type: none"> Improve and commercialize feedstock processing capabilities to align with fermentation-derived platform needs. Promote growth of fermentation feedstock supply directly (e.g., investment and resources) and indirectly (e.g., education). 	<ul style="list-style-type: none"> Organize industry-wide events to facilitate communication across the value chain. Identify and publicize higher-value uses within the alternative protein industry for raw materials that currently go into animal feed. Organize a pooled procurement strategy for key inputs to reduce costs and increase industry leverage. Launch a marketplace exchange platform for raw materials, ingredients, and inputs. Develop open-access “wish list” of desirable cultivated meat and plant-based inputs (novel growth factor variants, media supplements, scaffolding components, plant-based ingredients, and fermentation-derived ingredients). Develop and publish standards of identity for plant-based ingredients, fermentation feedstocks, and cultivated meat inputs. Develop and publish demand forecasts for novel and existing raw materials, ingredients, and inputs. Identify and publicize high-value uses for alternative protein side streams (starch fractions, cellular metabolites, spent media, etc.). Develop better analytical and characterization tools with predictive capabilities for plant-based ingredients, cultivated meat inputs (culture media components and scaffolding raw materials), and fermentation feedstocks.

Developing better tools for upstream raw input processing, particularly biological processing and characterization solutions, is a highly rated intervention. Establishing industry events to connect buyers and suppliers is also highly rated. Ingredient attribute wish lists and standards of identity are highly valued by ingredient suppliers and buyers, respectively.

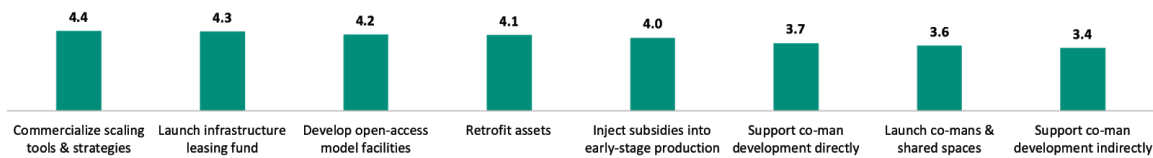
Many respondents noted that the three production platforms would have intersecting supply chains due to complementary needs. In addition to blends of whole-cell microbial biomass with plant-based or cultivated proteins in final food products, fermentation can be a source of enzymatic processing aids and value-added ingredients for plant-based and cultivated meat raw materials and end products. The three alternative protein platforms often rely on different fractions of crop and biomass inputs: high molecular-weight protein fractions are well suited for plant-based products, amino acids and small peptides are useful for cultivated meat production as ingredients for cell culture media, and the sugar and starch fractions have utility as feedstocks for microbial fermentation. This enables a future feed industry that utilizes every fraction of biomass input across the alternative protein landscape, thus maximizing ecological and economic efficiency.

Production

Plant-Based



Cultivated



Fermentation-Derived

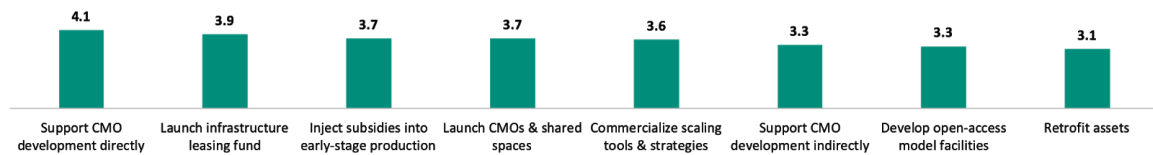


Figure 9. Production solutions for each production platform, ranked by impact scores.

Production Intervention Descriptions

Shared across all platforms

- Develop an infrastructure leasing fund to reduce upfront capital expenditures for building manufacturing capacity.
- Launch CMOs and develop shared manufacturing spaces.
- Consolidate and commercialize tools and strategies to scale manufacturing (e.g., training, consultants, talent acquisition, resources).
- Develop open-access model production facilities (e.g., showcase blueprints, share new or optimized production processes).
- Locate stranded or underutilized production assets and repurpose or retrofit for alternative protein product or ingredient production.
- Inject subsidies into early-stage production.
- Coordinate and support co-manufacturer development directly (e.g., recruiting and supporting organizations).
- Coordinate and support co-manufacturer development indirectly (e.g., listing organizations in a public directory).

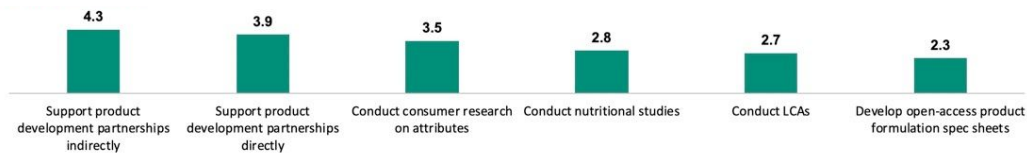
Most interviewees supported shared manufacturing spaces and contract manufacturing, although some voiced concerns around IP protection, usage priority and exclusivity, cross-contamination, food safety and allergenicity, and worker safety liability. Respondents from the cultivated meat industry felt that contract manufacturing and shared manufacturing spaces

would be challenging to implement, given the uncertainty about which forms of IP will be most valuable as cultivated meat commercializes. They also expressed concerns about partnership structures that could inadvertently disclose trade secrets or bargain away control of high-value business activities. Many respondents noted the need for additional contract capacity at all scales of production—pilot, demo, and commercial—and the lack of smaller-scale capacity as common bottlenecks for the product or process proof-of-concept needed to justify investment in larger facilities.

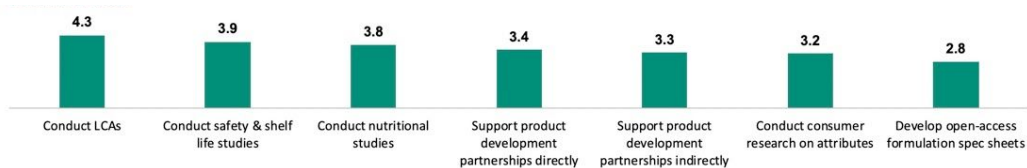
Infrastructure leasing (production/processing facilities and equipment) and investment funds were also highly rated, viewed by most respondents as enablers for alternative protein companies to rapidly expand capacity without large upfront capital investments. These interventions could entice corporate players who otherwise would not have considered alternative proteins to enter the space. It could also spare many smaller alternative protein startups from undertaking large, equity-backed capital raises early in their expansion.

End Products

Plant-Based



Cultivated



Fermentation-Derived

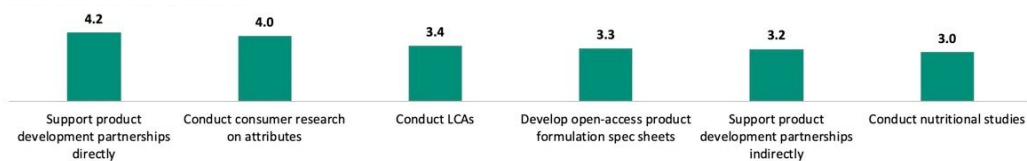


Figure 10. End product solutions for each production platform, ranked by impact scores.

End Product Intervention Descriptions

Specific to cultivated meat	Shared across all platforms
<ul style="list-style-type: none"> Conduct safety and shelf life studies to support 	<ul style="list-style-type: none"> Perform life cycle assessments for alternative protein products. Support product-development partnerships directly (e.g., coordinate introductions).

regulatory approval and ongoing inspection frameworks for cultivated meat products.

- Support product-development partnerships indirectly (e.g., develop partnership framework and guidelines).
- Conduct consumer research on alternative-protein product attributes and the extent to which existing products fulfill specific organoleptic properties.
- Develop open-access sample product-formulation spec sheets (e.g., composition, format, species, price).
- Conduct nutritional studies for alternative protein products.

Distribution Channels

Plant-Based



Fermentation-Derived

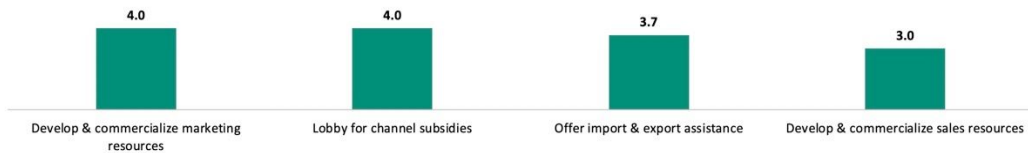


Figure 11. Distribution channel solutions for the plant-based and fermentation-derived production platforms, ranked by impact scores.

Distribution Channel Intervention Descriptions

Shared across both platforms

- Develop and commercialize plant-based and fermentation-derived product marketing resources, tools, and training for retailers, foodservice operators, distributors, and other food industry groups.
- Lobby for channel subsidies directly (e.g., petitioning government for marketing support or subsidies to retailers/foodservice operators to incentivize inclusion of alternative proteins) and indirectly (e.g., coordinating public demand campaigns).
- Offer import and export assistance via legal consulting services, facilitating introductions to in-country distribution partners, and aggregating listings of government support programs.
- Develop and commercialize sales resources, tools, and training for B2B salespeople representing plant-based and fermentation-derived products.

Additional Interventions in the Solutions Database

For solutions and interventions suggested by the expert interviewees but not part of our original questionnaires, please see our [solutions database](#), which filters by technology sector and supply chain segment. The solutions database contains concept notes articulating potential research projects, commercialization opportunities, and interventions to support the broader alternative protein ecosystem. Researchers, businesses, nonprofits, governments, and other stakeholders can use the solutions database to identify solutions they are interested in pursuing, alert GFI

about solutions they are already working on, request additional information, and much more. We welcome stakeholder feedback and contributions to this dynamic resource, as GFI will continue to update and refine the database to ensure industry resources are channeled toward the activities with the highest expected impact.

Visualizing the Value of Catalytic Efforts: Alternative Protein Growth Flywheel

The dilemmas underlying many of the bottlenecks and market shortcomings identified throughout this project can best be characterized as “chicken vs. egg” situations. For example, plant protein processors have a hard time justifying the R&D or investment to develop new processing methods and infrastructure for novel plant proteins when very few manufacturers are using these proteins. But at the same time, manufacturers are unable to launch products that utilize novel plant proteins because processing capacity sufficient to ensure reliable access to these ingredients does not exist. However, the encouraging observation about these “stalemate” situations is that they are a hallmark of co-dependencies that will drive toward feed-forward loops once the industry can leapfrog out of the stalemate.

If a government, multilateral organization, or trade association were to guarantee an advanced market commitment for a specific volume of plant protein derived from a novel crop, ingredient manufacturers could safely invest in the R&D and infrastructure to bring this novel protein ingredient to market. In parallel, plant-based product manufacturers would feel comfortable undertaking product development and formulation using this novel ingredient, with the assurance that it would be commercially available at a guaranteed minimum volume within a known time frame. These formulation efforts and subsequent product launches would, in turn, demonstrate that interest in this novel ingredient was merited and thus draw in more processors to increase volume and quality of the ingredient, as is currently happening with pea protein: A surge in launches of pea-protein products is driving an influx of new processing capacity, thereby enabling more widespread use of pea protein in more products.

Indeed, two key constraints emerged through this analysis of the alternative protein industry as a whole: investment in R&D and the infrastructure to scale production of inputs and final products. The recent success of pioneering plant-based brands demonstrates strong product-market fit, in that consumer demand for meat and dairy alternatives has kept growing despite premium pricing, early-days product quality, and occasionally limited availability. With the right product improvements and increased capacity, this industry could catapult to significant market share over the next few decades.

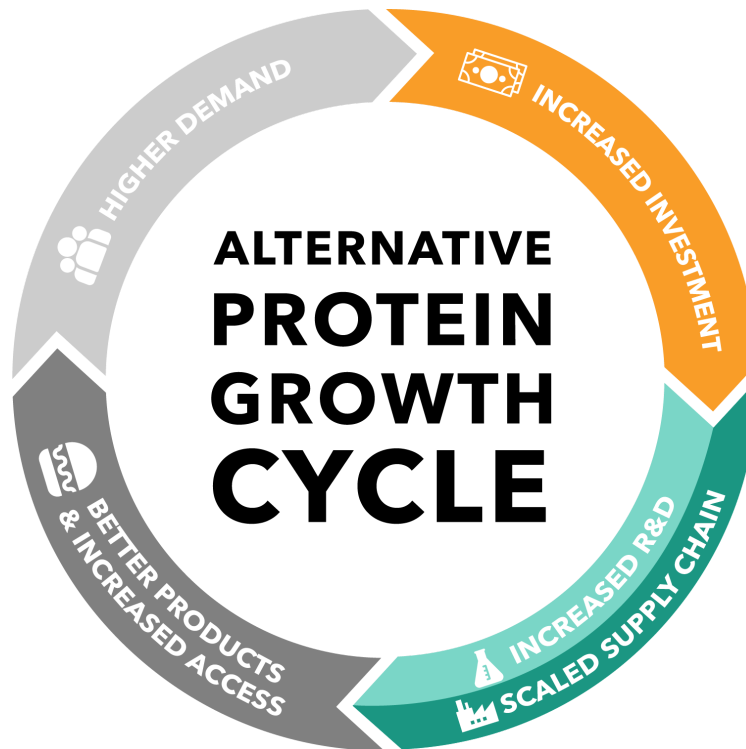


Figure 12: Alternative protein industry growth cycle

Research on alternative protein ingredients and inputs, production equipment and processes, and end-product formulations will enable the industry to develop better products. Infrastructure investments to expand processing capacity and build new end-product manufacturing facilities will unlock economies of scale and provide assured supply. This combination will allow the industry to improve the most important demand attributes:

1. **Quality:** R&D will improve desirable sensory and experiential properties, such as taste, texture, smell, and cooking performance, as well as clean-label eligibility.
2. **Variety:** Technical efficiencies and extra capacity will allow for new and diverse product offerings.
3. **Price:** Better inputs and processes combined with efficiency from scaled production will enable the industry to create products at lower costs and sell them at better prices.
4. **Availability and accessibility:** Increased capacity will allow the industry to make alternative proteins widely available to consumers and ensure that supply keeps pace with rapidly growing demand.

Funding for necessary R&D and manufacturing investment will come from a variety of sources, including product sales and retained earnings, individual and institutional investors, and government grants. Established corporate players from the food, agriculture, life sciences, and other parallel industries—particularly suppliers of key alternative protein inputs—are also

important sources of R&D and infrastructure funding and add value to partnerships by leveraging relevant expertise and experience. Many manufacturing industries take this collaborative approach. Carmaker Tesla's battery and vehicle assembly gigafactory was [financed primarily by Panasonic](#). In the pharmaceutical industry, smaller companies with new drugs from innovative R&D often bring in [larger pharma companies as partners](#) to finance production.

Recognizing R&D innovation and infrastructure investment as the critical rate-limiting factors to industry growth underscores the need for investments and enabling interventions that accelerate both the pace of scientific innovation and the rapid dissemination and commercialization of new technologies. Such interventions include the following:

1. Conducting open-access or non-exclusive licensable research that alleviates duplicative research and development efforts, creating a foundation for private companies to expand and develop their own value-added, differentiated intellectual property.
2. Collaborating on pre-competitive operational activities, such as determining food safety, technical, and product labeling standards; testing; talent sourcing and training; and regulatory advocacy.
3. Creating more shared and contract manufacturing capacity that enables individual alternative protein companies to prove and scale their technology from benchtop to pilot-, demo-, and full-scale production without raising massive capital to build out vertically integrated operations.

As alternative protein options improve, consumers will demand greater volumes and varieties, leading to ever-higher consumer awareness and further accelerating the growth flywheel cycle. Investment in this industry has never been more opportune, and targeting the solutions identified in this analysis will power a sustained and profitable future for alternative proteins.

Recommended Next Steps

Explore the Other Deliverables from This Project

As part of the first iteration of our analysis, GFI developed a suite of materials intended to facilitate continual refinement of our understanding of the industry and to solicit meaningful engagement from stakeholders who are able to transform ideas into real-world solutions. These resources are open-access to encourage ongoing creative brainstorming and to coordinate activity around specific ideas as they matriculate through the engagement pipeline. Refer to Box 1 for links to all the reports and dynamic resources associated with this project, or visit www.gfi.org/alternative-protein-solutions.

Conduct Further Research

While the first iteration of this analysis yielded a wealth of insights, gaps to fill, and high-impact solutions, it is not exhaustive. We aim to keep expanding the analytical tools, focus areas, and engaged stakeholders to identify additional solutions as they arise.

A significant limitation of the current analysis is its focus on more heavily industrialized economies in the global north. Further analysis focused on low- and middle-income countries with large and fast-growing populations would be extremely valuable. Animal protein consumption is closely correlated with income growth; as GDP per capita rises, consumers tend to integrate more meat, eggs, and dairy into their diets. Industrialized animal agriculture is often minimal or less pervasive in developing countries, potentially positioning their food systems to leapfrog to a reliance on non-animal proteins from the start. Additionally, many countries are comparatively advantaged in labor, supply of raw materials, or expertise for a variety of alternative protein supply chain needs, enabling a more globalized market.

The current analysis also focuses most attention on supply-side considerations. Understanding how to generate, sustain, and grow demand is also important for the alternative protein industry. This could involve expanding research to other countries or to underdeveloped areas, such as fermentation, for which little data currently exist. Research could include sensory testing; market research; and measuring the impacts of various types of marketing, promotional campaigns, product positionings, labeling, and nomenclature on consumer adoption. Rigorous consumer behavior analysis to understand the drivers and barriers of product trials, repeat purchasing, and long-term loyalty would also be helpful.

These are some additional analyses GFI would like to see or conduct that are complementary to the aims of the Advancing Solutions for Alternative Proteins initiative:

- Analysis of which types of research would be most valuable for an open-access model, with a determination of how to structure open-access research so it hastens rather than stifles commercialization in the private sector.
- Financing and investment gap analysis, with an assessment of diverse investment and funding mechanisms and their relative value at various stages of industry maturity.
- Production and processing capacity analysis and supply chain modeling.
- Product quality and sensory analysis comparing animal proteins with alternative proteins on attributes that consumers value.
- Cost of goods sold and techno-economic analyses comparing animal proteins with alternative proteins on products and inputs. (A techno-economic analysis for cultivated meat is currently underway, but these efforts should be expanded to all platforms.)
- Portfolio and real-options analysis to create the optimal portfolio of market interventions given various risk, labor, time, and financial constraints.

Get Connected with Partners

We would love to hear from you about the biggest challenges and most needed solutions in the alternative protein industry. If you would like to discuss the analysis process, provide feedback on key project insights, find collaborators, or offer support on critical solutions—or if you are working on or interested in working on a challenge or solution we have identified—[contact us!](#)

Conclusion

Food system transformation is a challenging but vital endeavor. While the initial success of pioneering alternative protein companies and preliminary results from scientific research are promising, this transformation is not inevitable. It is important to build on early successes by investing heavily to remove growth constraints and implement solutions that can scale the alternative protein industry to significant global protein market share. This process will be much faster and easier if the industry effectively integrates insights, tools, and expertise from parallel industries and industrial transformation case studies.

This level of change in the food system is not without precedent. The displacement of small-scale agriculture by industrialized factory farming was itself made possible by scientific and business model innovations, such as refrigerated storage and shipping, boxed beef and processed animal meat cuts, mass feed crop production, centralized slaughtering and processing, and low-cost transportation infrastructure. The result has been cheap and relatively abundant animal protein, but such abundance comes with externalized costs and drawbacks that face increasing scrutiny.

The animal species used for meat, eggs, and dairy were often selected for ease of domestication, not taste, ecological efficiency, or nutrition. Alternative proteins, by contrast, can be designed from the ground up for optimal taste, personal health, public health, and ecological sustainability. They offer a platform with unparalleled variety, nutrition, production consistency, resilience, supply security, and efficiency. The alternative protein industry enables consumers to eat the meat, eggs, and dairy they want, just produced in a better way—making the tasty, healthy, just, and sustainable choice as simple as switching brands.

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Appendices

Appendix 1: Methodological Recommendations: Procedures and Outcomes

Methodological Learnings and Plans for Future Analyses

The scope of the work demanded high time requirements from the participating experts. We asked the same set of questions during interviews as in the online survey, but completing a detailed online survey can be particularly fatiguing. Subsequent iterations of the analysis will encourage greater survey and interview participation through a simplified, shorter questionnaire.

While we found enormous value in one-on-one interviews and asynchronous brainwriting sessions, we would like to integrate in-person interviews and multiple-stakeholder feedback sessions and workshops into future versions of this analysis.

The first iteration yielded comprehensive insights, a list of high-impact solutions, and a framework for continued engagement with the industry. GFI plans to update the analysis and deliver refined versions on a regular basis, building on initial learnings. We will conduct shorter, more targeted versions of the expert interviews, coinciding with the Good Food Conference and other events, such as workshops and summits focused on discrete technology sectors or segments of the value chain, to continue gathering targeted insights.

One potential future direction entails developing a dynamic, scalable, and easy-to-use quantitative decision model. The market is such a complex system of internal and external interrelations that many challenges and opportunities from the first iteration will generate positive and negative feedback loops as the market progresses. Thus, future analyses must consider the system holistically rather than compartmentally. The influence diagram would serve as the model's foundation, but the next step would be to assign numerical values or probability distributions to the impact pathways between opportunity and challenge nodes. After impact

variables had been established, we would conduct sensitivity analyses to identify the most influential nodes and highest-impact interventions or solutions. Adjusting model parameters, refreshing data, and refining nodes or relationships in response to market changes would be straightforward, yielding up-to-date perspectives on the most efficacious solutions.

Changes to Project Methodology and Scope

As a result of early conversations with decision analysis experts, we made some changes to our preliminary methodological goals. We had initially planned to focus equally on all segments of the value chain. However, due to greater complexities, a belief that a supply-side focus is most important for the long-term success of alternative proteins, and lower certainty of influence on the demand side, we determined that focusing on the supply side would give the exercise greater informational value. This focus also aligns with GFI's core competency and the expertise of the vast majority of our industry contacts.

In addition, we discovered limitations that made a quantitative decision model less valuable for the first iteration. The nascence of the industry carries a great deal of uncertainty that could influence the results of the modeling through underlying biases. Furthermore, so that key actors could begin work on important solutions, the urgency to release insights from the expert participation rounds was high. The opportunity cost of time to build and vet a robust quantitative model was too great to justify withholding the qualitative insights. With a new framework in place to collect industry insights, we will continue to gather and refine data, with the expectation that building a quantitative impact model will be possible and worthwhile in the future.

Finally, we revised our model of the value chain and technology segmentation multiple times after the expert participation rounds to better reflect an overarching framework that most accurately contextualized the challenges and opportunities surfaced through this work. These new value-chain and technology segmentation frameworks have already proved useful for coordinating relevant work across multiple projects within GFI, and we plan to use them for ongoing external engagement and ideation exercises.

Appendix 2: Recommended Reading

Thinking in Systems: A Primer

Donella Meadows

Markets are complex, adaptive systems, which means their problems often cannot be solved by simply fixing one piece in isolation from the others, because even seemingly minor details have enormous power to undermine well-intentioned efforts. This primer is an introduction to systems thinking and provides tools for both understanding and changing complex systems.

Technological Revolutions & Financial Capital: The Dynamics of Bubbles and Golden Ages

Carlota Perez

This book describes the dynamics of technological innovation and associated financial bubbles. Perez traces how a model of financial irruption, frenzy, synergy, and maturity phases has repeated itself with the emergence of the age of steam and railways, the age of steel and

electricity, the age of mass production and the automobile, and the current era of information and telecommunication.

Healthy Markets for Global Health: A Market Shaping Primer

The United States Agency for International Development (USAID)

As explained in this [overview from USAID](#), market shaping has been used to improve outcomes in the public health sector. This primer includes a structured approach for assessing market-shaping opportunities through five steps: (1) observe market shortcomings, (2) diagnose root causes, (3) assess market-shaping options, (4) implement a customized intervention, and (5) measure results.

Mastering the Dynamics of Innovation

James Utterback

Most industrial manufacturing markets have evolved similarly, with lots of entrants early on as the technology is nascent, but as a dominant design and production paradigm emerges, a few players consolidate the majority of market share until the next disruptive technology is developed. Tracing this pattern through countless industries, from typewriters to computers and glassmaking, Utterback’s work provides a template for understanding the evolution of manufacturing markets.

Appendix 3: Expert Participants

Note that this is a partial list, as some experts chose not to be identified in this report.

Name	Title	Affiliation	Name	Title	Affiliation
Jim Laird	CEO	3F BIO	Mark Langley	Portfolio Manager	New Crop Capital/Unovis Partners
Lisa Dyson	CEO & Founder	Air Protein			Noblegen
Askar Latyshev		ArtMeat	Giuseppe Scionti	CEO	Novameat
Andy Bass	Chief Marketing Officer	Atlant Food Co	Markus Klinger	Head of Alternative Protein	Novozymes
Gavin McIntyre	Director of Business Development	Atlant Food Co	Eva Sommer	Co-Founder and CPO	Peace of Meat
Simon Kahan	President	Biocellion SPC	Massimo Balacchi	Managing Director	Plant Indeed Consulting
Iñigo Charola	Co-founder and CEO	BioTech Foods	Kimberlie Le	Co-Founder and CEO	Prime Roots
Kris Chatrathi, Ph. D., P.E.	Process Engineer	Black & Veatch	Gary Lin	Founder	Purple Orange Ventures
Celine Schiff-Deb	VP New Product Development	Calysta	Geoff Bryant	Technology Director	Quorn Foods
Caio Malufe	Investment Officer and Business Development Professional	Cargill	Christie Lagally	Founder & CEO	Rebellyous Foods
Arlin Wasserman	Managing Director	Changing Tastes	Daniel Dikovsky	Head of Innovation	Redefine Meat

			and Technology		
Ling Ka Yi, Ph.D.		Chief Scientific Officer/Co-Founder of Shiok Meats	Peter Hurford	Co-Executive Director	Rethink Priorities
Javier Gines Galera	Commercial Development Manager	Chr Hansen	Catherine Tubb	Senior Research Analyst	RethinkX
Curt Albright	Managing Member	Clear Current Capital	Durgalakshmi Sathiakumar	Business and Operations Manager	Shiok Meats Pte Ltd
Dil Thavarajah	Associate Professor	Clemson University	Melissa Facchina	Co-Founder / Co-General Partner of Siddhi Capital and CEO of Siddhi Ops	Siddhi Capital / Siddhi Ops
Rosie Wardle	Programme Director	Coller Foundation	Doug Beacom	VP of Manufacturing / Commercialization	Siddhi Ops
John Garnett	VP Science & Technology	Conagra Brands	David McCormick	COO of Siddhi Ops and Operating Partner of Siddhi Capital	Siddhi Ops and Siddhi Capital
John Sheehy	Global Business Development Manager, Plant Protein Market	Coperion and Coperion K-Tron	Justin Hanlon	Vice President - Alternative Proteins	Smithfield Foods
Huw Thomas		Counterfactual	Elliot Roth	CEO	Spira Inc.
Costa Yiannoulis	Investment Director	CPT Capital	Ido Savir	CEO & Co-Founder	SuperMeat
Vince Sewalt	Head of Regulatory Science & Advocacy	DuPont Nutrition & Biosciences	Avi Shpigelman	Assistant Professor	Technion - Israel Institute of Technology
David Meyer		Food System Innovations	Siddharth Bhide	Science & Technology Specialist	The Good Food Institute
Lejly Gafour	Co-Founder	Future Fields	Wim de Laat	Founder CEO	The Protein Brewery
Jalene Anderson-Baron	Co-Founder and COO	Future Fields	Marcia Walker	Vice President R&D/Innovation	Tofurky
Kurt Schmidinger	Food Scientist, Geophysicist	Future Food	Natalie Rubio	New Harvest Research Fellow	Tufts University
Alexander Lorestani, PhD	CEO	Geltor, Inc.	Fengru Lin	CEO	TurtleTree Labs
Scott May	VP Innovation and Head of MISTA	Givaudan / MISTA	Ian F. Smith		UC Irvine
Chris Gregson, PhD	Founder	Greenstalk Food Consulting	Amy Rowat	Faculty, Integrative Biology and Physiology	UCLA
Benamina Bollag	Founder	Higher Steaks	Marianne Ellis		University of Bath, UK
Alex Kopelyan	Partner & Program Director	IndieBio	Eike Luedeling	Prof. Dr.	University of Bonn
J. Kevin Kraus	Senior VP and Special Advisor	Lallemand Inc.	Dan Altschuler Malek	Managing Partner	Unovis Asset Management & New

			Crop Capital		
Raffael Wohlgensinger	Co-Founder & CEO	Legendairy Foods	Tim Noakesmith	Co-Founder / Chief Commercial Officer	Vow
Yossi Quint		McKinsey & Company	George Peppou	CEO	Vow
Tyler Huggins, PhD	Co-Founder & CEO	Meati Foods	Soroush Pour	Head of Engineering	Vow
Shou Wong	Head of Technology Scouting	Merck KGaA / MilliporeSigma	Atze Jan van der Goot	Prof. Dr.	Wageningen University
Robert Yaman	Business Operations Manager	Mission Barns	Mark Warner	Founder	Warner Advisors LLC
Larisa Rudenko	Research Affiliate	MIT, Program on Emerging Technologies	Brian Plattner	Process Technology Director	Wenger Manufacturing, Inc.
Peter Verstrate	COO	Mosa Meat			Wildtype
Thomas Jonas	CEO & Co-Founder	Nature's Fynd	Parendi Birdie		
Brian Spears	CEO	New Age Meats	Michael Sadowsky	Data Scientist	
Mihir Pershad	Founder & CEO				

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About GFI

The Good Food Institute is a global nonprofit building a sustainable, healthy, and just food system. With expertise across the scientific, regulatory, industry, and investment landscape, we are accelerating the transition of the world's food system to alternative proteins, using the power of food innovation and markets.