American National Competitiveness & the Future of Meat

Why the United States needs to build up a domestic alternative protein industry

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Executive Summary

The United States is at a protein-policy crossroads. In recent years, plant-based meats, eggs and dairy have grabbed media attention and, more to the point, market share. Now comes a potential game-changer in the form of "cellular agriculture," a suite of biotechnologies that can replicate actual animal products, but without the animals. The benefits are potentially enormous: economic growth and stronger national competitiveness in global markets, new tools to meet climate and biodiversity targets, and mitigation of pandemic and antibiotic-resistance risks.

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The protein sector is being remade not just by technology, but by consumer trends. The world's population is growing in numbers and affluence, and this means greater demand for protein-rich foods. At the same time, consumers' concerns about personal health and environmental sustainability are driving openness to animal-free options, especially among rising middle-aged and younger market segments that will dominate future demand. These factors have led to an explosion of investor interest in the alternative protein space, with 2021 seeing record deals and growing production capacity. Governments around the world have taken note and are increasing public support for these new ways of making meat.

What does all this mean for the United States? In the short- to medium-term, alternative and conventional proteins can both grow in an expanding market. But alternative proteins are growing faster and, over time, are likely to capture more and more market share. As investment follows consumer spending, shocks will ripple up and down the value chain, generating real impacts for local communities around the country. This means both opportunity and risk. On the one hand, traditional American strengths in agriculture, food processing and biomedical technology, together with research and development capabilities that are among the best in the world, give the United States a natural advantage in what promises to be a global

innovation race. On the other hand, if we fail to act, the initiative will pass to other nations (as we have seen with wind and solar energy), and Americans could face not only lost opportunity, but the social and economic dislocations that tend to accompany value-chain realignments.

The US private sector is doing its part, but government support currently lags behind. Huge promise always comes with formidable challenges, and the alternative protein industry is no exception. Government must step in to bridge key gaps when it comes to scientific research, regulation, commercial scale-up, and workforce development. Europe, Canada, Israel and Singapore have already dedicated significant funds and are planning more, while Japan and China show signs of accelerating involvement. These interventions will reshape the alternative protein space. As former Secretary of Agriculture Sonny Perdue pointed out, "We're going to see these technologies go to places around the world that are more conducive to their development, and frankly China may be one of those." [1] Indeed, China has signaled its ambitions in recent comments by President Xi Jinping and in its latest five-year plan, which together make explicit commitments to the full range of alternative protein processes and technologies.[2]

How the federal government decides to act on alternative protein policy may well dictate the role that the United States can play in the future of protein production. An expansive and ambitious policy platform that can nurture a domestic alternative protein industry will foster economic development and job growth in the face of international competition, while aligning with the longer-term aim of promoting climate-smart agricultural production.

The overarching goal of US alternative protein policy should be a level playing field. This means making it easy for US companies to innovate, grow and continue to do business at home, here in America. The same system that has afforded the conventional animal agriculture industries with billions of dollars in R&D investment and subsidies each year must be extended to alternative proteins in order to ensure that the United States remains a global leader in this emerging space. What specifically needs to happen? The policy platform for alternative proteins consists of three planks: (1) publicly-supported open-access research; (2) assistance in commercial scale-up, including infrastructure, regulation, and manufacturing facility investments; and (3) capacity building through workforce development.

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Now is the crucial moment. Countries that support their alternative protein industries will enjoy first-mover advantages. With excellent prospects for developing a new industry of global significance—one that promises clean manufacturing with good-paying jobs, diversified domestic demand for farmers' crops, and new sources of valuable IP—the United States must lead the world in supporting the future of meat.

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Source: UPSIDE Foods

1. Introduction

Alternative proteins—a term used here to refer to the full range of substitutes for conventional meat, eggs and dairy—have grown rapidly in just the past few years. Once relegated to niche market segments, these foods have gone mainstream thanks to technical advances in plant processing and consumer demand shifts toward "flexitarian" diets that incorporate both conventional and alternative options. This is a welcome trend. On an individual level, it gives consumers more choice, which improves their welfare. On a social level, it means efficient conversion of inputs to outputs for a climate-friendly supply of protein. Moreover, it reduces a range of social health risks associated with intensive animal agriculture, especially the worrying increase in resistance to antibiotics and the danger of new epidemics crossing over to humans from concentrated livestock populations.

With growth comes new challenges. The alternative protein industry is fast approaching make-or-break moments that will determine whether it can achieve the full scope of its promise and what this will mean for the United States. On the horizon are crucial decisions about scaling up production, including how to surmount attendant scientific, technical and commercial barriers and where to site facilities.

To understand what is at stake, it is helpful to begin with a brief overview of alternative protein technologies, which can be classified into three

broad categories: plant-based, cultivated and fermented. Plant-based meats—like the Impossible and Beyond burgers—use advances in production methods, ingredient development, and, in some cases, genetic modification to provide the taste and texture of meat. The newer products have been able to attract not just vegetarians but also meat eaters. Their makers ultimately aim to achieve complete price and taste parity with conventional meat in order to fundamentally shift consumer preference. Although still a relatively small proportion of the overall meat market, their dramatic growth is driving expectations that market share will climb rapidly. The success of plant-based milks, which now make up about 15% of the overall US milk market, has already shown the way.

Cultivation goes one step further to produce actual meat without animals. Sometimes referred to as cell-based, lab-grown, or cultured, cultivated meat is real meat grown in bioreactors (specialized vessels known colloquially as "cultivators") and then shaped into final cuts using food-based scaffolds or 3D printers. Although currently not available for commercial purchase anywhere but Singapore, cultivated meat startups have generated enormous media and investor interest as a genuine threat to disrupt the entire global meat industry.

A third development is the rise of precision and whole biomass fermentation. Making meat analogs by traditional fermentation is an age-old practice in which foods such as soybeans are changed by microbial treatment into a product with different taste, texture, and nutrition, such as tempeh. However, precision and whole biomass fermentation are newer food processes. Precision fermentation is a scientifically and technologically sophisticated method that uses carefully designed microorganisms to produce specific functional ingredients—such as beef or milk proteins, vitamins, fats and flavors—for alternative protein products. Biomass fermentation takes advantage of the rapid growth of microorganisms to efficiently produce large amounts of protein-rich foods by utilizing the microorganisms themselves as the ingredient.

This brief run-through is enough to clarify two key points. First, the alternative protein space is highly scientific and technological, sitting at the juncture of agriculture, biochemistry, industrial engineering and materials science. This means its further growth will depend heavily on research and development (R&D). It also means that it faces the typical commercialization challenges of industries that are young and R&D-intensive. In particular, the move from proof-of-concept to commercially viable production at scale is especially difficult. It requires working out countless technical problems in a cost-effective manner while developing reliable supply chains and marketing channels.

Governments will play an essential role in moving the industry forward. The question is, which governments?

This leads to the second key point. Government will play an essential role in moving the industry forward. The question is, which governments? At present, US companies are leaders in the

space, but their position cannot be guaranteed as global competition intensifies and large scale production becomes the name of the game. Too often, in recent decades, American scientists, technologists and entrepreneurs have innovated, only to see production and continuing development migrate somewhere else. Were that to happen in alternative proteins, Americans would lose out on a huge growth sector that will bring with it good jobs in clean manufacturing facilities, improved prospects for exports of foods and production equipment, and valuable intellectual property.

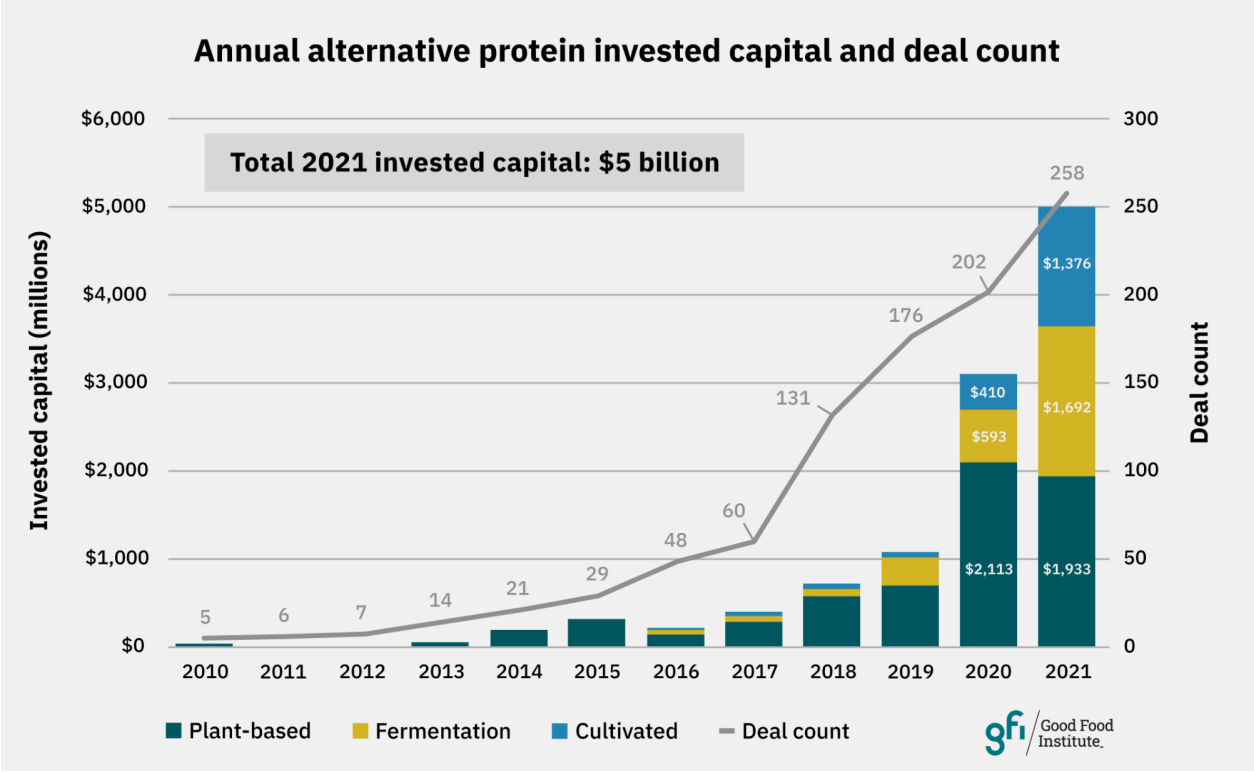
This white paper aims to help the United States steer the best possible course. It begins by laying out the current landscape of private investment in order to show the industry's soaring growth and imminent arrival at key decision points. It next looks at what governments around the world are doing to advance their domestic alternative protein industries, including, crucially, the siting of large-scale production facilities. This acts as a springboard for considering the inadequate role played by the US federal government to date and why the current trajectory of inaction must be corrected. Finally, specific policies are recommended.

2. Investors are betting on alternative proteins

2.1 Key Points

- Investors are pouring money into alternative proteins, betting that consumers are ready and willing to increase their purchases of plant-based, fermented and cultivated foods now. Many believe that alternative proteins have similar transformational potential as renewable energy and electric vehicles.
- Consumer trends and academic research back up these growth expectations and indicate that alternative proteins enjoy key demographic advantages with rising generations.
- Investment is leading to construction of production facilities and creating new jobs with upstream benefits for farmers, processors and equipment manufacturers.
- Key scientific, technological, production, supply chain, and financial challenges remain.
- **Upshot**: The federal government must provide R&D, regulatory and infrastructure support or risk seeing investment go elsewhere.

Figure 1: Annual alternative protein invested capital and deal count



2.2 Investment is accelerating

Investor interest in alternative proteins has surged in dramatic fashion over the past two years. Between 2010 and 2020, nearly $6 billion of venture capital flowed into the sector, with more than half of the total coming in just 2020.[3] The momentum continued in 2021, which proved a banner year for alternative protein investment with some $5 billion in new funding. In the plant-based space, Impossible Foods added a $500 million funding round in November. In the rapidly emerging fermented and cultivated spaces, Eat Just, Perfect Day, Nature's Fynd, and Future Meats each raised $300 million or more. Altogether, cultivated meat companies alone attracted $1.4 billion in new funding in 2021.[4]

Major alt protein funding rounds in 2021

Company	*Space*	*Amount (mil)*
Impossible Foods	Plant-based	$500
NotCo	Plant-based	$235
v2foods	Plant-based	$110
Fazendo Futuro	Plant-based	$58
Miyoko's Creamery	Plant-based	$52
Eat Just	Plant-based & cultivated	$467
Future Meat	Cultivated	$347
Aleph Farms	Cultivated	$100
Mosa Meat	Cultivated	$85
Blue Nalu	Cultivated	$60
Perfect Day	Fermented	$350
Nature's Fynd	Fermented	$350
Meati Foods	Fermented	$50

Source: Pitchbook data.

High current and projected growth rates — together with upside risk for industry-wide disruption—are driving this investment.

In 2020, US plant-based food sales grew 27 percent, nearly twice the 15 percent rate for retail food sales overall. Similar growth occurred in Europe, and observers agree that prospects in Asia are very large.[5] The most bullish analyses foresee alternative proteins overtaking conventional ones worldwide between 2040 and 2050, but restrained outlooks also project impressive growth. Kearney consultants predict that alternative proteins will make up 45 percent of the global protein market by 2035, whereas the Boston Consulting Group puts the share at a more conservative 11 percent.[6] Even the lower figure, however, implies an extremely significant increase. Taking a middle path between these and other projections, the investor network FAIRR envisions alternative proteins' growth arc rising to about 28% of the market by 2035. This translates into a $400-500 billion industry with years of high growth still ahead.[7]

2.3 Consumers are eager to buy alternative protein products

Plant-based substitutes for animal products have been around for a long time, but two recent developments have raised their profile and brought them to new markets. First has been the stunning rise of plant-based milks, which now claim 15 percent of the US milk market.[8] Second has been the blockbuster rollout of the Impossible and Beyond burgers, which mimic conventional patties far better than previous products and are now available in tens of thousands of grocery and restaurant outlets around the world. Whereas previous plant-based foods primarily targeted niche vegetarian markets, the new products are pitched more broadly. In the short term, they aim for the growing "flexitarian" market segment of people who consume both conventional and alternative options. In the long term, they aim for everyone.

Among Zoomers and Millennials in the U.S. and UK, a third (31-34%) were "very" or "extremely likely" to buy cultivated meat and nearly another half (46-49%) were "somewhat" or "moderately likely."

"US and UK Consumer Adoption of Cultivated Meat: A Segmentation Study"

Biomass fermentation under the brand of Quorn has also been commercially available for decades, but the past couple of years have seen additional biomass fermentation companies like Nature's Fynd and Meati Foods use novel fungi to biomimic meat and dairy products. In the precision fermentation category, Perfect Day sells ice cream and other foods made with cow-free dairy proteins that it produces by reprogramming specialized microflora.

Cultivated foods using cutting-edge production processes are just beginning to come onto market. Eat Just, maker of the popular plant-based JUST Egg, has gained regulatory approval from Singapore to sell its cultivated chicken nuggets. The cultivated seafood startup Wildtype recently announced restaurant and retail deals that could soon bring cultivated salmon to sushi counters nationwide.[9] With regulatory approval in the large American, European and Asian markets thought to be imminent, cultivated meat and seafood are likely to become consumer realities very soon.[10]

Investors expect that consumers will buy more and more of these products, and this expectation is backed up by substantial academic research. Plant-based meats currently hold 1.5 to 3 percent of the US protein market, by sales, but surveys find that 20 to 33 percent of consumers would substitute them for conventional meats if prices were the same. That rate falls to 5 to 17 percent for cultivated meat, which remains only a hypothetical option at this point. Yet even a conservative scenario implies a huge total addressable market (TAM) worth billions of dollars, and given overall growth in the protein market, alternative proteins' gains are not limited to substitution. Studies generally find "that around two thirds of Americans say that they would try cultivated meat, and 25–50% say that they would eat or buy it regularly." There is also good reason to believe that once a critical mass of early adopters swings toward alternative proteins, momentum will increase.[11]

A key fact is that alternative proteins enjoy important demographic advantages. Consumer research consistently finds that younger generations are more likely than older ones to buy plant-based meats and to want to try cultivated meats once they become available. For example, among Zoomers and Millennials in the US and UK, a third (31-34%) were "very or extremely likely to buy" cultivated meat and another nearly half (46-49%) were "somewhat or moderately" likely to. A second important finding is that consumers with children under the age of twelve are also significantly more open to alternative meats, suggesting that the

youngest generations will form lifelong eating habits around alternative proteins from early childhood. Together, these data imply large latent demand that will respond rapidly as plant-based, fermented and cultivated meats become more widely available and price competitive.[12]

2.4 Investment is materializing on the ground

With these trends in mind, investors are beginning to channel capital into the construction of new production facilities. The past few years have seen the opening of ever-larger plant-based meat and biomass fermentation factories in the US, Europe and Asia. Newer entrants are moving to production, too. Toward the end of 2021, Perfect Day announced a $350 million Series D funding round that will go, in part, to expanding its operations at the Synthetic Bioprocessing Facility it acquired from Utah State University the year before.[13] In December, Nature's Fynd announced plans to begin construction on a 200,000-square-foot production facility in Chicago that will employ 200 workers by 2023.[14]

Puris's pea-protein production facility in Dawson, Minnesota

Source: Puris

Upstream suppliers are also scaling up. In 2019, Cargill invested $75 million in Puris, a maker of concentrated pea protein, to remodel a 200,000-square-foot facility in Dawson, Minnesota. Opened in October, the facility creates nearly 100 local jobs and sources raw peas from more than 400 area farmers.[15] Meanwhile, in 2020, Ingredion poured $185 million into expanding its plant-based protein business, including a state-of-the-art facility in South Sioux City, Nebraska, for the manufacture of pea-protein isolates and starch.[16]

Until very recently, precision-fermented and cultivated foods were produced only in company labs. That began to change in late 2021, when Upside Foods opened the world's first commercial-scale, cultivated-meat production facility in Emeryville, CA—a 50,000 square-foot space that the company says will be able to produce 400,000 pounds (about 180 metric tons) per year.[17] Shortly thereafter the Israeli cultivated meat startup, Future Meat, raised $347 million that it says it will use to build a manufacturing plant somewhere in the Midwest.[18] These developments are already leading to positive upstream effects. Cultivated meat is made in bioreactors, which are currently produced only for pharmaceutical applications. A huge field lies open for equipment manufacturers that can design food-grade bioreactors, and the startup Ark Biotech has formed to address this opportunity.[19]

2.5 Upshot

The alternative protein industry has enormous promise, but many barriers remain as upscaling occurs. For example, until now, plant-based meat makers have had to source proteins mainly from the side streams of major commodity crops. This means that there is a critical need to diversify and optimize protein inputs while also building out robust supply chains. Similarly, there is a need to improve manufacturing equipment and other techniques for plant-based production and processing.

The challenges and opportunities multiply when it comes to cultivated meat. The industry is limited by a lack of well-characterized animal cell-lines—for both seafood and land animals—that are optimized to food manufacturing at scale, high-cost growth media based on medical- instead of food-grade ingredients, the technical difficulty of producing whole cuts such as steak and chicken breast, and expensive manufacturing processes and equipment that are currently incapable of mass-production at conventional meat industry levels.

Similarly, the fermentation industry relies on and is limited by a lack of microbial species that have been characterized, screened and commercialized for food production. Fermentation firms, like plant-based and cultivated meat firms, are hampered by high-cost inputs and feedstocks due to a lack of products optimized for these novel industries and to immature supply chains. Again, as with the rest of the alternative protein industry, fermentation production at scale requires new manufacturing processes and equipment that can be efficient and cost-effective at scale.
To overcome these barriers, governments will have to step in. In particular, governments have to fund open-access R&D, set appropriate regulations, establish relevant skills training, and incentivize capital expenditures for commercial scale-up. It is important to stress that scientific and technological progress in these key areas could be very rapid. Although nothing is guaranteed and the technical challenges should not be underestimated, the essential question might not be if critical milestones will be reached but when and by whom. A "global race for alternative proteins" is already taking shape, according to some.[20] The next section reviews current efforts by governments around the world to win that race.

3. Governments are putting money into alternative proteins

3.1 Key points:

- The United States currently trails Europe, Canada and possibly Singapore in public R&D funding for alternative proteins, with Israel close behind. Several other countries, including Britain, Japan and China appear to be ramping up their public commitments. When including private sector subsidies, the UK, Israel, Singapore, and Qatar move well ahead of the US in overall public support for alternative proteins.
- Foreign government investment in alternative proteins is being driven primarily by food security concerns, climate targets, and prospects for economic growth. Additional drivers pertain to human health, particularly the mitigation of antibiotic resistance and prevention of new pandemics from zoonotic transference. These drivers will remain powerful forces for the foreseeable future.
- Asia is the largest and fastest-growing market for alternative proteins, positioning its companies to reap the greatest rewards and motivating growing support from regional governments.
- **Upshot:** While private investment has given the US an early advantage, the current low level of US government vision and support suggests that American leadership in the alternative protein space is far from guaranteed. To avoid being left behind, federal and state governments must dramatically increase their involvement.

3.2 What governments around the world are doing

The current wave of alternative protein research and commercial production has mainly come from university scientists and early-stage investors. To date, governments have mostly remained on the sidelines, but that is changing quickly.

Europe, Canada, Israel and Singapore are dedicating significant funds and planning more, while Japan and China show signs of accelerating involvement. Because funding is often rolled into larger programs, it is difficult to say exactly how much is being directed toward alternative proteins. Moreover, the role of state-owned investment funds and enterprises, which is especially relevant to Asia, can be opaque. But it is clear that public investment in the alternative protein space is growing.

Leaderboard

Known government grants for alt protein R&D

Rank	Country	Total (mil. $)
1	EU nations	42.9
2	Canada	39.7
3	United States	26.4
4	Singapore	25.2*
5	Israel	17.2
6	China	3.1**
7	Japan	2.8

Source: GFI Research Grant Tracker. Figures include R&D funding only, excluding government support for commercialization.

**Singapore has committed tens of millions of dollars in funding for alternative protein research and has awarded numerous grants, but exact figures are unavailable. Under its "Future Foods: Alternative Proteins" program, Singapore has funded four projects at up to $11 million each (https://www.a-star.edu.sg/Research/funding-opportunities/singapore-food-story-r-d-programme-future-food-alternative-protein-iaf-pp-grant-call). Under its "1st Alternative Protein Seed Challenge" program, it has funded seventeen projects at up to $370,000. It is therefore possible Singapore has surpassed the United States and even the EU nations in awarded grant money. The figure in the table assumes that awardees have, on average, received 50% of the grant maximum.*

***Information about China is hard to come by. It is ranked here above Japan because it has announced several initiatives, including a Ministry of Science and Technology grant estimated at 20 million RMB or $3.1 million.*

US spending to date has been relatively paltry. In December, the USDA announced a five-year, $10 million grant to a consortium of universities led by Tufts University to study cultivated meat, while the NSF has already begun supporting related research at UC Davis with a $3.5 million grant. Besides this, US funding for alternative protein R&D consists of a handful of SBIR phase I and II grants, a smattering of state and federal funding for a few isolated scientific studies, and a project by the state of North Carolina to establish a food processing innovation center that will, among other things, develop plant-based ingredients.[21] Total US funding for alternative protein R&D is in the neighborhood of $25 million, which is unimpressive relative to competitor nations. Indeed, the $13 million in R&D grants made by the Good Food Institute puts this five-year old nonprofit organization uncomfortably close on the heels of the entire US government—federal, state and local.

Both what other governments are doing and the larger trends driving their decisions threaten to disrupt the United States' early lead in the sector, which was secured by private

investment. Europe is focusing increasing attention and resources in this space. Over the last few years, the European Union has committed over €50 million (about $57 million) in research grants through several different initiatives.[22] This alone goes well beyond what the United States has done. But individual EU member nations have also provided substantial funding for scientific research, commercial upscaling and supply chain buildout, with Denmark recently announcing €168 million ($190 million) in funding to advance plant-based foods.[23] Britain, which no longer takes part in EU programs, has included alternative proteins in a new, £90-million ($122 million) agricultural modernization initiative. Its national food strategy review recommends raising alternative protein funding by £125 million ($170 million) or more, citing fears of falling behind.[24] Altogether, then, European government spending may soon surpass that of the United States by *an order of magnitude* or more.

Closer to home, Canada has also far outspent the United States. At both the federal and provincial level, it has committed hundreds of millions of dollars with the aim of establishing Canada as a global leader in the supply of alternative protein ingredients and finished products. To this end, the Protein Industries Supercluster, a public-private venture to develop and support plant-based companies, leverages $173 million in government spending with $227 million in industry investment. It has funded over 20 projects and helped to develop more than 300 new products and services.[25] Simultaneously, Saskatchewan has abundantly supported its alternative protein industry through its Food Industry Development Centre Inc., a public-private non-profit that aims to position the province as key to the plant-based protein industry. Thanks to such public leadership and financial support, Canada is successfully building a formidable plant-based protein supply chain that already represents something of a lost opportunity for American farmers and ingredient makers.

Singapore, Israel and Qatar, with a combined population less than a twentieth the size of the United States, have also equaled or surpassed US efforts, especially when it comes to research and commercialization of cultivated meat. Singapore has made alternative-protein R&D grants up to $50 million, provided early regulatory approval to cultivated meats, and launched a new government-funded research initiative to facilitate cultivated meat development through public-private partnerships.[26] Furthermore, its sovereign wealth fund, Temasek, has invested heavily in plant-based and cultivated meat companies. Meanwhile, the Israel Innovation Authority has approved a new Cultivated Meat Consortium, consisting of twelve companies and nine academic labs, which will receive up to $19 million in government investment. It has also signaled high-level support with its former prime minister and current president each engaging in well-publicized tastings of cultivated chicken. Finally, Qatar's sovereign wealth fund, the Qatar Investment Authority, led a $200 million investment round for Eat Just, while Doha Venture Capital (a state-backed investment fund) and the Qatar Free Zones Authority have announced plans to construct a $200-million Eat Just cultivated meat production facility.[2]

Supply chain disruptions from the pandemic have only increased awareness of food security and sovereignty and strengthened national resolve to lower import dependency.

3.3 What is driving these government interventions?

Several factors are motivating governments to devote resources and attention to alternative proteins now. None of these factors is likely to wane soon, suggesting the trend of rising government involvement will continue. A top concern is food security and sovereignty, especially for small, land-constrained countries like Israel, Qatar, Singapore, and the Netherlands. Supply chain disruptions from the pandemic have only increased awareness of the issue and strengthened national resolve to lower import dependency and to open new avenues of protein supply. The pandemic has also underscored the relevance of food sovereignty for larger powers like the EU, Japan, and China, each of which has said it wants to reduce reliance on imports of livestock feed like soybeans, an important US export.[28] Potential trade disruptions from geopolitical competition between the United State and China further raises the stakes for securing adequate sources of protein.

Climate targets and economic growth potential are the two other leading drivers, especially in Europe and Canada. A recent IPCC report highlights agriculture's contribution to global greenhouse gas emissions, which at about a fifth of global emissions exceeds that of transportation.[29] Animal products are responsible for a large proportion, perhaps more than half, of that figure. The plurality of both global methane and global nitrous oxide emissions, which are about 30 and 300 times as potent as CO2, come from ruminant digestion and manure decomposition, respectively. As the world shifts toward renewable energy, the proportion of greenhouse gasses attributable to meat production will continue to rise. In addition, planting animal feed requires vast acreage, leading to deforestation. Conversely, reducing fodder crops and reconstructing ecosystems offers a climate mitigation opportunity as high as 547 gigatons of CO2 equivalents by 2050.[30]

The EU and its member states, which have set aggressive climate targets in keeping with domestic political trends increasingly attuned to climate change, now regard alternative proteins as a key means to reduce agriculture-related emissions. At the same time, alternative proteins are understood as an important economic growth opportunity. For example, Canada aims to supply 10 percent of the world's alternative protein exports in the coming years while prioritizing climate-smart agriculture and clean manufacturing.[31] Similarly, Horizon Europe—the EU's innovation investment program—recently announced a €32 million ($36 million) alternative proteins program in line with the climate cluster within its "Global Challenges & EU Industrial Competitiveness" pillar.[32]

Finally, a shift to alternative proteins will mitigate other key risks that should also serve as key incentives for governments. More than 70 percent of antibiotics produced globally are fed to farm animals. This is causing antimicrobial resistance that is already a leading cause of death and is predicted to kill more people per year than cancer by 2050.[33] A distinct but equally alarming health threat comes from the likelihood that new pathogens will continue to leap from animals to humans, a process known as zoonotic transference. According to the United Nations Environment Program, such zoonotic transference from increased meat production is the most likely cause of the next pandemic.[34] Expansion of alternative proteins therefore promises to come with massive health benefits.

3.4 A closer look at Asia

Asia will be the largest and fastest-growing consumer market for alternative proteins over the coming decade, offering immense opportunities for companies that succeed in mastering new innovations, production processes, and supply chain management.[35] The Chinese plant-based meat industry alone now tops $1 billion.[36] Cargill, for instance, chose China to debut its new plant-based meat brand, PlantEver. The company anticipates "breakthrough innovations" in the alternative protein space and that "Asia will lead in that innovative process." Smaller regional companies, such as Indonesia's Green Rebel Foods and Singapore's Growthwell Foods, are expanding production capacity as much as tenfold, in some cases with the help of state-sponsored incubators and investment funds such as the food tech research facility run by Singapore's Agency for Science, Technology and Research (ASTAR) and Asia Sustainable Foods Platform, a company controlled by the state-owned Temasek Holdings.[37]

What role will Asia's heavy hitters play? This remains something of a question mark, but there are signs of a new determination to move resources into the alternative protein space. In 2020, Japan declared alternative proteins an "important sector" and may already have earmarked $20 million for "various cell-based meat projects." The government has granted $2.2 million to IntegriCulture, a Japanese food tech startup aiming to supply growth media and other technical solutions to cultivated meat makers. The grant funded the construction of a pilot production facility that presumably helped secure the firm's $7 million funding round announced in January 2022.[38]

The Japanese government's new focus appears to derive from concerns over food security due to climate change and the increasing frequency of zoonotic transference. In recent years, meat from land animals has displaced fish as the main protein source in Japanese diets and demand is expected to continue rising despite a shrinking population.[39] With an exceptionally high dependence on long-distance imports, this situation has caused concern among national

policymakers. We can reasonably surmise that Japan will pursue protein innovation as a key to its agricultural, environmental, developmental, and strategic interests.

India appears to be making similar calculations. In 2019, the Centre of Excellence in Cellular Agriculture, a partnership between the Good Food Institute India and the Institute of Chemical Technology Mumbai, opened with funding from the state of Maharashtra. The center aims to actualize India's potential as a manufacturer of cultivated meat to export internationally and to meet growing domestic demand for meat products. The national government has also provided funding to two research centers—the Centre for Cellular and Molecular Biology and the National Research Centre on Meat—for R&D to upscale cultivated meat production to bolster India's position as a protein producer.[40]

China has likewise made recent moves suggesting a turn toward alternative protein research and development. Public information is hard to come by, but several known initiatives seem to indicate the government's direction, including the inclusion of cultivated meat in the most recent Five-Year Plan. More concretely, the Ministry of Science and Technology is funding a Green Biological Manufacturing R&D program that will provide an estimated $3.1 million for alternative proteins work. A project titled "High Efficiency biological manufacturing technology of artificial meat" received three-year funding at Jiangnan University, one of China's top agricultural science programs. And there is additional funding for plant-based and cultivated meat research through the National Natural Science Foundation of China, the China Meat Food Research Center, and the Beijing Academy of Food Sciences.[41]

As elsewhere, larger trends suggest what is driving Chinese interest in alternative proteins. China is the world's biggest meat producer, but its population density and growing affluence mean it will have trouble supplying rising meat demand domestically. Its heavy reliance on soy and corn imports for animal feed—overwhelmingly from the United States, Argentina and Brazil—raise food security concerns. Since the Chinese Communist Party (CCP) has asserted its claims to authority based on rising living standards, it may be especially sensitive to any potential disruptions to meat consumption. This is likely behind recent moves toward approving the use of high-yielding, genetically modified (GM) soy and corn seeds.[42] Presumably it is also the reason that the famed Belt and Road Initiative aims to strengthen agricultural trade with the prime grain, soy, and grazing lands of Central Asia.[43] Kazakhstan and Mongolia, in particular, have seen large investments in meat processing and animal feed crops.[44] For example, Kazakhstan's soybean production has seen rapid growth from almost none in 2000 to over 250,000 tons in 2018, a compound annual growth rate of 26%.[45] However, this is still a miniscule amount compared to American and Brazilian imports. Central Asia can at best supplement China's demand for meat and animal feed, and even this will take a long time. While the use of GM seeds could have a bigger effect, this too would take time.

Given the basic situation of limited land and rising protein demand, it is probable that China will show increasing interest in alternative proteins as at least a food security hedge, with the ability to quickly ramp up production should a promising moment arrive. According to one well-placed fund manager, "China is starting to look at cell-based as a way of providing protein for its population." Large increases in agricultural R&D funding by government agencies and state-owned enterprises over recent decades hint at China's capacities. In addition, the need to reduce greenhouse gas

emissions while continuing to rely on coal energy, the risks of crippling livestock diseases recently underscored by the devastating African Swine Flu epizootic, and the prospects for economic growth all suggest that government support for alternative proteins will continue to grow.

3.5 Upshot

What can we learn from this brief survey of government funding activities around the world? First, the United States is already behind in terms of government involvement, especially when it comes to funding targeted R&D and providing commercialization support. Second, it is safe to assume that foreign governments will continue to increase their public commitments, as has been the trend over the last two years, because the underlying drivers are fundamental and durable. Consequently, the United States public funding gap could widen.

Unless federal and state governments step up their efforts, American leadership in the alternative protein space cannot be assured. That leadership, to date, has emerged from core national strengths in basic research, risk-taking startup culture, and robust early-stage investment institutions.

But the coming set of challenges revolve around systematically investigating specific scientific questions as they emerge, solving and optimizing a matrix of technical requirements, addressing the economic difficulties of moving from proof-of-concept to commercial viability at scale, training a skilled workforce, and incentivizing huge investments in physical infrastructure within the United States. These require new and greater government commitments. The next section expands on the upcoming risks and opportunities before delving into specific needs and policy recommendations.

4. What will this mean for the US?

4.1 Key Points

- Generating innovation is not the same as building an industry. Without support for the crucial middle stages between proof of concept and commercial viability—the "commercialization valley of death"—American companies that currently lead in alternative proteins could lose out to foreign competitors. A comparison to the history of wind and solar energy illustrates the problem.
- Investing in alternative protein R&D and commercial scale-up here in the United States will deliver clean, high-tech domestic manufacturing with jobs up and down the value chain and beyond.
- Alternative proteins may complement, as well as compete with, conventional proteins so there is scope for mutual benefit in the context of rising global demand. However, the United States should implement damage-mitigating and compensatory measures should displacement occur.
- **Upshot:** Government-controlled variables will help determine both the global and domestic siting of new production facilities and knowledge centers. The most important of these variables are R&D, regulation, workforce training, and financing.

American policymakers will have to grapple with a range of issues as alternative proteins gain ground in the global marketplace. They will have to consider the domestic repercussions of a rolling protein transition, including its impacts on workers, farmers, equipment suppliers, and financial stakeholders. To avoid negative shocks, they will have to consider how American businesses can continue to lead the field through the shift from early-stage innovation to a maturing industry and how to do so in ways that maximize broad-based gains while minimizing losses. The goal should be to nourish full-spectrum development here in the United States, with a focus on large-scale, efficient, and competitive manufacturing. Only in this way can the US continue to lead alternative proteins forward while generating good jobs, remunerative sales for farmers and suppliers, and attractive opportunities for investors.

4.2 From innovation to industry: avoiding the "innovate here, produce there" trap

The United States generates plenty of innovations but too often fails to ensure they develop into maximally successful American industries. A variety of government supports, from basic research to early-stage development grants, together with a robust venture capital ecosystem, are enough to ensure that promising ideas are quickly recognized and brought to the proof-of-concept stage. But at this point a problem typically appears: how to secure financing to cross the "commercialization valley of death"—the space between proof of concept and sufficient operational scale and know-how to win in the global marketplace. It turns out that the US financial system is poorly structured for this task. The venture capital model depends on big paydays from a handful among many early-stage investments. This means that even good and workable innovations can get dropped if their financial upside appears limited or distant. On the other hand, large institutional investors prefer known quantities over risky bets and hesitate to provide financing until commercial viability has been demonstrated. As a result, many promising ideas never get to commercialization or only do so abroad in a pattern sometimes called "innovate here, produce there."[49]

This, in a nutshell, is the scenario that American alternative protein companies are quickly approaching. As mentioned, American companies are currently at the forefront of the alternative protein space. This advanced position builds on decades of public investment in scientific research, reflecting the US commitment to basic science as a core feature of its innovation system. But the next step is to grow past the early adopter consumer segment to satisfy broad consumer metrics around taste and price while simultaneously scaling production to commercial levels. This will involve solving numerous technical and operational problems, from sourcing inputs in sufficient quantities to optimizing equipment and process design to managing sales and marketing for diversifying product lines. It requires patient investment in targeted R&D, infrastructure buildout, and market outreach. At the moment, the United States is not well positioned to help companies overcome these challenging—yet fundamentally surmountable—barriers.[50]

A lesson can be learned here from past American successes and failures with green energy technologies. Aided by early government funding for basic R&D, US companies led the global market in photovoltaics (PV) throughout the 1960s and 1970s. As late as 1990, they produced 32 percent of the world's solar panels. But that position eroded quickly as first Japanese and then German firms took over the market, each aided by major government interventions. In Japan, the Ministry of International Trade and Industry provided multifaceted support and direction from early on, whereas in Germany the introduction of feed-in tariffs for renewable electricity generated an enormous market that domestic firms stepped up to supply. In the 2010s, highly-capitalized Chinese firms rose to market dominance thanks, in part, to billions of dollars in government-provided credit.[51] Since 2004, the Chinese-manufactured share of global solar panel shipments climbed from 1 to 67 percent, while the US-manufactured share tumbled from 14 to 1 percent.[52] All the while, American funding for basic R&D remained strong, but this could not rescue the domestic PV industry from obsolescence because initial innovation was no longer the key factor. Instead, it was the capacity to produce massively and cheaply, which could be stimulated by both demand- and supply-side policies, that determined who won the market.

A positive development has been the success of some states, notably Texas, in leveraging smart policies to encourage domestic wind and solar power. Texas established a renewable portfolio standard in 1999 and followed it up with ambitious administrative rulemaking, then added a $7 billion investment in transmission capacity in 2005. Coupled with federal investment tax credits, these policies led to a boom in wind turbine installation that quickly made Texas the top wind power producer in the country—a literal windfall for towns across the states' panhandle and western parts, as well as domestic manufacturers such as General Electric, which recently became the world's largest wind turbine maker on the strength of the thriving domestic market.[53]

Today, Texas continues to lead in new wind installation while also dramatically expanding its solar and storage. From 2011 to 2020, Texas was second only to California in new solar capacity installation and is expected to grow faster than any other state over the next five years. The combined growth of renewables in the state has been spectacular: from 2015 to 2020, wind and solar's share of electricity consumption doubled to more than 23 percent. Output of conventional generation has held steady, even as its share declined, thanks to rising consumption. In other words, renewables accounted for nearly all the growth but did not displace conventional electricity producers. As with alternative proteins, however, short-run complementarity will eventually give way to displacement.[54]

4.3 Why alternative proteins should be made in the USA

A good outcome for both alternative proteins and the United States would look more like the Texas wind case. Although the relevant policies may be very different, the basic aim is similar: to provide a promising new industry a path to succeed here in the United States. Success should be measured by physical production capacity rather than just innovative ideas. This is essential for two reasons. First, large-scale manufacturing of alternative proteins will deliver high-paying jobs in clean, hygienic, technologically-sophisticated conditions. American workers should not be deprived of these opportunities. Second, as alternative protein processing moves into high gear, further innovation will increasingly result from a process of learning-by-doing, as companies improve upon existing production processes. Failure to locate significant production capacity within our borders will erode domestic innovation—and the ability to capture value—over the long term.

At this early stage it is difficult to project employment with any certainty. A very conservative scenario for 2030 would see a minimum of 10,000 new domestic jobs in the plant-based space alone, whereas a more aggressive but still realistic scenario for the entire alternative protein sector worldwide (including cultivated and fermented) would put the number at 200,000.[55] More optimistic numbers are being ventured in other quarters. A major recent report from Ontario Genomics, a non-profit funded by the Canadian and Ontario governments, states that cellular agriculture (a category combining fermented and cultivated but not plant-based products) could account for as many as 142,000 new Canadian jobs by 2030.[56] Similarly bullish is a recent analysis by the Good Food Institute Israel, which suggests as many as 50,000 new Israeli jobs in the larger alternative proteins sector. If these projections prove correct, the comparable figure for US alternative protein jobs would be in the neighborhood of half a million.[57] Based on a careful examination of the methodologies underlying these various estimates, and taking a conservative approach, we believe that 50,000 to 100,000 new domestic jobs in alternative protein production can realistically materialize within the coming decade if the US government does not fall behind other nations in supporting the industry's growth.

Upside Foods's state-of-the-art cultivated meat production facility in Emeryville, California

Source: UPSIDE Foods

Employment in manufacturing delivers prosperity to Americans as individuals, but it also generates important opportunities and capabilities for the United States as a nation. To begin with, manufacturing's high jobs multiplier means that for every new job in alternative protein production, we can expect five more in the supply chain and from spillover effects.[58] As important, manufacturing increases private R&D spending that continually produces new intellectual property. It also develops a skilled workforce, building essential stocks of tacit knowledge and practical knowhow. The latter point must be underlined. Advanced manufacturing involves a great deal of "learning-by-doing"—on-the-job experience that not only leads to the highest quality work but also to incremental refinements and advances that cumulatively determine which firms will be at the vanguard of their industries. Without domestic manufacturing of alternative proteins, the United States will lose its current leading position, just as it did with solar panels when it failed to ensure that the largest-scale production remained on shore.[59]

4.4 Complementing and competing with conventional proteins

If alternative proteins achieve moderate growth projections over the coming decade, approaching 10 percent of the global protein market, they will begin to have large effects on current agricultural value chains. How might this play out and what should the United States do to prepare? Economic studies in this area are extremely limited.[60] The USDA's Economic Research Services (ERS), having recently hired new personnel with relevant expertise, is only now beginning to investigate the question.[61] The existing research suggests that alternative protein products may complement, as well as

compete with, conventional meats—at least in the short run. In the medium to long run, however, alternative proteins are likely to capture much of the growth in domestic and global protein demand and eventually to begin displacing conventional meat production.

The small number of existing studies have come in response to the rapid rise of the Impossible and Beyond burger brands. They primarily focus on ground beef and its plant-based competitors. Hannah Taylor (now with ERS) drew on data from the monthly Meat Demand Monitor survey overseen by Glynn Tonsor, a Kansas State University agricultural economist, to examine how demographic factors might affect the market for alternative and conventional meats. In her model, countervailing trends among demographic groups largely offset each other, leading to "very little change in the percentage of consumers selecting beef and plant-based protein" between 2020 and 2030. She concludes that "due to the growth in overall protein demand, plant-based proteins will likely continue to grow, but not necessarily at the expense of beef demand."[62] In this scenario, alternative proteins may capture a large share of protein sector growth while conventional production holds steady for a time.

Agricultural market dynamics are complex. In another study, Margaret Cornelius (also now with ERS) looks at the likely price response from conventional meat producers should plant-based alternatives continue to make market inroads. Conventional ground beef is produced jointly with higher-value products such as steak, with each individual animal contributing to both market segments. This means that producers can adjust prices in one or the other segment more easily than supplies. Consequently, growing market share for plant-based ground beef will likely lead to substantial price reductions in conventional ground beef, raising headwinds for continued market penetration. In turn, lower ground beef prices will eventually translate into lower demand for beef cattle, but a simultaneous rise in the price of higher-value choice and select beef cuts could blunt this effect.[63] There is also potential for complementarity if plant-based alternatives substitute for imported rather than domestic ground beef. The United States imports lean ground beef for blending with the fattier output of domestic producers. By substituting for these imports, domestically manufactured plant-based ground beef could improve the US international trade position while having minimal impact on American beef producers.[64] From this perspective, domestic conventional meat producers have little to fear for now.

However, these studies remain limited and must be qualified in many ways. Most important, they acknowledge the possibility, but do not investigate, how rising consumer preference and declining prices for alternative proteins could dramatically change the picture in the medium and long term. If consumers continue their trend toward greater preference for foods friendly to the environment and animal welfare, and if producers continue to lower prices and improve quality, a threshold could be reached where the market begins to shift sharply. For instance, cultivated meat companies have announced major advancements in product quality and cost reduction in the last year. According to an analysis by McKinsey & Company, cultivated meat costs have declined at a faster rate than costs for genome sequencing did in the past, another case of a novel biotechnology once thought to be decades away from cost-effective deployment at scale.[65]

If alternative proteins follow a similar trajectory, they could compete at both the low end (e.g., ground chicken and fish sticks) and the high end (e.g., choice and select whole cuts), forcing reductions in underlying stocks of farm animals.

The overall picture is one in which alternative proteins do not immediately threaten conventional producers and, by extension, the farmers who supply them with feed. But over a period of years, the growth of alternative proteins will indeed impact agricultural value

chains. In a recent working paper, the economists Florencia Baldi and Nicolas Merener calculate that if 5 to 10 percent displacement of conventional meat occurs by 2030, corn and soybean prices would decline 23 and 35 percent, respectively. "These would be very significant price declines," they observe, "of opposite sign but comparable magnitude to that caused by the ethanol mandate in 2005-2010."[66] While alternative protein manufacturing would open up new avenues for agricultural supply, its inherent efficiency would mean smaller markets for farmers. Policymakers must be prepared to minimize losses with appropriate reconfiguration of the agricultural sector and to implement compensatory measures where necessary. Ignoring the problem will not make it go away. If Chinese and other Asian producers move decisively ahead in alternative protein manufacturing, for instance, the effect on soybean and corn export markets will propagate back to American farmers, without even the benefits of a domestic alternative protein sector to compensate.

4.5 Upshot

It is in American interests that significant alternative protein processing capacity be sited domestically. Company decisions will be based, of course, on business considerations such as access to crop inputs and consumer markets. But there are also variables that governments can do much to determine. These include regulation, public R&D funding, commercialization support, appropriate investment incentives, and workforce training.

To date, Canada has been strongest in the plant-based space while Singapore and Israel have done most for cultivated meat. Each of these countries is bidding not only to lead in product innovation but also to ensure that significant physical production occurs domestically. Yet these remain small countries in terms of population and market size. If alternative proteins are to reach their lofty growth projections, many more and larger manufacturing facilities will take root elsewhere. In addition to Europe and Japan, Brazil, India, China, South Korea, and Southeast Asia loom as likely winners. Notably, Israel's new cultivated meat hub is being led by the country's largest food company, Tnuva, which is controlled by a Chinese parent company.

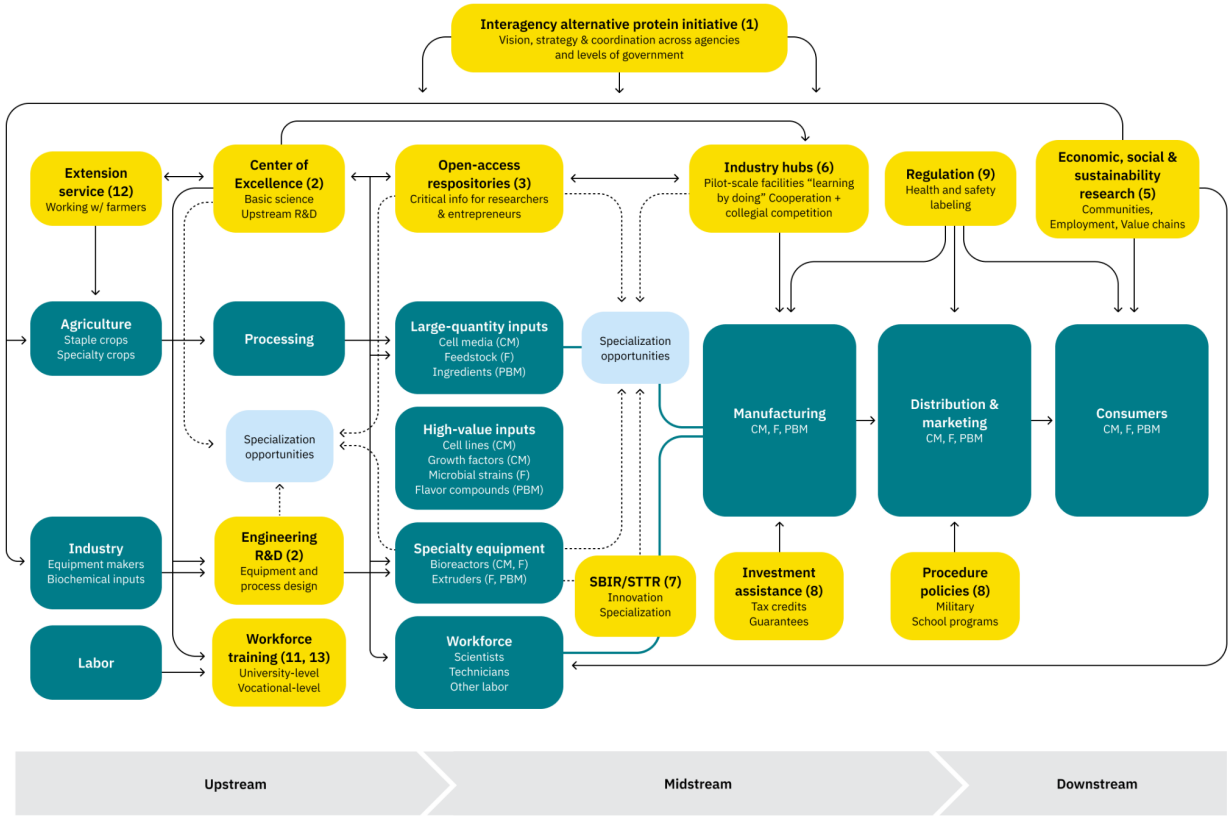
American lawmakers must be particularly mindful that China can move quickly to scale production should its leaders choose to do so. Not only has the country massively increased its governmental investments and capacities in food and agriculture-related R&D over the last two decades, but so have its "private" firms, many of which are actually state-owned enterprises presumably receptive to CCP directives.[67] As former Secretary of Agriculture Sonny Perdue observed about alternative proteins: "We're going to see these technologies go to places around the world that are more conducive to their development, and frankly China may be one of those."[68]

5. What ought to happen? Policy recommendations

The United States should lead the world in advancing alternative proteins. Producing these foods for domestic consumption and export will ensure economic opportunity and growth, as well as provide benefits to food security and the climate. To seize this opportunity, federal and state governments should ensure a level playing field, so that companies can innovate, grow, and provide ample employment opportunities.

The policy platform for alternative proteins consists of three planks: (1) publicly-supported open access R&D; (2) assistance in commercial scale-up; and (3) capacity building through workforce development. A detailed look at each of these planks follows below.

Flow chart of government interventions to build alternative protein value chains



5.1 Open-access R&D

1. Interagency Alternative Proteins Initiative

Alternative protein R&D will require long-term vision, strategy, and coordination across multiple agencies and levels of government. An interagency initiative, modeled on the National Nanotechnology Initiative, would minimize gaps and redundancies across agencies and funding programs, and public-private partnerships can work alongside more localized "centers of excellence" to best leverage public funding for innovative research. The White House Office of Science and Technology could establish such an interagency initiative, modeled on the National Nanotechnology Initiative, and act as the alternative protein czar to accelerate progress on alternative protein innovation. In the value chain flow chart, this box oversees the entire set of proposed policy interventions.

2. Interdisciplinary "centers of excellence" for alternative proteins

Alternative protein development requires integrating knowledge from many technical disciplines, including biochemistry and biomechanics, agricultural science, industrial engineering, materials science, artificial intelligence research, and more. Experts from these disparate areas must be brought together to understand the nature of the problems to be overcome and to fashion integrated solutions. Federal and state governments can achieve this by establishing and funding centers of excellence focused specifically on alternative protein research and development. In many cases, this can be done under agencies' existing authority. Congress or state legislatures could accelerate progress by explicitly authorizing these centers and then funding them, or they could simply use the appropriations process to signal their intent to funding agencies. Universities or institutions with comparable research capabilities, such as national laboratories, should host such interdisciplinary centers. In the value chain flow chart, this box connects directly to all of the key midstream value functions, as well as to both specialization opportunities.

3. Open-access data and biomaterial repositories

Databases and biomaterial banks are classic examples of public goods that governments are best positioned to create and maintain. To minimize duplicated effort and maximize innovation, governments should establish the following repositories on an open-access basis:

- **Input and ingredient characterization database**, including media formulation assessment for cultivated meat, plant protein characterization for plant-based meat, and feedstock data for fermentation
- **Animal protein characterization database** to aid alternative protein producers in replicating or mimicking animal protein attributes
- **Animal cell line bank** for cultivated meat, which could mirror existing public cell line repositories like those used in the pharmaceutical and biotechnological industries
- **Plant germplasm (seed) banks** expansion to include plants important to alternative protein production and to provide data about relevant functional and sensory attributes
- **Microbial libraries** to identify novel microbial strains for use for both precision and biomass fermentation

These repositories can be operated according to several models, including control by a federal agency, partnership with a land-grant institution, or contracting with a private entity. The important thing is to ensure that, in each case, the model selected fits the prime aim of open and easy accessibility of the relevant data and materials. This is a relatively low-cost way to achieve major impact, because it will enable academic researchers to push outward on the scientific frontier at the same time as it will

allow commercial ventures to experiment widely with product design. In the value chain flow chart, this box connects to each of the two major manufacturing input streams.

4. **Ingredient processing and manufacturing equipment**

Research to develop better ingredient processing and manufacturing equipment is an urgent need. The technologies currently being used have largely been repurposed from their original uses and are sub-optimal with respect to scale, cost, and functionality. Agencies could engage in this research directly or fund it through grantmaking programs. Priorities include:

- **Protein and ingredient extraction methods** that are low-cost, scalable, and gentle enough to preserve important functional and nutritional properties.
- **Extrusion and newer manufacturing technologies** to improve plant-based meats' texture and taste while reducing energy inputs.
- **Bioreactor and process design** for cultivated meat and precision fermentation to replace existing bioreactors which were designed for pharmaceutical applications that work on a far smaller scale than food production.

5. **Economic, social and sustainability research**

There is an urgent need to begin systematically studying the potential long-term impacts of alternative proteins' growth and to develop policies that will ensure the industry benefits society and workers. This work has only just begun at USDA's Economic Research Service and should be expanded, while additional funding should be provided to extramural social science and humanistic research by the National Academy of Sciences and the National Endowment for the Humanities, as well as by the USDA and National Institutes of Health. In the value chain flow chart, this box pertains especially to workforce development and community preservation, but it also feeds back into the most upstream stages of the value chain in order to build efficiency and sustainability into every aspect of the required infrastructure.

5.2 Scaling Up

6. **Industry hubs on the "Manufacturing USA" model**

Industry hubs connect researchers, businesses, and labor pools to create thriving industrial ecosystems. In recent years they have proven highly effective drivers of innovation and growth. The Manufacturing USA program provides seed funding for "manufacturing innovation institutes" that bring businesses, universities, and development organizations together, eventually becoming self-supporting through membership fees. The institutes provide a unique space for cooperative innovation and collegial competition. For instance, they operate pilot production facilities that allow new firms to test and demonstrate novel products without compromising process knowledge and IP. Alternative protein work can and should be incorporated into some of the existing 16 institutes, such as BioMADE in St. Paul, MN, which focuses on biomanufacturing of all kinds. In addition, a dedicated alternative protein institute should be set up. In the value chain flow chart, this box is one of the two key programs for manufacturing.

7. **Expanded use of the SBIR and STTR programs**

The Small Business Innovation Research program (SBIR) and Small Business Technology Transfer program (STTR), known as "America's seed fund," have become critical parts of the US innovation system by providing R&D grants to promising young firms. Yet alternative proteins have struggled to access these programs, in part because the USDA consistently fails to

meet its mandated SBIR and STTR funding targets. The USDA should instead work harder to promote these programs to alternative protein companies. Particularly now, as the alternative protein industry is poised for rapid growth, there is great scope for small and medium-sized new firms to optimize various facets of production through specialization and technological innovation, which SBIR and STTR are well-positioned to facilitate. In the value chain flow chart, this box points to specialization opportunities.

8. Investment assistance

Investment tax credits, loan guarantees, and other forms of financial support have been critical to the explosive growth of renewable energy. Similar policies must now be directed toward alternative proteins to support investment in physical infrastructure. As with renewables, the key challenge is the vast scale of production that will be needed. Federal investment assistance could help companies to purchase or lease expensive processing equipment or manufacturing facilities for a lower cost of capital than is available for private equity financing. Public support for capital investment could also prioritize rural areas to ensure the smoothest possible transition from conventional to alternative protein farming, processing, and manufacturing. Additional support should be provided for crops that are typically used for alternative proteins, including by expanding insurance programs for specialty crops like yellow peas. In the value chain flow chart, this box is the other key intervention to expand manufacturing.

9. Fair and nimble regulations

Regulation will determine whether American alternative proteins can compete on an even playing field. Fortunately, early signs at the federal level are positive.

The Food and Drug Administration (FDA) is working cooperatively with companies to ensure the safety of precision fermentation ingredients, and the agency is working with USDA to ensure that safe and properly labeled cultivated meat and seafood can come to market in the United States. Were this to change, an inhospitable regulatory environment could risk draining the United States of key players in the industry, who will look abroad to countries like Singapore. Moreover, state-level labeling restrictions may cause unnecessary economic harm. Labeling should be truthful, not misleading, and reflect the language that consumers use and understand. There should be no discrimination in the use of descriptors like “meat” and “dairy,” and alternative protein producers should be given due latitude to choose their own preferred terminology. In the value chain flow chart, this box connects to the entire downstream segment.

10. Federal procurement of alternative proteins

The federal government spends billions of dollars on food for school lunches, the military, and other programs each year. Estimates suggest that animal-based products made up as much as $2 billion of federal food procurement in 2018. Reforming federal food procurement to include and prioritize alternative proteins would provide a clear end-market for alternative protein manufacturers, both de-risking investments and providing certainty for producers aiming to expand production to achieve economies of scale. Advanced market commitments from federal agencies like the Department of Defense would be a strong indicator of future success for alternative protein firms and investors and could help the industry reach the scale necessary to lower prices and compete more directly with conventional meats. In the value chain flow chart, this box pertains to downstream distribution.

5.3 Workforce Development

11. Training for alternative protein technical workforce

USDA programs could train existing agricultural and meat processing workers to transition from conventional to alternative protein manufacturing. Public-private partnerships to create apprentice programs for alternative meat production facilities could also be important. The federal government already supports apprentice programs for advanced manufacturing industries through Manufacturing USA, which could serve as a framework for an alternative proteins-focused apprentice program. In the value chain flow chart, this box incorporates point 13 below and connects labor to the trained workforce.

12. Cooperative extension for alternative protein planting

The Cooperative Extension Service should develop programs and expertise to inform farmers about opportunities to grow input crops for alternative protein production and to assist them in implementing best practices. In the value chain flow chart, this box not only connects with a double arrow to the centers of excellence, as well as to upstream agriculture.

13. Public information, coursework and degree programs

Through public-facing educational programs, sponsorship of the above-mentioned interdisciplinary centers of excellence, and generally through its many partnerships with universities and vocational schools, the federal government should promote awareness of the alternative protein sector and development of relevant technical knowledge and skill. For instance, public-private partnerships can be used to create internship and fellowship opportunities for students to get hands-on experience, mirroring the Army Educational Outreach Program, which provides funding for students to intern at university, public, and private research institutions in order to advance STEM fields and gain experience. Specifically, these programs should aim to expand support to include the public and land-grant universities, including the 1890 institutions, tribal colleges, and minority-serving institutions to diversify and improve the alternative protein workforce.

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